Urban Forest Strategy Review -2024

City of Melville

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ArborCarbon *Creating Sustainable Ecosystems*

City of Melville

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Table of Abbreviations

Abbreviation	Definition
ABC	Aerial bundled cables
ABS	Australian Bureau of Statistics
AI	Artificial intelligence
APS	Available planting space
AS	Australian Standards
CP	Council Policy
DPLH	Department of Planning, Lands and Heritage
HBI	Harry Butler Institute
KPI	Key performance indicator
LGA	Local Government Area
LPP	Local Planning Policy
LPS	Local Planning Scheme
LST	Land surface temperature
MIS	Minimum Industry Standard
OP	Operational Policy
PSHB	Polyphagous shothole borer
RCP	Representative concentration pathways
SPP	State Planning Policy
SRZ	Structural root zone
TPZ	Tree protection zone
UHIE	Urban heat island effect
ULE	Useful life expectancy
VTA	Visual Tree Assessment
WALGA	Western Australian Local Government Association
WAPC	Western Australian Planning Commission
WSUD	Water sensitive urban design

Acknowledgement of Country

The City of Melville acknowledges the Bibbulmun people as the Traditional Owners of the land on which the City stands today and pays its respects to the Whadjuk people, and Elders both past and present.

City of Melville nagolik Bibbulmen Nyungar ally-maga milgebar gardukung naga boordja-il narnga allidja yugow yeye wer ali kanya Whadjack Nyungar wer netingar quadja wer burdik.

Executive Summary

The City of Melville adopted the *Urban Forest Strategic Plan* in 2017, in order to renew its aging tree population, increase canopy cover in targeted areas, establish and maintain its tree database in order to optimally manage the urban forest, and integrate forest protection into urban planning instruments. This document reviews the delivery of the existing *Urban Forest Strategic Plan*, and based on what has been achieved, sets new targets and goals for the City's updated Urban Forest Strategy.

The Strategy outlines numerous challenges that the City faced in terms of successfully achieving its goals, and opportunities to overcome these. Challenges include population increase and urban consolidation, protection of existing trees, an aging tree population that is more susceptible to the impacts of climate change and pests and diseases, and physical challenges associated with increasing tree canopy cover and available planting space.

The potential impact that the increased rate of urban development will have on trees on privately owned land was determined. If each residential lot in the City of Melville with development potential is developed to its capacity, this will result in a significant decrease in canopy cover on residential land from 6.7% to 3.6%. Considering that approximately half of the land area in Melville is residential land, this will significantly impact the City's canopy cover.

This potential loss of canopy cover on private land was considered during the development of some ambitious yet achievable canopy cover targets for the City. In order for the City to increase canopy cover from 12.5% to 14%, the City will need to plant an additional 35,000 trees on City-managed land in the next ten years.

As part of this analysis, the total space available for planting trees was determined for the City. Even if the City filled all available space in City-managed land with tree canopy, the City would reach canopy cover of 17%. This really illustrates that the 30% minimum canopy cover target adopted by many LGAs around Australia is unrealistic for the City of Melville, particularly with current regulations around tree management on privately owned land.

In order to increase canopy cover on City-managed land, the Strategy provides a Planting Prioritisation Plan for streetscapes and recreational areas. These plans take into account, current canopy, urban heat, available planting space, and economic and social conditions.

The Urban Forest Strategic Plan 2017 – 2036: Part A City-Controlled Land has four goals:

1. The City will **renew its ageing City trees** with **no net loss of urban forest canopy on City land** over the period of the plan, and **increase planting in targeted areas** to achieve locally optimal levels of tree canopy cover.
2. The City will establish and maintain a **tree database** to ensure it has extensive and current knowledge of the location, profile and condition of the City's urban forest, and **potential additional planting sites**. It will support locally relevant urban forest research.
3. The City will strive for **excellent urban forest management,** delivering resilient, diverse, sustainable, fit-for-purpose urban forest on City land supported by **active, innovative community participation**.
4. The City will **integrate urban forest protection into urban planning instruments** and practices and its land and infrastructure asset management.

These goals have been revised as part of this review which reflect the current key focus areas for the City of Melville. These goals are:

1. Value and protect the existing urban forest
2. Increase tree canopy cover across the City to achieve an ambitious yet achievable target
3. Grow a resilient forest by balancing age classes and species diversity
4. Expand and maintain data collection and monitoring

The implementation table provides a series of actions that will enable stakeholders to successfully implement the Urban Forest Strategy and achieve its goals.

1 Introduction

The City of Melville Urban Forest Strategic Plan 2017 – 2036: Part A City-Controlled Land was adopted by Council in 2017, and 2022 marks five years along the Plan's implementation timeline. The purpose of the Strategic Plan was to give practical effect to the Urban Forest and Green Space Policy (adopted in 2016), the objectives of which are below.

1. To protect, preserve and enhance the aesthetic character of the City of Melville.
2. To realise the social, environmental and economic benefits of trees and other vegetation as an integral element of the urban environment.
3. To contribute to community well-being by integrating and aligning the efficient provision of physical, social and green infrastructure and management of natural areas to achieve community wellbeing today and tomorrow.
4. To encourage a sense of shared responsibility and balance individual and community rights to equitably distribute the costs and the benefits of a greener City.
5. To ensure that the urban forest and green spaces integral to the City's sense of place are not compromised in areas of increased residential density.

The principal purpose of this update is to review the City's delivery of the existing Strategic Plan and the progress towards achieving its goals, as well as to develop a holistic Strategic Plan that applies to both City-managed and private land. It will:

1. Review the City's existing tree population and canopy cover and analyse changes in canopy cover since the Strategic Plan was adopted in 2017.
2. Review the progress of the City towards achieving goals set out in the Strategic Plan, identifying gaps, new challenges and opportunities, and adapting the objectives accordingly.
3. Develop data-driven, ambitious yet achievable canopy cover targets for streetscapes, open space and private land that consider policy guidelines and the impacts of development.
4. Update the implementation plan based on the outcomes of the review.

1.1 Urban Forestry

1.1.1 What is an Urban Forest?

'*Urban forests can be defined as all vegetation growing within the urban environment. This consists of two categories: the understorey, such as shrubs and hedges up to 3 metres, and the tree canopy, which is any vegetation above 3 metres*' (Better Urban Forest Planning, WA Department of Planning, Lands and Heritage).

The trees in urban areas are essential to a city's green infrastructure and contribute to livable and healthy cities. All trees within the City of Melville form part of its urban forest. This forest is comprised of all private and public trees, vegetation, including vertical gardens, rooftop greenery, and the soil, water, and ecological elements needed to maintain its growth.

1.1.2 Benefits of an Urban Forest

Urban green spaces go beyond environmental or ecological objectives and deliver social and health benefits that increase the quality of life and well-being of all urban residents. It is well known that urban trees can provide many ecosystem services for our cities and their inhabitants, from temperature reduction to improved health and wellbeing. To ensure these services are maximised, cities require well managed, healthy, functioning, and diverse urban forests.

Growing interest in the urban forest in recent decades has stimulated significant research, monitoring and management evaluation. These investigations have demonstrated that extensive, diverse, and healthy urban vegetation is essential for the livability of a place. Vegetation, and trees in particular, provide important economic, social, health, environmental and aesthetic benefits for urban areas (McPherson *et al*. 1994, McPherson *et al*. 1997, Bowler *et al*. 2010a, Roy *et al*. 2012, Keniger 2013).

The contribution of trees to ecosystem services is significant. These services include air and water filtration, shade, animal habitat, oxygen production, carbon sequestration, and nutrient cycling. Add to this the connection that the urban forest provides between nature and people, and it's clear that trees and vegetation play a crucial role in the urban landscape.

From the native fauna species with improved access to food and shelter, to community members who have enhanced recreational opportunities and water and air quality, to individual property owners who have a more comfortable environment and often increased property resale value – all benefit from a robust and extensive urban forest.

<u>Health and Social Benefits</u>

Urban forests provide a range of health and other social benefits for residents. These include:

- **Encouraging outdoor activity.** Urban forests encourage outdoor activity like walking in local areas and engaging in physical activities like cycling and bushwalking, thus improving wellbeing and reducing healthcare costs. This is especially important as lifestyle-related illnesses like obesity increase in prevalence (Jerrett and van den Bosch 2018).

- **Sun and heat protection.** Shade canopy also reduces exposure to harmful ultraviolet rays from the sun (Heisler and Grant 2000, Grant *et al*. 2007, Bowler 2010b). Shade from urban forests and the relative coolness of vegetation compared to non-vegetated surfaces also reduce temperatures both within and outside shaded buildings, significantly reducing the incidence of heat-related illness and mortality (Donovan *et al*. 2013).

- **Physical well-being.** Urban forests may also influence our biology in more subtle ways, acting on the autonomous nervous system and reducing chronic stress (Egorov *et al*. 2017). This can reduce 'systemic inflammation', a common cause of many non-communicable diseases and related deaths (Jerrett and van den Bosch 2018).

- **Mental well-being.** Added to physical health benefits, a robust and extensive urban forest significantly improves the mental health and wellbeing of people living in cities. A world-first scientific study found a 63% decrease in depression and "feelings of worthlessness" in groups with access to community gardens or green spaces (South *et al.* 2018). Urban forests may also directly affect brain structure and function, reducing the symptoms of depression (Bratman *et al.* 2015). Furthermore, hospital patients with access to views of trees and green spaces recover more quickly than those without (Ulrich 1984, Brack 2002, Frumkin 2003, Verlarde *et al*. 2007). The economic implications of these improved recovery times are significant. Maintaining and extending the urban forest, especially in lower-socioeconomic areas, is an important contribution to the mental health and wellbeing of the community.

- **Traffic calming and crime reduction.** Other social benefits of greening have been found, from traffic calming and road safety effects to reduced crime rates (Mouratidis 2019; Kuo and Sullivan 2001). Slowing traffic and reducing the incidence of crime due to greening are likely to vary significantly depending on location, but it adds to the positive social and health outcomes of urban vegetation.

Environmental Benefits

The environmental benefits of the urban forest include:

- **Greenhouse gas mitigation and reduction.** Trees, shrubs, and understorey convert carbon dioxide to stored carbon through photosynthesis and transpiration. Urban trees thus make a significant contribution to greenhouse gas mitigation and reduction. The aquatic plants and algae in natural swamps and wetlands also store carbon (Chmura *et al.* 2003).

- **Improved air quality.** Urban forests also improve overall air quality through the absorption of gaseous pollutants, including nitrogen dioxides and sulphur dioxide, simultaneously producing oxygen from photosynthesis (Dwyer *et al.* 1992; Brack *et al.* 2002).

- **Water cycling and erosion mitigation**. Tree canopies, understorey vegetation, gardens, and roots intercept, filter and absorb rainfall and reduce stormwater flows (Xiao *et al.* 1998, Kuehler *et al.* 2017). This reduces runoff and pollutants entering watercourses and stabilises the volume of water within the water cycle. Additionally, roots provide structure to the soil, reducing erosion. Robust canopy and understorey also provide a buffer from strong winds, further reducing erosion (and improving livability).

- **Biodiversity.** Extensive urban forest canopy, total vegetated area, and diverse vertical complexity and canopy connectivity lead to strong biodiversity outcomes. Vertical complexity refers to the diversity of groundcover, understorey, midstory and canopy vegetation. When there is good vertical complexity, the habitat is diversified, and the biodiversity of mammals, birds, reptiles, and insects is improved, and conservation outcomes are supported (Alvey 2006; Craig, 2004; Garkaklis *et al*. 2004; Gibson *et al*. 2004; Strehlow *et al*. 2004). Connecting areas of habitat improves access to resources and allows for repopulation of areas where particular species have become uncommon. Improved urban forest design should link areas of habitat through canopy connections and wildlife corridors. Retention of older trees also provides habitat hollows for various species.

Cultural Benefits

- **Incorporation of First Nations knowledge.** Expanding and improving the urban forest provides an opportunity to strengthen these cultural connections, to include First Nations knowledge and cooperation in managing the urban forest, and to improve community awareness of the cultural value of the urban forest.

- **Social connection.** Urban forests improve social connection; they offer a sense of place and support community interaction through events, festivals and passive daily interaction. Parts of the urban forest can become closely linked with people's identities and sense of place.

- **Community cohesiveness.** Studies have also shown that green space in major Australian cities is unevenly distributed, with less green space in areas with a higher proportion of low-income residents (Astell-Burt *et al.* 2014). Improving the distribution of green space and urban forests in the City of Melville may foster improved community cohesiveness and a sense of shared identity.

- **Aesthetic value.** Trees and naturally vegetated areas are considered beautiful by many people. The aesthetic value of trees enhances many of the other advantages discussed in this Strategy, including the mental health, economic, and other cultural values of urban forests. Furthermore, aesthetic value motivates individuals and groups to enhance the urban forest for present and future generations (Dwyer *et al.* 1991, Chapin & Knapp, 2015).

Economic Benefits

Urban forests provide a wide range of economic benefits across an urban area, for local and other government layers, businesses, and residents. These include:

- **Reduced energy costs.** By shading buildings and their surroundings, canopy reduces heat effects and the need for artificial cooling. Past studies found that increasing tree cover by 10% saves annual residential cooling costs between $50 and $90 per dwelling (McPherson and Rowntree 1993, City of Melbourne 2014, Ko 2018). This effect will become increasingly valuable as average temperatures rise with global warming.

- **Increasing property values.** Areas with attractive and extensive urban forests have higher property values than similar areas with lower canopy cover. Tree-lined streets and gardens are attractive to potential buyers, with research demonstrating that a 10% increase in tree canopy for a suburb (Annandale, NSW) can result in a $61,000 increase in the value of property (Aecom - Brilliant Cities Green Infrastructure Report, 2019).

- **Improving retail performance.** Shopping precincts with well-maintained, high-quality urban forests within the precinct and in the surrounding area are likely to be more commercially successful. Studies have shown that people will spend more time and money, return more often, and travel further to visit retail areas featuring high-quality trees (Joye *et al*. 2003; Wolfe 2007).

- **Avoiding costs of infrastructure degradation.** The shade from tree canopy improves the useful life expectancy of municipal assets like roadways and buildings by protecting them from damaging UV rays

(McPherson 2009, City of Melbourne 2014). An increased canopy reduces infrastructure maintenance costs and complexity.

- **Marketing the City.** Urban forests, gardens, and open spaces contribute to the culture and image of a local area or City. An extensive and attractive urban forest communicates an attractive image for locals and visitors. Green spaces help to attract visitors to boost the local economy (Konijendijk 2010).

- **Health system savings.** The overall health benefits of trees lead to considerable savings for health systems. The wellness value of street trees can be greater than $100,000 over their lifespan (Burden 2006). In Canada, the urban forests of eighty-six cities removed 16,500 tonnes of air pollution in one year, leading to human health effects valued at $227.2 million Canadian (Nowak *et al.* 2018).

1.1.3 Climate Change, Heat Islands and Melville's Urban Forest

Australia's climate is predicted to increase in temperature, with rainfall becoming less predictable and more variable, and severe weather events more common. Figure 1 illustrates how climate change may affect the South-west region of Western Australia, for two time periods (2030 and 2090) and for two emission scenarios (RCP4.5 and RCP8), compared to current climatic records (1986 – 2005). Representative concentration pathways (RCP) depict potential greenhouse gas and aerosol emission scenarios. RCP4.5 is considered a moderate scenario in which emissions peak around 2040 and then decline, while RCP8.5 is the highest baseline emissions scenario in which emissions continue to rise. Under a moderate scenario, the south-west region of WA is predicted to experience an average temperature increase of 0.8°C by 2030, and 1.7°C by 2090, while under the highest baseline emissions scenario, the region will experience an average temperature increase of 0.8°C by 2030, and 3.4°C by 2090.

Variable		Current (1986–2005)	2030		2090	
			RCP4.5	RCP8.5	RCP4.5	RCP8.5
Annual rainfall			-13 to 0% (minor difference between scenarios)		-22 to -1%	-36 to -2%
Extreme rainfall and drought			Under all emissions scenarios, the time spent in drought is projected to increase. The intensity of heavy rainfall events is also projected to increase with medium confidence.			
Average temperatures			+0.8 °C (0.5 to 0.9)	+0.8 °C (0.5 to 1.1)	+1.7 °C (1.2 to 2.0)	+3.4 °C (2.6 to 4.0)
Frequency of hot days in Perth	**Days over 35 °C**	28 days	36 days	-	43 days	63 days
	Days over 40 °C	4 days	6.7 days	-	9.7 days	20 days
Fire weather (average number of days with a 'severe' fire danger rating)		4.2 days	5 days (19% ↑)	4.7 days (12% ↑)	5.3 days (26% ↑)	6.9 days (64% ↑)
Sea level rise			+0.07 to 0.17 m (minor difference between scenarios)		+0.28 to 0.65 m	+0.39 to 0.85 m

Figure 1: Projected climate change indicators for the South-west region of Western Australia. Image source Department of Water and Environmental Regulation (2021).

The Urban Heat Island Effect (UHIE) is where urban or metropolitan areas are warmer than their surrounding rural areas. It is caused by various factors, particularly the abundance of manufactured surfaces that absorb and emit heat from solar energy. This leads to cities being significantly hotter than nearby densely vegetated rural areas during hot weather (as shown in Figure 2) (Loughnan *et al.* 2013). The UHIE is a global issue, with cities consistently having higher temperatures than their rural surroundings. Additionally, within a city, the UHIE operates at a smaller scale, with some areas having higher temperatures than others due to limited vegetation coverage.

The steadily increasing warming trends associated with climate change are intensifying already higher temperatures in heat island areas. This is expected to worsen as urban areas increase and vegetation decreases.

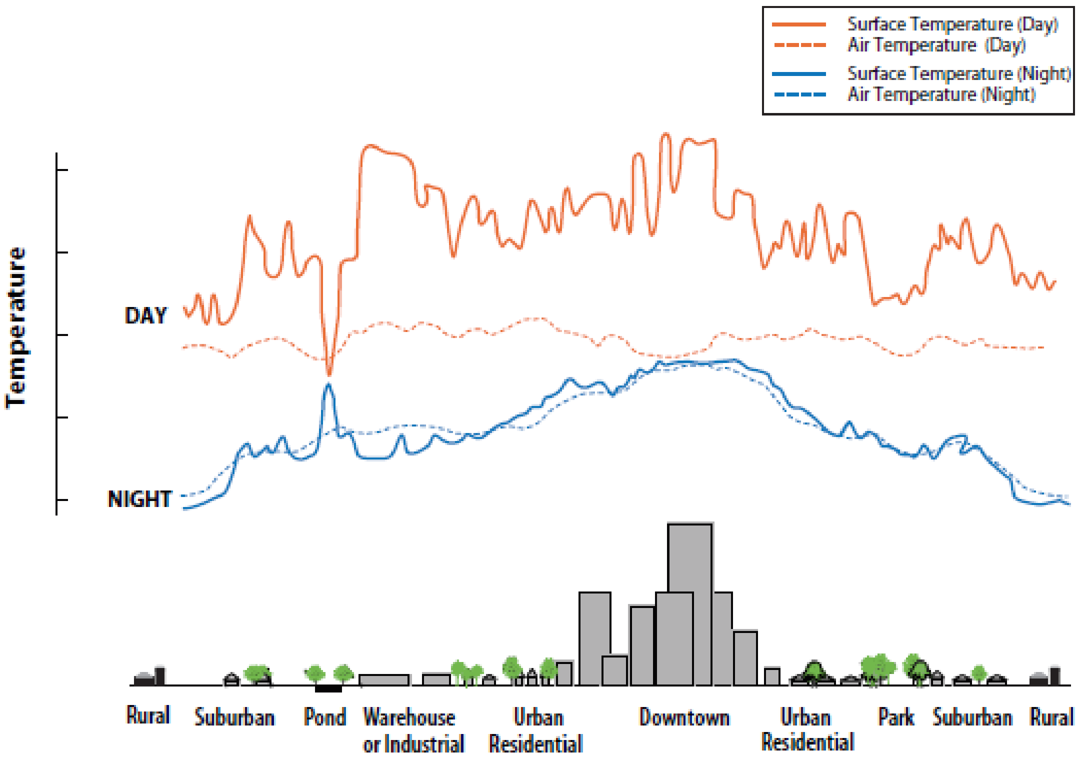


Figure 2: Schematic representation of changes in air temperature in relation to surface characteristics (EPA, 2014).

The UHIE is a major concern during heatwaves, particularly for vulnerable populations. Heatwaves are already a leading cause of human death in Australia (Borchers Arriagada *et al.* 2020). To minimise the impact of the UHIE and reduce heat-related fatalities, it is essential to enhance the urban forest, particularly in areas with low canopy cover.

The UHIE also impacts the quality of life for residents by making outdoor activities less comfortable due to higher temperatures and hot spots in the city. This exacerbates health problems and the costs of cooling buildings.

The UHIE has significant environmental consequences in the long-term. For example, consumption of energy will be expected to increase, resulting in water resources becoming scarcer; this will place added stress on remaining green spaces, street trees and native vegetation. Remnant vegetation is generally more resilient to the UHIE, but it is not unaffected and can struggle to survive and remain healthy at increasingly extreme temperatures and under water stress, both exacerbated by the UHIE. The maintenance costs of infrastructure will also increase because of heat exposure degradation.

Trees, parks, gardens and conservation areas all play a role in reducing the UHIE, with trees being particularly effective in lowering surface temperatures (Loughnan *et al.* 2013). Water also has a cooling effect on urban areas through the surface cooling effect of waterways and proper irrigation of vegetation.

To address the impacts of urban heat, the City of Melville aims to maintain a diverse and well-connected urban forest across land use types and guided by its Urban Forest Strategy. Trees are long-lived assets. As trees planted today will form the future landscapes, it is important to select species resilient to climate change.

Impacts of climate change on the urban forest could include:

- Increased likelihood of water stress and tree mortality due to reduced average rainfall. Existing trees may require regular, long-term irrigation, which would have significant resource implications for Melville.
- Leaf burn and canopy dieback caused by heat waves. These can also increase the imperviousness of existing soils as they dry under increased and extended hot weather periods, leading to decreasing water tables and increasing overland flow volumes (Li *et al.* 2019). Heat waves can also increase fire risk, frequency, intensity and spread.
- Canopy damage and/or total tree failure due to increased frequency and intensity of storms. Intense rainfall events and floods can destabilise root plates and increase soil salinity.
- Disruption to flower and fruit production and/or seed dispersal due to extreme weather events. This may affect the reproductive cycles of plant species and the native fauna species whose survival depends on such food resources.

1.1.4 Purpose of the Melville Urban Forest Strategy

The City of Melville has established a set of objectives and goals for the Urban Forest Strategy. The main objective of the Urban Forest Strategy will be to increase canopy cover across the City.

Broadly, the objectives of the Urban Forest Strategy are to:

- Value and protect the existing urban forest,
- Increase tree canopy cover to achieve an ambitious yet realistic and achievable target,
- Grow a resilient forest by balancing age classes and species diversity,
- Support biodiversity by increasing vegetation connectivity and health,
- Strengthen planning and development standards to promote green infrastructure,
- Collaborate with stakeholders to grow and maintain the urban forest, and
- Engage with the community to increase environmental awareness of how trees enhance livability.

The Urban Forest Strategy aims to reverse the decline in canopy cover and ensure that the City of Melville's urban forest will be planned and managed in an integrated manner that optimises resilience against continued urbanisation and climate change challenges. It will give practical effect to the *Urban Forest and Green Space Policy*. It will complement and extend The City's *Strategic Community Plan, Public Open Spaces Strategy, Local Housing Strategy*, and *Natural Area Asset Management Plan*.

1.2 Policy Context

1.2.1 Legal Requirements

There is no State legislation specific to providing, protecting or maintaining urban forest elements in Western Australia. Legislation that may be relevant under specific circumstances includes:

- *Local Government Act 1995 (WA)*
- *Planning and Development Act 2005 (WA)*
- *Environmental Protection Act 1986 (WA)*
- *Biodiversity Conservation Act 2016 (WA)*
- *Swan and Canning Rivers Management Act 2006 (WA)*
- *Rights in Water and Irrigation Act 1914 (WA)*
- *Heritage of Western Australia Act 1990 (WA)*
- *Environmental Protection and Biodiversity Conservation Act 1999 (Cwlth)*
- *Environmental Protection (Clearing of Native Vegetation) Regulations 2004 (WA)*
- *Planning and Development (Local Planning Schemes) Regulations 2015 (WA)*

1.2.2 National Initiatives

Government: The Australian Government Department of the Environment and Energy, through the National Landcare Program, manages a "20 Million Trees Program" which seeks to "work with the community to plant 20 million trees by 2020 to re-establish green corridors and urban forests". It has engaged three service providers to deliver large-scale tree planting projects nationally and funds local planting projects through a competitive grants process for community groups, landcare associations and local governments.

The Clean Air and Urban Landscapes Hub is a research consortium funded under the Australian Government's National Environmental Science Programe. Its mission is to take a comprehensive view of the sustainability and livability of urban environments, and the "Urban Greening" priorities in its Public Research Plan are relevant to urban forestry.

Non-government: There are national campaigns focused on research, technical advice and advocacy for tree planting/ green spaces. These include the *National Urban Forest Alliance Australian Partnership Plan* 2014-20, and the Greener Space Better Places movement (formerly 202020 Vision, 20% more green space in Australian cities by 2020). The horticulture/nursery industry initiated both campaigns and are now supported by various national and state government agencies, local governments, academic institutions, industry players and community groups.

1.2.3 Western Australia

There are no existing State Government requirements, policies or initiatives specific to urban forest management and protection, although general environmental and planning policy is pertinent in some circumstances. These include:

1. **Department of the Premier and Cabinet**

The Perth and Peel Green Growth Plan for 3.5 million resulted from the Strategic Environmental Assessment of the Perth and Peel Regions undertaken under the Commonwealth's *Environmental Protection and Biodiversity Conservation Act 1999*, and a parallel regional assessment under the State's own *Environmental Protection Act 1986*.

2. **WA Planning Commission / Department of Planning**

Bush Forever reservations under the *Metropolitan Region Scheme* constrain or prohibit clearing and development on property containing designated bushland.

Directions 2031 and Beyond promotes greater infill and higher suburban residential density, with targets for each local government area - a key driver of current residential redevelopment trends in the City of Melville.

Perth and Peel @ 3.5 million is a suite of sub-regional planning frameworks and policy documents that support the State's *Green Growth Plan.*

The *Better Urban Forest Planning guidelines* were developed by the Department of Planning, Lands and Heritage (DPLH) in partnership with the Western Australian Local Government Association (WALGA) to support the enhancement of urban forests in WA, and are designed to assist Local Governments and urban forest managers with best practice actions and data to support the ongoing management of urban forests.

The *State Planning Strategy 2050* provides the strategic context for planning and development decisions throughout the State. It mandates the demonstration of exceptional architectural design and environmental sustainability. At the same time, the Environmental Protection Authority's Interim Advice for *Perth and Peel at 3.5 Million* demands establishing a structure to preserve and improve green spaces and urban tree canopies, in alignment with local government initiatives for tree preservation and management.

The Design WA suite of guidance documents, including *State Planning Policy 7 – Design of the Built Environment*, and a companion document, *Apartment Design*, addresses tree retention and provision of deep soil areas (suitable for tree growth) in proposed design criteria for multiple dwelling and mixed-use developments.

Better Urban Water Management is a strategy for incorporating water-sensitive urban design principles into urban planning in the Perth and Peel regions. It supports *State Planning Policy 2.9 Water Resources* and the *State Water Strategy for Western Australia* (Department of Water).

3. State infrastructure providers

Policies and standards managed by Main Roads WA (road safety) or Western Power (electrical safety), sometimes restrict the size and location of trees near roads or power infrastructure. However, this tends to affect individual trees rather than the urban forest as a whole.

1.2.4 City of Melville

The primary function of the Urban Forest Strategy is to give effect to *Council Policy 102: the Urban Forest and Green Space Policy* and meet the strategic objectives of that policy.

Other Council Policies relevant to this Plan are:

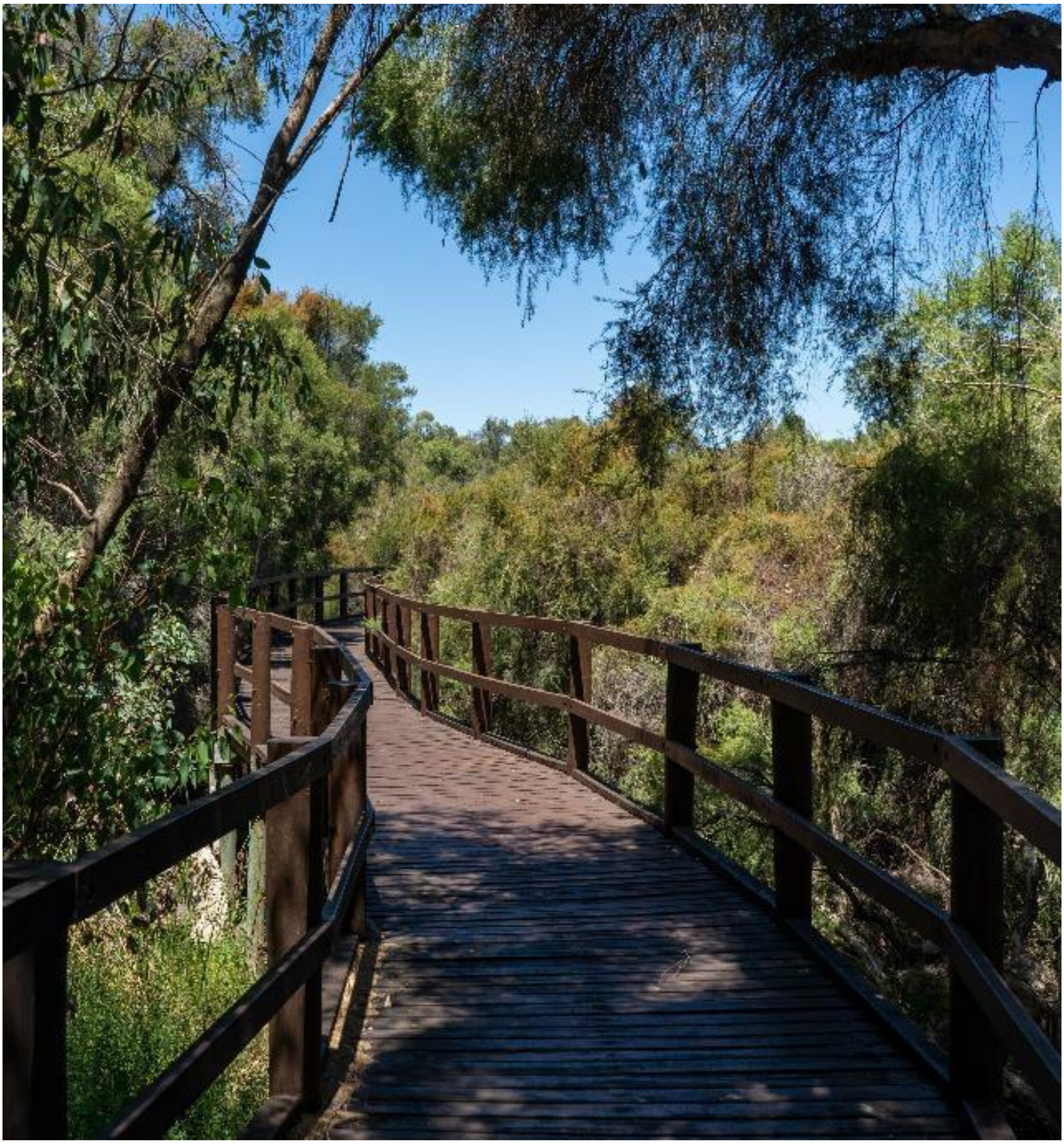
- *CP-029 Tree Policy*
- *CP-086 Verge Treatment Policy*
- *CP-002 Stakeholder Engagement Policy*
- *CP-057 Sustainability Policy*
- *CP-120 Climate Action Policy*
- *CP-030 Environmental Policy*
- *OP-20 Public Open Space Water Usage Policy*

Relevant Operational Policies and Informing Plans include:

- *Corporate Climate Action Plan 2023*
- *Strategic Community Plan 2020*
- *Active Reserve Infrastructure Strategy 2020*
- *Corporate Business Plan 2020*
- *Local Housing Strategy 2018*
- *Public Spaces Strategy 2018*
- *Corporate Environmental Strategic Plan*
- *Long-Term Financial Plan*
- *Natural Area Asset Management Plan 2019*
- *Infrastructure Asset Strategy and Plan*

Urban Planning Instruments:

- *Local Planning Scheme No. 6*
- *Local Planning Strategy 2016*
- *Local structure and precinct plans*



2 Existing Tree Population

2.1 Street Trees

In 2012, the City began an individual street tree survey across the City's street tree population, which has formed the basis of the tree inventory. The survey is ongoing, and the City collects data on 20% of the street trees annually, in order for each tree to be assessed every five years. The City has now recorded over 44,000 street trees throughout the City's streetscapes. The inventory data also includes identifying suitable but unutilised planting sites that can be used for infill or additional planting.

A desktop assessment involving the examination of the City's street tree inventory was undertaken to determine key statistics to indicate overall urban forest health. These key statistics include:

- Urban forest diversity (genera and species)
- Tree health
- Tree structure
- Age and useful life expectancy (ULE)

2.1.1 Diversity

Diversity is critical for urban forest resilience. Increasing urban forest species diversity is important in building resilience to climate change. Species diversity can be measured by analysing the composition of family, genus and species of the urban forest. Urban forest diversity also incorporates life forms, shapes and sizes, that make up a complex and rich ecosystem. Diverse urban forests are composed of many cultivars and species and multiple vegetation layers that offer the best opportunities and resources for fauna.

Many of Melville's established streets are defined by single species avenues and rows of trees. Commonly, these are exotic species such as Jacaranda, and are often all the same age as they were planted simultaneously. While these avenues create striking visual landscapes, they provide for poor species and age diversity. They are however historically important to Melville and provide significant canopy cover.

Low species diversity will leave an urban forest vulnerable to pests and diseases and future climate scenarios (Kendal *et al.* 2014). If species diversity is low, focus should be placed on diversifying the species planting palette and avoiding planting already overrepresented species.

Genetic diversity as a measure of urban forest health is discussed in more detail in Section 6.6.2.

2.1.1.1 Genera

The City's urban forest includes a variety of different genera, 113 in total. The top twenty species are presented in Figure 3. *Jacaranda* dominates the tree urban forest (approx. 7000 trees); however, there are also significant numbers of *Eucalyptus* (5000 trees), *Callistemon* (4000 trees) and *Lophostemon* (3500 trees).

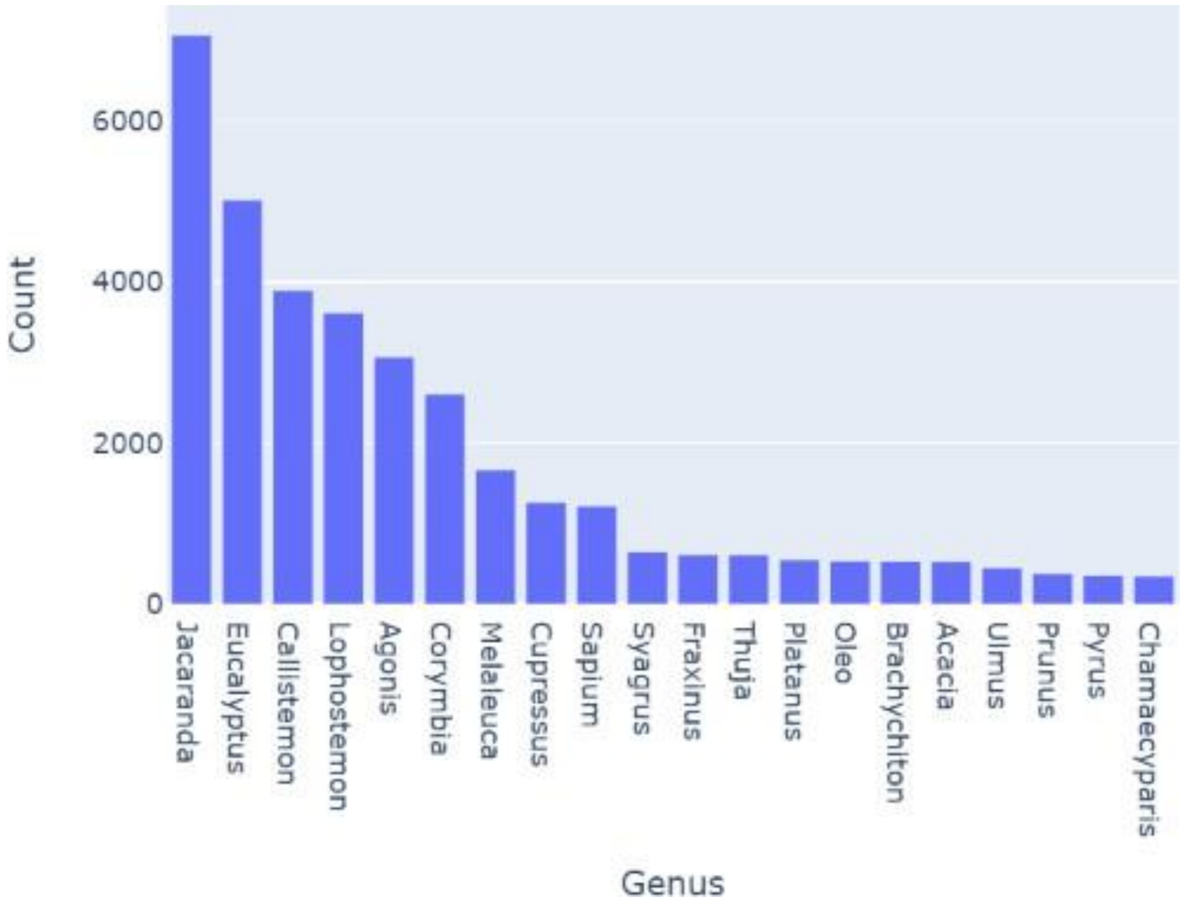


Figure 3: Top twenty genera in the Melville urban forest and their counts.

2.1.1.2 Species

Jacaranda mimosifolia dominates the species diversity in the City of Melville, as seen in Figure 4. Over 7000 of the trees in the City's urban forest are *J. mimosifolia*. The next most common species is *Lophostemon confertus*; however, this is still only half the amount of *J. mimosifolia* (approx. 3500 trees).

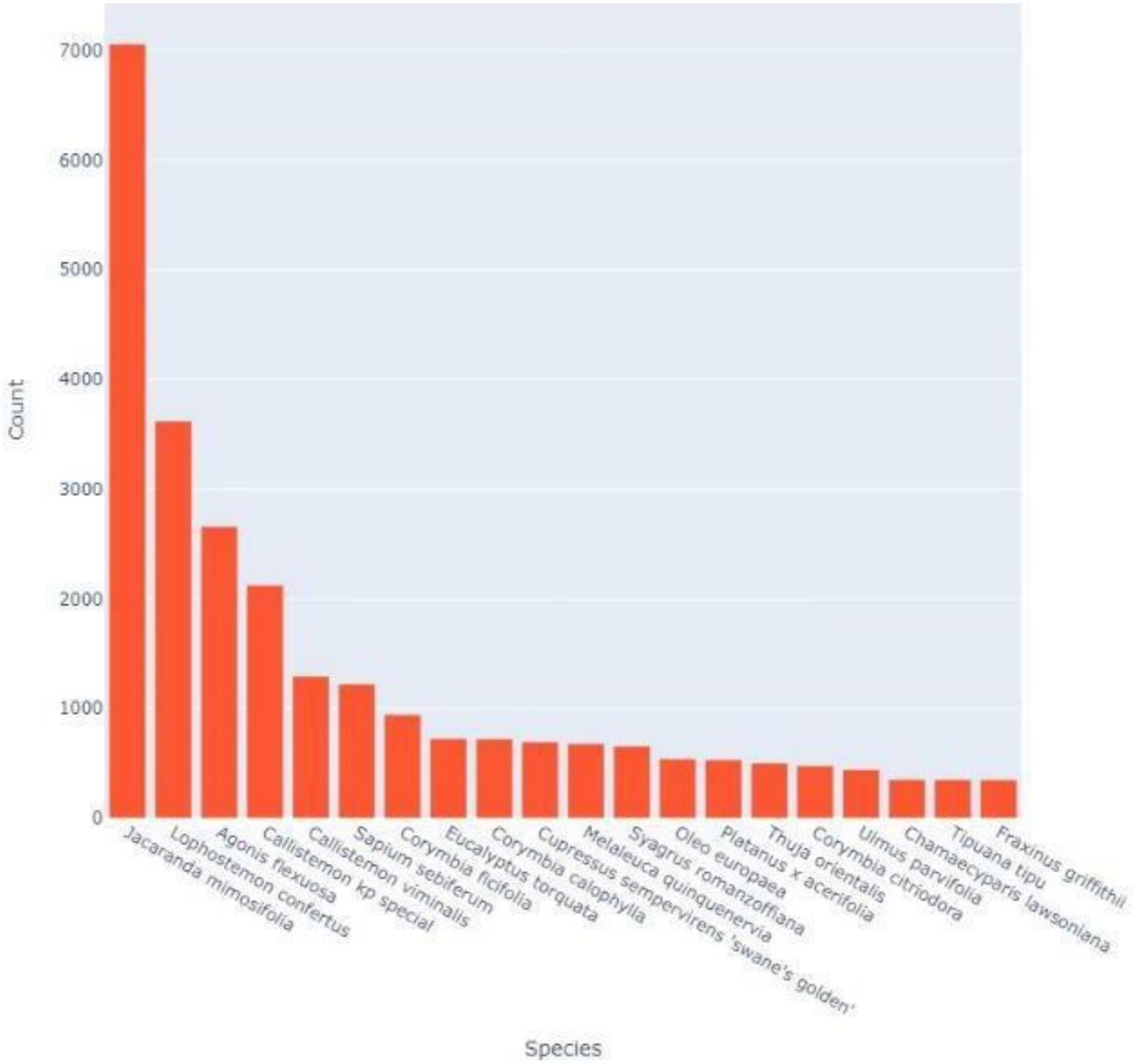


Figure 4: Top twenty species in the Melville urban forest and their counts.

2.1.1.3 Origin

The City of Melville street tree population is 41.7% native to Australia, 14.6% local native (native to South West WA), and 43.7% exotic (Figure 5).

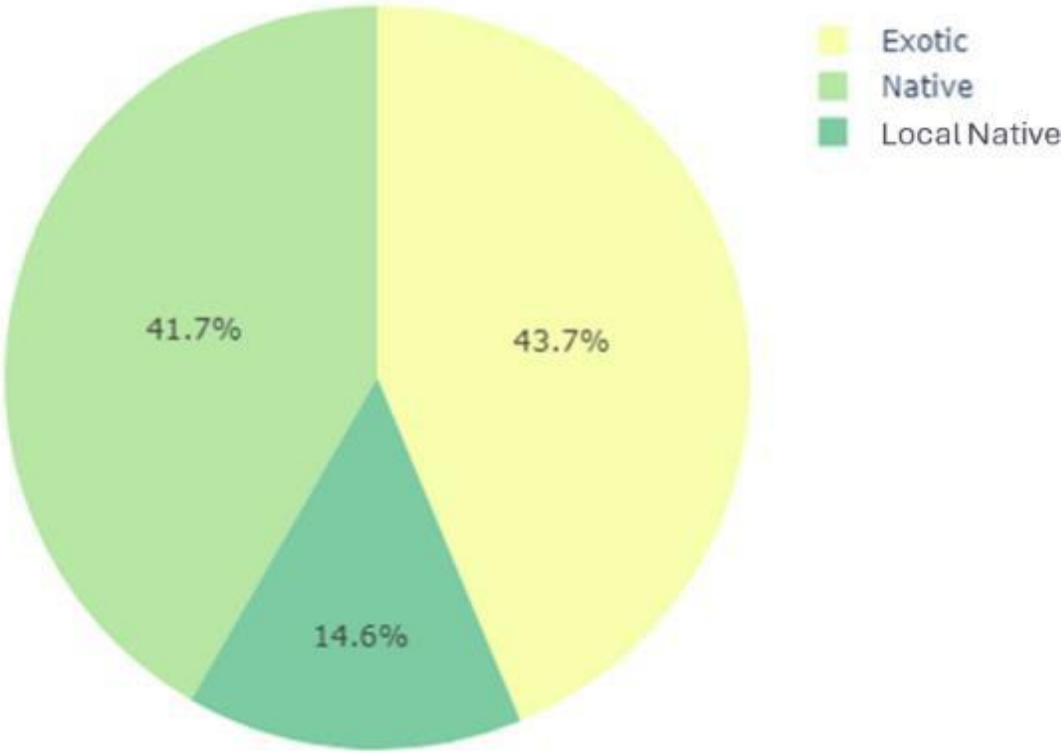


Figure 5: Proportion of City-managed trees that are exotic, native to Australia, and local native.

2.1.2 Health

Tree health refers to an individual tree's health; it indicates overall vitality and vigour. A tree with good vigour demonstrates excellent or exceptional growth, exhibiting a full crown of foliage and no significant abiotic or biotic health disorders. Conversely, a tree that has poor health is not growing to its full capacity, where new growth is minimal, and the crown is thinning or sparse. It may have large amounts of deadwood and/or suffers significant abiotic or biotic stress.

The trees in the City of Melville are rated for health on a scale of ‘Excellent’ to ‘Very Poor’. Qualified arborists undertake this subjective assessment. Most trees were rated ‘Good’ (approx. 28,000 trees) (Figure 6). A further approx. 12,000 trees were rated ‘Fair’. Approximately 1600 trees were rated as having ‘Excellent’ health. Very few trees were given the rating of ’Very Poor’ (approx. 400 trees) or the lowest health rating of ‘Dead’ (approx. 500 trees). This indicates that most trees were in reasonable health at the time that they were audited.

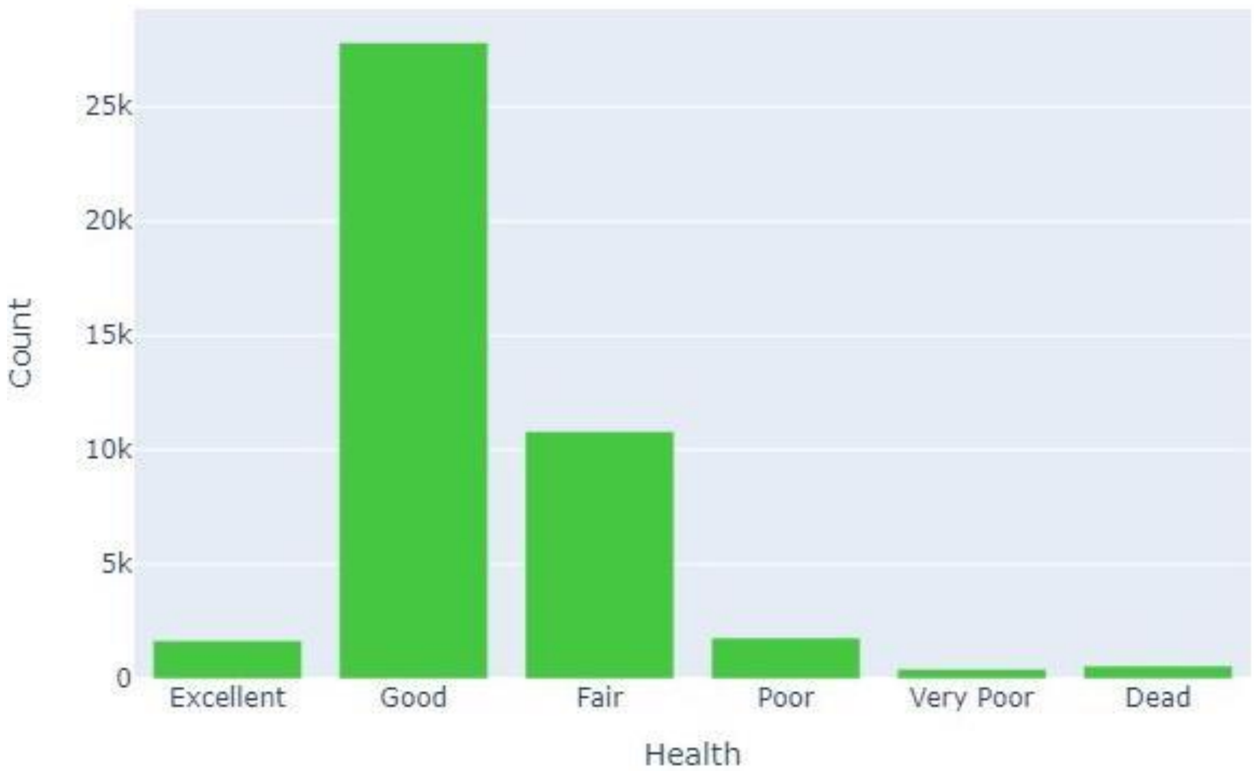


Figure 6: Count of tree health status of the City of Melville’s urban forest tree population.

2.1.3 Structure

Tree structure refers to the structural integrity of an individual tree; it should consider the presence of defects and the condition of canopy, trunk and root plate according to the Visual Tree Assessment methodology (Mattheck and Breloer 1994). A tree with good structure has strong branch unions, with no defects evident in the trunk or the branches. A tree that has poor structure may have a poorly structured crown, and the crown may be unbalanced or exhibit large gaps. Branches may be rubbing or crossing over, and branch unions may be poor or faulty at the point of attachment.

The trees in the City of Melville are rated for structural integrity on a scale from 'Excellent' to 'Has Failed'. This subjective assessment is undertaken by qualified arborists. Most trees (approx. 25,000) were rated as having 'Fair' structural integrity, indicating most of the tree population is of reasonable structural integrity (Figure 7). Very few trees were rated as having 'Very Poor' structure (approx. 500 trees).

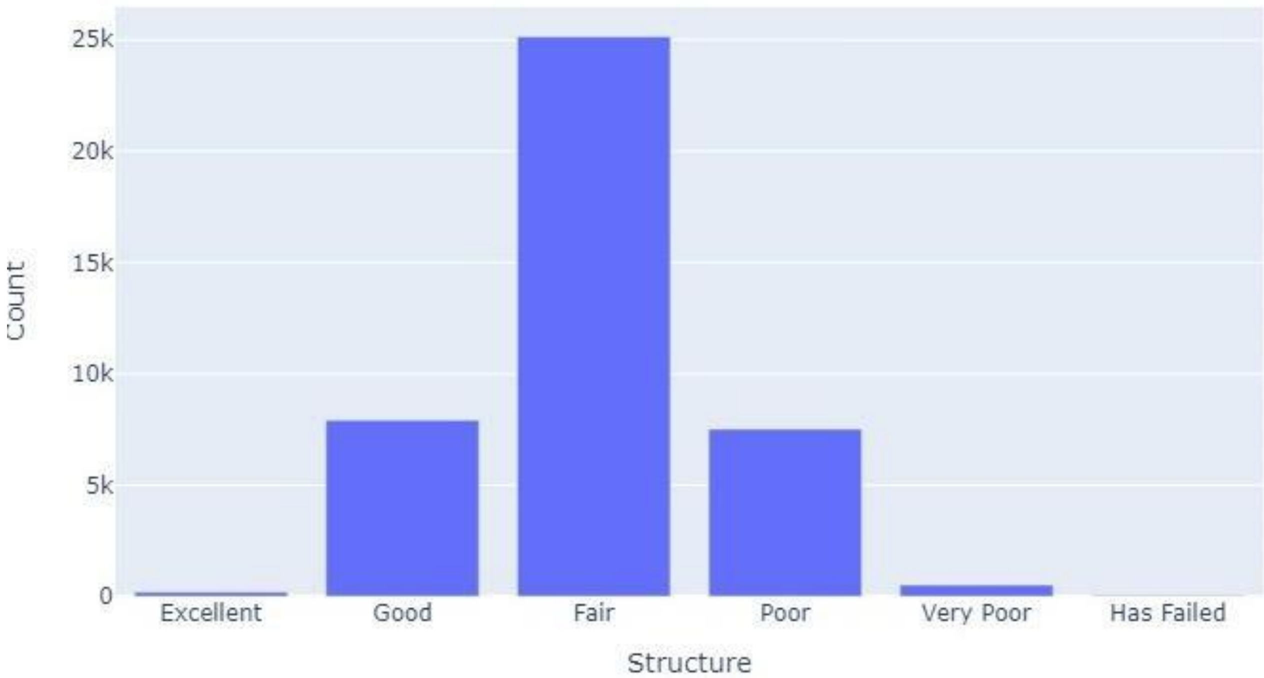


Figure 7: Count of tree structure ratings of the City of Melville urban forest tree population.

2.1.4 Age and Useful Life Expectancy (ULE)

Trees are living, dynamic organisms that have a finite life span. Due to the unfavourable conditions under which urban trees grow (i.e., reduced growing space, poor soil conditions, low soil moisture, conflicts with infrastructure), urban trees typically have a shorter lifespan than those found in their natural forest environment (Norris 2003). Age class distribution is a critical factor in determining the health and resilience of urban forests. Age class refers to the distribution of trees across different age groups within a forest. An urban forest should have a diverse age-class structure, with a mix of young, mature, and old trees.

Tree health as a measure of urban forest health is discussed in more detail in Section 6.6.4.

Melville's urban forest has a high representation of mature trees (approx. 19,000, Figure 8). There are two schools of thought around age class distribution. The first is that the ideal urban forest has an even mix of young, semi-mature and mature trees within the tree population; under this scenario, a high representation of mature trees is generally not ideal as this may impact tree canopy cover as these trees require removal as they become over-mature, and are more susceptible to damage from pests, diseases and other factors of tree stress (Nowak and Crane 2002). The second school of thought is that a higher proportion of mature trees is desirable since mature trees have larger canopies and provide the greatest benefits (Pretzsch *et al.* 2021).

The main goal for the City of Melville will be to strike an equilibrium between the desire to maximise the benefits that larger mature trees provide and the necessity to remove older trees as they near the end of their useful lives. The City of Melville will need to focus on the continued delivery of the annual vegetation planting program to ensure that there is a succession of tree age classes and that all trees that are removed are replaced. Ensuring good tree maintenance practices, such as appropriate species selection, ensuring quality stock, correct planting and establishment maintenance, proactive maintenance throughout the lifetime of the tree, and appropriate pest and disease control, will also contribute to improving age class distribution by ensuring that mature trees are well-managed and reach their full age potential.

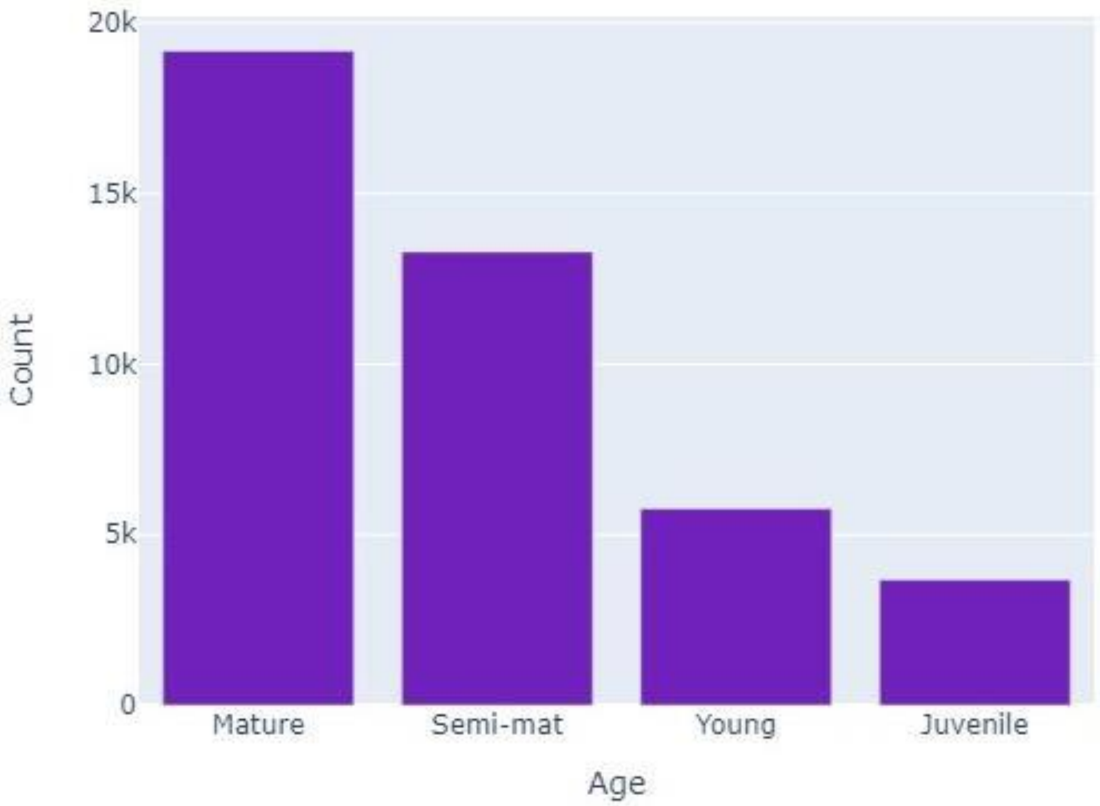


Figure 8: Count of tree age classes of the City of Melville urban forest tree population.

ULE is a measure of how long a tree will remain in the landscape before it requires removal. ULE considers a tree’s age, health, structure and appropriateness for its location and allocates a period in which it will continue to provide a useful contribution to the urban forest. Like age and species, an urban forest should have a good spread (high diversity) of different ULEs to ensure no significant loss of the tree population during one particular period (Pretzsch *et al.* 2021).

The trees in the City of Melville are rated for ULE on a scale from 0 years to more than 50 years. This subjective assessment is undertaken by qualified arborists. Whilst there is a high proportion of mature-age trees in the City of Melville, the majority have a ULE rating of 10 – 20 years (approx. 20,000 trees), or 20-50 years (approx. 15,000 trees) (Figure 9). This indicates these mature trees are healthy and have many years to live. However, there is a significant gap between trees with a ULE of 20 – 50 years, and those with a ULE of >50 years. The City has increased its planting program, so this gap is likely to decrease in size in future assessments of the City's tree audit.

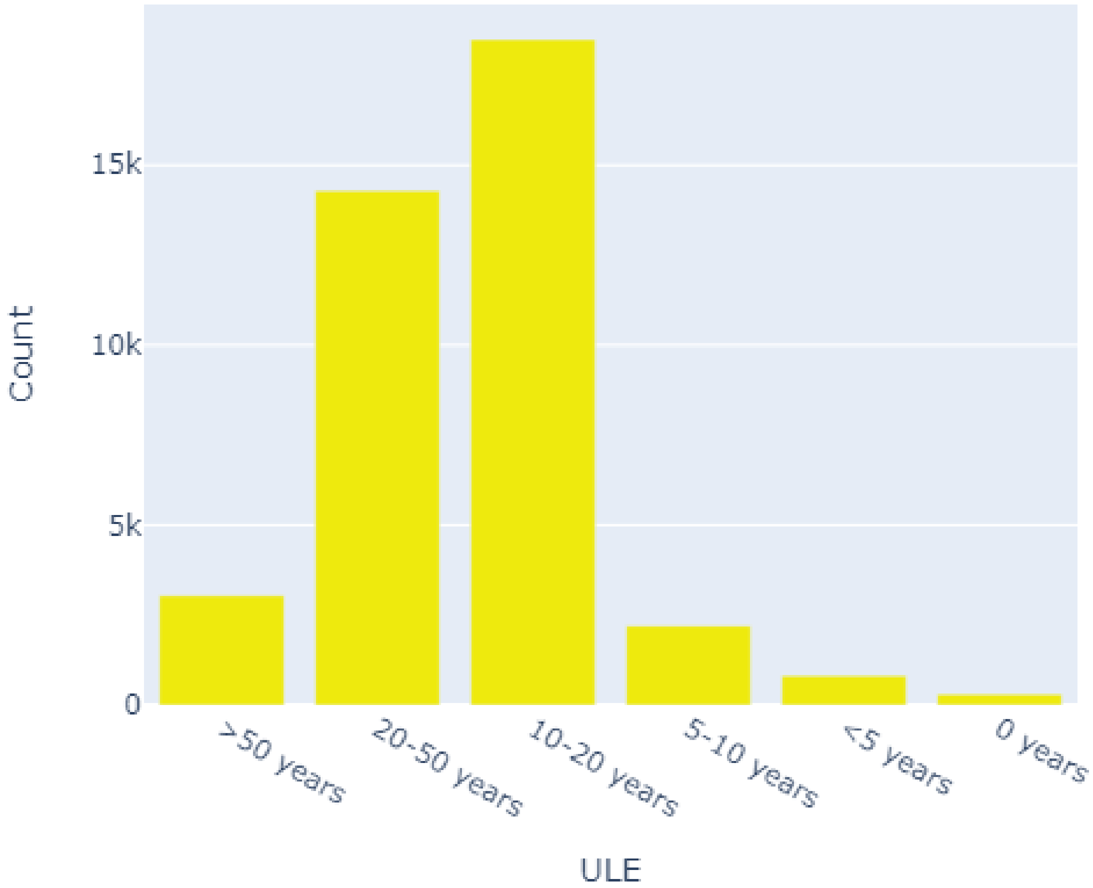


Figure 9: Count of tree ULE classes of the City of Melville urban forest tree population.

2.2 Canopy Cover

The City has committed to aerial assessment of vegetation cover every five years. The most recent acquisition occurred in February 2022, and was undertaken using airborne ArborCam™ imagery. Data was acquired over the entire City area, including parks, natural areas, road reserves, and privately owned land. Vegetation and canopy cover statistics were extracted from suburbs (Figure 10), parks (Figure 11) and land tenure (public and private land) (Figure 12).

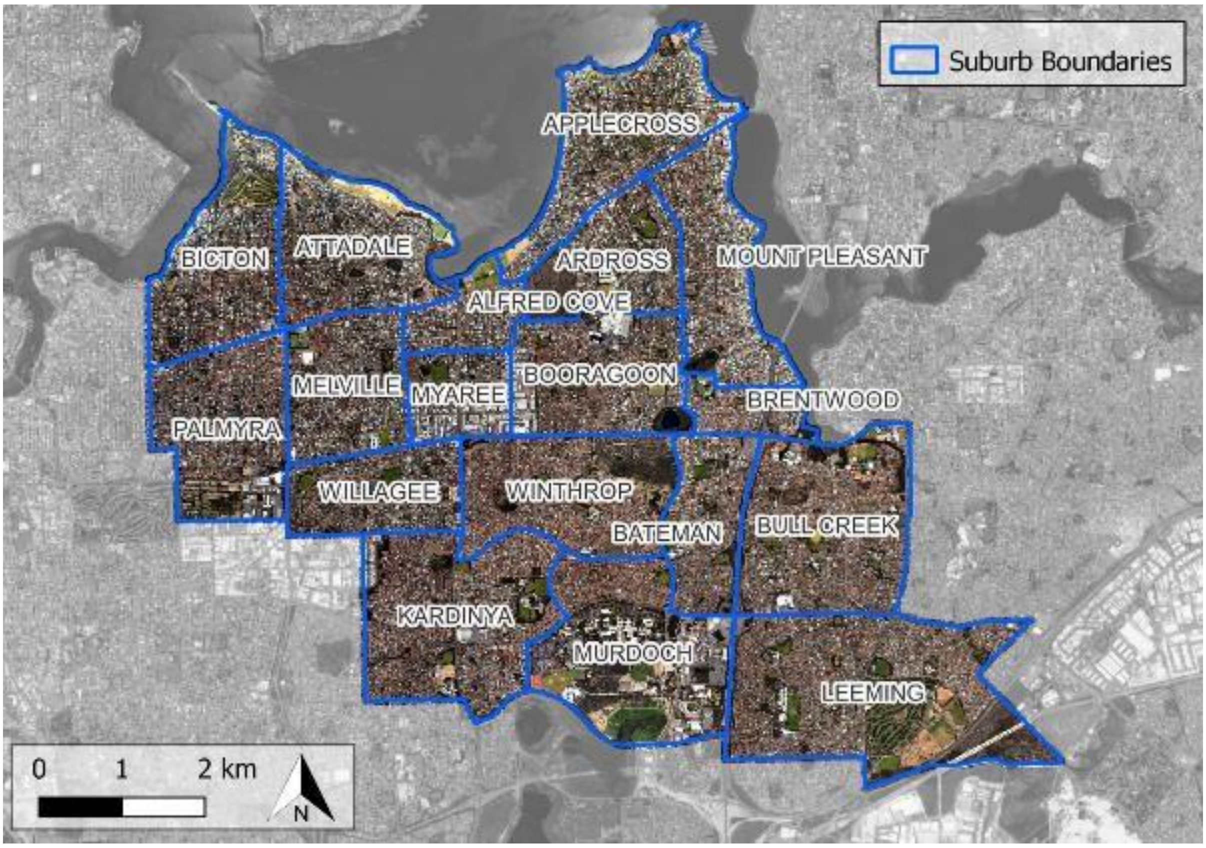


Figure 10: Suburb boundaries used to extract vegetation cover statistics for the City of Melville.

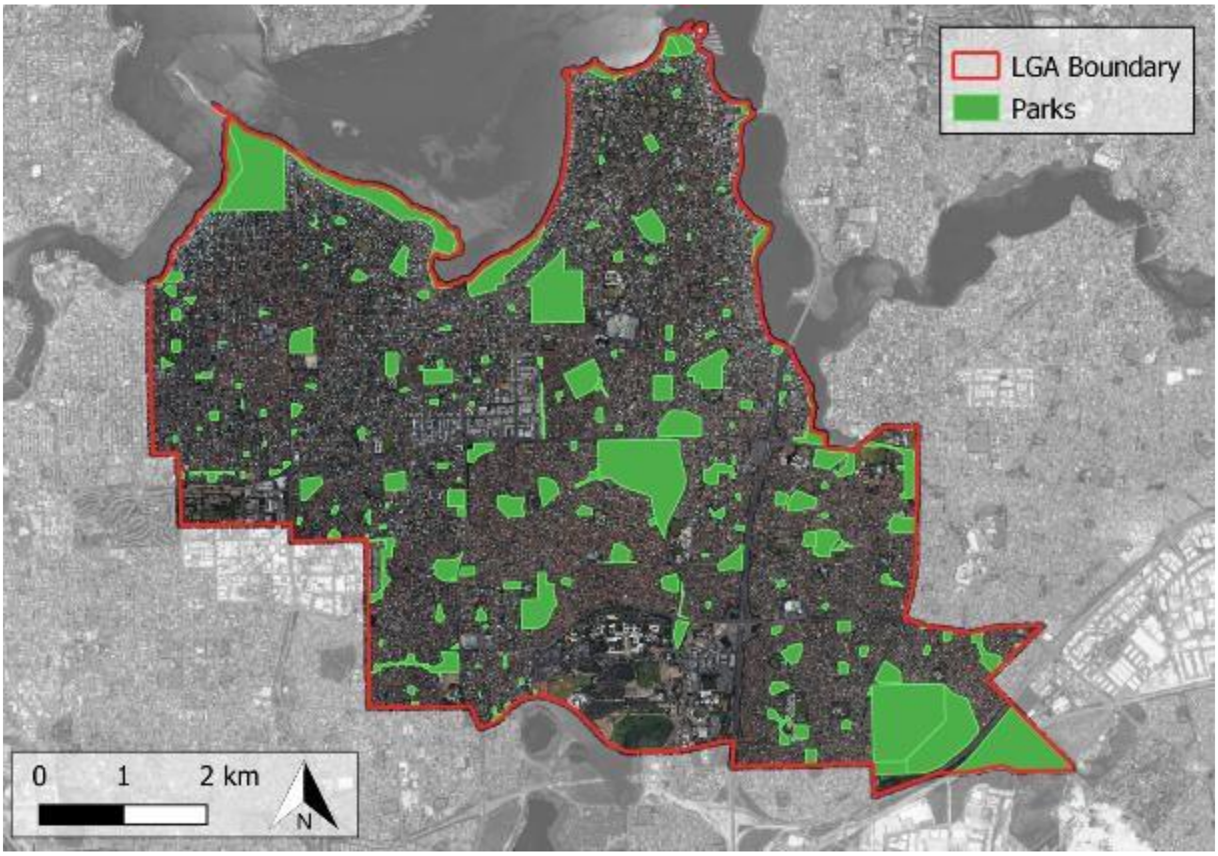


Figure 11: Park boundaries used to extract vegetation cover statistics for the City of Melville.

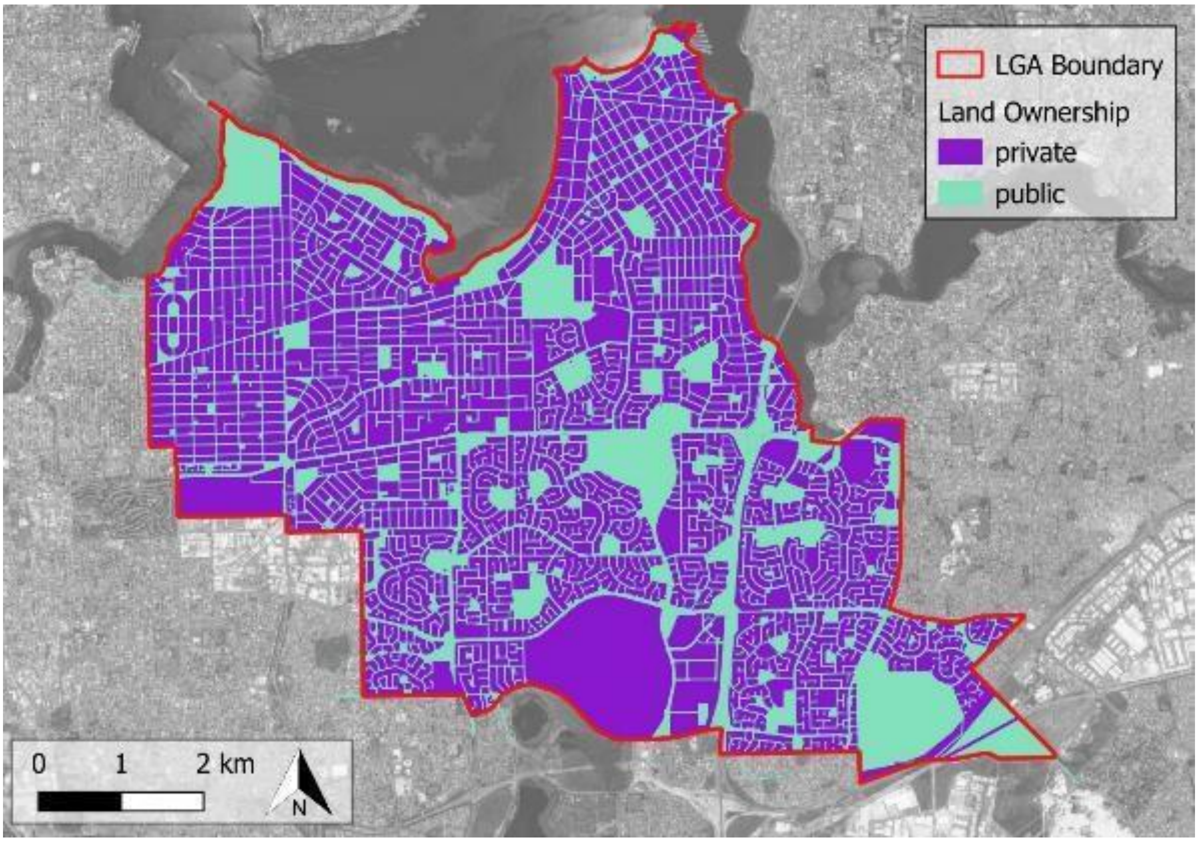


Figure 12: Land ownership boundaries used to extract vegetation cover statistics for the City of Melville.

Height-stratified vegetation cover statistics were calculated for each suburb, ward, park, and public and private land. This analysis defines tree canopy **as vegetation 3 or more metres in height.** This is in line with the definition of canopy outlined in the *Better Urban Forest Planning* Guide (Department of Planning, Lands and Heritage), and with general guidelines worldwide.

2.2.1 City Wide

The City has an entire area of 5268 ha. Approximately one-third of the City (1551.2 ha, 29.4 %) was covered by vegetation. The remaining 3716.7 ha (70.6%) was non-vegetated surfaces, such as buildings, roads and bare earth (Figure 13). Vegetation classified as turf occupied 304.7 ha (5.8% of the total area) and 590.5 ha (11.2% of the total area) was classified as vegetation 0-3m in height. Canopy (vegetation 3m and above) covered 656 ha (12.5% of the City).

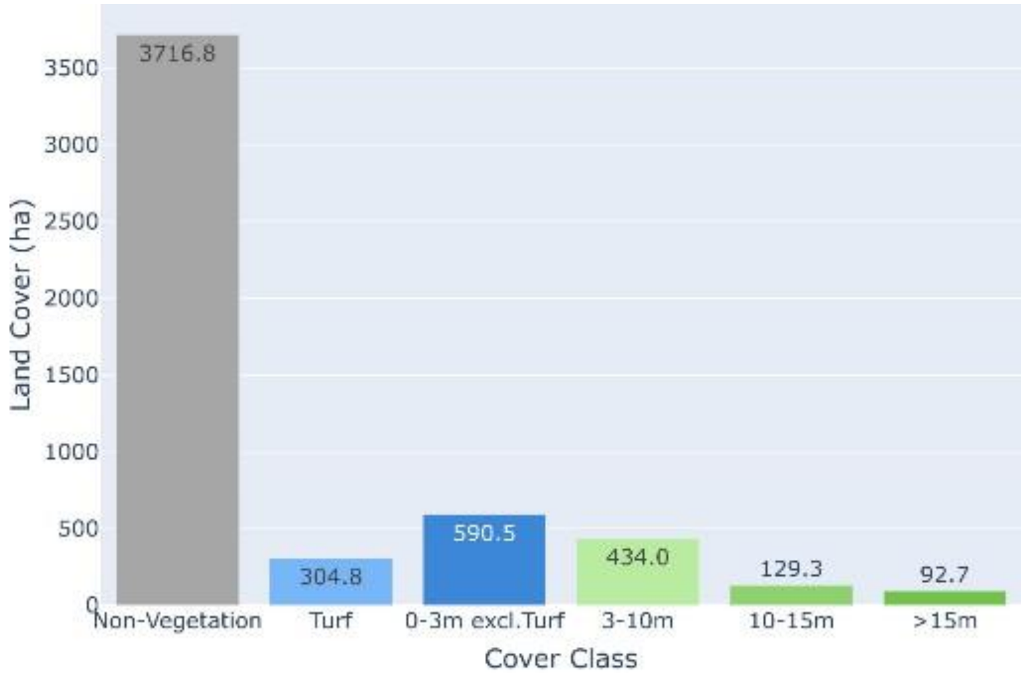


Figure 13: Land cover classification proportion (%) (left) and hectare coverage (right) of the entire City of Melville LGA boundary.

2.2.2 Suburb

The average canopy cover for the City of Melville was 12.5%. Canopy cover varied for each suburb.

Murdoch had the highest proportional canopy cover, at 17% of its total area (Figure 14). Bicton had the second highest (16.3%), followed by Ardross (14.2%). Myaree had the lowest proportional canopy cover (6.6%), followed by Alfred Cove (8.6%), Bateman (9.7%) and Kardinya (10%).

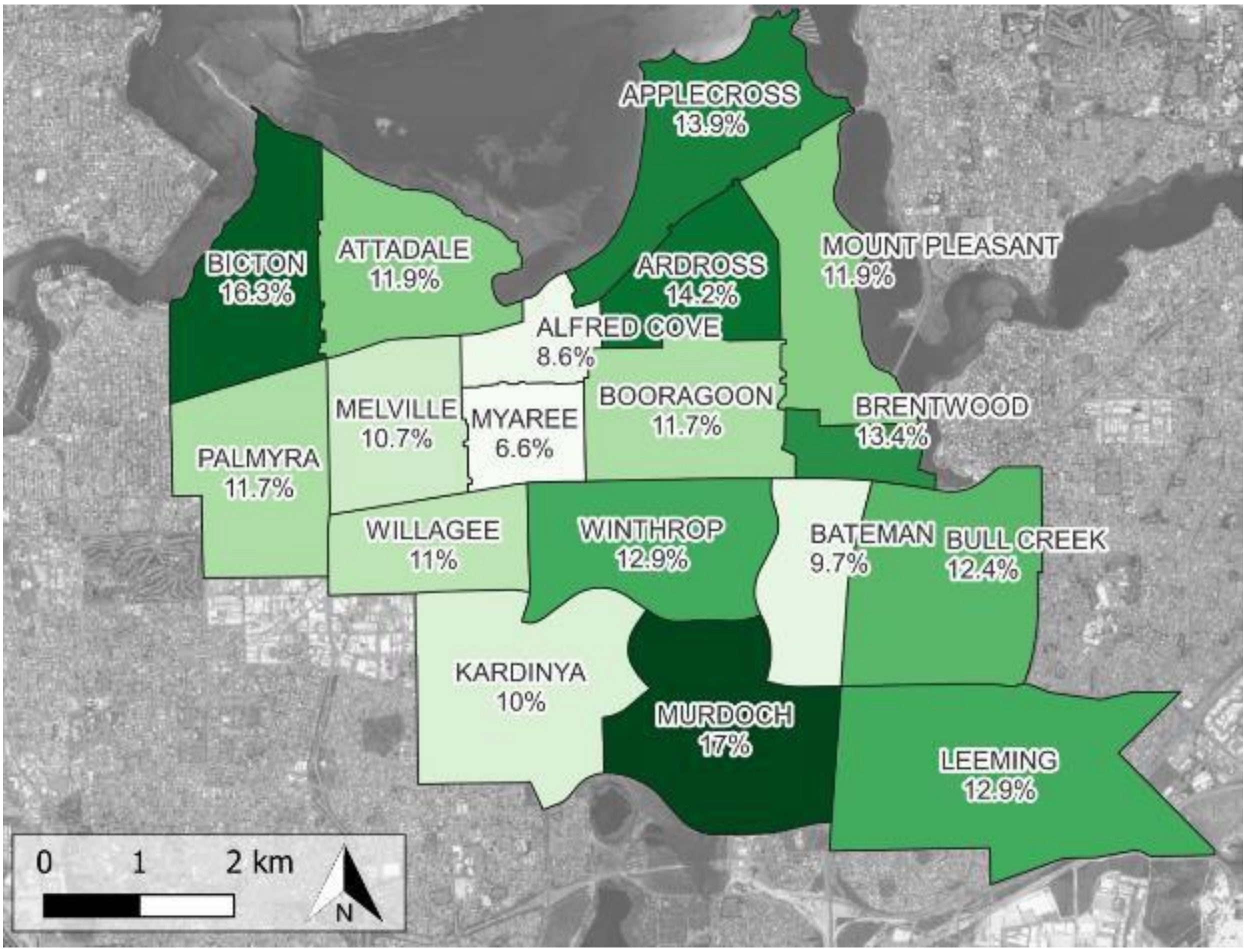


Figure 14: Thematic map showing canopy cover as a percentage of total suburb area. The darker green indicates higher relative canopy cover percentage.

2.2.3 Parks

Height-stratified vegetation cover statistics were determined for total Park area (733.4 ha in total) and each individual Park. In total, 417.2 ha (56.9%) of Park area in the City was vegetated (Figure 15). A significant portion (316.1 ha, 43.1%) of Park area was non-vegetated area. This can include dead grass, bare earth, synthetic playing courts, footpaths, carparks, waterbodies and buildings. 127.8 ha (17.4%) of Park area was turf. 202.6 ha (27.6%) of Park area was covered by canopy.

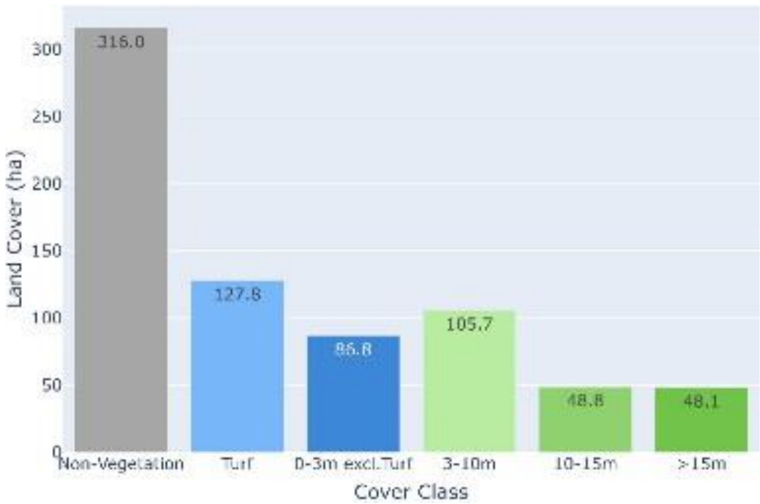


Figure 15: Land cover classification proportion (%) (left) and hectare coverage (right) of Parks in the City of Melville LGA boundary.

The percentage of canopy cover in each individual Park is spatially presented as a thematic map (Figure 16). Increasing green intensity in the map corresponds to increasing proportional canopy cover.

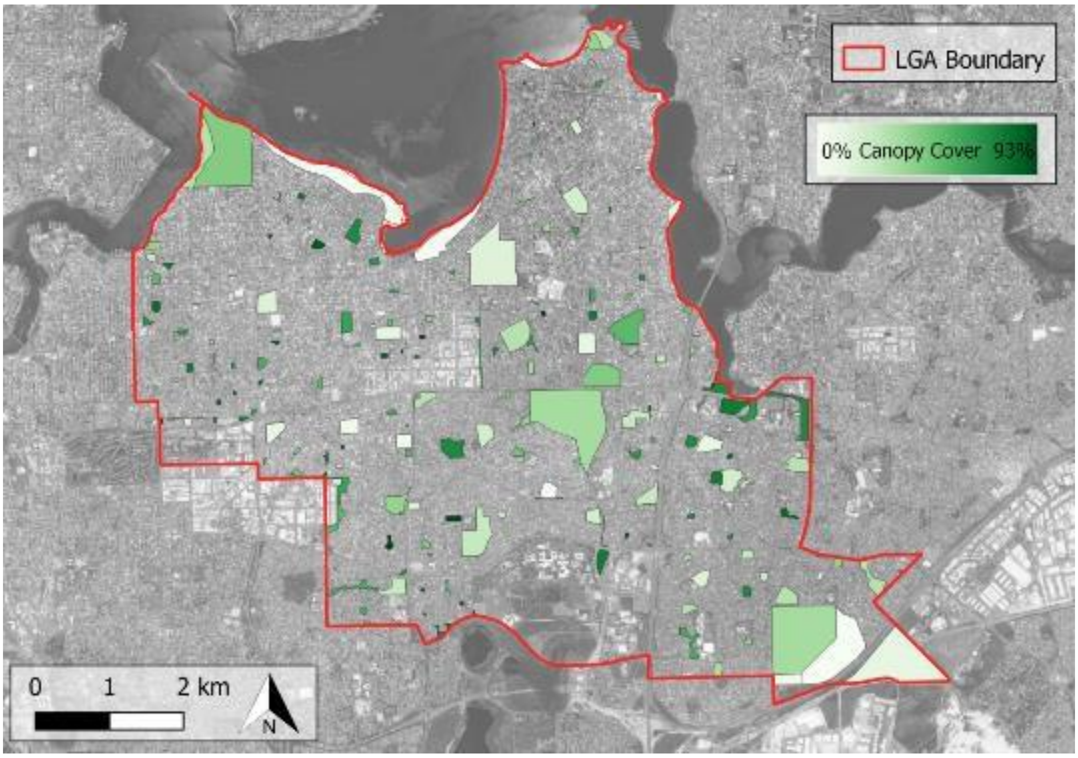


Figure 16: Thematic map showing canopy cover as a percentage of each Park. The darker green indicates higher relative canopy cover percentage.

2.2.4 Land Ownership

In total, 712.8 ha (36.2%) of Public land was classified as vegetation (Figure 17). The remaining 1257.6 ha (63.8%) was classified as non-vegetation. Canopy covered 18.8% (359.6 ha) of Public land (Figure 18). In total, 838.8 ha (25.3%) of Private land was classified as vegetation. The remaining 2472.3 ha (74.7%) was classified as non-vegetation. Canopy covered 296.6 ha (8.7%) of Private land.

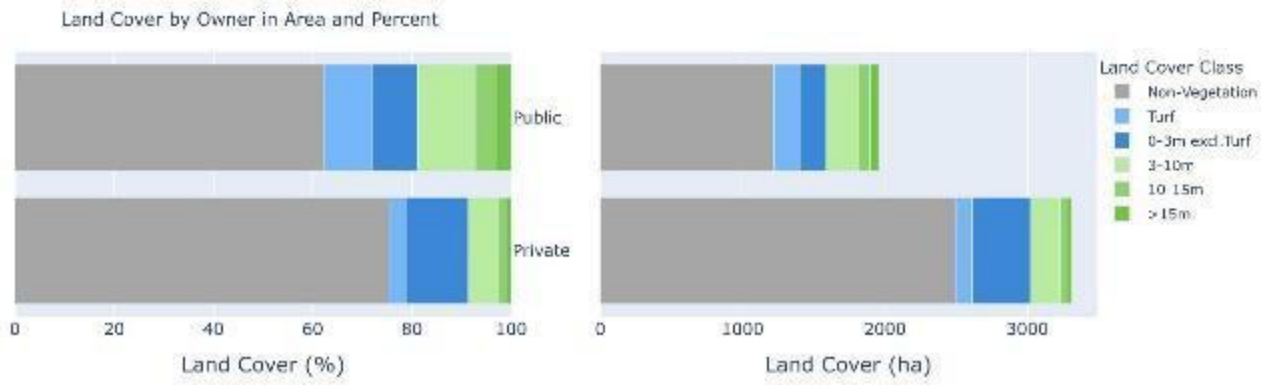


Figure 17: Land cover classification proportion (%) (left) and hectare coverage (right) of Public and Privately managed land in the City of Melville.

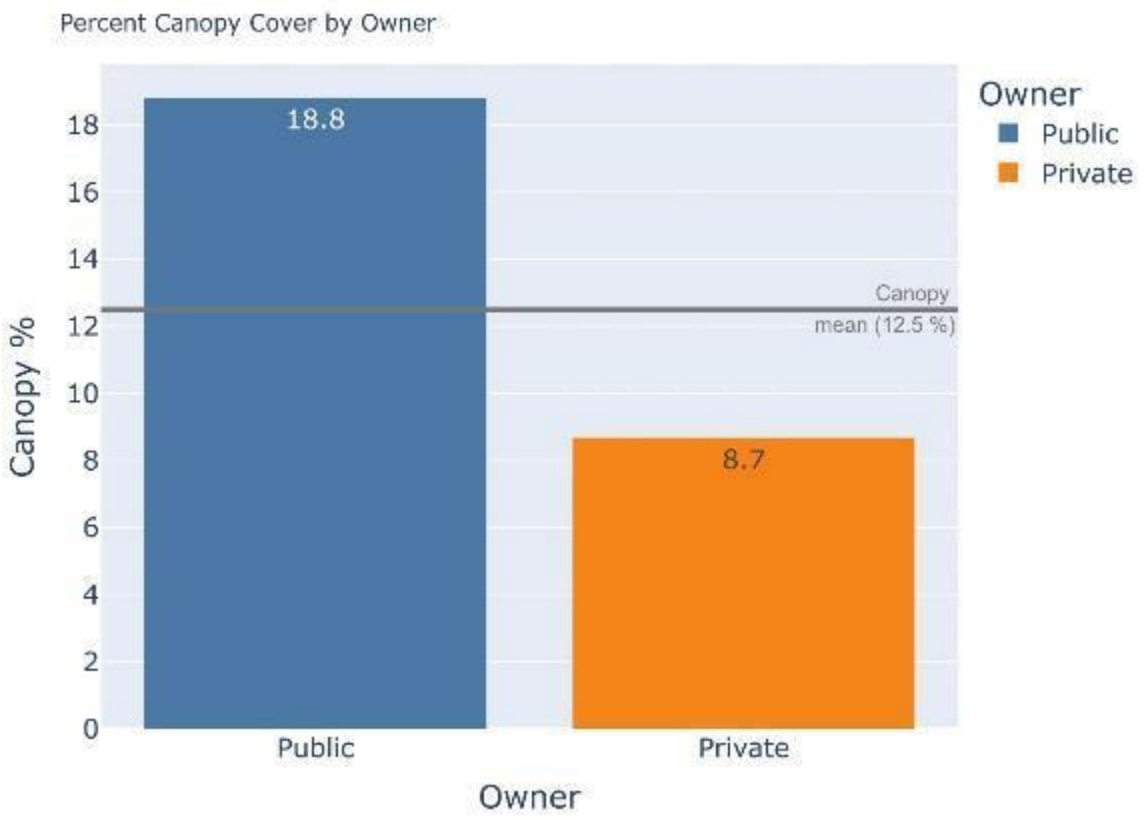


Figure 18: Proportional canopy cover of Public and Privately managed land in the City of Melville.

2.3 Change in Canopy Cover Over Time

In 2016, the City undertook aerial data capture, including quantification of canopy cover. In 2022, the City engaged a consultant to undertake similar aerial data capture and calculate canopy cover statistics across the City. The data acquired in 2016 set the baseline for canopy cover used in the 2017 Urban Forest Strategy. However, issues with the 2016 dataset resulted in an overestimation in baseline canopy cover, and the 2016 dataset was re-analysed to determine a more accurate baseline figure.

The 2016 vector data was compared to the 2022 dataset to determine the change in canopy cover over time. The 2022 dataset reported a canopy area of 656.0 ha (12.5%), compared with 734 ha for the 2016 layer, a loss of 78 ha over 6 years (Table 1).

To validate this loss of canopy cover, a canopy loss layer was produced. The analysis showed that there had been net canopy loss across the City between 2016 and 2022; this supports the canopy level results calculated from the 2022 data and reanalysis of the 2016 data. By comparing results from the 2016 acquisition reanalysis to those from the 2022 acquisition, an estimate of canopy loss between the dates has been calculated. Across the 5268 ha of the City, 78 ha of the canopy has been lost, equating to a 1.4% decrease in the canopy cover between 2016 and 2022, or a loss of 10% of the City's 2016 canopy.

Table 1: Calculation of canopy change between 2016 and 2022.

Year	Canopy area (ha)	Canopy percentage (%)
2016	734.0	13.9
2022	656.0	12.5
Change 2016-2022	-78	-1.4

The key contributors to loss become clear from inspecting the canopy loss layer. The most striking examples of loss are areas of development where canopy trees have been removed in the construction process (Figure 19 and Figure 20). Other loss includes individual tree removals on private property (Figure 21) and road reserves (Figure 22). Figure *23* shows canopy loss over a wider area of the City to illustrate the extent of canopy loss.

Figure 19. An example of canopy loss between 2016 and 2022 is due to development at the corner of North Lake Road and Archibald Street. (A) shows high resolution imagery from 2016 (source: NearMap™), which demonstrates there were trees present at that site in 2016; (B) demonstrates the development between 2016 and 2022; (C) demonstrates the canopy loss layer, which shows where trees have been removed in the period.

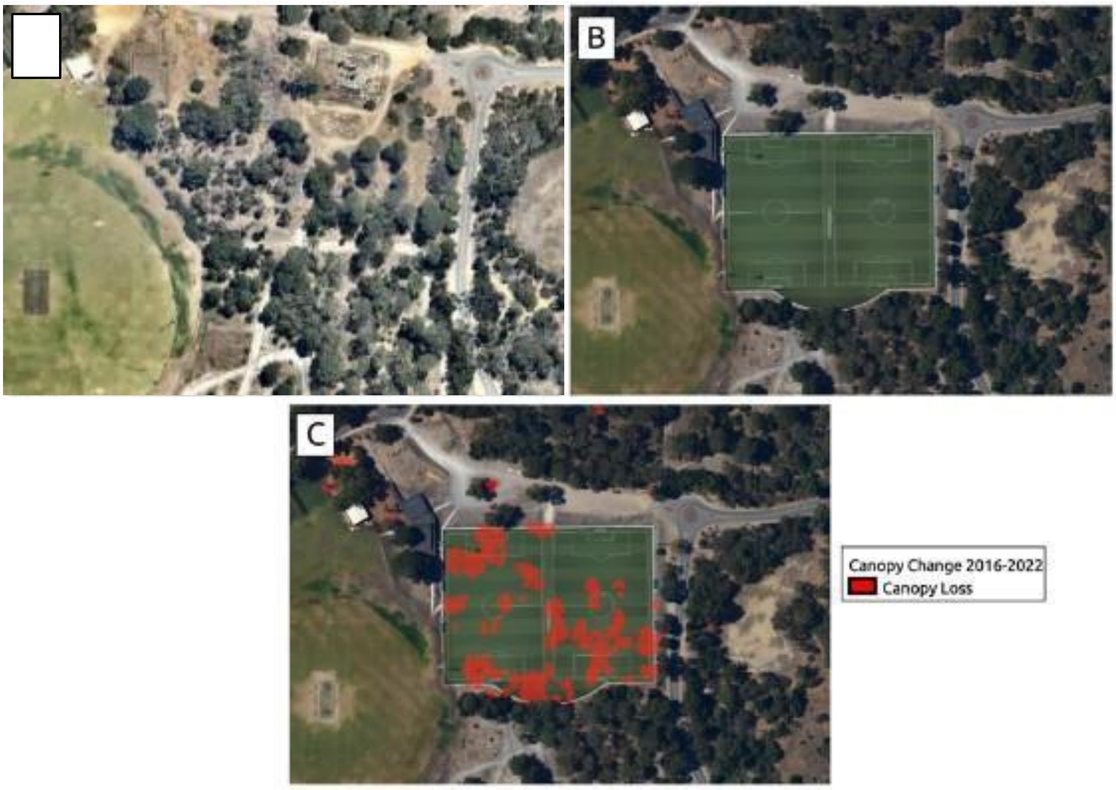


Figure 20: An example of canopy loss between 2016 and 2022 at Murdoch University due to the development of sporting fields. (A) shows high resolution imagery from 2016 (source: NearMap™); (B) demonstrates the 2022 high-resolution imagery; (C) demonstrates the canopy loss layer, which shows where trees have been removed in the period.

Figure 21: An example of canopy loss between 2016 and 2022 at Williams Road, Melville, due to the removal of individual trees on private land. (A) shows high resolution imagery from 2016 (source: NearMap™); (B) demonstrates the 2022 high-resolution imagery; (C) demonstrates the canopy loss layer, which shows where trees have been removed in the period.

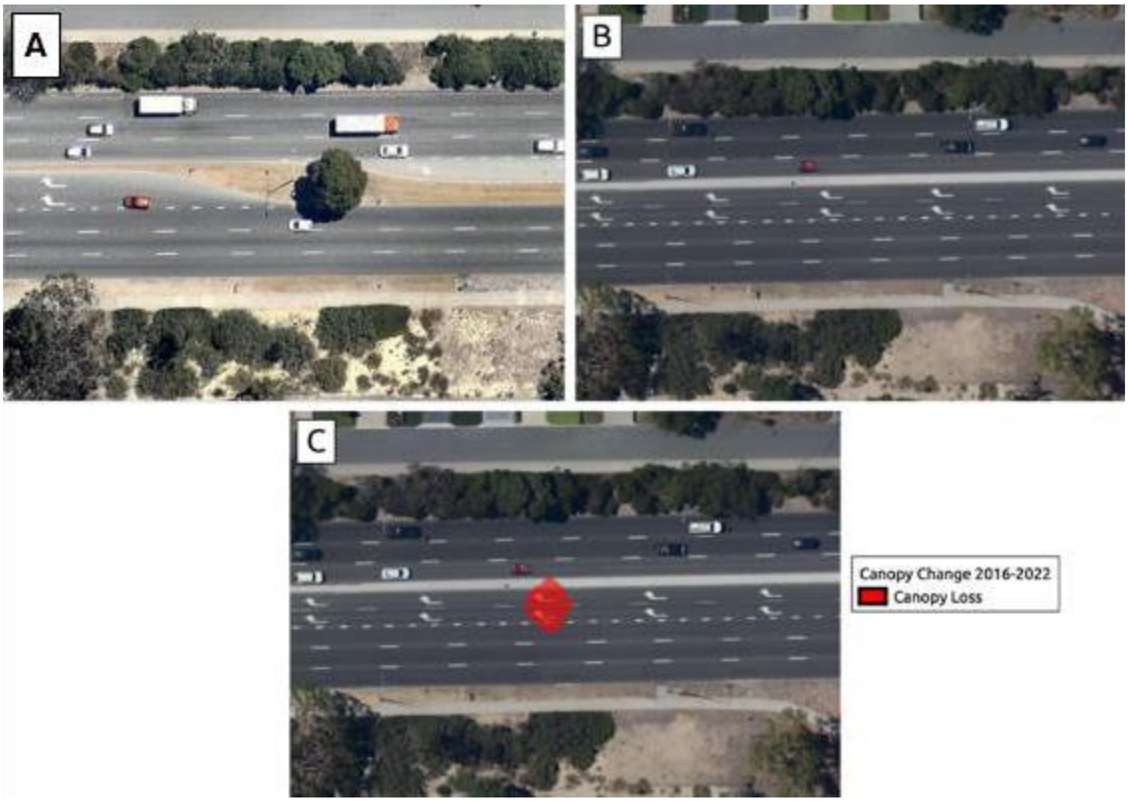


Figure 22: An example of canopy loss between 2016 and 2022 at Leach Highway, due to removal of a tree for road redevelopment. (A) shows high resolution imagery from 2016 (source: NearMap™); (B) shows the 2022 high-resolution imagery; (C) shows the canopy loss layer, which shows where the trees were removed at some point in the period.

Figure 23. An illustration of widespread instances of canopy loss in an area of the City, centred on Melville Primary School.

3 Review of Urban Forest Strategic Plan 2017-2026

Part A : City-Controlled Land

The existing Urban Forest Strategy has four goals:

1. The City will **renew its ageing City trees** with **no net loss of urban forest canopy on City land** over the period of the plan, and **increase planting in targeted areas** to achieve locally optimal levels of tree canopy cover.
2. The City will establish and maintain a **tree database** to ensure it has extensive and current knowledge of the location, profile and condition of the City's urban forest, and **potential additional planting sites**. It will support locally relevant urban forest research.
3. The City will strive for **excellent urban forest management,** delivering resilient, diverse, sustainable, fit-for-purpose urban forest on City land supported by **active, innovative community participation**.
4. The City will **integrate urban forest protection into urban planning instruments** and practices and its land and infrastructure asset management.

Each goal had associated **Indicators**, **Aspirational Targets**, **Current Status**, **Tactics**, and **Measures of Success**. In the following review, each Goal will be broken down by Indicator, and assessed whether the Aspirational Targets were achieved using the proposed Tactics and Measures of Success.

3.1 Goal 1

'The City will **renew its ageing City trees** with **no net loss of urban forest canopy on City land** over the period of the plan, and **increase planting in targeted areas** to achieve locally optimal levels of tree canopy cover'

Indicator: Change in the extent of total urban forest over time as measured by aerial analysis.

Aspirational Targets	Outcomes
In 2036, tree canopy/understorey cover on City land will equal or exceed the following: - Total: 30% trees/19% understorey Natural areas: 62% trees/19% understorey Other parks and recreational areas: 47% trees/11% understorey Streetscapes: 27% trees/19% understorey	Canopy cover on City managed land had increased from 17.1% in 2016 to 18.3% in 2022. This increase of 23.6 ha of canopy is considered a success. Several community incentives to increase understorey planting on private verges and land have been undertaken, including educational workshops and free plant giveaways. However, change in understorey has not been quantified, and anecdotal evidence suggests that change has been minimal. Canopy cover on private land decreased from 12.2% to 9%, resulting in an overall decrease in LGA-wide canopy cover from 14% in 2016 to 12.5% in 2022. The *Local Planning Strategy* is currently under review and may result in better outcomes for canopy cover on private land.

Indicator: Progress towards specific local urban forest canopy cover targets by land use and by priority areas.

Aspirational Targets	Outcomes
Plant sufficient trees and understorey vegetation by 2036 to deliver a canopy/vegetation cover on maturity that will meet targets for defined areas consistent with existing land use.	Targets were not set for land use and suburbs. As part of the Strategy review, evidence-based, achievable, sustainable targets will be set for land use categories and suburbs. Areas with low or no tree canopy cover in 2016 were prioritised for planting. The increase is yet to be quantified as the trees are still young.
Key City amenities are connected by walkable green corridors.	The City has increased street tree planting, increasing cover on active transport routes and biodiversity links.

Indicator: Urban heat performance

Aspirational Targets	Outcomes
All public gathering places have shade available.	Planting of parks has been prioritised based on the shade available. The City undertakes a community survey every two years on the satisfaction of parks and community spaces, but not specifically on shade.
Areas identified in 2016 thermal analysis as being in the top quartile of night-time temperature are cooler following the increase in tree canopy cover.	This has been addressed to a degree; planting has been prioritised in areas with low canopy cover, and high-temperature areas, e.g., Bull Creek had the lowest canopy cover and highest temperatures, and therefore was prioritised first for increased planting. Planting is now scheduled on a suburb rotation to address all areas within the City

3.2 Goal 2

'The City will establish and maintain a **tree database** to ensure it has extensive and current knowledge of the location, profile and condition of the City's urban forest, and **potential additional planting sites**. It will support locally relevant urban forest research.'

Indicator: Completeness and currency of City tree database

Aspirational Targets	Outcomes
Complete, current, publicly accessible database of street trees, park trees, tree planting sites and significant understorey plantings in key locations.	The City has started a current and accessible street tree database that is regularly updated, with each tree's species and location, and more frequently with new plantings. The database is ongoing and does not cover the entire City's street tree population as of this review. A database for park trees is incomplete. A database of available planting spaces has begun and will be completed as part of this Strategy review. Understorey plantings have not been mapped.
Complete and current natural area urban forest profiles.	Not achieved. Minimal data provided (species and photo). Ideally, more information should be collected.

Indicator: Identification and utilisation of planting sites on City land

Aspirational Targets	Outcomes
Database of suitable planting sites on City land, including characteristics and constraints, completed by: • 2018 for streets • 2019 for parks and recreation reserves	Developed as part of this review.

Indicator: Locally relevant environmental research and valuation models are available to inform decision-making

Aspirational Targets	Outcomes
The City contributes to and collaborates in local research related to local urban forest sustainability.	The City has been involved in local research and considers this a successful outcome. However, the City recognises the importance of continually learning and keeping up to date with current research.
An economically robust urban forest valuation model is developed to support investment decisions.	A sound valuation model has been developed and is in use.

3.3 Goal 3

'The City will strive for **excellent urban forest management,** delivering resilient, diverse, sustainable, fit-for-purpose urban forest on City land supported by **active, innovative community participation**.'

Indicator: Efficient delivery of a healthy, diverse and sustainable urban forest on City-controlled land that defines and supports the character of the City

Aspirational Targets	**Outcomes**
The City's urban forest scores highly on measures of: • Age/ULE diversity • Biodiversity • Plant health • Low tree attrition • Tree longevity compared with expected life • Demonstrated sustainability • Community satisfaction	Urban Forest Management is recognised as a discrete function within the City's structure, budget and long-term financial plan. The City has two funds and staff dedicated to the urban forest. The City has commenced collection and analysis of urban forest health indicator data, and uses this to derive actionable insights. Tree mortality is not currently recorded for street trees, but anecdotal evidence suggests it has decreased. In terms of score, the City has not benchmarked itself among other Cities or best practice levels to determine how high it scores.
Measures are in place to deal with long-term strategic risk management and emerging issues affecting the urban forest, including factors related to climate change.	The City has recently completed a comprehensive Vulnerability, Risk & Opportunity Assessment, which has identified specific risks to the urban forest. Some actions to address this are included in the *Corporate Climate Action Plan* (released July 2023), and the *Community Climate Action Plan* (due in 2024)
A single tree species will comprise no more than 15% of the population other than in defined local character areas.	The City has focused on increasing tree species diversity by including dominant species less in new plantings. This has increased diversity, However, the City does not remove healthy and structurally sound trees to decrease the number of dominant

	species; therefore, change will likely be slow, and this goal is long term. Some neighbourhoods still have uniform plantings for aesthetic purposes.
City of Melville's urban forest management is recognised as the best local practice.	This is difficult to determine as no recognised best local practice for urban forest management exists.

Indicator: The City's urban forest is adapted to future climate change

Aspirational Targets	Outcomes
The City's urban forest proves resilient to climate change and suffers minimal losses or poor conditions attributable to drought, groundwater depletion and heat stress.	In progress. The City recognises that increasing species diversity will provide resilience towards climate change, and drought-tolerant species are selected where possible. In addition, the City has just completed a climate risk analysis, identifying specific urban forest risks. These risks will be addressed in the *Community Climate Action Plan*.

Indicator: Public awareness and participation

Aspirational Targets	**Outcomes**
The community is knowledgeable about urban forest issues, supports the City's urban forestry activities and has a sense of shared responsibility for the urban forest	The City runs numerous educational events such as information sessions, workshops, community planting days, and tree give aways, as well as participates in Perth or State wide events such as WA Tree Festival and Millenium Kids. The City provides education events through the Piney Lakes Environmental Education Centre. The City website provides valuable and up-to-date information regarding the urban forest. The City also has a dedicated community education and engagement officer. However, more education opportunities exist and should be considered, such as targeting particular groups with high impact in urban forestry, such as developers.
There is significant community participation in tree planting, nurturing and monitoring programs	As above.
The community is satisfied with their access to urban forest participation and the opportunity to contribute to decision-making processes	Unknown – a survey has not been undertaken. However, the community will be able to provide feedback on the progress of the urban forest strategy in the public comment of this strategy update.

3.4 Goal 4

'The City will **integrate urban forest protection into urban planning instruments** and practices and its land and infrastructure asset management.'

Indicator: The urban forest is referenced explicitly in planning and development instruments. Due regard is given to urban forest protection in planning and development approvals processes and in land and infrastructure asset management

Aspirational Targets	**Outcomes**
Urban planning instruments explicitly promote the protection and enhancement of the urban forest and facilitate the optimum distribution of urban forest benefits.	This is ongoing. Currently, Tree Protection Zones are the only tool in the current LPS for protection of trees, and deep soil requirements in new Design Guides are the only tool enhancing tree planting on private land. Several options are being put forward to the Council to protect and preserve the urban forest, including an option to have tree removal permits and an enforced/non-voluntary tree register, with appropriate resourcing.
Management of the City's land assets preserves and contributes to the quality of the City's urban forest.	As above.
Infrastructure asset management incorporates urban forest components.	Trees and urban forest elements are now prioritised in Activity Centres and major redevelopment projects, and a tree provision is now in each plan. Additionally, the urban forest is now embedded in the asset management system and the long-term financial plan at a basic level.

4 Challenges and Opportunities

4.1 Challenges

4.1.1 Population Increase and Urban Consolidation

Population growth, subdivision of land and increasing densities of urban areas are probably the biggest threats to Melville's capacity to maintain current canopy coverage on private lands. Informed Decisions (id.com.au) projects that Melville's population will increase by more than 18,000 people (17.47% growth) to a population of 125,507 in 2036, with dwellings forecast to grow from 42,887 in 2021 to 50,400 in 2036. In 2018, the WA Planning Commission (WAPC) estimated the City should be able to accommodate approximately 11,000 new dwellings by 2031, and the *City of Melville Local Housing Strategy* (2018) expected this target to be comfortably met. Most of these new dwellings will be accommodated within the Activity Centres and through low density in-fill. If 'Other' refers to the subdivision of residential lots, then this will result in large mature trees being removed, with less space available for the planting of large trees. Redevelopment of free-standing houses inevitably results in larger building footprints, removal of mature trees, and limited space for planting large trees (Figure 24). Increased housing density in residential areas has the potential to impact the Melville urban forest negatively. This impact has been modelled and will be discussed in Section 5.

Figure 24. Residential development under construction with a larger footprint close to existing, mature street trees (Image Credit: Paul Barber).

The current state legislation does not provide mechanisms for improved canopy outcomes, nor are they conducive for local governments to pass suitable local laws. Currently, fines for tree removal in areas of development are too low to be a deterrent. Consequently, existing trees on private land are being removed from new developments.

4.1.2 Physical Challenges and Protection of Existing Trees

The urban public realm is a highly contested space, and finding room for trees can be challenging. Trees did not evolve to deal with urban pressures. However, they have become essential assets in our cities, and we need them to maintain livability and resilience. Conflicts with infrastructure such as roads, buildings, footpaths and utilities are perhaps the most challenging issues. A significant factor in the premature decline of verge trees is the impact caused by the adjacent development of residential lots. The City has made good progress in the protection of the structural root zone (SRZ) of verge trees from development through the erection of tree protection barriers; however, this does not protect the root systems that may extend beyond this immediate barrier into the tree protection zone (TPZ) in adjacent lots or verges (Figure 25).

Figure 25. Residential development under construction, with development occurring immediately outside the SRZ (Image Credit: Paul Barber).

This was noted as a critical factor in the premature decline of Jacaranda trees throughout the City (ArborCarbon 2022a). The physical impacts combined with poor planning or species choices can lead to the premature removal of trees.

Impacts from powerline clearance pruning to street trees can be observed throughout the LGA, particularly in the suburbs of Melville, Kardinya and Willagee. This pruning significantly impacts the ability to establish good canopy cover and severely limits available tree-planting locations. The repeated pruning and resulting stress on trees can also predispose trees to infection by plant pathogens and attack from pests. Some locations where conflict occurs are exacerbated by poor tree species selection.

4.1.3 Social Challenges

Negative attitudes towards trees were identified as a major obstacle to improving urban forest outcomes. These negative attitudes can range from a fear of trees, a lack of acceptance of trees from an aesthetic point of view, to competition with other factors, such as obstruction of solar panels and river views. There have been numerous trees poisoned throughout the City to improve river views, as well as for crossovers, cultural practices and due to the perception of trees as a psychosocial hazard. Improved education and engagement around trees are identified as ways to improve these issues. Most of the land area in the City of Melville is privately owned; hence, the impact of changes in the canopy on private land is significant. Negative community attitudes towards trees often result in poor urban forest outcomes.

4.1.4 Climate Change, Urban Heat and Water Availability

The earth's atmosphere is predicted to warm 2.7 ^{o}C above pre-industrial levels this century. This will result in more frequent, longer and intense heat waves, drought, and increased frequency of natural disasters like fires, floods and storms (Australian Academy of Science, 2021). If global temperatures rise 3^{o}C, days above 50^{o}C will likely become a regular occurrence in Perth, with potentially disastrous consequences for vulnerable people living in cities. Perth is an arid city, with low rainfall, high temperatures, and soils with low water-holding capacity. The City is highly dependent on irrigation for its trees, particularly during the establishment and maintenance period for new plantings. Unseasonably low rainfall can also have a devastating impact on the health of mature trees that may not be well-adapted to extreme changes in rainfall. This reliance upon irrigation is problematic as limitations on water use are being placed on the City through state government, and these are likely to continue over coming years/decades.

As Australia's climate changes over the next 50 to 100 years, tree species within Melville's Urban Forest may not be suited to the altered urban environment. Gallagher *et al*. (2019) indicated that 47% of vegetation in Australia is potentially at risk from increasing temperatures and showed low adaptability to climate change. Species selection is an example of climate change adaptation and a form of risk management (Rychetnik *et al*. 2018). This Urban Forest Strategy will support the City's commitment to climate change adaptation and the commitment to be net zero by 2050 as a geographical region, as per the Climate Emergency Declaration in June 2021.

The urban heat island effect (UHIE) is the build-up of heat in urban areas due to the higher occurrence of hard exposed surfaces, which retain more heat than natural surfaces, such as water and vegetation. The UHIE will only be exacerbated by increasing environmental temperatures due to climate change. Setting ambitious but achievable targets for canopy and vegetation increases, improved diversity in the urban forest, and a well-structured implementation plan in the Urban Forest Strategy are the most important first steps in reducing the UHIE. Mechanisms to reduce the UHIE through increased canopy and green-space cover include investment in and maintenance of the existing canopy cover and green space in the City, including natural vegetation in reserves. This is challenging, however, when there is a lack of adequate protection for private trees from development. Decreasing the loss of canopy from tree clearing on private property, renewal and revegetation of degraded watercourses, and support of appropriately designed and maintained green-building developments will reduce the UHIE. The community must be engaged in managing the City's UHIE.

4.1.5 Data Collection and Management

Sustainable management of urban forests can only be achieved if data such as tree type, location, size and health are current, accurate, and easily accessible. The City undertakes an audit of street trees every five years. This data-gathering process relies upon arborists to collect information such as species, age, health and tree risk, using digital tablets and pre-loaded data forms. The collection of tree data has been improving from an ad-hoc approach towards a systematic approach of renewing street tree data. Data collection and maintenance of the data is an ongoing learning process for the City. Consequently the data to date is not as accurate as it could be.

The reliability of data and lack of a dedicated tree asset management system presents many challenges to the city when attempting to manage their tree population sustainably. The lack of adequate high-quality data will ultimately lead to greater loss and replacement of trees, inefficiencies in responding to resident requests, and a continued reactive approach to tree management. These outcomes will result in a wastage of funds and resources, and a less healthy and expansive urban forest. A coordinated specific tree management and data collection system should be implemented as soon as practical to alleviate these issues.

4.1.6 Abiotic and Biotic Stress

Manion (1981) listed the urban environment as a predisposing factor causing the premature decline of trees and forests, along with age and species. Many of the City's street tree populations were planted at a similar time, often during the development of a suburb or neighbourhood. Consequently, the City has numerous trees of the same age nearing post-maturity. This can lead to a sudden loss in significant areas of canopy, and a surge in spending required for removals and replacement. The City strives to replace trees soon after removal or death; identifying and removing trees that have reached the end of their useful life. In addition, many neighbourhoods were planted with the same species (e.g., Jacaranda) to create a theme and impact, resulting in low species diversity..

Low species diversity can reduce the resilience of urban forests to inciting factors that trigger a decline in health. These often-diverse factors can be grouped into abiotic (e.g., water stress, heat stress, or airborne pollution), or biotic factors such as pests and diseases (e.g., Polyphagous shot-hole-borer, Phytophthora Dieback, Myrtle Rust) (Barber *et al*. 2013). Polyphagous shot-hole borer (PSHB) *Euwallacea fornicatus* is a beetle native to south-east Asia that has a wide host range, and poses a significant threat to amenity trees, native vegetation, and the horticulture industry. It has a symbiotic relationship with a *Fusarium* fungus, killing the vascular tissues in susceptible trees, leading to death and/or decline. An eradication program is underway across 25 LGAs in Perth, with more than one million trees assessed and over 800 trees removed as of the development of this Strategy. Myrtle rust is a serious disease that kills many plants belonging to the Myrtaceae family, including eucalypts, peppermints, paperbarks and bottlebrushes. As of the development of this Strategy, it has been found in the north of WA, and if not eradicated, will potentially spread to Perth over the coming years. With the increasing movement of people and commodities into Australia, it is highly likely that new pests and pathogens will be introduced and cause the decline and death of urban trees if not eradicated or managed.

4.1.7 Existing Tree Population

The City's tree population is aging, with over 50% of its street trees (up to 25,000 trees) predicted to reach the end of their expected lifespan in the next 10-20 years. In some suburbs, this figure is up to 90%. Replacement of these large, old street trees with much smaller juvenile trees will have temporary, but in some places locally significant, impacts on tree canopy cover until the young trees mature around 15-20 years after planting.

In addition, many of the City's existing mature trees were planted at a time when rainfall averaged 160mm/year (23%) more than now, groundwater recharge rates were higher, average daily maximum temperatures were almost 1 ^{o}C lower, and there were rarely more than 2-3 days each year (and frequently none) with maximum temperatures over 40^{o}C. The Bureau of Meteorology predicts that local rainfall will continue to decline, potentially by up to 15% (compared with a 2011 base) by 2030 and 30% by 2090, that average temperatures will continue to rise, and that the risk of bushfires and frequency of heat waves and storms will increase. The climate trends will put increasing pressure on the City's aging tree population.

4.2 Opportunities

4.2.1 Population Increase and Urban Consolidation

Planning teams within LGAs play an important role in protecting trees and urban canopy. The planning, urban forestry and arborist teams within the City have a good relationship and collaborate well with the engineering department. They are also developing a key relationship with the Sustainability and Climate Action team, apparent during the Urban Forest strategy workshop. Such cohesion and collaboration are not always evident within LGAs, but it is essential for achieving good greening outcomes. This strong collaboration is a great foundation to build upon, and should be harnessed and continually supported. Developing a thorough and detailed Urban Forest Strategy and developing and approving an achievable Implementation Plan will be critical to successfully achieving the desired canopy cover targets. This should be facilitated by the highly engaged and informed staff who actively seek to improve tree management and increase canopy.

Some Cities within Perth, such as the City of Canning, Nedlands, South Perth and Town of Cambridge, are showing leadership in their attempts to protect trees on private property. As an example, The City of Nedlands has recently voted in favour of Amendment 12 of the Local Planning Scheme No. 3 to protect significant trees on private property, requiring that a development application be lodged for permission to remove trees with certain criteria (i.e., crown diameter ≥6m, tree height ≥8m, trunk circumference ≥1.5m for single trunk trees). Nedlands also adopted a draft *Local Planning Policy – Trees on Private Land*. The Town of Cambridge also recently approved the advertisement of an amendment to LPS (Local Planning Scheme) No. 1 and draft *Local Planning Policy (LPP) 3.25: Trees on Private Land* to protect trees prior to development on residential lots zoned R30 or below. The City of Melville has a great opportunity to work collaboratively with local Councils to build on this momentum and assist with conserving canopy cover on private property.

ACTIONS

Undertake a review of internal and external (i.e. City of Nedlands, Town of Cambridge) initiatives for tree protection on private land, determine the most suitable initiative(s), and finalise for review by Council.

4.2.2 Physical Challenges

Good progress has been made to protect trees on verges during development over recent years, with the installation of tree protection barriers around the trunk and structural root zones (SRZs). An opportunity exists to expand the protection of trees on verges, where practical, by establishing Tree Protection Zones (TPZs) based on the *Australian Standard Protection of Trees on Development Sites AS 4970-2009*. The health of trees is not only dictated by the above-ground portion of trees, but also by the extensive below-ground root zone. The root zones of many trees may extend well beyond the drip zone of the crown, under cross-overs and into private property. Amendments to LPS and LPPs could potentially consider significant trees growing on adjacent verges that may be impacted by development, as appears to have occurred for numerous Jacaranda trees throughout the City (ArborCarbon 2022a).

Although a large portion of the City has underground power, above-ground powerlines exist throughout multiple suburbs such as Melville, Kardinya and Willagee. Installation of aerial bundled cables (ABC) in strategic areas, or undergrounding power would enable improved tree planting outcomes and conserve existing canopy. The constant pruning of trees reduces not only the vertical but horizontal expansion of the canopy, but it can also have a detrimental impact on the health of trees. Energy reserves used by trees to respond to pruning can reduce the reserves available for defense against pests and pathogens. They can increase susceptibility to such factors, as well as other abiotic factors such as sunscald, leading to premature decline and death of existing trees, and increased resources for removing and replacing trees. The benefits of undergrounding or bundling power will likely far outweigh the long-term negative impacts on the canopy and budgets by doing nothing. The City does have an effective proactive maintenance program, including underwire pruning twice a year of street trees, formative pruning, and regular site assessments by an internal team, including risk assessment and monitoring. This should be encouraged and supported.

ACTIONS

Review existing LPS and LPP's and determine whether an opportunity exists to include protection for significant trees growing on adjacent verges.

4.2.3 Protection of Existing Trees

The assessment of tree assets' worth serves as motivation for decision makers to prioritise design plans that preserve and safeguard mature, thriving trees. The practice of valuing trees is increasingly widespread among Australian Cities, such as the City of Melbourne, Thyler, and Burnley. Having a clear and dependable method for monetarily valuing trees is crucial for building a strong argument for the preservation of the urban forest.

The City of Melville should undertake a preliminary investigation of the different valuation methods employed by various LGAs in Australia, and determine a preferred valuation method. The City of Melbourne is considered to have a good valuation model (Arboriculture Australia & NZ Arboricultural Association 2022). It meets Minimum Industry Standards (MIS) and takes into consideration the amenity and ecological values of a tree.

ACTIONS

- *Adopt a preferred tree valuation methodology .*
- *Protect existing mature trees as a priority.*

4.2.4 Social Challenges

Improved education and engagement around trees are often seen as a way of overcoming social challenges. However, it is difficult to do well. Proactive maintenance has positive implications for tree management, as trees are maintained and regularly assessed, therefore not reaching a point where reactive customer requests are the dominant form of maintenance. This proactive management and visibility of the City's capable maintenance crews assure residents that hazards are managed and provide confidence that trees are well-maintained.

The City receives some pressure for native tree species to take precedence in new plantings throughout the City's urban forest. It is important to recognise and accept that both native and exotic large trees provide important environmental services and that they should be valued equally. The City's current street tree audit data indicated that 44% of the urban forest is exotic tree species, while 56% is Australian native species (15% local native). While, in some instances, native species may be suitable for local conditions, the growing conditions within the urban environment have often changed, resulting in highly disturbed soils, compaction, and altered drainage patterns. Consequently, native trees may not be the most suitable street trees. Exotic trees play an important role in the urban forest as they include many deciduous trees, providing better solar access in the winter months. There are limited numbers of native deciduous species. A healthy, diverse, and resilient urban forest is one that includes both native and exotic species (Richards 1983). Both have a role to play and provide important ecosystem services, however the selection of native tree species in Melville should be given higher weighting due to their established visual amenity and greater contribution to the local native ecosystems.

Some Cities, like the City of Melbourne, have raised the community's awareness of the benefits of trees and green space. They have achieved this through multiple avenues, including enabling residents to access highly visible information for all trees (i.e., photos, size, species) within the urban forest via a web portal. They have also initiated a Citizen Forester program whereby the City trains and empowers these volunteers to grow the urban forest and improve urban ecology by carrying out essential advocacy, monitoring and research tasks. The City of Melville has highly visual and engaging data on the City's urban forest and surface temperatures, demonstrating the cooling benefits of trees (Figure 26).

Figure 26. Split screen of the airborne ArborCam imagery centred on Murdoch University showing the height stratified vegetation cover dataset (left) overlaid on the true colour imagery with blue representing vegetation below 3m height and green pixels above 3m, and surface temperature (right) showing hottest temperatures (red) through to coolest temperatures (blue).

ACTIONS

- *Explore and test different incentives to encourage residents to increase understory planting on private verges and land.*
- *Increase the amount of information residents receive about the benefits trees provide around the house, including real-estate values, and decreased energy consumption.*
- *Improve engagement of the community with the City's urban forest through the display of aerial datasets on a dedicated interactive webpage.*
- *Improve Council engagement during tree planting programs. Involve the nearby community in watering newly planted trees, e.g., by providing information on the species and how to look after it.*
- *Develop and implement a program whereby the community is surveyed to determine their level of satisfaction with the City's urban forest.*

4.2.5 Climate Change, Urban Heat and Water Availability

Given the warming and drying predictions for south-west WA, the susceptibility of the urban forest to heat and water stress should be considered during tree species selection, as well as adjustment of maintenance programs to adapt to a changing climate. A study should be conducted into the drought and heat stress tolerance of the existing tree species population and potential suitable species for planting throughout the City. Similar studies have been conducted in the Northern Hemisphere (Teskey *et al*. 2015). A project of this kind would greatly benefit multiple LGAs throughout Perth and, as such, presents an opportunity for collaboration. The location of Murdoch University and the Harry Butler Institute (HBI) within the City of Melville, and the campus comprising a significant portion of the urban forest, also presents an opportunity for close collaboration.

An opportunity exists to utilise the City's existing aerial imagery datasets to measure and monitor the urban forest and surface temperatures. The extraction of data at the individual tree crown level, including the size, condition and temperatures, presents an exciting opportunity to benchmark the performance of a wide variety of tree species and age classes in varying site conditions, including irrigated and non-irrigated streets and parks. This approach is novel, innovative, scientifically robust, and efficiently uses available resources. This approach has been tested on a small corridor of trees within the City of Melville to monitor the impacts of PSHB, resulting in a Parks and Leisure Australia WA Award (2023) for Best Use of Technology. Again, an opportunity exists to collaborate with surrounding and nearby LGAs with access to airborne aerial data (e.g., Canning, South Perth, Victoria Park, Nedlands, Kwinana).

Trees can be negatively impacted by urban heat, but can also play a vital role in mitigating urban heat by cooling urban spaces to improve livability during heat waves. Higher land surface temperatures (LSTs) throughout the City relate to lower vegetation cover and soil, dead grass, synthetic playing fields, and impervious surfaces such as asphalt, with lower LSTs related to denser vegetation cover (ArborCarbon

2022b). Areas of dead grass and soil, in particular, should be given priority for tree planting to reduce the local UHIE and improve amenity value.

ACTIONS

- *Review and partake in academic research, preferably within the City, into the drought and heat stress tolerance of the existing tree species population and suitable species for future planting.*
- *Extract condition data at the individual tree level, along with tree audit data. This data can be utilised in future studies.*
- *Prioritise areas of dead grass and exposed soil, where possible, for tree planting to reduce the local UHIE and improve amenity value.*
- *Quantify the amount of shade within each park, and determine the optimal level of shade required for subsequent setting of targets that can be measured against.*
- *Review the urban forest risks within the Climate Adaptation Strategy when complete, and align with future programs that assess the resilience of urban tree species in a changing climate.*

4.2.6 Data Collection and Management

The City has adopted airborne remote sensing techniques to measure its urban forest canopy cover, condition and surface temperatures, rather than a field-based or random point sampling method. These latter methods can be resource-intensive and/or result in large inaccuracies. Not all remote sensing methods are equal, as shown during a comparison of the original baseline used in 2015 with the most recent acquisition in 2022. The original airborne LiDAR-based acquisition found that the canopy cover was approximately 24%, but a later review of the data and reanalysis found the canopy cover was approximately 14% (ArborCarbon 2022b). Such significant errors can have substantial negative impacts when measuring the success or failure of Implementation Plans for achieving canopy targets.

The City monitors changes in canopy cover, condition and surface temperature across the urban forest every five years. Large changes can occur in that time, and mitigation of negative impacts may be less effective, particularly if they have occurred soon after the previous data acquisition. Other LGAs utilizing airborne aerial data do so annually or biennially to facilitate their urban forest management and ensure they are meeting the objectives of their Implementation Plans. Even though the canopy cover of the entire LGA may not vary greatly from year to year, large changes can occur within smaller areas (i.e., lots, suburbs, wards) that may be of concern.

Individual ground assessment of individual trees provides more specific data on the health and development and is as important as the aerial data. It provides data that helps direct replacement/succession programs and decisions, as well as providing key data on the development/suitability of species and their resilience to changing climate conditions.

With increasing risks to the urban forest from pests, diseases, climate change and development, combined with the lack of available, qualified personnel (i.e., arborists, forest pathologists), and limited budgets to undertake traditional 'field-based' monitoring, there is an excellent opportunity for the City to continue with its innovative and data-driven approach. Precision Urban Forest management utilises a combination of airborne remote sensing, Artificial Intelligence (AI), and field-validation to monitor all trees in the private and public domain, at the individual tree level. It is imperative, however, that the data generated is easily managed, accessed, and utilised by City personnel to facilitate management. Software systems that are platform-agnostic and easily used will assist. It is therefore recommended that the City increase the frequency of its data capture program and expand its use of software systems currently being utilised to improve the currency of data and tailor to the management of trees as important assets.

ACTIONS

- *Maintain consistency with future urban forest measures by utilising the same airborne aerial datasets and their derivatives.*
- *Consider increasing the frequency of airborne measures of canopy cover, condition, and surface temperatures to annually or biennially to align with numerous other Perth LGAs (i.e. Town of Victoria Park, City of Canning) and urban forest thought leaders (i.e. City of Sydney, Melbourne), and explore opportunities to combine acquisitions with them to achieve efficiencies.*
- *Expand the use of currently utilised software systems to improve currency of data and tailor to the management of tree assets.*
- *Work/Partner with a research provider who holds relevant expertise, preferably within the City i.e., Murdoch University.*
- *Procure funding to increase planting budgets, enabling the implementation of a broader tree planting and establishment initiative for urban areas.*

4.2.7 Abiotic and Biotic Stress

The first stage to improving the urban forest's resilience is to understand the species present and their quantities throughout the city. This requires the tree audit database to be up to date for all trees within the public realm. Once that has occurred, there is an excellent opportunity to utilise remote sensing and artificial intelligence technologies to benchmark each tree's cover, condition and performance. Santamour (1990) introduced a 10-20-30 guideline for urban tree diversity to build resilience to pests and diseases, arguing that each city's urban forest should not have more than 10% of the same species, 20% of the same genus and 30% of the same family. In the City of Melville, and many Australian cities, this may be unachievable or counterproductive (Kendal *et al.* 2014), as the family Myrtaceae and native genus *Eucalyptus* are particularly abundant and well-adapted to arid conditions. Kendal *et al*. (2014) proposed that the relative abundance of the most common taxa was a useful predictor as measured by the Shannon Index. It is important to acknowledge the benefits of these different approaches and perhaps customise a guideline or approach following the completion of a tree audit, particularly given the imminent threat posed by pathogens and pests such as Myrtle Rust and PSHB.

Effective and efficient systems for surveillance, eradication, containment and management of biosecurity threats to the Urban Forest, such as Myrtle Rust and PSHB, require methods to predict establishment, population growth and spread (Weiss *et al*. 2018). The City of Melbourne recently developed a georeferenced tree database with filtering by host, pest or pathogen, enabling spatial investigation of their risk profile across parks and gardens, and providing a mechanism to develop planting plans that will increase species diversity (ArborCarbon 2023). The City of Melville has an excellent opportunity to lead the way in WA and build upon the work undertaken for the City of Melbourne.

ACTIONS

Develop a georeferenced tree database with filtering by host, pest or pathogen for the spatial investigation of their risk profiles.

4.2.8 Internal Culture and Alignment

The internal culture and attitudes regarding trees pose a significant hurdle in implementing optimal urban forest management practices. To effectively reach canopy targets, each section of the Council must foster support and acknowledge trees as indispensable assets. This encompasses all tiers of the organisation, spanning elected Council members, executives, managers, officers, and crews.

The protection and planting of trees need to be integrated within the delivery of the City's capital and works programs. With urban space for trees diminishing, all infrastructure projects should strive to integrate and allocate funds for the following: innovative design ideas that offer increased soil volume; expanded canopy and root space to accommodate larger trees; principles of Water Sensitive Urban Design (WSUD); and structured soil, soil vaults, and permeable paving surfaces.

ACTIONS

- *Continue to work collaboratively to facilitate integration and alignment of capital and operational works within the City with a key focus on establishing the importance of incorporating urban greening into all aspects of operation.*
- *Continue to drive Council-wide cultural change to recognise that all large trees are valuable because they provide important environmental services.*
- *Expand upon on the success of the establishment of funds and training of dedicated staff for Urban Forest Management through increased funding and employment*

4.2.9 Others

There are exciting opportunities for LGAs to contribute to mitigating climate change and protecting and enhancing biodiversity. Finally, awareness is increasing around the great benefits trees provide for the sequestration of carbon, and provision of biodiversity values. Large corporate entities are seeking opportunities to offset their carbon footprint, but this demand also facilitates opportunists and the exploitation of loopholes in some of the existing methods. The City of Melville should explore further the potential to utilise the aerial data for providing accurate measures of carbon and biodiversity values within the urban forest, and mutual benefits that can be realised with corporate partners. Examples exist where aerial data has been analysed to produce carbon sequestration measures.

ACTIONS

Explore the use of aerially acquired data for accurately measuring carbon and biodiversity values in the urban forest, quantifying current carbon sequestration in the City, and a plan to include all future plantings as carbon offsets.

5 Development Impact Modelling on Canopy Cover

As discussed in Section 4.1.1, one of the biggest risks to the City's urban forest is the impact of development. Tree canopy cover in some residential areas has significantly declined on private land in the last 30 years due to subdivision for higher-density residential development, but the City's capacity to address this issue directly is limited by current legislation. This has resulted in the removal of large mature trees, and less space available for large trees to be planted. Redevelopment of free-standing houses inevitably results in larger building footprints, less room for planting large trees and removal of mature trees.

The effects of development in residential land throughout the City were modelled to estimate the impact that development will have on projected canopy cover.

The method used to determine the following impacts of development on canopy cover is provided in Appendix 2.

A map of the cadastral lots with and without development potential is provided in Figure 27 and the total number of lots in each category presented in Figure 28.

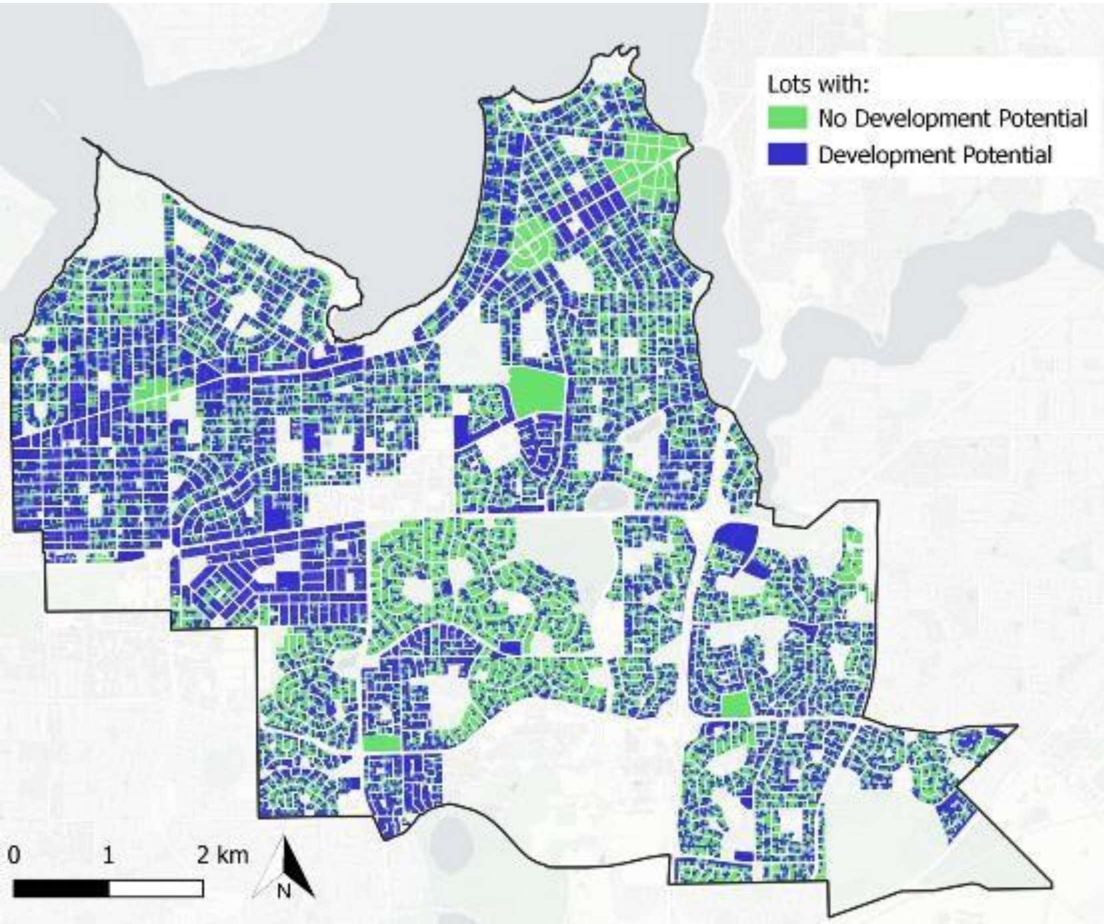


Figure 27: Each lot is colourised by development potential. Blue lots have development potential and will potentially undergo significant canopy loss, while green plots are considered fully developed and unlikely to lose canopy.

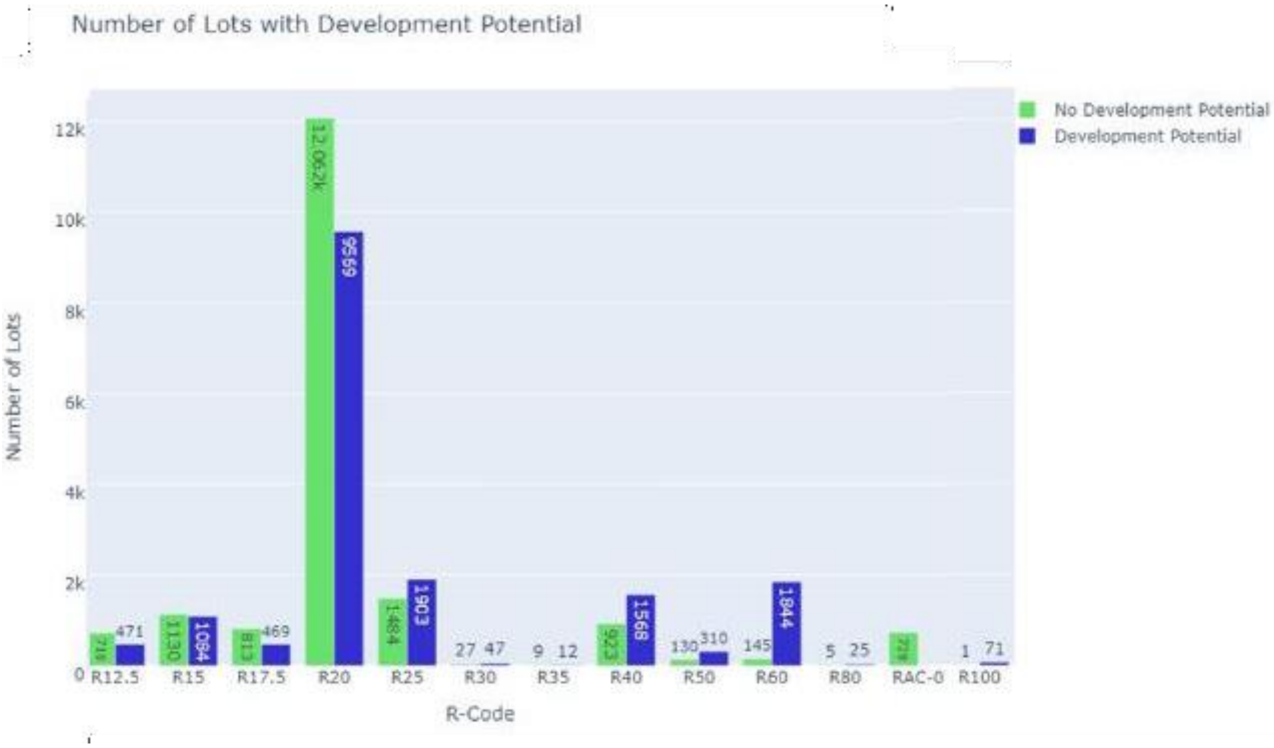


Figure 28: Number of lots with and without development potential, categorised by R-Code.

To determine the projected canopy cover on private land, the average canopy cover of all lots categorised by R-code, that were considered as not having development potential (developed to capacity), was applied to all lots with development potential. The resulting canopy cover estimates are presented in Figure 29 and are taken into consideration in Section 6, Canopy Cover Targets.

If each residential lot in the City of Melville with development potential is developed to its capacity, this will result in a significant decrease in canopy cover on residential land from 6.7% to 3.6%. This is a loss of approximately 9500 ha of canopy, or 18,400 trees. Considering that approximately half of the land area in Melville is residential land, this will significantly impact the City's canopy cover.

It is important to consider the assumptions of this method of canopy cover projection. For example, it assumes that each lot considered fully developed (no development potential) already has its maximum established canopy. For example, there may have been significant recent development of R25 lots, which have not yet had the opportunity to establish their canopy cover. Therefore, the projected canopy cover may be underestimating canopy cover. In addition, this method assumes every lot will be developed, which is unlikely to be the case. It also does not provide a time-line – the rate of development is unknown, and this outcome is the 'final' outcome. Finally, the City is currently considering options to promote/protect the existing tree canopy on private and public land, which might mean that past performance in protecting trees during infill does not indicate future performance.

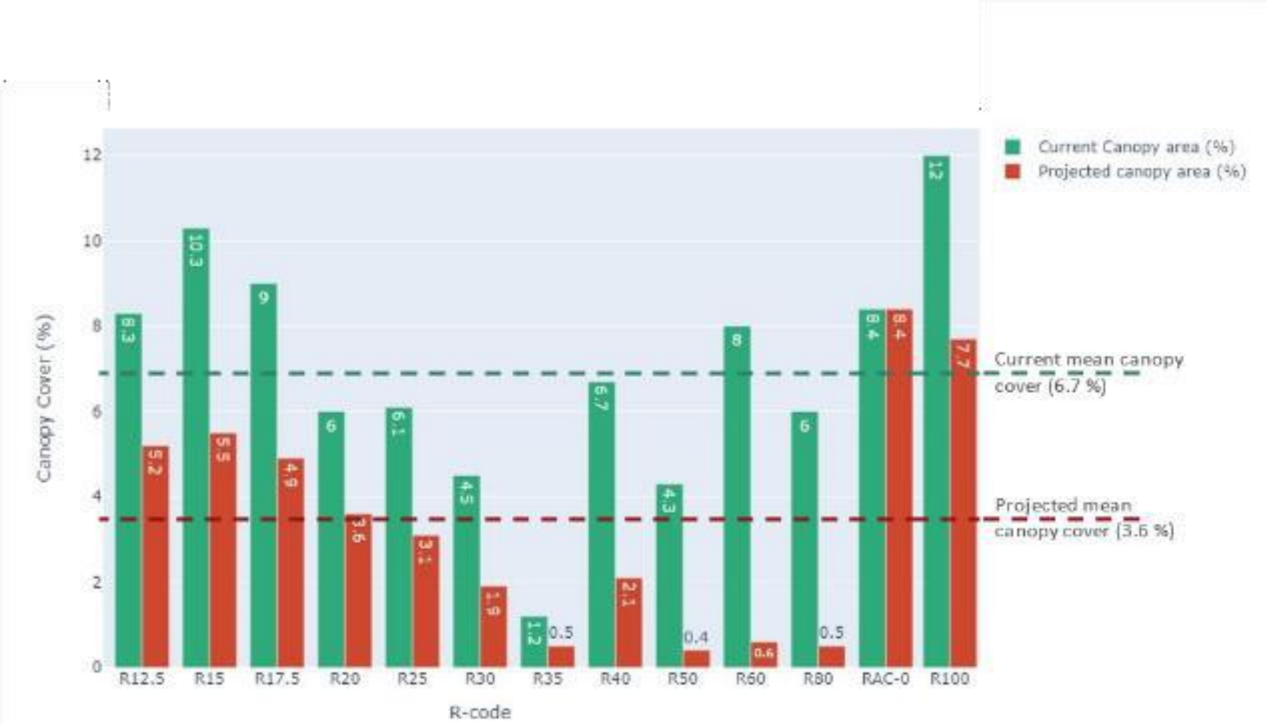


Figure 29: Current and projected canopy cover (%) for each R-Code.

6 Targets

In the context of the urban forest, targets typically are focused on the extent and distribution of canopy cover, as this is regarded as a useful proxy for the range of environmental, wellbeing and amenity values provided by the urban forest (City of Melbourne 2012). Canopy cover targets identify key metrics which can be reliably evaluated as an indicator of progress towards the overall goals and vision of the strategy. Periodic evaluation of strategy and policy is a key principle of adaptive management and allows refinement if the current approach is not meeting the required outcomes.

6.1 Definition of Canopy Cover Targets

In reviewing the range of urban forest cover targets set by other LGAs, it is apparent that there are some differences in the definition or purpose of a canopy cover target. An attempt has been made to differentiate various types of 'targets' to ensure clarity of purpose in developing the canopy cover targets.

Capacity: Often, Councils will develop a 'target' based on the maximum capacity of an area to support tree canopy - if every vacant site or soil volume is planted with an optimally sized tree. Often, environmental and social factors are not taken into consideration.

Aspiration: Aspiration refers to the desires and values of the residents (or people developing the target). It reflects what people want to see, not necessarily what is achievable. Again, this does not always consider limitations such as budgetary or environmental factors, which may limit canopy cover. It differs from canopy capacity in that it considers the desires of the human occupants of the space, e.g., it may be possible to plant parks close to 100% canopy cover, but this is typically not desirable.

Projection: A canopy projection is a forecast of the likely canopy cover in the future. This can be based on knowledge of proposed developments or changes to land use zoning, or by comparing proposed developments to mature developments designed under similar development controls. Projections are usually predicted changes to canopy cover under 'business as usual' conditions and do not factor policy changes into account.

Target: A term that generally encompasses all of the above. However, the NSW Integrated planning and reporting handbook defines a target as a statement of "*Where do we want to be?*" compared with a baseline measure "*Where are we now*?". The target should have an associated timeframe in which it is expected to be achieved. It should be achievable, and data-driven.

It is important that targets challenge and inspire the community to participate in making changes for the future, yet are realistic and achievable. Targets which are unrealistic can have the opposite effect and de-motivate staff and residents, particularly when progress is evaluated and falls short. For targets to be realistic, they must balance the aspiration to achieve an increased canopy cover, with the various limitations present within the City. How a City chooses to balance these competing factors should be based on the values of the local community and City organisation.

6.2 Canopy Cover Target Development

The canopy cover targets developed for the City of Melville consider the projected canopy loss on private land due to residential development (Section 5). The canopy cover targets focus on increasing canopy cover on City-managed land, including parks, reserves and streetscapes.

Two sets of canopy cover ‘targets’ have been developed for the City of Melville. The first is the City’s **maximum capacity** for canopy cover, and applies a maximum canopy potential based on planting the maximum number of trees on all available planting spaces (APS) across the City-managed land. It includes modelled projected loss from residential development, but is not considered achievable. The second is an actual **target** based on realistic and achievable outcomes. It considers the modeled projected canopy loss on residential land, and calculates the number of trees required to achieve a desired and realistic increase in canopy cover across land categories.

The City land area has been divided into the following broad land use categories for target development (Figure 30):

- Residential
- Recreational Areas
- Natural Areas
- Streetscapes
- Other (includes land that does not fit into the categories above, e.g., Murdoch University, commercial land, playing fields)

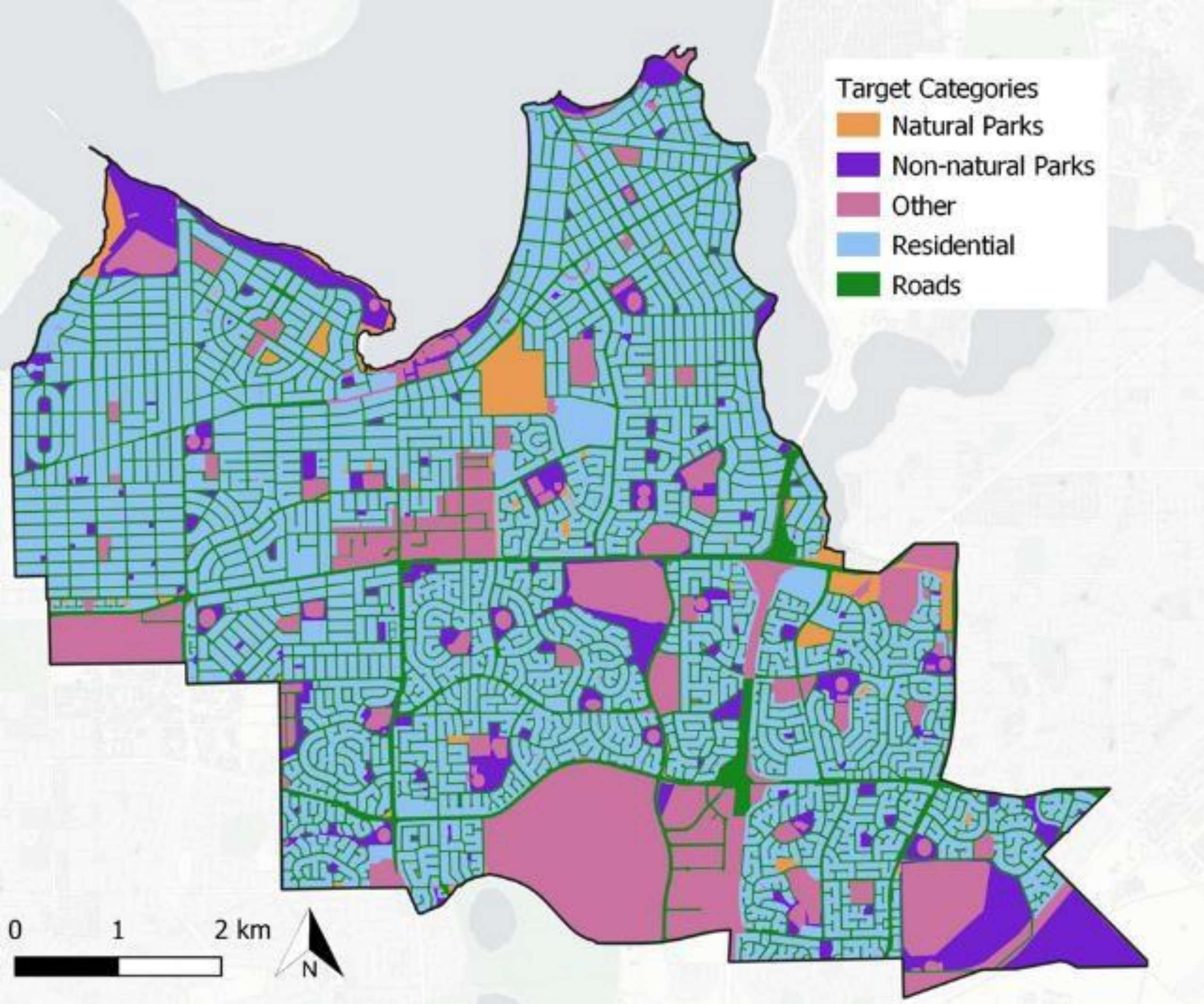


Figure 30: Broad land use categories used to develop canopy cover targets.

Note:

- Current canopy and canopy area targets for parks exclude sporting fields
- The target for residential land is actually projected loss due to development (see Section 5), but is listed in the target column for simplicity
- The target for land classified as other is set to no net loss or gain

6.3 Available Planting Space

A lack of planting space on public land has been identified as a limiting factor to increasing urban canopy. Analysis of available planting space (APS) was undertaken to identify land available for planting trees and increasing canopy cover. APS was determined as areas identified as grass or bare earth in the 2022 aerial imagery, limited by numerous factors, including the area shape and size, assets such as powerlines and lighting poles, distance to road intersections, and sporting fields.

The resulting APS dataset identified many verges, median strips and other road spaces with no canopy cover, and the space available for one or more trees (Figure 31). The analysis identified 242.5 ha of APS managed by the City.

Figure 31: Available Planting Space on public (green) and private (purple) land, as well as limiting factors used to determine areas of APS.

This APS data was used to calculate the canopy cover **capacity** of Recreation Areas and Streetscapes. This capacity was combined with projected loss on residential land, and the canopy cover targets set for Natural Areas and the remaining land area classified as 'Other' to provide canopy cover **capacity** (Table 2).

Table 2: Proposed canopy cover capacity for each category, including current canopy cover (%) and number of additional trees to reach the canopy cover capacity, based on APS.

Category	Current Canopy Area (%)	Canopy Target (%) (based on capacity)	No. of Additional Trees
Natural Areas	33	**70**	9403
Recreation Areas	27	**60**	30260
Other	19	**19**	0
Residential	7	**4**	-18387
Streetscapes	13	**24**	28489
Whole LGA	12	**17**	**68153**

This shows that **by filling every available planting space on City-managed land with canopy trees, the City could achieve a canopy cover target of 17%**. Considering that it is unlikely that all available space will be planted, this target is considered unachievable, particularly in the time frame for the current Strategy. Some regions in Australia have adopted a 30% minimum canopy cover target and there has been discussion around Western Australian LGAs doing the same. This analysis indicates that a 30% target is unrealistic and unachievable for the City of Melville.

A set of achievable canopy cover targets are provided below.

6.4 Canopy Cover Targets

Number of additional trees have been calculated using an average tree size of 50m^2. Approximate costs have been calculated using an estimated cost per tree of $650 (including installation, labour, maintenance and watering for three years).

6.4.1 City Wide

The canopy cover targets proposed for the City of Melville are designed to be realistic and achievable as a benchmark to evaluate the success of the Urban Forest Strategy.

For the City of Melville to increase its canopy cover **from 12.45 to 14%**, the City will need to plant an additional **34,953 trees on City-managed land** (Table 4). This is a proportional increase of 16.7% from the baseline canopy cover. This accounts for a projected loss in canopy cover in residential land of over 18,000 trees, from 7% to 4%. The estimated cost for achieving this canopy is $22.7 million (approx. $2.2 million per year for a planting period of ten years).

The City will need to increase planting efforts in parks significantly. Natural Areas must double their canopy cover from 33% to 70%, which translates to an additional 9400 trees. Recreational Areas, including local parks, pocket parks and sporting grounds (excluding playing fields), will need to increase their average canopy cover from 27% to 50%, translating to an additional 21,000 trees. To increase canopy cover on Streetscapes from 13% to 15%, another 4800 trees will need to be planted on verges.

Table 3: Proposed canopy cover targets for each category, including current canopy cover (%), number of additional trees to reach the canopy cover target, and approximate cost for planting additional trees.

Category	Total Area (ha)	Current Canopy Area (ha)	Current Canopy Cover (%)	Canopy Target Area (%)	No. of Additional Trees	Estimated Cost for Public Trees
Natural Areas	113	37	33	**70**	9403	$6,111,950
Recreational Areas	410	111	27	**50**	20784	$13,509,600
Streetscapes	1156	152	13	**15**	4766	$3,097,900
Other	927	176	19	**19**	0	N/A
Residential	2262	180	7	**4**	-18387	N/A
Whole LGA	5268	656	12	**14**	**34953**	**$22,719,450**

6.4.2 Suburb Targets

Suburb-specific targets were developed based on the relative area of each of the categories in Table 3 within each suburb.

Canopy cover targets vary widely across suburbs, with some suburbs, such as Leeming and Ardross proposed as achieving a noticeable increase, whilst others such as Palmyra decrease (Table 4). Note that these targets are a combination of targeted increase in Natural Areas, Recreational Areas and Streetscapes, a projected decrease on Residential Land, and no change on land classified as Other.

Table 4: Proposed canopy cover targets for each suburb, including current canopy cover (%). Note that some suburbs have decreased due to them having a high proportion of residential land that will experience loss of canopy due to development.

Suburb Name	Current Canopy Area (%)	Target Canopy Area (%)
LEEMING	13	19
MURDOCH	17	17
BULL CREEK	12	13
BATEMAN	10	10
APPLECROSS	14	14
ARDROSS	14	22
MOUNT PLEASANT	12	11
BRENTWOOD	14	16
BOORAGOON	12	11
ALFRED COVE	8	7
MYAREE	7	7
MELVILLE	11	9
ATTADALE	12	16
BICTON	17	19
PALMYRA	12	10
WILLAGEE	11	8
WINTHROP	13	16
KARDINYA	10	11

At the October 2024 Ordinary Meeting of Council, this review was adopted unanimously (12/0):

1. **Endorse the City of Melville Urban Forest Strategy Review Report 2024 (Attachment 1), with two amendments:**
   - **(a) Changing the target for residential tree canopy cover in table 3 from 4% to is "no less than 4%".**
   - **(b) Amending 6.4.2 suburb targets to include a review the Suburb canopy cover targets in 2027, with a view of investigating measures to achieve a minimum of no net loss for each suburb by 2050 and a longer-term aspirational target of achieving 15% for each suburb**
2. **Adopt an interim City-wide canopy cover of 15% by 2050, with a review of progress to be undertaken following the next aerial tree survey in 2027.**

6.4.3 Time Frame

While setting canopy cover targets for the urban forest, it is often challenging to balance the aspirations for enhanced canopy cover and what is achievable within the required timeframe. The timeframe for the City's canopy cover targets is **2050**. Given that the full benefit of a tree is not expected to be attained for 10-20 years following planting, as the tree approaches maturity, ideally the additional trees should be established within the next ten years to reach the canopy cover target by 2050. In addition, protecting existing mature trees should be considered a priority.

ACTIONS

Achieve canopy cover targets outlined in Table 3 *and* Table 4 *by 2050.*

6.5 Other Targets and Indicators of Urban Forest Health

Canopy cover is a metric widely used to measure the growth of an urban forest and the success of urban forest management. There are many advantages of measuring canopy cover – it is a simple, intuitive indicator of the extent of an urban forest. It is used worldwide, making it an acceptable benchmarking tool. Communities use it to set tree planting goals. It can also correlate to services provided (e.g., ecological services, stormwater management etc.) (Miller 1997). However, canopy cover measurements do not provide information about other important indicators of urban forest health and are required to manage and sustain an urban forest effectively. For example, canopy cover does not directly indicate species diversity, vegetation health, or age/size class distribution.

In general, all indicators relate to two themes of urban forestry (Ordóñez and Duinker 2013); tree loss/gain and tree diversity. They can also be separated into the type of measurement – quantitative or qualitative. To set a quantitative target, there is usually a baseline measurement. Since this is often not the case, and many indicators are difficult to quantify, many Councils use qualitative targets (e.g., to increase, build upon etc.) These indicators are described below, as well as any best practice targets associated with them, and how they can be applied to Melville. Given the City's pro-active approach to quantifying urban forest metrics through the use of airborne remote sensing and artificial intelligence, we also present options for this higher-precision approach.

6.5.1 Structure

The 'structure' of an urban forest describes patterns in the spatial distribution of vegetation (Fan *et al.* 2019). This includes both vertical (i.e., ground cover, understorey vegetation, canopy cover, and all vegetation height strata) and horizontal distribution across landscapes and within land use boundaries. Structure also refers to the crown and stem density (Roeland *et al.* 2019) and how vegetation is arrayed in relation to other objects, such as infrastructure (MacLachlan *et al.* 2021, McPherson *et al.* 1997). The complexity of vertical structure within areas of vegetation (e.g., the presence of groundcover and shrub understorey plants) is also important to support bird life and mammals within the urban environment (Chalker-Scott 2015).

Measuring canopy and vegetation cover is the most common and accessible way to measure urban forest structure, and best practice targets have been outlined in Section 6 Targets.

Connectivity of vegetation within the landscape is also important to promote the movement of native fauna within and across the urban area. This supports the transfer of genetic material between populations which can support genetic diversity and ecosystem resilience, as discussed below. In the urban setting this is typically achieved by establishing "biodiversity corridors". Analysis to identify options for the creation and enhancement of biodiversity corridors, and their ongoing measurement and monitoring can be achieved within the existing program utilising airborne remote sensing datasets.

ACTION

Undertake analysis of airborne imagery and other geospatial datasets to identify options for the creation and enhancement of biodiversity corridors, and their ongoing measurement and monitoring.

6.5.2 Genetic and Species Diversity

Genetic diversity refers to the genetic variability within a population, which can occur at multiple scales, both within species (e.g. intraspecific diversity) and between species and other taxonomic groups. Greater genetic diversity is associated with increased resilience to disturbance (Kendal *et al.* 2014). Genes convey different levels of tolerance to environmental conditions. Therefore, a greater diversity of genes present in a population increases the probability that some members of the population will remain adapted if conditions change.

In the urban forest context, maintaining genetic diversity is an important way to promote a healthy and resilient urban forest (Santamour 1990). Maintaining genetic diversity is a function of the number of families, genera, and species present and how those taxa are spatially distributed across the community. Satamour (1990) proposed the 10/20/30 benchmark, which states that a municipality should aim for no more than 10% represented by a single species, no more than 20% represented by a single genus, and no more than 30% representation by a single family. However, it's important to acknowledge the limitations of the benchmark and that it does not account for all competing priorities in species selection. In particular, it should not be used as a mechanism to reduce the abundance of local native species, where trees are primarily from the Myrtaceae family and the *Eucalyptus* genera. Despite its limitations, the 10/20/30 rule remains a useful rule of thumb (Kendal *et al.* 2014).

Lack of intraspecific diversity in urban forestry is the result of lack of genetic diversity in supply nurseries. Often times in tree nurseries a few cultivars with known superior qualities are selected and clonally propagated, yielding plants of known and sound qualities, but with very little intraspecific diversity (Morton and Gruszka 2008). The use of a few, widely distributed cultivars and clones may pose a risk to generic diversity via biotic homogenisation. This homogenisation, including plantings based on a restricted number of genotypes, are at increased risk of attack from pests and diseases (Vanden Broeck *et al*. 2018). Intraspecific diversity is an issue that is difficult for the City to control if it continues to outsource tree stock from nurseries. The best way to decrease the risk would be to in-house tree supply, and therefore have complete control over genetic diversity. Alternatively, the City should source stock from multiple suppliers in order to reduce risk of homogenisation. The City should also determine which trees are known avoid planting trees that are known to be cloned from one cultivar by contacting tree suppliers, and avoid these trees if possible.

Intraspecific diversity is particularly important for exotic tree species. Native tree species planted in urban areas can transfer traits with native species in natural areas, and vice versa. Private trees also play a role in bringing diversity and resilience into an urban forest (Chambers-Olster, 2024), as these trees are often sourced from different suppliers than City trees.

The genetic diversity (genus and species) of Melville's current street tree population is discussed in Section 2, Existing Tree Population.

ACTIONS

- *Review existing methodologies for improving tree diversity and resilience and develop a customised approach for the City's tree population.*
- *Trial new species identified as climate resilient for their suitability for planting throughout the City. This will require forward planning on behalf of the City to ensure nurseries have appropriate stock.*
- *Consider in-housing tree supply, in order to have control over tree genetic diversity. Alternatively, source tree stock from multiple suppliers, and give preference to those suppliers that take genetic diversity into consideration.*

6.5.3 Age-class Diversity

Age diversity and distribution is an indicator of urban forest health. A healthy urban forest has a reasonably even representation of age classes. To avoid an abrupt decline in the services an urban forest provides, it is important to understand its age structure and maintain its diversity (Song *et al.* 2018).

Age diversity of Melville's current street tree population is discussed in Section 2, Existing Tree Population. There is no widely accepted target of age distribution among urban forest managers. Many urban forest strategies suggest broad targets of even age class distribution, including the City of Melbourne, which set an aim in their Urban Forest Diversity Guidelines 2011 to achieve an even spread of tree ages. However, some recent strategies and papers indicate that age spread should be relative to the proportion of life that a tree spends in that age group. For example, a tree spends most of its life and provides the most benefits while in the 'mature' category, and therefore, a corresponding proportion of the City's tree population should be in that age category. There should be a balance of maximizing benefits of larger, more mature trees, with the intention to remove them when they reach their ULE (Pretzsch *et al.* 2021). Therefore, age-class benchmarks should reflect this. The City of Sydney adopted this age-class distribution in their recent Urban Forest Strategy Draft October 2022. Their current and benchmark range for street and park tree populations have been adapted for the City of Melville and are displayed in Table 5.

The City of Melville Should adopt this age-class benchmark for their street tree population.

Table 5: Tree age classes and benchmark ranges, and their application to tree management, adapted from the City of Sydney Urban Forest Draft Strategy 2022.

Age Class	Description	Indicative tree of 50-year life span Years within age class and % of life span	Benchmark range (City of Sydney)	Percentage of tree population 2022
Juvenile/young	Approximately the same size as nursery-grown advanced sized stock, easily replaceable	Years 0-5 10%	8-12%	18%
Semi-mature	Not yet achieved a mature appearance and still actively increasing in biomass, not easily replaceable from regular nursery stock	Years 6-20 30%	24-36%	26%
Mature	Have grown to a size where biomass remains relatively constant	Years 21-50 60%	48-72%	56%
Over-mature	Static or declining biomass and repeated symptoms of decline		Less than 1%	No Available Data

The cost of maintaining different age classes of the urban forest should also be considered. Hauer *et al*. (2015) compared the theoretical benefits and costs over the life-time of a tree (Figure 32). Although the benefits of trees were most observed during the mature stage of life, most costs are associated with early and late phases in a tree's lifecycle e.g. establishment costs during the early phases, and the maintenance and eventual dismantling costs associated with a post-mature tree.

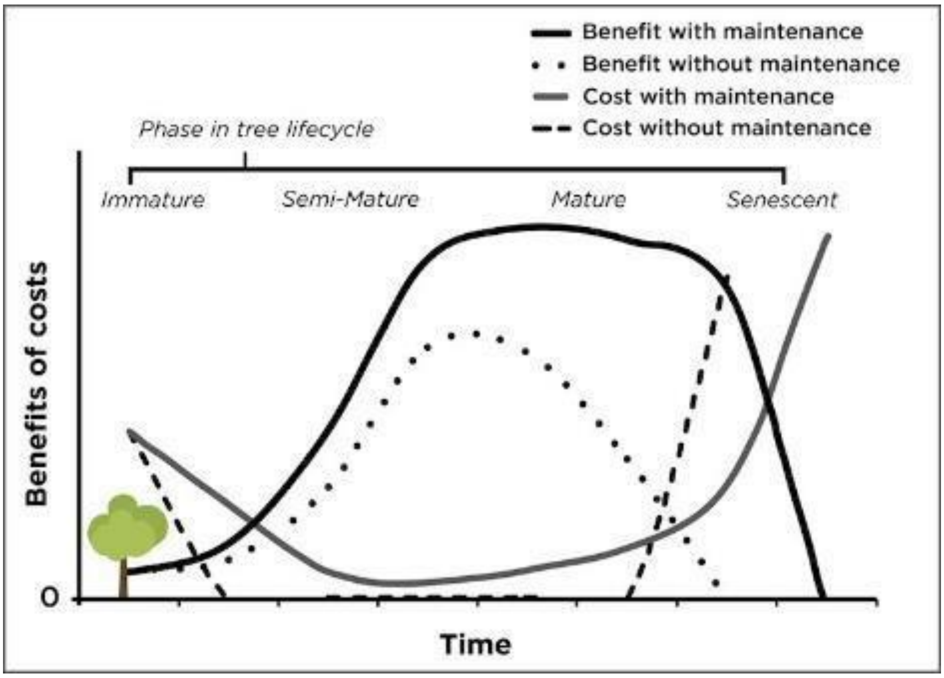


Figure 32: Theoretical costs and benefit profiles over the lifetime of an individual tree, with (solid lines) and without (dashed lines) adequate maintenance. Benefits are maximised during the mature phase of a tree and decline rapidly through senescence, while costs show an inverse pattern. (Source: Hauer et al. 2015)

ACTIONS

- *Implement a regular and continuous tree planting program to ensure a greater age distribution, including targeted succession planting of the City's aging tree population.*
- *Plant large, long-lived trees to improve the continuation of canopy cover.*
- *Manage trees to their full ULE and avoid removal of mature trees unless necessary due to unacceptable risk. Implement a standardised assessment framework for tree removal.*
- *Add an 'over-mature' age class in the City's audit data attributes.*
- *Adopt an age diversity target relative to the proportion of life a tree spends in that age group.*

6.5.4 Health and Condition

Vegetation health and condition is an important criterion that can be used to evaluate the success of forest management and support strategic planning. A sustainable urban forest requires healthy trees, and healthy vegetation will provide the maximum capacity of their ecosystem services (Clark *et al.* 1997).

Numerical targets for tree health are not commonly set as many Cities do not have robust data on the current health status of their trees and regular tree audit collection to compare change since the baseline is typically beyond the budget of most. The City of Melbourne set a target in their Urban Forest Diversity Guidelines 2011 to ensure that no more than 10% of their trees would be in poor health by 2040. The health of Melville's street tree population is discussed in Section 2, Existing Tree Population.

Some local and state government agencies throughout Australia are exploring the use of airborne remote sensing data to quantify and measure change in the condition of trees throughout entire City areas. The City of Melbourne benchmarked the condition of more than 1500 Elm trees in 2019 and expanded this to more than 40,000 trees throughout the City in 2020, with repeat data in 2021 (ArborCarbon 2019, ArborCarbon 2020, ArborCarbon 2021a). The method involves delineating tree crowns and extracting a mean Vegetation Condition Index value from the spectral data for each tree crown. The result is a quantitative, repeatable, objective, rapid and affordable measure of the condition of all trees, with a tool for early warning of a decline in the condition of trees, triggering field inspection and possible intervention. The City of Melville has undertaken a similar management tool on dozens of London Plane Trees in Applecross, the outcomes of which resulted in targeted management.

ACTIONS

Benchmark tree condition of street trees using a combination of the tree audit database and airborne imagery and derived datasets. Set a target based on analysis of this baseline data and monitor regularly to provide early warning of loss in health and condition of trees.

6.5.5 Tree Survivorship/Rate of Mortality

Urban tree survival is essential to sustain the ecosystem services of urban forests, and monitoring is needed to accurately assess benefits and for Councils to reach their numeric canopy cover goals (Ko *et al.* 2015). Understanding the rate at which trees survive or die after being planted will enable accurate estimations on when canopy cover goals will be reached and provide insight into the health of an urban forest and patterns of underlying issues. It is important to understand the survivorship of both City-managed trees and those on private land.

Tree survivorship is the inverse of tree mortality. Determining tree mortality rates will enable tree survivorship to be determined. Numerical goals are uncommon, as mortality rates are often unknown, particularly on private land. Generally, the target is to decrease mortality rates, therefore increasing survivorship. However, if survivorship numbers are known, numerical goals can be set above the baseline.

The City of Melville should set a target to improve upon current levels of survivorship, and measure levels of mortality to take this into account for reporting on canopy cover targets. This will first involve measuring baseline mortality rates. This information can be collected and added to the existing street tree audit. Once a baseline figure has been determined, a target to increase survivorship can be set and measured regularly.

ACTIONS

- *Record all tree deaths in the tree asset database. Report annually on mortality, split into the following categories:*
  - *Failure at establishment (<3years)*
  - *>3 years of age*

  Cause of death should be recorded if evident.
- *Summarise mortality rates by species to identify trends in species performance. As species performance is expected to change as the climate changes, it will be important to understand these trends and respond by changing species distribution or removing species from the palette if required.*

6.5.6 Native Biodiversity

Biodiversity is a broad term, but in this context, it relates to the variety of organisms (plant, animal and microbial) that are endemic to the region that the City of Melville is a part of – the South West of WA. Global efforts at mitigating biodiversity loss often focus on preserving large, intact areas of natural habitat. However, the continuing trend towards urbanisation increases the importance of biodiversity in urban areas as well. Biodiversity determines many ecosystem functions and underlying services, while contributing to the overall resilience of ecosystems (Roeland *et al.* 2019).

Biodiversity can be assessed and measured by several criteria, including habitat provision (Roeland *et al.* 2019), connectivity (both from a genetic dispersal perspective and an enhancing population dynamic perspective) (Ordonez and Duinker 2013) species diversity, and the abundance of invasive species.

Qualitative goals include to protect and extend habitat connectivity and habitat corridors. Biodiversity corridors are defined as spaces used by species that facilitate the movement of plants or animals over time between multiple patches of otherwise disjunct habitat (Hilty *et al.* 2006).

6.5.7 Carbon Sequestration

Carbon sequestration is an indicator of ecosystem services provided by urban forests. It refers to their capacity to remove CO_2 from the atmosphere. Trees absorb carbon from the atmosphere, which is then stored in above- and below-ground biomass and soil organic matter (Roeland *et al.* 2019). Biomass measurements can then be converted into carbon sequestered.

Several other LGAs have developed strategies which set targets and goals relating to carbon sequestration and offsetting, such as: offsetting 0.5% of city emissions; increasing carbon storage by 2% over 10 years; and creating a carbon credit system (Ordonez and Duinker 2013). Councils throughout Australia are exploring opportunities to quantify the carbon stored in their urban forests, and the potential to offset their carbon emissions through targeted planting and urban forest management. ArborCarbon has undertaken several projects for various clients (e.g., National Grid UK, Lake Macquarie City Council, City of Boroondara) exploring the use of airborne remote sensing data to estimate carbon sequestered at the individual tree level (ArborFlight 2020, ArborCarbon 2021b). The technology shows great promise as a more accurate alternative to the currently adopted approaches that rely upon models and plot-based measures to derive a carbon measure across tree populations.

ACTIONS

Develop a program to derive carbon stored by the street tree population, for example by combining aerial data and tree audit attributes.

7 Planting Opportunities and Priorities

7.1 Street Trees

Within the City of Melville, there is a substantial variation across streets' tree canopy cover. While the more established areas have large trees with closed canopies over the street, more recently developed areas often have lower density and size of trees, with a corresponding reduction in shading, amenity and other benefits.

A **street tree planting prioritisation framework** has been developed to create a more equitable distribution of canopy cover within the City and maximise the benefits of future investment in street tree planting.

Each street within the LGA was assigned a priority score based on the:

- Current canopy over the road corridor (according to the 2022 aerial data),
- Proportion of available planting space (APS) (dataset derived from the 2022 aerial data),
- Mean land surface temperature (LST) of the road section (according to the 2022 aerial data),
- Current density of street trees (according to the City's tree audit),
- Previously identified vacant street tree planting locations (according to the City's tree audit), and

Streets were ranked on each feature and split into quartiles. A priority score was assigned to each street, depending on its ranking. Proportional canopy cover and available planting space were given slightly heavier weighting than the other categories. The priority score for each road feature was summed to create the combined priority score for each street ranging from 1 to 20. The lower the score, the higher the priority for planting.

A detailed description of the method used to determine the overall street tree planting prioritisation plan can be found in Appendix 2.

An overall planting prioritisation ranking was developed by taking into consideration all these criteria (Figure 33).

The highest priority areas in Figure 33 are marked in red, with the highest proportion of area in Kardinya, Bull Creek and Leeming. Numerous streets in these neighbourhoods have low canopy cover, and a high number of vacant sites. Applecross, Mount Pleasant and Ardross have the least number of streets considered high priority for planting.

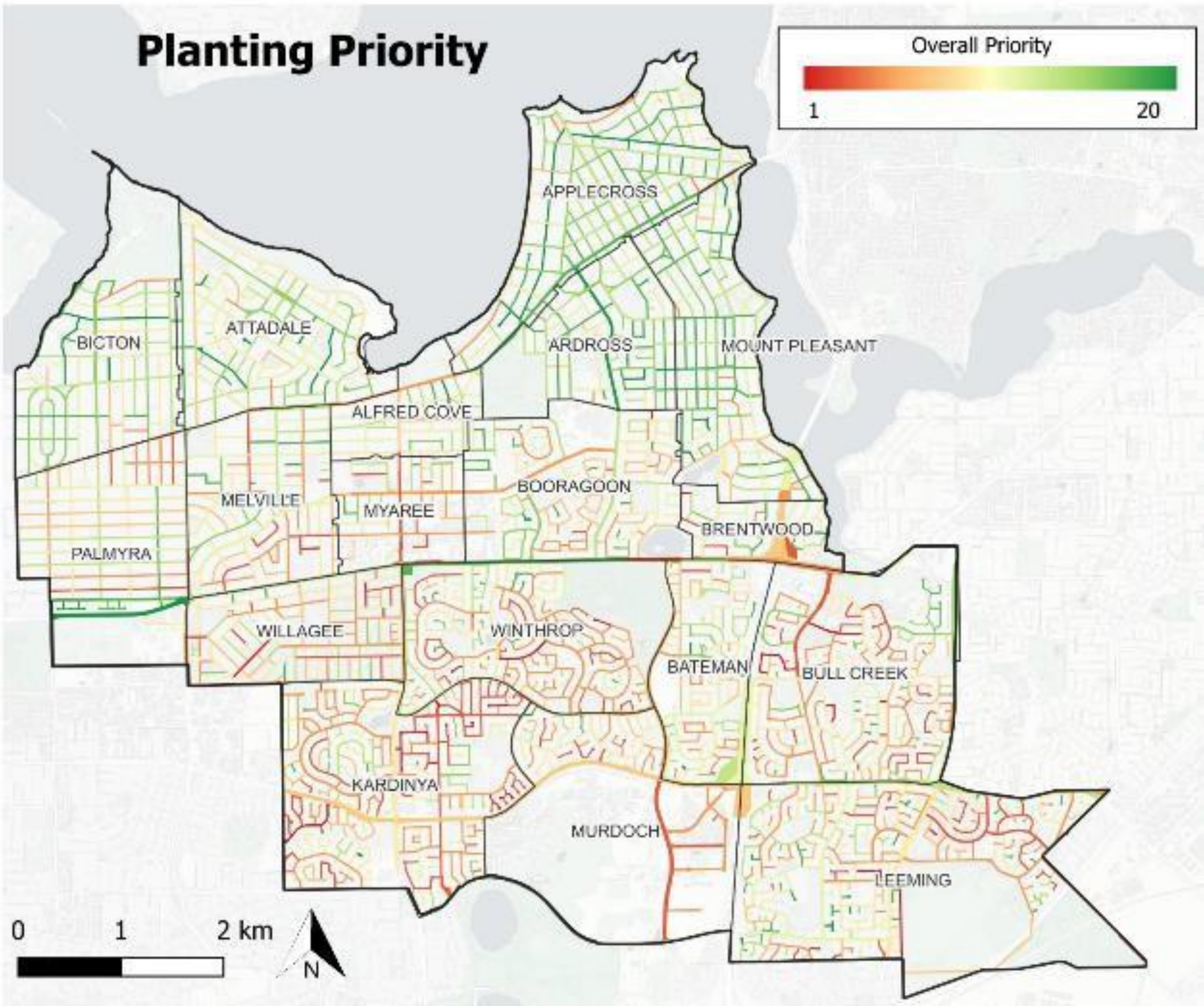


Figure 33: Roads in the City of Melville ranked by planting priority.

7.2 Recreational Areas

A similar **tree planting prioritisation framework** has been developed for Recreational Areas, to create a more equitable distribution of well-canopied recreational space, and provide the City with a guide to prioritise planting operations.

Areas of natural bushland and sports playing fields were excluded from each Recreational Area boundary. Then, each Recreational Area within the LGA (Local Government Area) was assigned a priority score based on the:

- The average distance of each cadastral lot within a particular suburb to a Recreational Area (community access to open space),
- The population density of the suburb that each Recreational Area is in (ABS),
- Current canopy of the Recreational Area (according to the 2022 ArborCam data),
- Mean land surface temperature (LST) of the Recreational Area (according to the 2022 ArborCam data),
- , and
- The average canopy cover of the suburb that each Recreational Area is in (according to the 2022 ArborCam data).

Recreational Areas were ranked on each feature and split into quartiles. A priority score was assigned to each Recreational Area depending on its ranking. The priority score for each Recreational Area was summed to create the combined priority score for each Recreational Area, ranging from 1 to 20. The lower the score, the higher the priority for planting.

A detailed description of the method used to determine the overall Recreational Area planting prioritisation plan can be found in Appendix 3, along with the complete planting priority table.

An overall planting prioritisation ranking for Recreational Areas was developed by taking into consideration all these criteria (Figure 34). The highest priority Recreational Areas are marked in red.

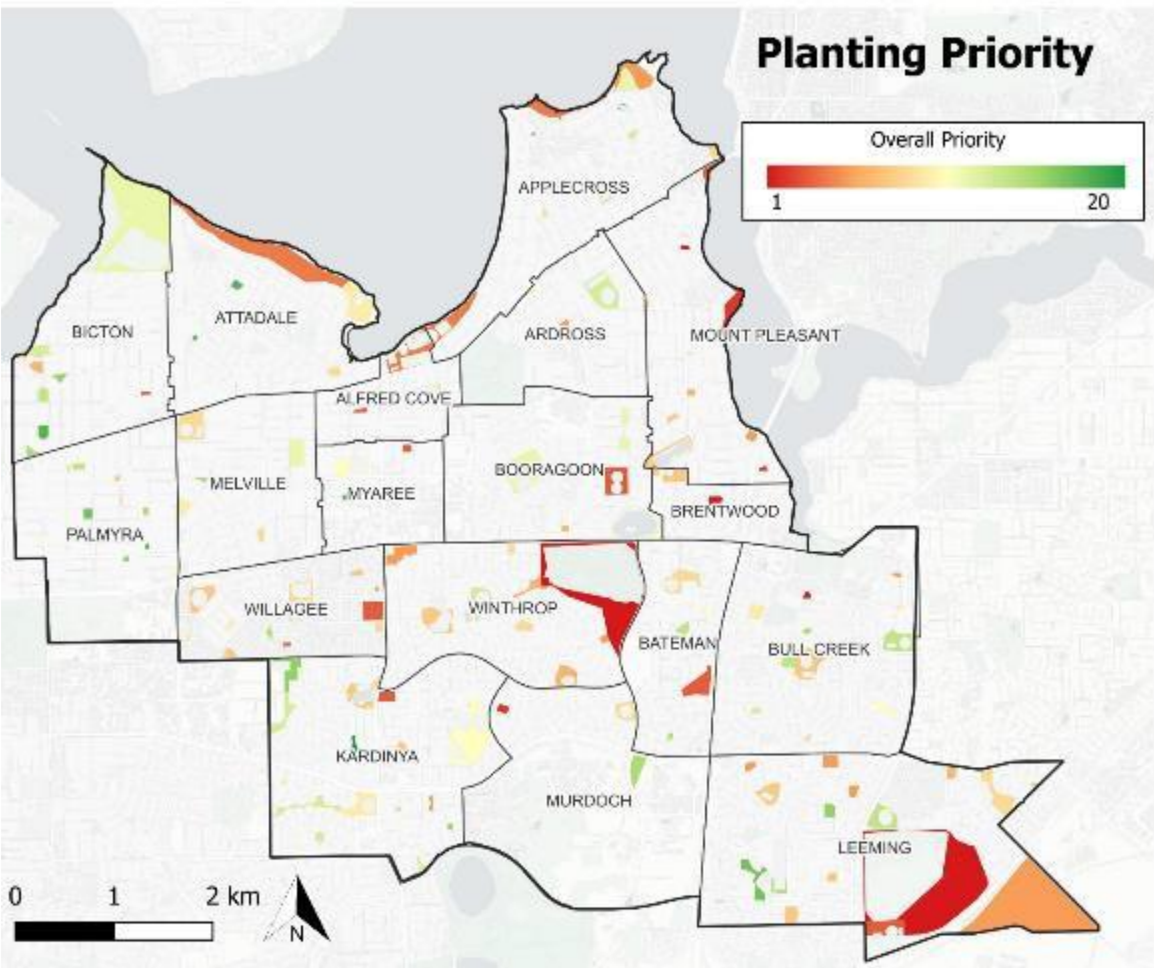


Figure 34: Recreational Areas in the City of Melville ranked by planting priority.

ACTIONS

*Utilise the **street tree and recreation area planting prioritisation framework** to inform planting programs.*

8 Action and Implementation Plan

The Urban Forest Strategy review –. The revised goals are:

1. Value and protect the existing urban forest
2. Increase tree canopy cover across the City to achieve an ambitious yet achievable target
3. Grow a resilient forest by balancing age classes and species diversity
4. Expand and maintain data collection and monitoring

A series of goals and actions are detailed to enable stakeholders to successfully implement the Urban Forest Strategy through an Action and Implementation Plan. These actions prioritised as high (within 12 months), moderate (2 – 3 years), low (4 – 5 years), and ongoing (throughout the Strategy duration). This enables the City to achieve, and expand upon, the key objectives of the original strategic plan.

Successful implementation of this plan will require integration of the targets with the capabilities and resources required to establish and sustain a resilient urban forest. These actions must be integrated into strategy and operations at all levels of Council.

Table 6: Actions implementation table, prioritised as high (within 12 months), moderate (2 – 3 years), low (4 – 5 years), or ongoing (throughout the Strategy duration).

Goal	Action	Section	Priority
Value and protect the existing urban forest	*Undertake a review of internal and external (i.e. City of Nedlands, Town of Cambridge) initiatives for tree protection on private land, determine the most suitable initiative(s), and finalise for review by Council.*	4.2.1	HIGH
	Review existing LPS and LPP's and determine whether an opportunity exists to include protection for significant trees growing on adjacent verges.	4.2.2	HIGH
	Adopt a preferred tree valuation methodology.	4.2.3	MODERATE
	Protect existing mature trees as a priority.	4.2.3	ONGOING
	Increase the amount of information residents receive about the benefits trees provide around the house, including real-estate values, and decreased energy consumption.	4.2.4	ONGOING
	Improve engagement of the community with the City's urban forest through the display of aerial datasets on a dedicated interactive webpage.	4.2.4	HIGH
	Continue to drive Council-wide cultural change to recognise that all large trees are valuable because they provide important environmental services.	4.2.8	ONGOING
	Manage trees to their full ULE and avoid removal of mature trees unless necessary due to unacceptable risk. Implement a standardised assessment framework for tree removal.	6.6.3	ONGOING

Increase tree canopy cover across the City to achieve an ambitious yet achievable target	*Explore and test different incentives to encourage residents to increase understorey planting on private verges and land.*	4.2.4	MODERATE
	Improve Council engagement during tree planting programs. Involve the nearby community in watering newly planted trees, e.g., by providing information on the species and how to look after it.	4.2.4	LOW
	Prioritise areas of dead grass and exposed soil, where possible, for tree planting to reduce the local UHIE and improve amenity value.	4.2.5	ONGOING
	Quantify the amount of shade within each park, and determine the optimal level of shade required for subsequent setting of targets that can be measured against.	4.2.5	MODERATE
	Continue to work collaboratively across council to facilitate integration and alignment of capital and operational works within the City with a key focus on establishing the importance of incorporating urban greening into all aspects of operation	4.2.8	MODERATE
	Expand upon on the success of the establishment of funds and training of dedicated staff for Urban Forest Management through increased funding and employment	4.2.8	MODERATE
	Achieve canopy cover targets outlined in Table 3 *and* Table 4 *by 2050*	6.5	ONGOING
	Undertake analysis of airborne imagery and other geospatial datasets to identify options for the creation and enhancement of biodiversity corridors, and their ongoing measurement and monitoring	6.6.1	MODERATE
	Plant large, long-lived trees to improve the continuation of canopy cover.	6.6.3	ONGOING
	Utilise the street tree and recreation area planting prioritisation framework to inform planting programs.	7	ONGOING
Grow a resilient forest by balancing age classes and species diversity	*Extract condition data at the individual tree level, along with tree audit data.. This data can be utilised in future studies.*	4.2.5	MODERATE
	Review and partake in academic research, preferably within the City, into the drought and heat stress tolerance of the existing tree species population and suitable species for future planting.	4.2.5	HIGH
	Review the urban forest risks within the Climate Adaptation Strategy when complete, and align with future programs that assess the resilience of urban tree species in a changing climate.	4.2.5	MODERATE
	Review existing methodologies for improving tree diversity and resilience and develop a customised approach for the City's tree population	6.6.2	MODERATE

	Trial new species identified as climate resilient for their suitability for planting throughout the City. This will require forward planning on behalf of the City to ensure nurseries have appropriate stock	6.6.2	HIGH
	Consider in-housing tree supply, in order to have control over tree genetic diversity. Alternatively, source tree stock from multiple suppliers, and give preference to those suppliers that take genetic diversity into consideration.	6.6.2	MODERATE
	Implement a regular and continuous tree planting program to ensure a greater age distribution, including targeted succession planting of the City's aging tree population	6.6.3	ONGOING
	Adopt an age diversity target relative to the proportion of life a tree spends in that age group.	6.6.3	ONGOING
Expand and maintain data collection and monitoring	*Develop and implement a program whereby the community is surveyed to determine their level of satisfaction with the City's urban forest.*	4.2.4	MODERATE
	Maintain consistency with future urban forest measures by utilising the same airborne aerial datasets and their derivatives.	4.2.6	ONGOING
	Consider increasing the frequency of airborne measures of canopy cover, condition, and surface temperatures to annually or biennially.	4.2.6	ONGOING
	Expand the use of currently utilised software systems to improve currency of data and tailor to the management of tree assets	4.2.6	MODERATE
	Work with/Partner with a research provider who hold relevant expertise, preferably within the City i.e., Murdoch University.	4.2.6	MODERATE
	Procure funding to increase planting budgets, enabling the implementation of a broader tree planting and establishment initiative for urban areas	4.2.6	HIGH
	Develop a georeferenced tree database with filtering by host, pest or pathogen for the spatial investigation of their risk profiles.	4.2.7	MODERATE
	Explore the use of aerially acquired data for accurately measuring carbon and biodiversity values in the urban forest, quantifying current carbon sequestration in the City, and a plan to include all future plantings as carbon offsets	4.2.9	MODERATE
	Benchmark tree condition of street trees using a combination of the tree audit database and airborne imagery and derived datasets. Set a target based on analysis of this baseline data and monitor regularly to provide early warning of loss in health and condition of trees	6.6.4	MODERATE

	Record all tree deaths in the tree asset database. Report annually on mortality, split into the following categories: • *Failure at establishment (<3years)* • *>3 years of age* *Cause of death should be recorded if evident.*	6.6.5	MODERATE
	Summarise mortality rates by species to identify trends in species performance. As species performance is expected to change as the climate changes, it will be important to understand these trends and respond by changing species distribution or removing species from the palette if required	6.6.5	LOW
	Develop a program to derive carbon stored by the street tree population, for example by combining aerial data and tree audit attributes.	6.6.7	MODERATE

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Appendix 1 – Development of boundaries

Land Ownership

Land cover classification was determined for the entire LGA, classified by land ownership. The land was divided into Public and Private land based on the cadastre layer provided by the City. All 'STPLN', 'SSPLN', and 'FHOLD' features in the ‘LOT_TYPE’ attribute of the cadastre layer was classified as Private land. All ‘CROWN’ features and any gaps in the cadastre layer (such as road reserves) were classified as Public land.

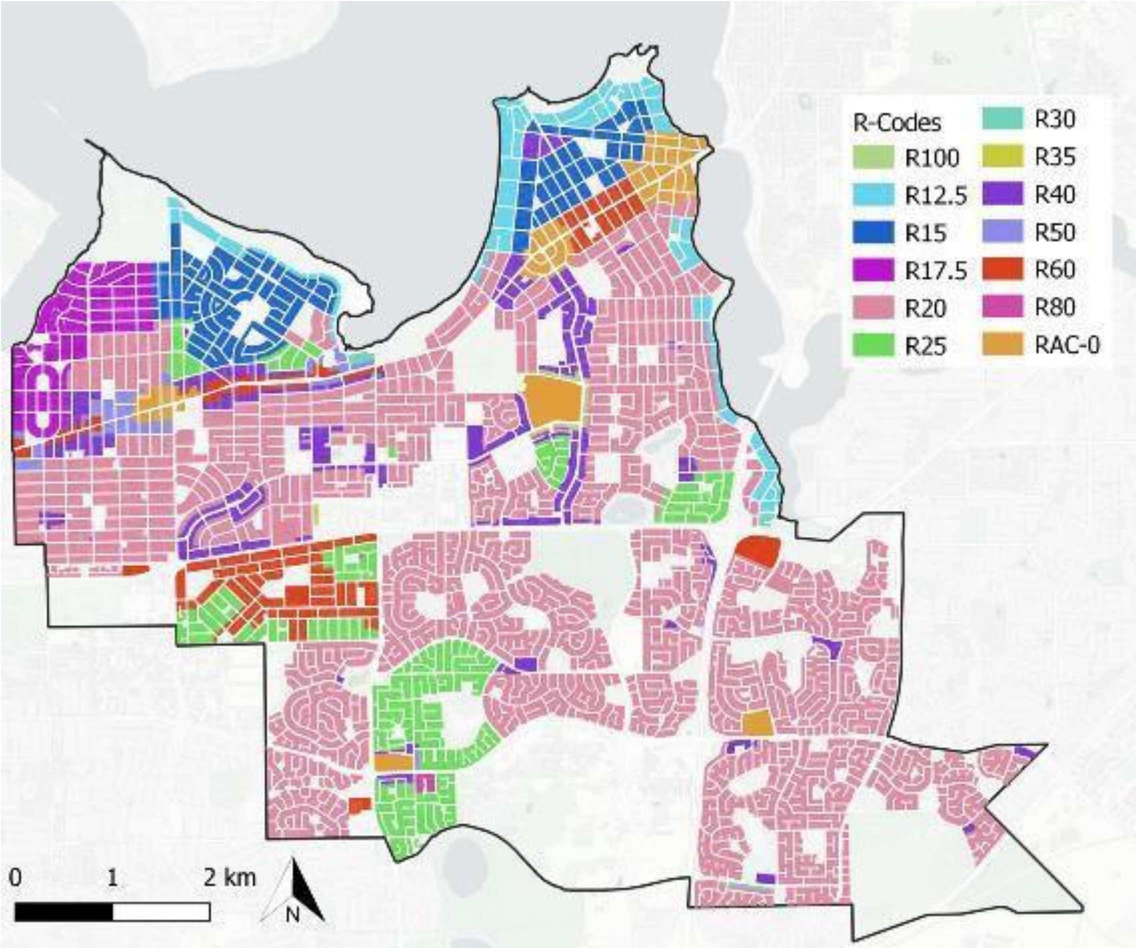
Appendix 2 - Method of Modelling the Potential Impact of Development on Canopy Cover

Analysis was conducted on residential lots according to their R-codes (see State Planning Policy (SPP) 7.3 – Residential Design Codes Volume 1 and 2 for specifications). The building footprint coverage of each lot was calculated from building footprints generated from airborne ArborCarbon ArborCam imagery acquired in 2022. The R-code specifications used to determine whether a lot was considered as having development potential were:

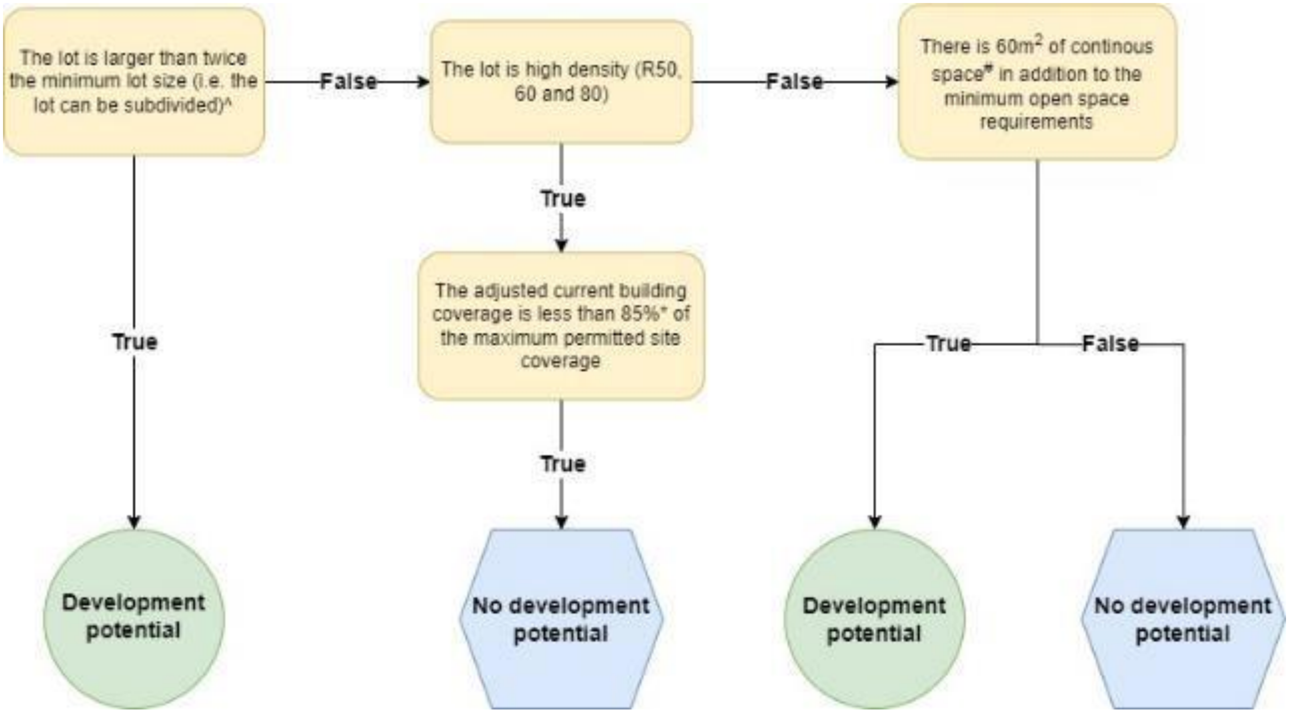
a) Site area per dwelling (m^2)
   i. Applicable to lots classified as all R-codes.
   ii. Lot is considered to have development potential IF the lot is larger than twice the minimum or average lot size (i.e., the lot can be subdivided).
b) Minimum open space (%)
   i. Applicable to low-density lots with single dwellings (classified R-codes R2 to 40)
   i. Lot is considered to have development potential IF the current open space/non-building coverage exceeds the minimum open space requirement by at least $60m^2$ of continuous space.
c) Maximum site coverage estimation (%)
   i. Applicable to high-density lots with multiple dwellings (classified R-codes R50 to 80 and RAC-0).
   ii. Lot is considered to have development potential IF the current building coverage is less than 85% of the maximum site coverage.

Overall, a Property lot was considered to have development potential if it met the requirements of a), b) or c). This resulted in each residential cadastral lot either having development potential or not.

The methodology is summarised in the flowchart below, and the assumptions and limitations of the methodology are provided.



Residential land categorized by R-code



Flowchart showing the methodology used to model the potential impact of development on canopy cover.

Assumptions:

- If R-code specifications provided both a minimum and an average lot size requirement, the average was used in the analysis.
- 85% (capacity minus 15%) was used to account for residents' lack of desire to build to capacity, and to account for estimated error in methodology.
- 60m^2 of continuous space would account for significant development on a single dwelling e.g., the addition of a granny flat.
- Although R40 is considered high density, this analysis considers it a low density/single dwelling (under SPP 7.3 Volume 1).
- Volume 1 is single and grouped dwellings; Volume 2 is apartments.
- A reduction in building coverage of 17% was applied to all building footprints to account for the exclusion of building elements that are visible in aerial imagery and including in the analysis, but do not count towards site coverage (e.g. eaves, patios).
- The maximum site coverage estimation of high density lots was determined by using the smallest value of either the:
  - Lot area multiplied by the plot ratio (assuming single story and based on plot ratio)
  - Lot area minus the setbacks (assuming double story, as increasing the story would decrease the site coverage percent, and assuming the 'worst case scenario'/least available space).

Limitations:

- Calculation of lot area minus setbacks assumes a square lot.
- The outcome is a 'worst case scenario' as it assumes all lots with development potential will be developed.

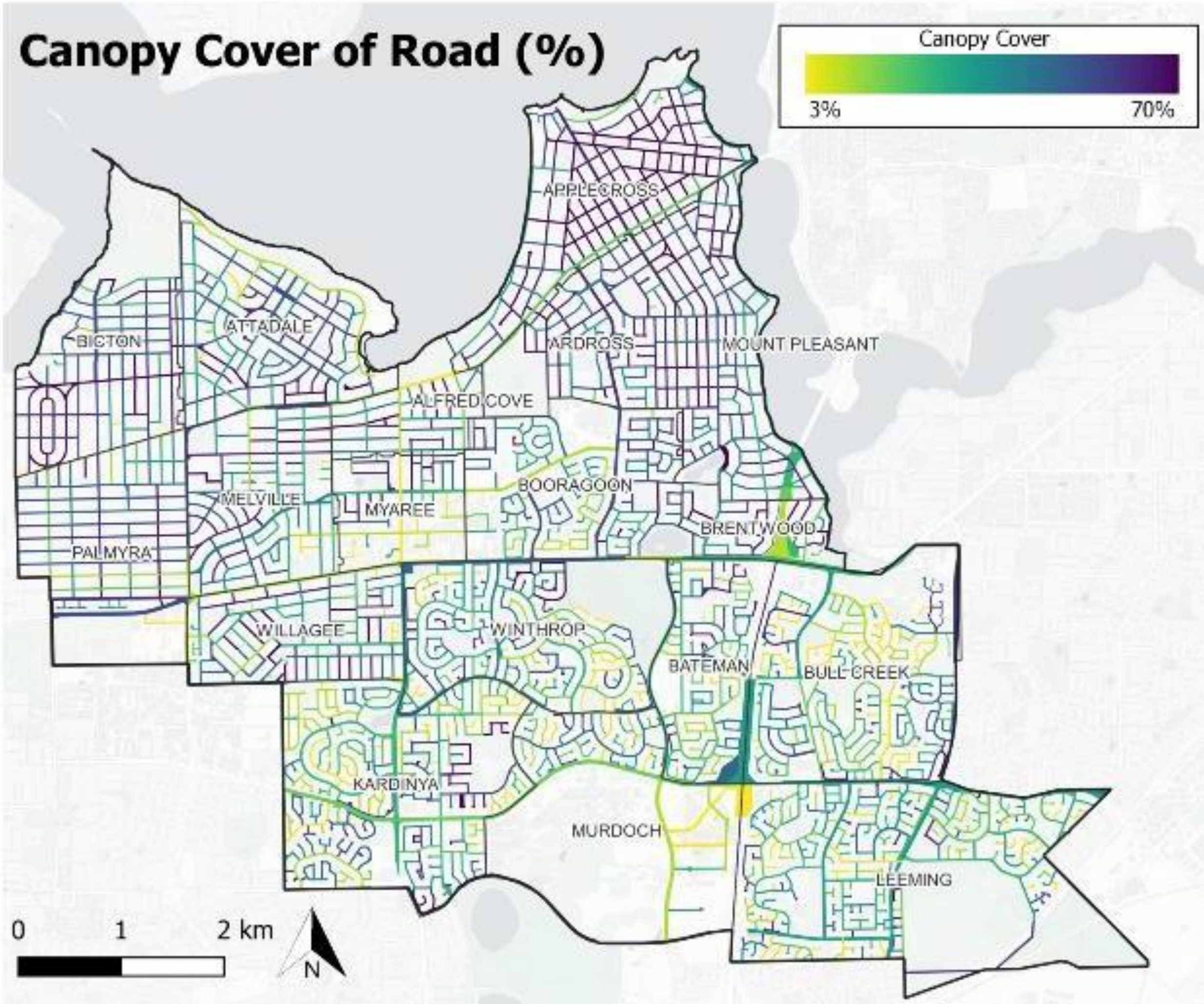
Appendix 3 – Method of Development of Street Tree Planting Prioritisation Plan

Each street within the LGA was assigned a priority score based on the:

- Current canopy over the road corridor (according to the 2022 ArborCam data),
- Proportion of available planting space (APS) (dataset derived from the 2022 ArborCam data),
- Mean land surface temperature (LST) of the road section (according to the 2022 ArborCam data),
- Current density of street trees (according to the City's tree audit),
  Previously identified vacant street tree planting locations (according to the City's tree audit

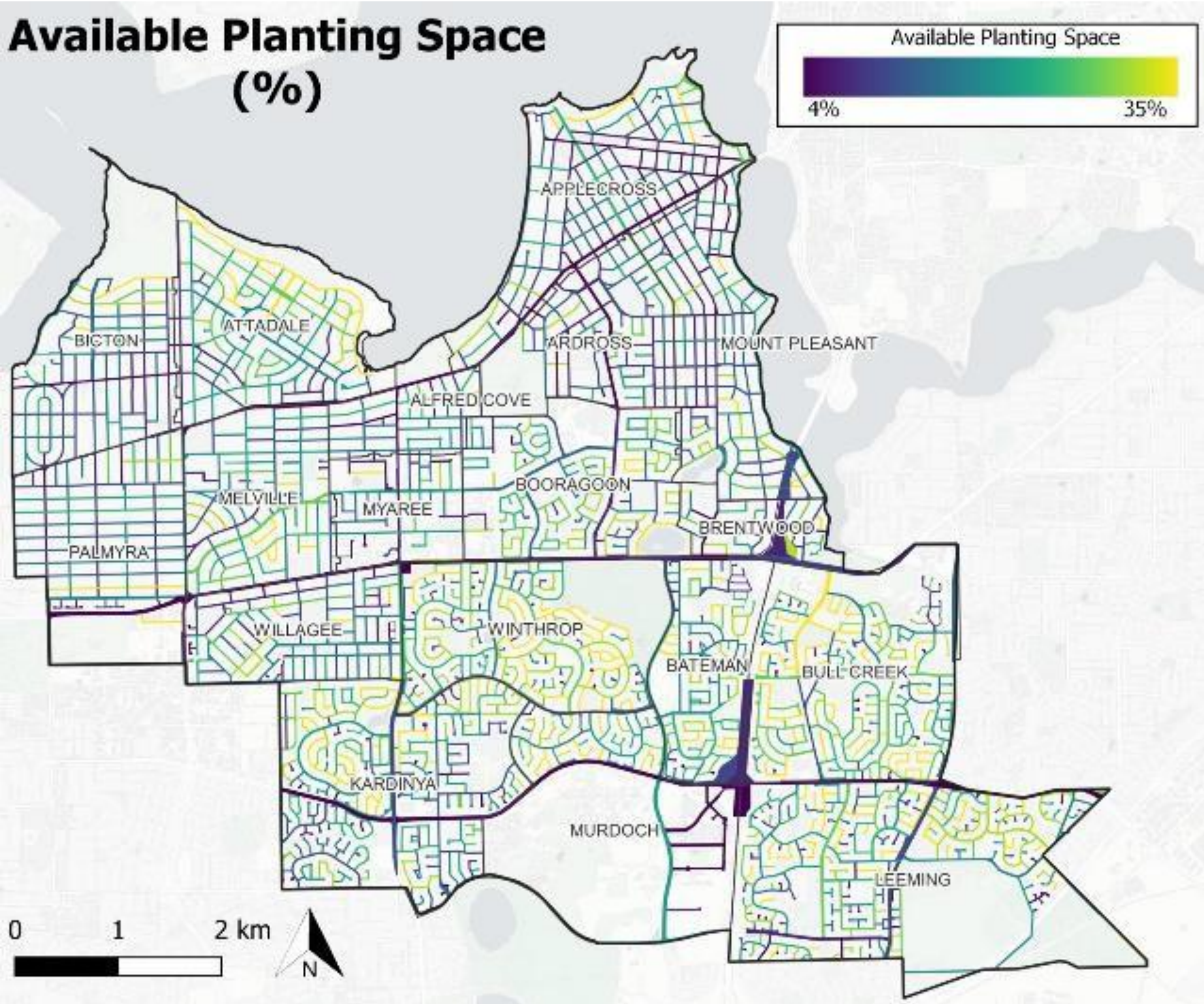
Streets were ranked on each feature and split into quartiles. A priority score was assigned to each street, depending on its ranking. Proportional canopy cover and available planting space were given slightly heavier weighting than the other categories. The priority score for each road feature was summed to create the combined priority score for each street ranging from 1 to 20. The lower the score, the higher the priority for planting.

The spatial differences in streetscape canopy cover are displayed in the figure below. It shows the percentage of canopy cover over each street segment across the urban area. Many of the high canopy cover streets are within the northern part of the City, near the River, in the established suburbs of Applecross, Ardross, Mount Pleasant, and Attadale. Bull Creek, Kardinya and Myaree had more roads with lower canopy cover.



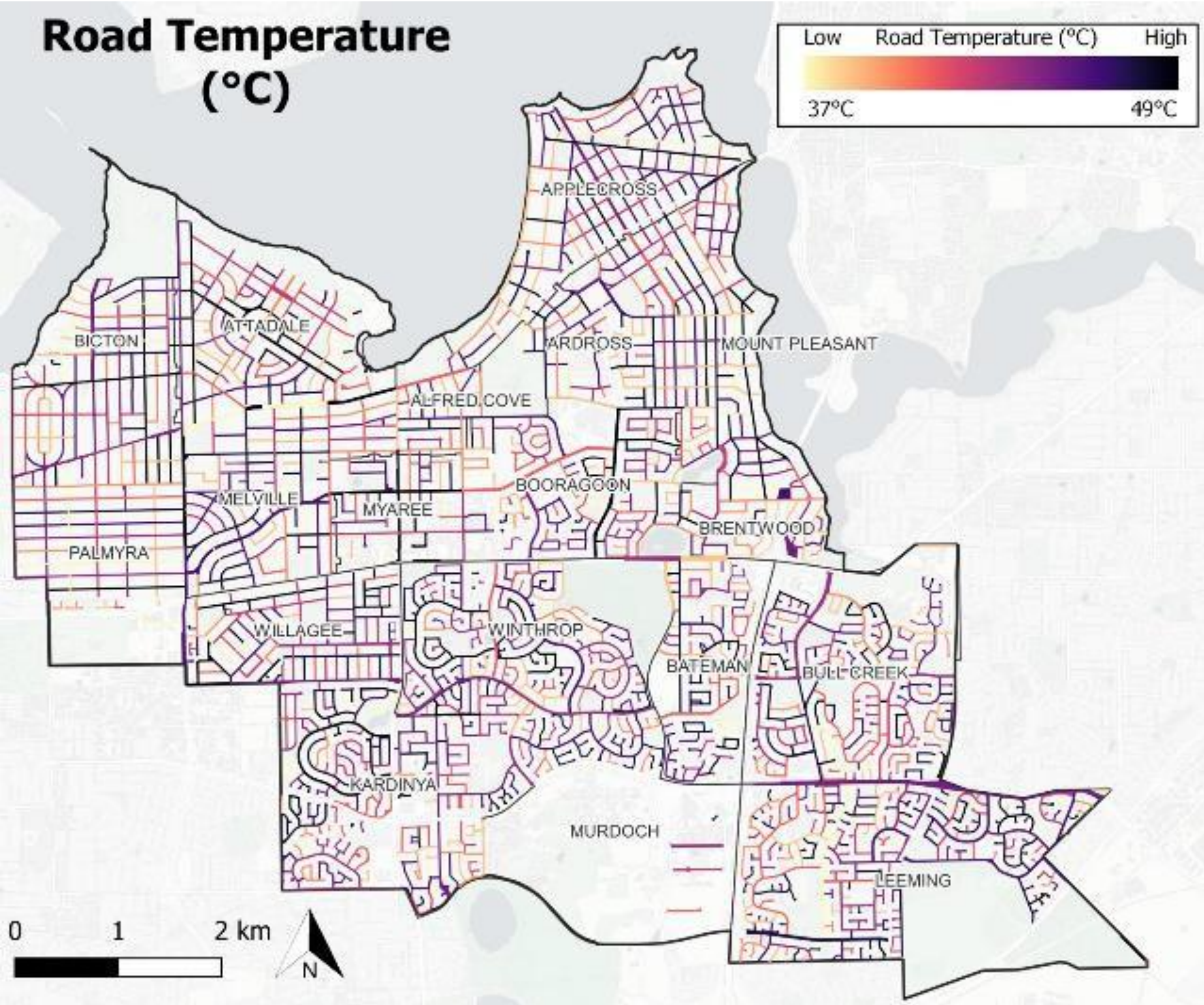
Percentage of canopy cover along the roads, segmented by road name and suburb.

Similar spatial presentation of Available Planting Space (APS) generally aligned with spatial representation of canopy cover. Bull Creek, Leeming, Leeming, Winthrop and Kardinya had many streets with up to 35% APS. Applecross, Ardross, Mount Pleasant, Bicton and Palmyra had fewer streets with APS.



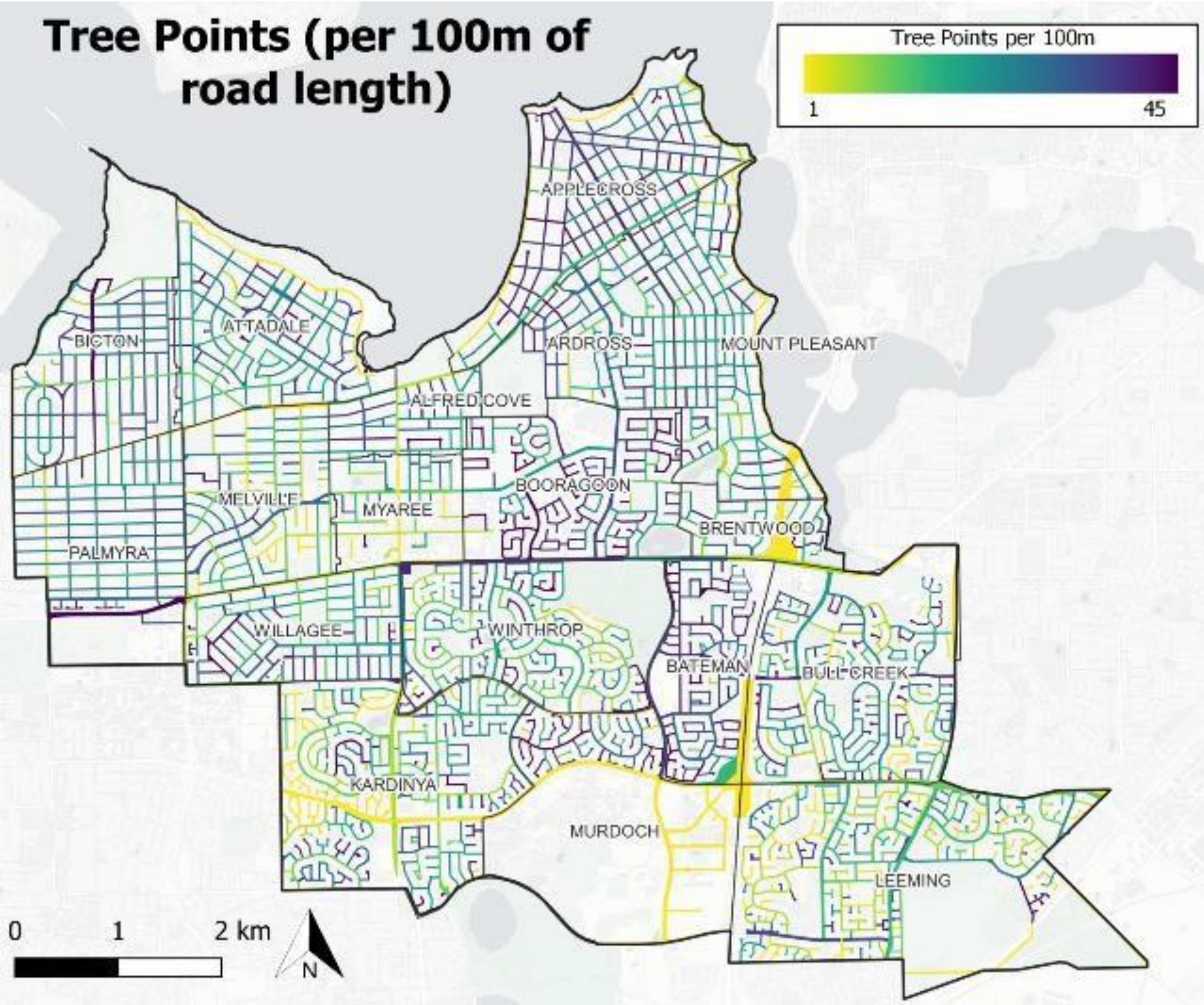
Proportional APS along the roads, segmented by road name and suburb.

Planting more trees and thus improving the canopy cover can reduce surface and air temperatures, mitigating some of the direct impacts of climate change on human populations. The figure below displays each street's median land surface temperature (LST), calculated from the ArborCam aerial dataset acquired in February 2022. Kardinya, Winthrop, Booragoon and Bull Creek had streets with the highest LSTs. Hall Place in Kardinya was the hottest street at 49°C.



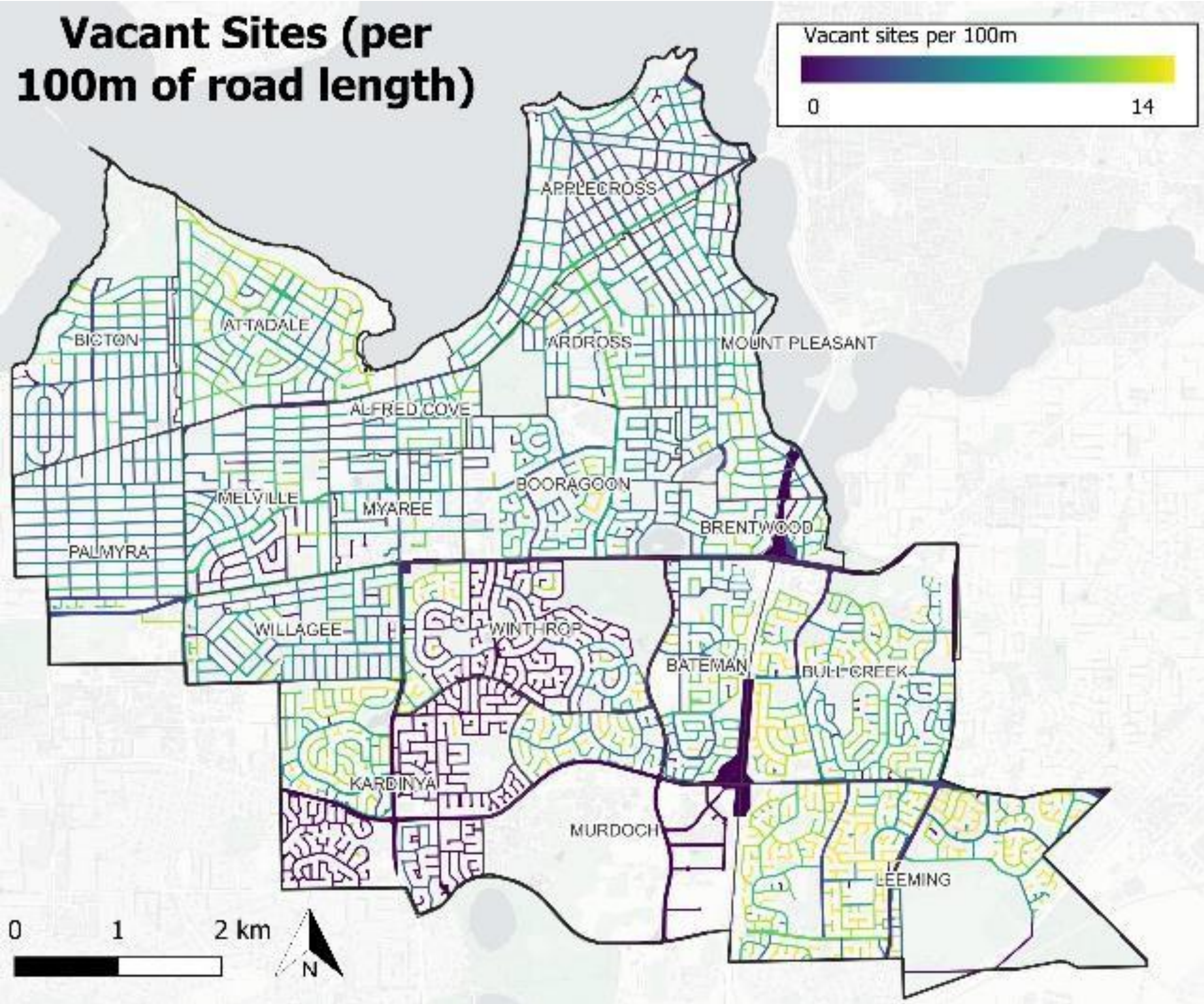
Mean road temperature (LST), segmented by road name and suburb.

There is a large variation in the density of street trees across the City's urban area. The figure below illustrates the street tree density (the number of street trees per 100m of street length), according to the most recent audit data. Bateman, Booragoon and Applecross appear to have the highest street tree density, while streets in Kardinya, Myaree, Melville and Leeming generally have low street tree density. However, several caveats exist due to the variability of the dataset. The dataset appears outdated in many areas, and the number of street trees is much greater or much lower. For this reason, canopy cover data, recently measured by airborne sensors, has been given a higher weighting for prioritisation. The street tree data is still of value, particularly in capturing more recent tree planting, where the trees are too small to be detected by aerial imagery.



Tree density (street tree per 100m of road length), segmented by road name and suburb.

As part of the tree inventory, the City has begun mapping vacant sites on road reserves suitable for tree planting. According to the most recent audit data, the density of vacant sites was determined for each street (the number of vacant sites per 100m of street length). According to the data, Leeming, Bull Creek, Murdoch and Kardinya have many streets with a high density of vacant sites suitable for planting, some as high as 14 sites per 100m of street length. However, many streets in these suburbs and Winthrop were mapped to have no vacant sites. This may indicate the dataset being incomplete; therefore, this dataset was given less weighting in the overall prioritisation plan compared to APS.



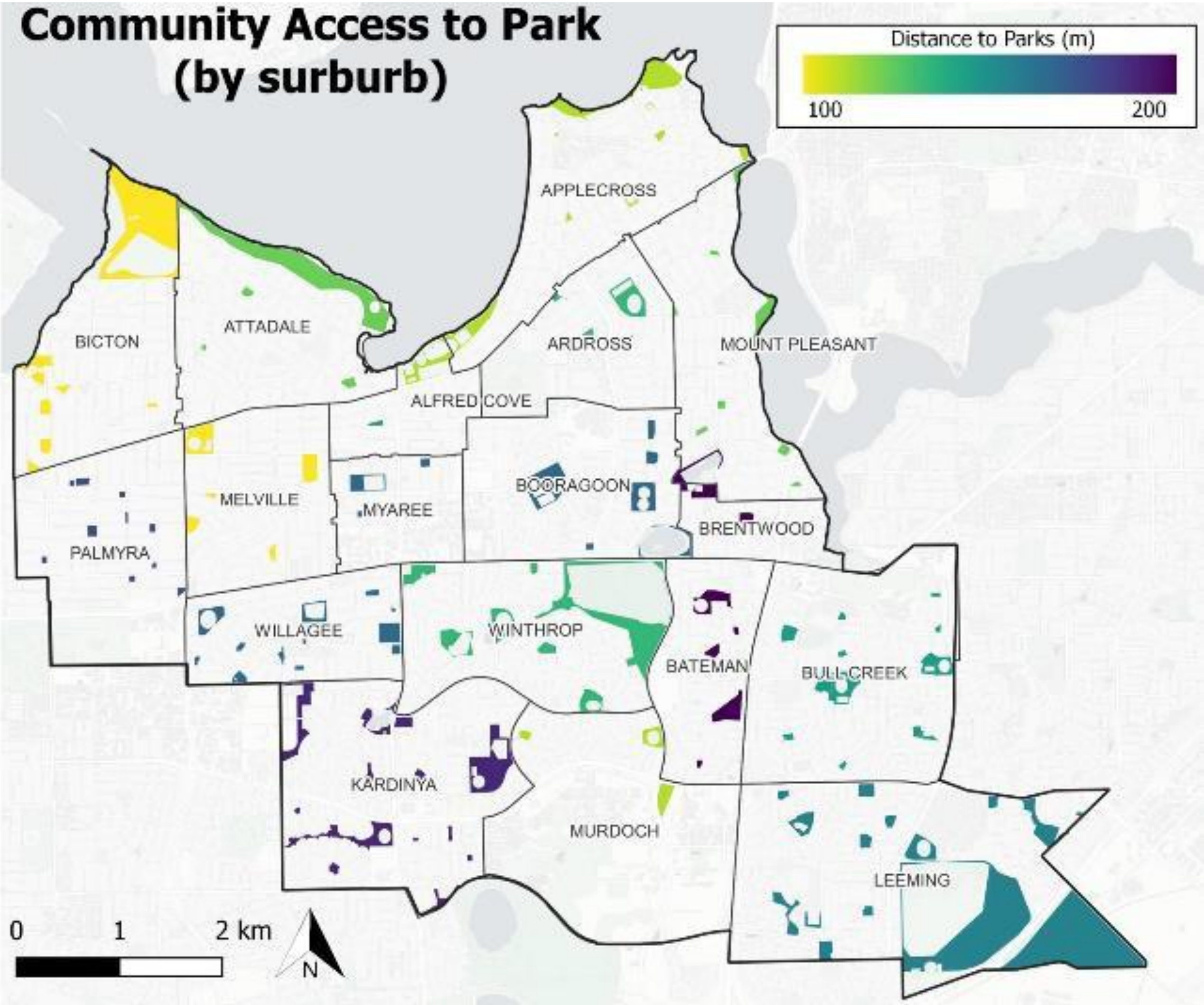
Vacant planting site density (site per 100m of road length), segmented by road name and suburb.

Appendix 4 - Method of Development of Recreational Area Tree Planting Prioritisation Plan

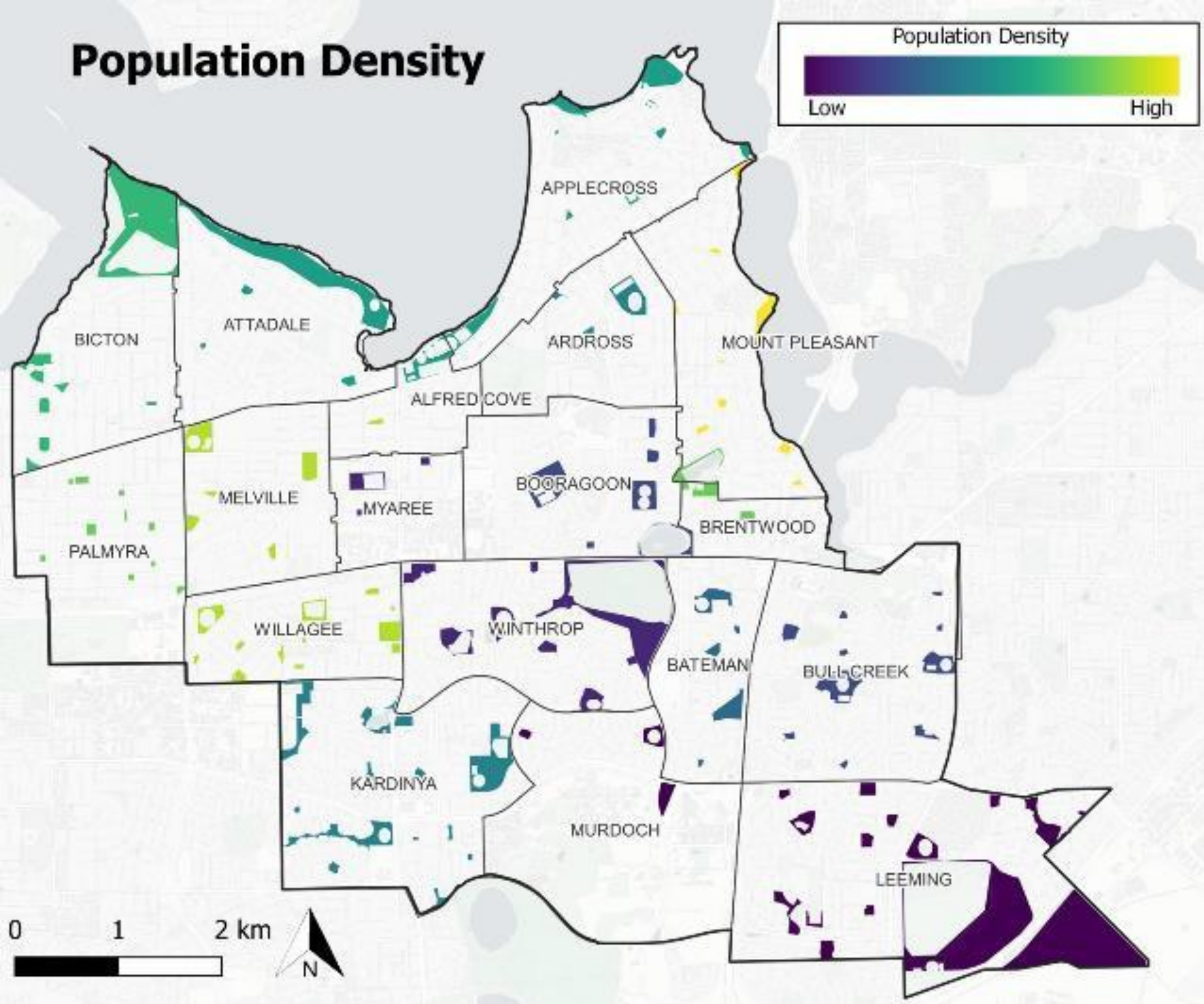
Areas of natural bushland and sports playing fields were excluded from each Recreational Area boundary. Then, each Recreational Area within the LGA was assigned a priority score based on the:

- The average distance of each cadastral lot within a particular suburb to a Recreational Area (community access to open space),
- The population density of the suburb that each Recreational Area is in (ABS),
- Current canopy of the Recreational Area (according to the 2022 ArborCam data),
- Proportion of available planting space (APS) in each Recreational Area (dataset derived from the 2022 ArborCam data),
- Mean land surface temperature (LST) of the Recreational Area (according to the 2022 ArborCam data),
- The average canopy cover of the suburb that each Recreational Area is in (according to the 2022 ArborCam data).

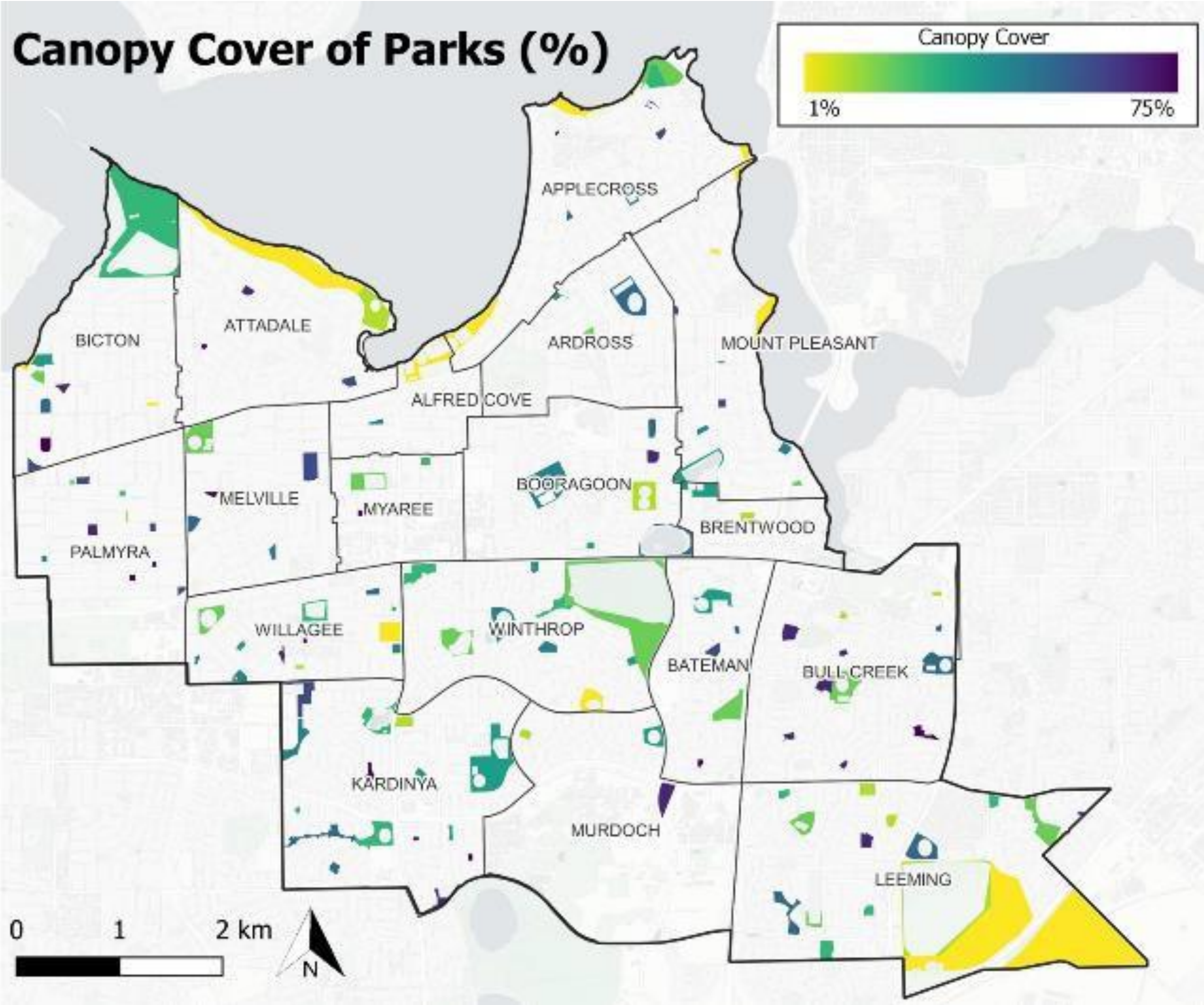
Recreational Areas were ranked on each feature and split into quartiles. A priority score was assigned to each Recreational Area depending on its ranking. The priority score for each Recreational Area was summed to create the combined priority score for each Recreational Area, ranging from 1 to 20. The lower the score, the higher the priority for planting.



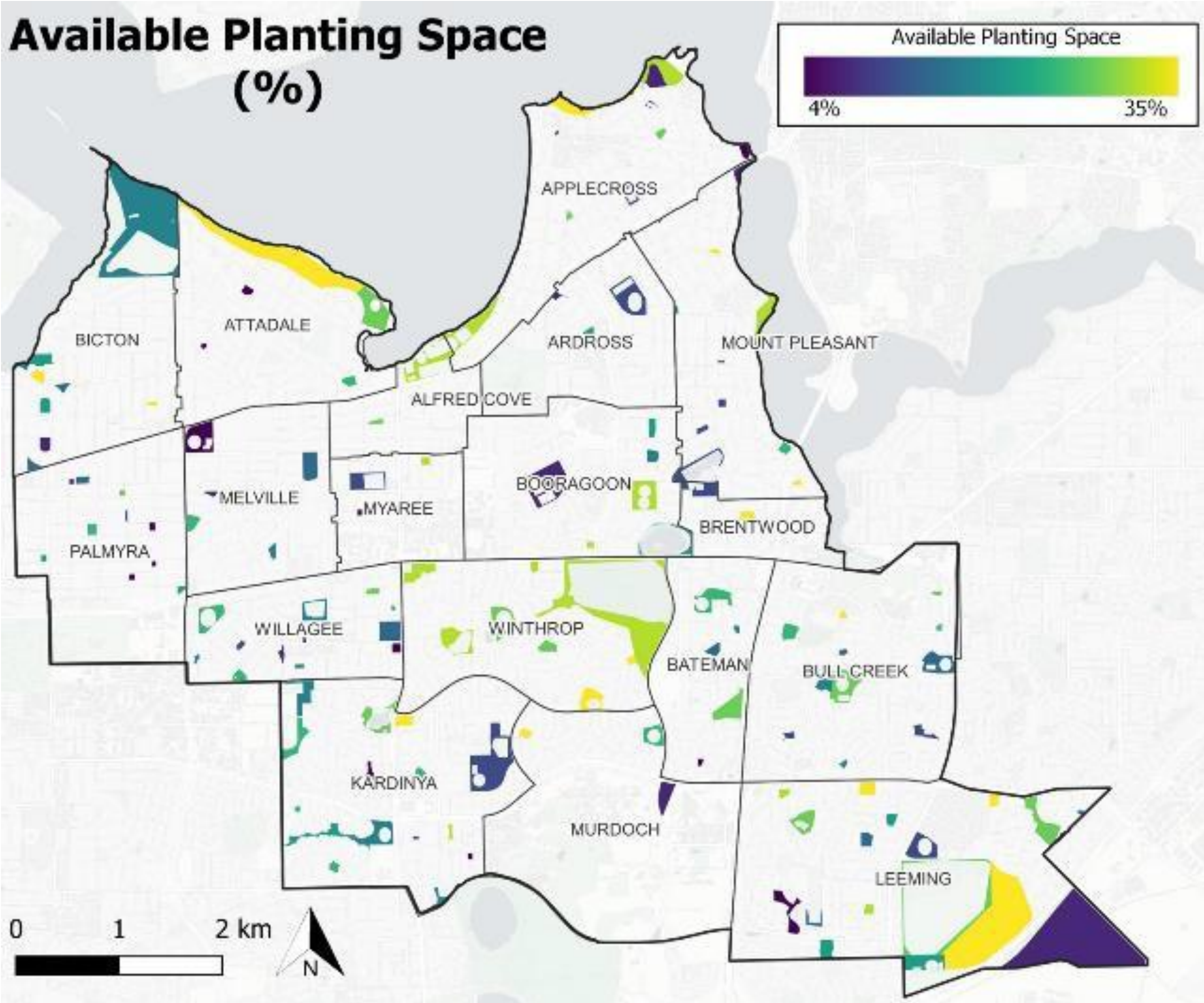
Recreational Areas colourised by the community's access to open space, categorised by suburb.



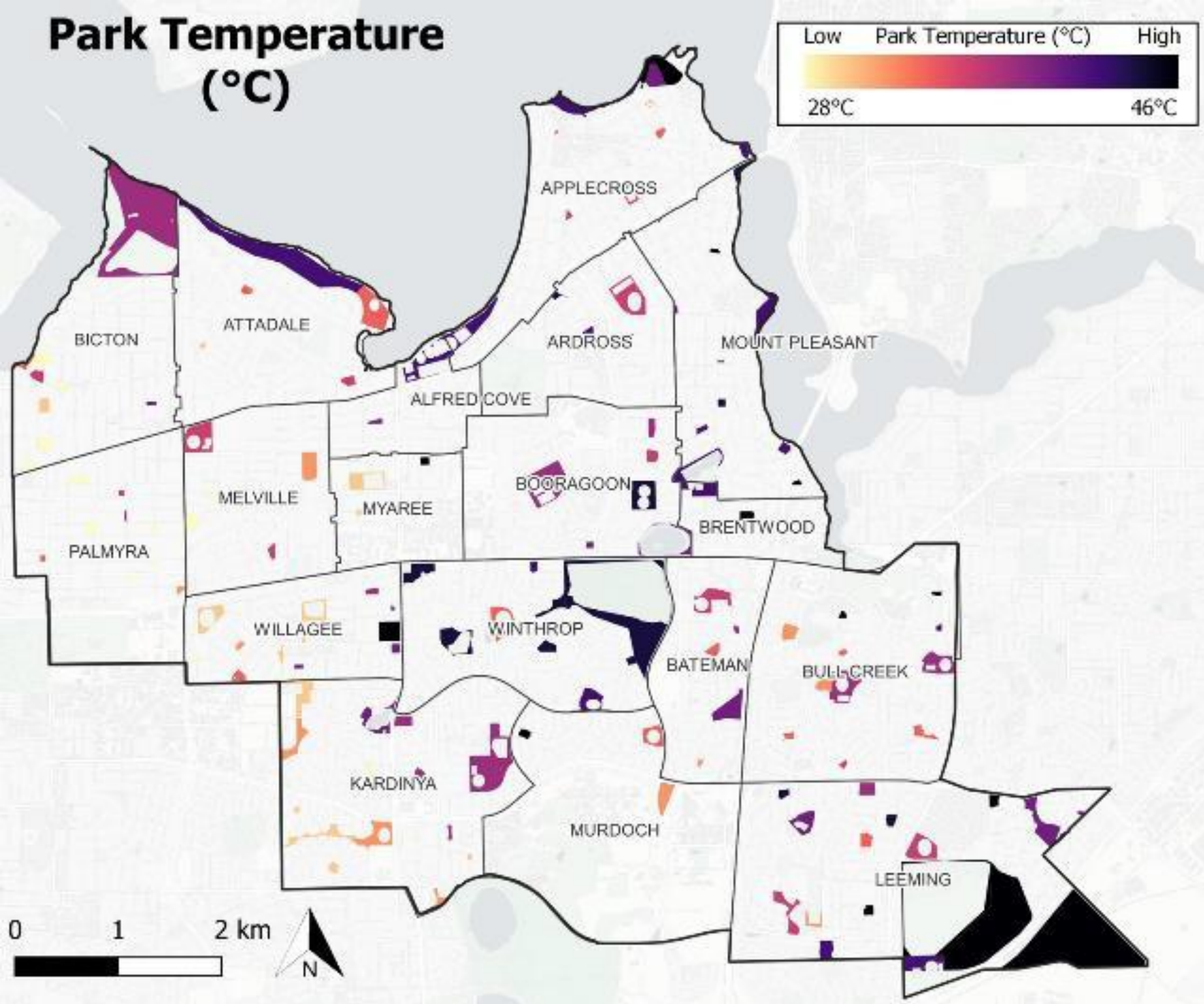
Recreational Areas colourised by the population density of the surrounding area, categorized by suburb.



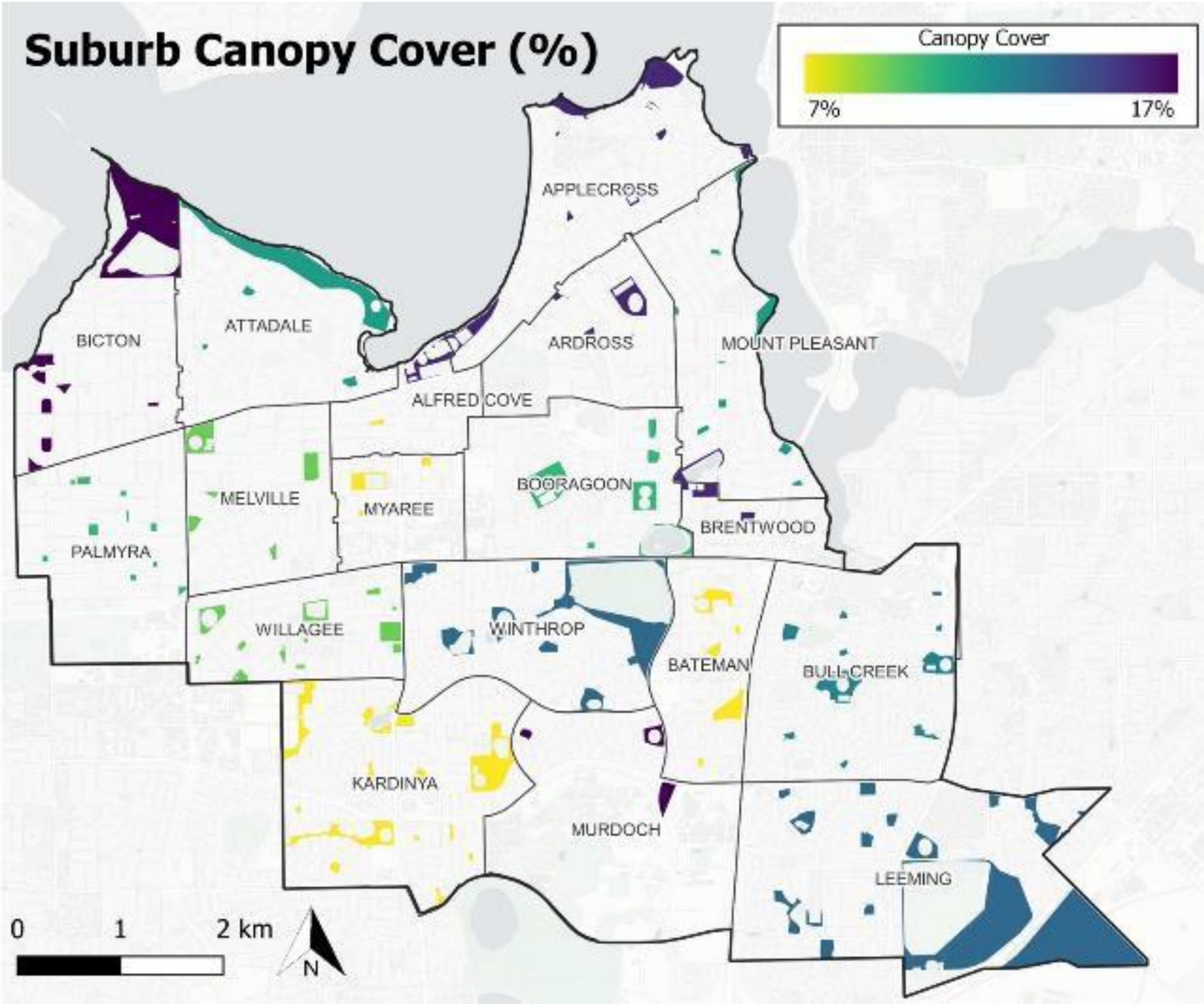
Percentage canopy cover of each Recreational Area.



Proportion of APS in each Recreational Area.



Temperature (LST) of each Recreational Area.



Recreational Areas categorised by the mean canopy cover of each suburb.