City of Kalamunda

Draft Urban Forest Strategy

October 2020

Table of contents

Acknowledgement of Country iv

Message from the Mayor/Executive summary v

1. Vision 1

2. Introduction 2

   2.1 What is an Urban Forest? 3

   2.2 Purpose of the Urban Forest Strategy 3

   2.3 What are the benefits of an Urban Forest? 5

   2.4 The relationship between Urban Forest Canopy Cover and Urban Heat Island Effect 8

3. The City's Urban Forest 11

   3.1 Overview 11

   3.2 Spatial analysis 11

   3.3 Swan Coastal Plain 13

   3.4 Darling Scarp 25

   3.5 Darling Plateau 31

4. How do we increase our urban forest? 35

   4.1 Goals 35

   4.2 Action plan 35

5. References 40

6. Appendix A: 42

   6.1 Urban Forest Canopy data 42

   6.2 Temperature Data 48

7. Appendix B 49

   7.1 Urban Forest Canopy Mapping 49

Table index

Table 1 Median Urban Forest Canopy Cover in Parks on the Swan Coastal Plain 16

Table 2 Number of private dwellings by suburb on the Darling Scarp Area (ABS, 2016) 27

Table 3 Action Plan.....36

Table 4 Summary of urban forest canopy cover in the Swan Coastal Plain Area 2018 42

Table 5 Urban Forest Canopy Cover by broad land use type in the Swan Coastal Plain Area 2018.....42

Table 6 Summary of urban forest canopy cover in the Darling Scarp Area 44

Table 7 Urban Forest Canopy Cover by broad land use type in the Darling Scarp Area.....44

Table 8 Summary of urban forest canopy cover in the Darling Plateau Area.....46

Table 9 Urban Forest Canopy Cover by broad land use type in the Darling Plateau Area.....46

Table 10 Temperature correlation to urban forest canopy cover in the City of Kalamunda.....48

Figure index

Figure 1 Community Values in the City of Kalamunda (City of Kalamunda, Local Environment Strategy2019).....4

Figure 2 City of Kalamunda Strategic Environmental Framework.....5

Figure 3 Summary of benefits of an urban forest (GHD, 2020).....6

Figure 4 Urban Heat Island Effect - Kalamunda Example: Street blocks with low canopy cover are warmer than the surrounding areas.....9

Figure 5 Urban heat island effect, GHD 2020.....10

Figure 6 Landform Areas in the City of Kalamunda (GHD, 2020) 12

Figure 7 Urban Forest Canopy Cover on the Swan Coastal Plain area of the City of Kalamunda (GHD, 2020) 14

Figure 8 Case Study: Urban Forest Canopy retention in Forrestfield.....17

Figure 9 Example: Grouped Dwelling High Wycombe – increasing density (R60) has resulted in decreased urban canopy cover 18

Figure 10 Example: Predicted Urban Canopy Cover Change with Planned Development at Forrestfield North 19

Figure 11 MKSEA aerial imagery comparison.....20

Figure 12 83% of roads in Forrestfield have less than 20% urban forest canopy cover (GHD, 2018) 21

Figure 13 Urban Forest Canopy Cover on the Darling Scarp Area of the City of Kalamunda (GHD, 2020) 26

Figure 14 Canopy cover on road reserves Lesmurdie (DPLH, 2018) 29

Figure 15 Kalamunda Town Centre has lower urban forest canopy cover compared to the rest of the suburb 30

Figure 16 - Urban Forest Canopy Cover on the Darling Plateau Area of the City of Kalamunda (GHD, 2020) 32

Acknowledgement of Country

We respectfully acknowledge the Traditional Owners, The Whadjuk Noongar People as the Custodians of this land. We also pay respect to all Aboriginal community Elders, past and present, who have resided in the area and have been an integral part of the history of this region.

Message from the Mayor

1. Vision

The City of Kalamunda is committed to an environmentally sustainable future. At a time when climate change and urban growth pose challenges to Kalamunda's 'Clean and Green' environment, the City seeks to conserve and grow its urban forest canopy for the wellbeing of all its residents.

Vision for the City's Urban Forest:

"Our diverse forest is valued as an intrinsic feature of our evolving urban landscape that supports a happy, healthy and prosperous community"

– UFS working group

2. Introduction

Prior to European settlement, Kalamunda's hills and sandplains were densely covered in native forest, woodlands and shrubland: a natural ecosystem supporting a variety of plants and animal species and local indigenous people. Natural shade and cooling effects provided by the vegetation have diminished over time as our City has grown and urbanised.

The City faces a major challenge in its future growth – how to ensure residents can live in cool, green and shaded suburbs, surrounded by nature, at a time when urban density is increasing and temperatures due to climate change are rising?

The danger signs are evident, with heat maps created for this project showing heat sinks in denuded residential and industrial zones, especially on the Swan Coastal Plain.

Many Local Government Areas of the Perth metropolitan area have set targets of a minimum 20% canopy cover across their cities to address heat sinks, improve overall community health and enhance landscape character. Yet urban forest canopy in approximately 60% of private land[1] in the City of Kalamunda's Swan Coastal Plain suburbs has been reduced to under 10%; and 78% of private land has less than 20% cover.

With the future pointing to the potential further loss of urban forest canopy in areas earmarked for development, it is important to limit this loss. For example, initial modelling for the Forrestfield North development suggests that the urban forest canopy could reduce from the current 30-40% to as low as 5-10% even with the proposed protection of vegetation in local reserves. This strategy will provide the tools to improve this for future developments in the City of Kalamunda.

On the wooded Darling Scarp and Darling Plateau, many trees remain – in gardens, orchards and national parks. The City and its residents have worked to conserve good tree and shrub canopy in many of its bush reserves and public parks.

In contrast, Kalamunda's greater town centre precinct and industrial areas are under-vegetated, many road verges have too few street trees and residential block infill is leading to mature tree loss on an unprecedented scale.

If we are to create cool, leafy suburbs into the future, we need to assess what urban forest we have today, conserve it where possible, and enhance it into the future. Our Urban Forest Strategy will sensibly address this challenge.

[1] Private land includes urban forest classified as street blocks, on the Swan Coastal Plain. This includes residential and industrial land.

1.1. What is an Urban Forest?

Urban forests can be defined as all vegetation growing within the urban environment, from grasses, shrubs and hedges up to 3 metres, up to tree canopy that grows above 3 metres (Western Australian Planning Commission, 2018).

It includes vegetation growing in parks, bushland reserves, road verges and residential gardens on private property. The grasses, shrubs and tree cover can consist of native and non-native species, with a diversity of species offering increased resilience against various risks such as disease.

By actively maintaining and increasing urban forest cover, the City and its residents can reduce heat, increase community mental and physical health, and contribute to lower electricity bills. An attractive and well-shaded neighbourhood can lead to better property prices, while environmental benefits include habitat for fauna and flora and reduced pollution in urban stormwater.

While tree canopy is not the only important measure of an urban forest, it is considered one of the most important measures for shading, cooling and neighbourhood amenity.

The City of Kalamunda's current urban forest has been assessed based on tree canopy cover (vegetation above 3 metres) measured in 2018 by the CSIRO and the Department of Planning, Lands and Heritage (DPLH).

1.2. Purpose of the Urban Forest Strategy

The purpose of an Urban Forest Strategy is to:

- prevent net loss of tree canopy and other vegetation;
- increase net tree canopy and other vegetation;
- improve species selection, and vegetation health; and
- assist with biodiversity conservation.

In order to achieve this, an Urban Forest Strategy must consider vegetation from a holistic view, considering both public and private land and different land tenures.

Local Government has a varying degree of influence over how different land uses and tenures impact upon urban forest coverage. For example:

- Existing streets and parks can be 'retrofitted' with additional greening
- Greening in streets and parks in new developments can be managed through urban planning controls, in discussion with developers and other regulators
- Greening on private land can be managed by ensuring existing high-value vegetation is protected
- Encouraging further planting and educating residents in the benefits of an urban forest.

The development of this Urban Forest Strategy responds to specific community feedback obtained during the development of the City's *Strategic Community Plan* and *Local Environment Strategy*. Its development was identified as an action in these documents.

Figure 1 outlines the values important to the Kalamunda community as identified through engagement undertaken during development of the Local Environment Strategy. The values identified here highlight the aspirations of the Urban Forest Strategy.

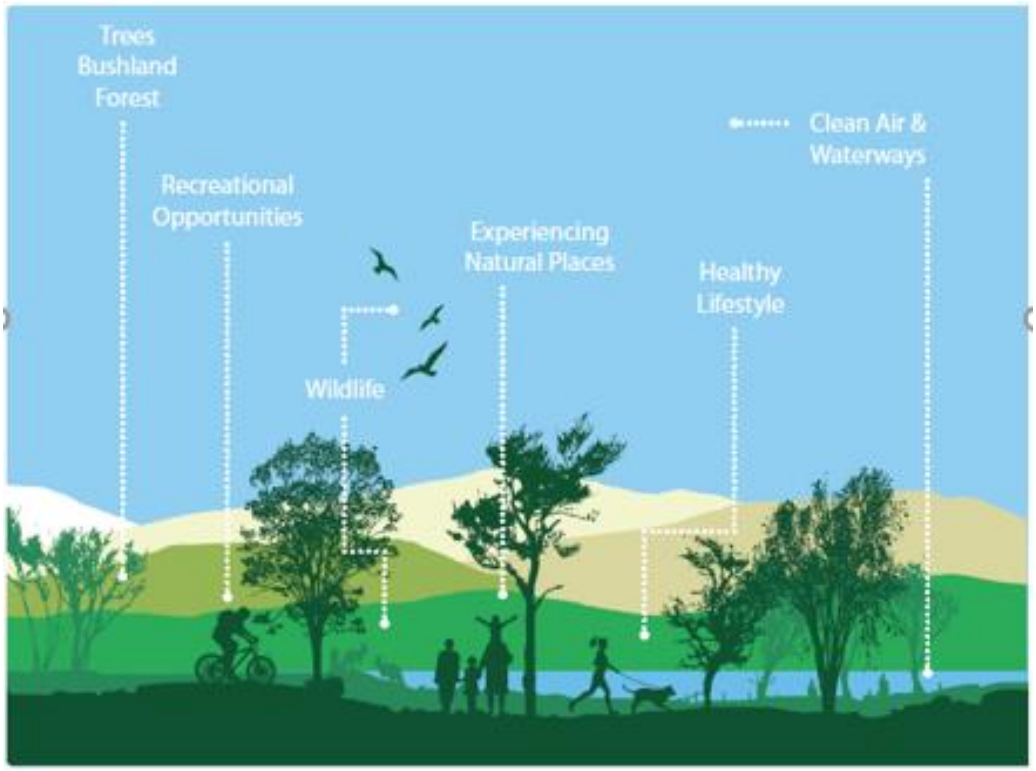


Figure 1 Community Values in the City of Kalamunda (City of Kalamunda, Local Environment Strategy 2019)

Figure 2 illustrates how the Urban Forest Strategy fits within the City's Strategic Environmental Framework and indicates how the range of strategies integrate to achieve common goals.

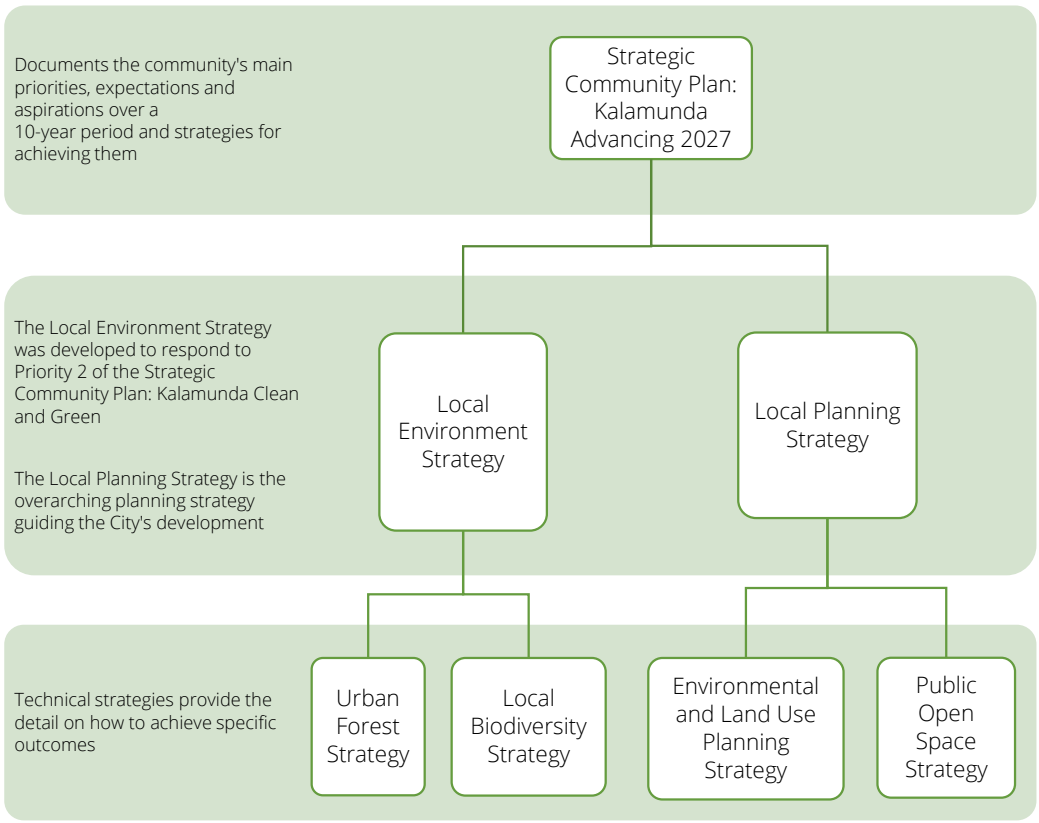


Figure 2 City of Kalamunda Strategic Environmental Framework

1.3. What are the benefits of an Urban Forest?

A significant volume of research, in WA, Australia, and internationally, has demonstrated the economic, environmental, psychological and physical health benefits provided by urban forests. Community members are able to directly notice these benefits in their daily lives, as demonstrated by community values identified in Figure 1.

Figure **3** provides a visual summary of the benefits that are provided by the urban forest. Further information regarding these benefits is provided in the following section.

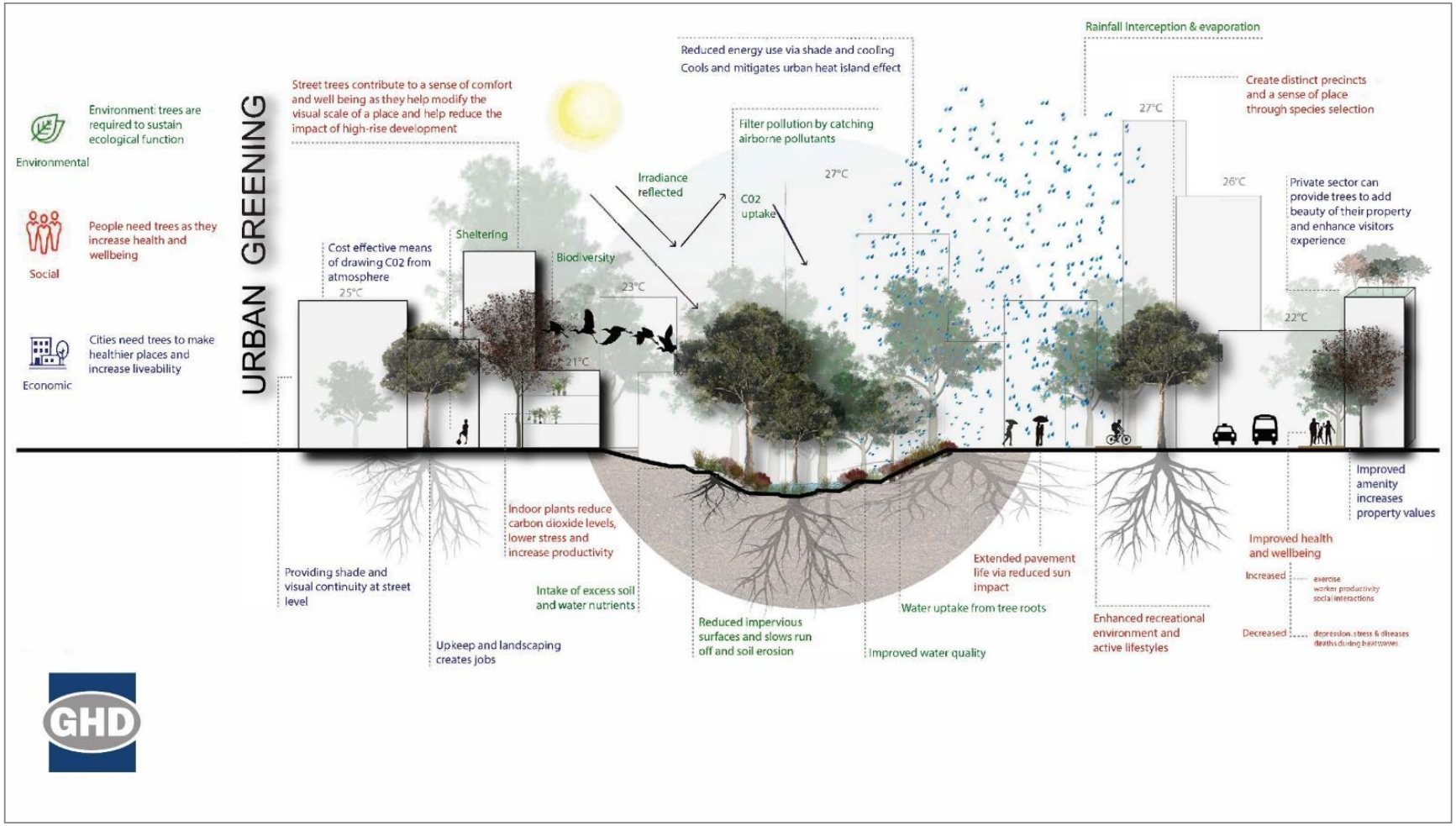


Figure 3 Summary of benefits of an urban forest (GHD, 2020)

Social and community health benefits

Trees and other vegetation in an urban forest combine to produce the following benefits for the local community and the local environment:

- Reduce the urban heat island effect
- Improve community health outcomes by:
  - encouraging exercise and social interaction;
  - positively increasing productivity and learning outcomes; and
  - increasing health outcomes buy positively impacting obesity, diabetes, heart attack, stroke, depression and anxiety (Astell-Burt, Feng, & Kolt, 2014).
- Positively support recreational opportunities through providing a diversity of green spaces (Giles-Corti, et al., 2005). For example, the City has a variety of spaces that support various recreational activities, such as:
  - highly modified parks that support sports and social gathering;
  - natural reserves that are actively managed by community members;
  - parks that include walking and running tracks with shaded areas; and
  - community gardens.
- Trees naturally filter air, and so planting vegetative barriers along transport corridors can be beneficial for removing diesel particulate matter and decrease residents' exposure (Pugh, MacKenzie, Whyatt, & Hewitt, 2012).
- Trees attenuate road traffic noise, with research showing that even a few rows of trees can have a significant positive effect on noise pollution (Peng, Bullen, & Kean, 2014).
- Simply viewing vegetation has a positive impact on human health, with research showing that surgery patients recover faster in hospital rooms that have a view of greenery (Franklin, 2012).

Economic benefits

- Increasing street tree canopy, and private garden canopy, such that it provides shading to houses can materially decrease the amount of air conditioning that is required, thereby reducing electricity bills (CoM, DELWP, 2017)
- Increasing tree cover and open space increases the desirability of neighbourhoods, supporting property values. Research suggests a positive economic benefit of $16,889[2] for a house where a broad leaf street tree is present on the verge (Pandit, Polyakov, Tapsuwan, & Moran, 2013).

[2] median property price in Perth

Environmental and biodiversity benefits

- Trees absorb carbon dioxide, reducing greenhouse gases (Independent Expert Panel, 2019).
- A healthy and diverse urban forest can support the persistence of threatened species, for example, by providing foraging habitat for the several endangered Black Cockatoo species. Research in Perth has shown that Cockatoo species forage from native and introduced plants and trees in an urban environment, however, they are more likely to recognise native species as food (Birdlife Australia, n.d.).
- The urban forest provides habitat for a wide range of insects and spiders (Majer, 1996).
- The urban forest creates linkages between areas of native vegetation and supports species movement through an urban landscape (supporting trees, bushland, forests and wildlife).
- Urban vegetation can slow and divert stormwater, which reduces erosion and removes sediments and pollutants from water (Berland, et al., 2017).
- Climate change adaptation - Trees can provide shade, wind protection and flood protection that may occur more frequently due to the changing climate (Ennos, 2015).

1.4. The relationship between Urban Forest Canopy Cover and Urban Heat Island Effect

The urban environment is highly modified, with harsher conditions experienced due to the different surface types represented in the urban context and the human activity occurring.

Impervious hard surfaces such as buildings and pavements have high heat absorption capacity. They tend to absorb heat from the sun and release it at night. This is particularly noticeable after a long hot summer day. Vehicles contribute to the heat generated in an urban environment by releasing heat and greenhouse gas emissions. When the weather is hot, air conditioner usage increases adding to the heat injected into our urban areas. Numerous other surfaces represented in our urban environment such as bare soil, natural grass and plastic lawn all impose different effects upon the surrounding environment and its inhabitants.

However, there is one quite simple rule of thumb; areas with high levels of canopy cover will have a lower temperature than those with low levels due to the natural cooling effects of shading and evapotranspiration. Put simply, more urban forest canopy means less heat.

In the City of Kalamunda, this is clearly noticeable when analysing land surface temperatures. In the suburb of Kalamunda, Street Blocks with 0-10% canopy cover (Kalamunda Town Centre) have a mean temperature of over 3^{o}C warmer than the mean temperature of the suburb as a whole, and up to 10^{0}C warmer than nearby areas of the City with over 40% canopy cover.

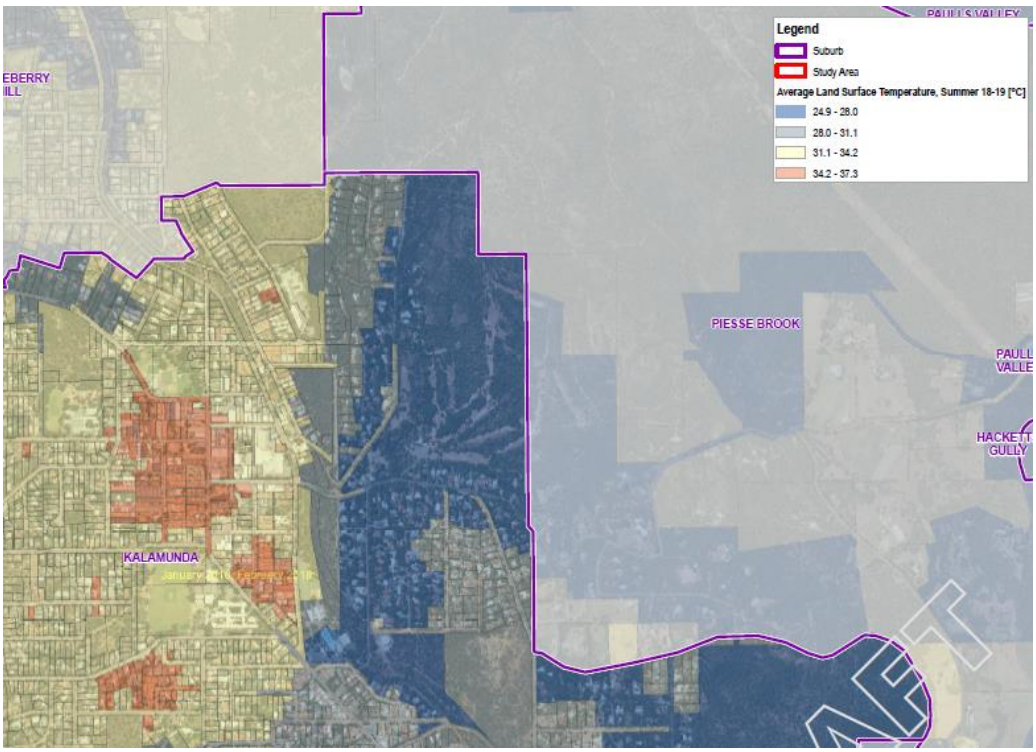


Figure 4 Urban Heat Island Effect - Kalamunda Example: Street blocks with low canopy cover are warmer than the surrounding areas

Figure 4 above and Figure 5 below illustrate how conditions for residents of the City can vary and could be improved in summer by increasing urban canopy cover. The supporting data is provided in Appendix A.

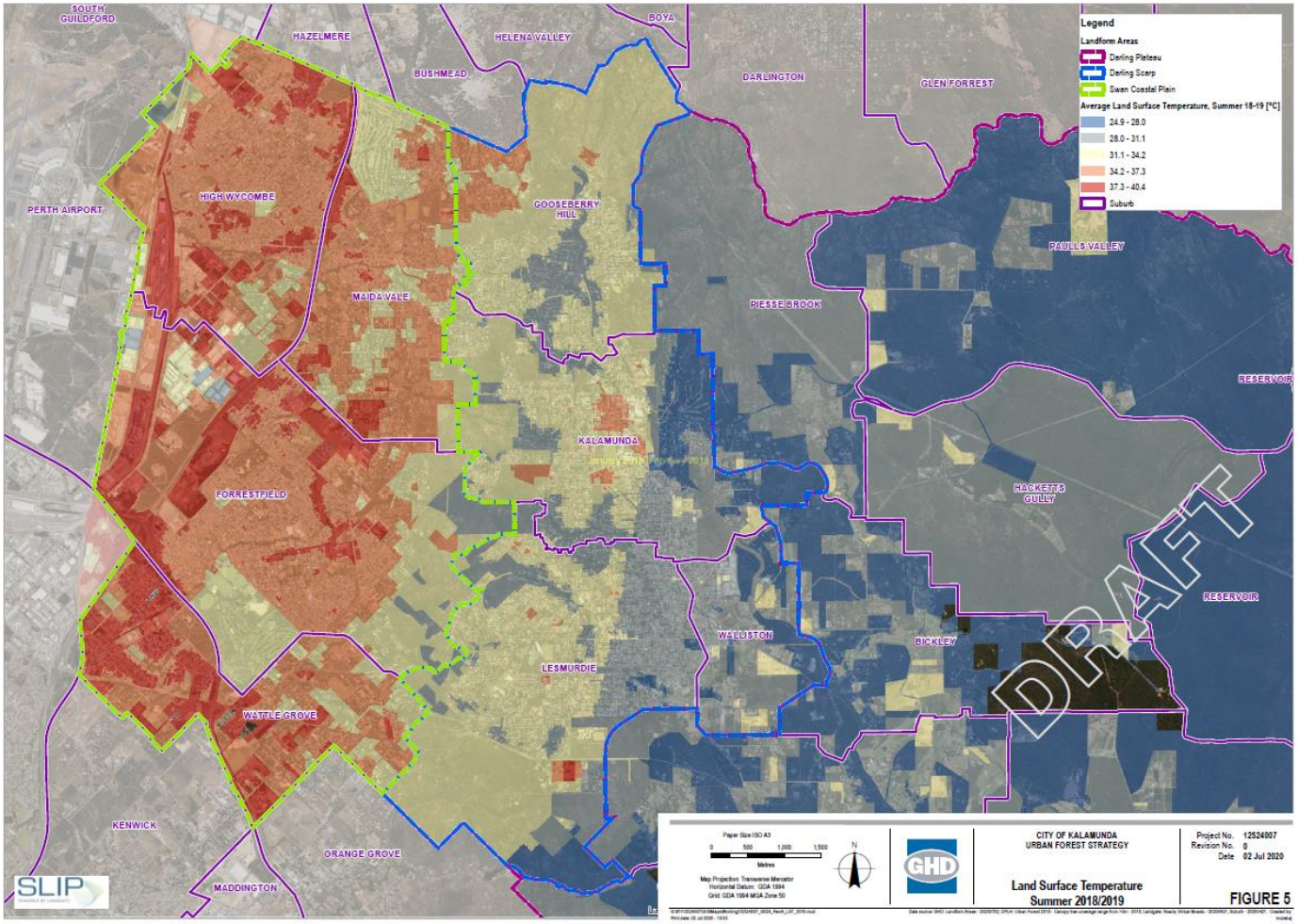


Figure 5 Urban heat island effect, GHD 2020

3. The City's Urban Forest

1.5. Overview

The City of Kalamunda's urban forest canopy (trees greater than 3 metres) includes around 1,522 hectares in streets (5% of the City), 23,145 hectares in parks (71% of the City) as well as 7,224 hectares across the private realm (22% of the City in residential, industrial, commercial and rural blocks). Trees and other vegetation contribute significantly to the character and identity of the local area, creating significant social benefits which are valued by communities, as well as being home to diverse animal species such as Carnaby's Black Cockatoos, Baudin's Black Cockatoos, Forest Red-tailed Black Cockatoos, Quenda, Chuditch and kangaroos. Recent research (City of Kalamunda, 2020) has suggested that there has been a loss of approximately 630 hectares of native vegetation from the City in the period from 2008-2020.

This section outlines the findings from spatial analysis of tree canopy cover over the City of Kalamunda, explores the factors which support or limit tree canopy and the emerging threats to these assets. This assessment has been completed by dividing the City into three distinct areas, which have unique biophysical components and similar development constraints.

1.6. Spatial analysis

The City's urban forest has been mapped, with percentage canopy cover (all vegetation above 3 metres) used as an indicator of the City's overall urban forest. The mapping represents the distribution of trees across parks, roads and street blocks[3], reporting on the total area of canopy cover within a defined geographic location based upon landform.

The City of Kalamunda is comprised of three distinct landform areas – the Swan Coastal Plain, the Darling Scarp and the Darling Plateau. The western area of the City is predominantly suburbs on the Swan Coastal Plain. The central area of the City includes suburbs predominately on the Darling Scarp and the eastern precinct includes suburbs predominantly on the Darling Plateau[4] (**Error! Reference source not found.**).

The three landform areas highlight significant differences in current urban forest canopy cover. The three areas also have distinctive differences in the threats and opportunities imposed upon urban forest canopy and its management.

[3] Lots in private ownership

[4] Actual landform type may differ to grouping listed in this strategy due to the additional suburb and development pressure criteria.

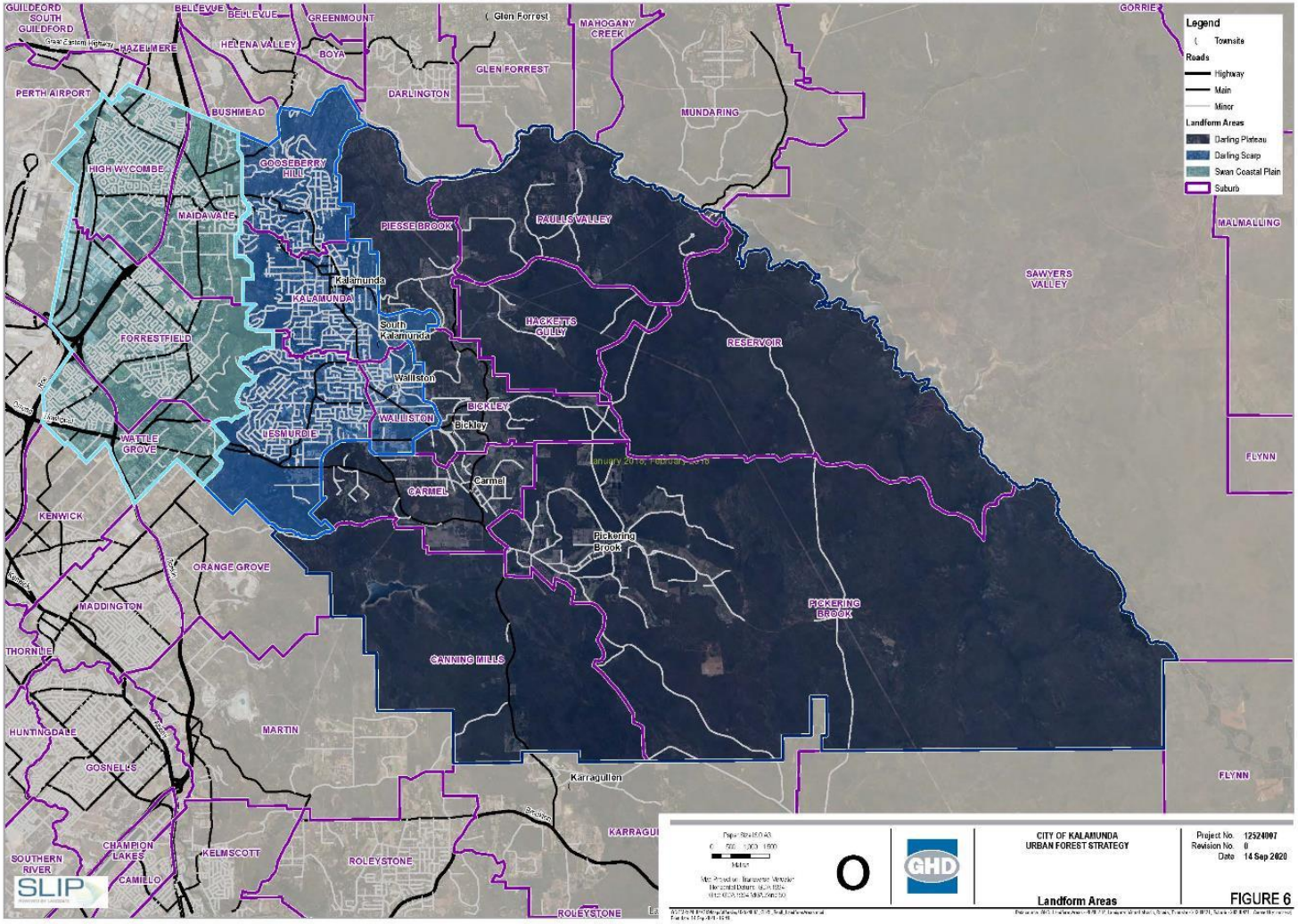


Figure 6 Landform Areas in the City of Kalamunda (GHD, 2020)

1.7. Swan Coastal Plain

The Swan Coastal Plain extends westward from the lower edge of the Darling Scarp, and generally features sandy soils over a relatively flat terrain.

Native vegetation consists of open forests of Eucalypts and Banksia species, and includes some of the most biodiverse native plant expanses often found only on the Swan Coastal Plain.

This area of the City features Banksia Woodlands, ancient stands of woodlands unique to Western Australia. Perth is often described as the only capital city in Australia to be surrounded by Banksia Woodland.

The removal of Banksia Woodland for urban expansion has resulted in its listing as a Threatened Ecological Community under the Federal *Environment Protection and Biodiversity Conservation Act 1999* and State *Biodiversity Conservation Act 2016*.

Suburbs on the Swan Coastal Plain include: High Wycombe, Maida Vale, Forrestfield and Wattle Grove[5].

Canopy cover across the suburbs of the Swan Coastal Plain is summarised in **Error! Reference source not found.** and is measured in categories ranging from 0-5% to over 40%.

The median canopy cover varies across the four suburbs. The suburbs most deficient in urban forest canopy cover are High Wycombe (5-10%) and Forrestfield (10-15%) compared to Wattle Grove (15-20%) and Maida Vale (20-25%).

A major reason for the large areas of low canopy cover – indicated by the red areas in **Error! Reference source not found.** below - lies in the fact that 84% of the population growth experienced in the City since 2001 has occurred in the four suburbs of the Swan Coastal Plain.

[5] Small areas of Kewdale and Perth Airport are also included, however, are not discussed in detail due to the small area and limited influence of the City. Relevant actions will still apply as appropriate.

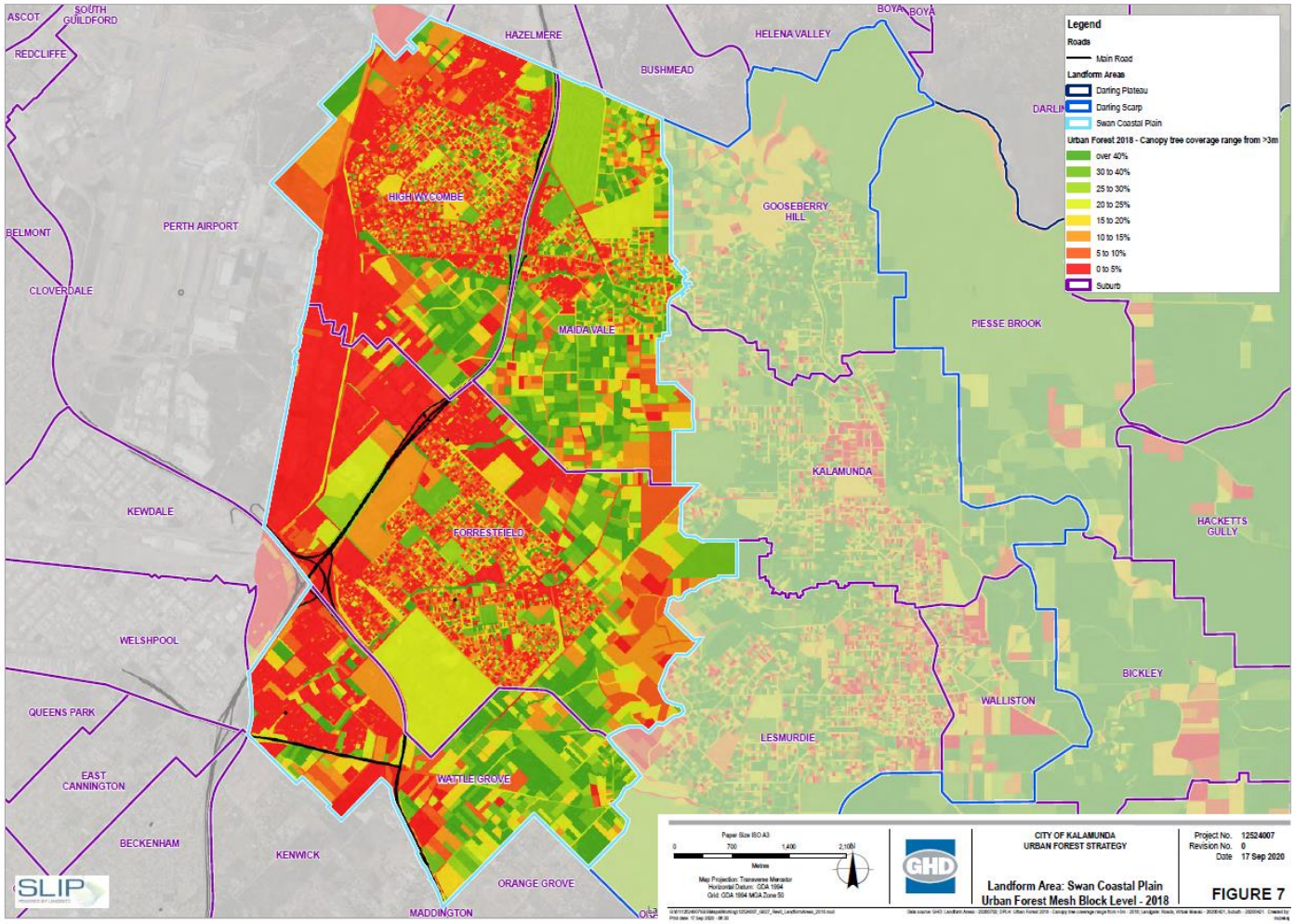


Figure 7 Urban Forest Canopy Cover on the Swan Coastal Plain area of the City of Kalamunda (GHD, 2020)

Reasons for differences in the urban forest canopy cover across the Swan Coastal Plain Area

The suburbs of the Swan Coastal Plain area have been the focus for urban development within the City over the past ten to twenty years, leading to increased residential densities, residential infill and industrial development. These changes have impacted the urban forest, with decreases in urban canopy experienced.

84% of the population growth experienced in the City since 2001 has occurred in the four suburbs of the Swan Coastal Plain.

Urban development has often failed to retain urban forest or make provision for a single tree

The differences in tree canopy cover across the suburbs are reflective of population and residential densities. High Wycombe and Forrestfield are the two most populous suburbs of the City with the highest residential densities. Wattle Grove still has a significant area of rural zoned land, which allows for the retention of trees and increases the average canopy across the suburb. Canopy cover is, however, low in residential areas. Maida Vale is largely residential, however, zonings such as residential bushland, which feature low density R-codes, has allowed for higher level retention of trees within the urban forest.

Older, more established residential areas generally have higher tree canopy cover, indicating:

- it takes time for trees and other vegetation to grow and replenish;
- a reduction in lot sizes and increasing house size over time has led to an increase in building footprints and paved outdoor residential space, and less garden and trees; and
- other planning and engineering requirements such as changes in R-codes and the necessity to fill blocks with soil to satisfy drainage requirements have also exacerbated the removal of trees and decreased the ability to replace those removed.

There has generally been relatively high retention of urban forest canopy in City-managed parks across the Swan Coastal Plain area, with the median canopy coverage in parks across the Swan Coastal Plain being at least 10-15% (in Wattle Grove) and higher in all other suburbs (**Table 1**).

Table 1 Median Urban Forest Canopy Cover in Parks on the Swan Coastal Plain

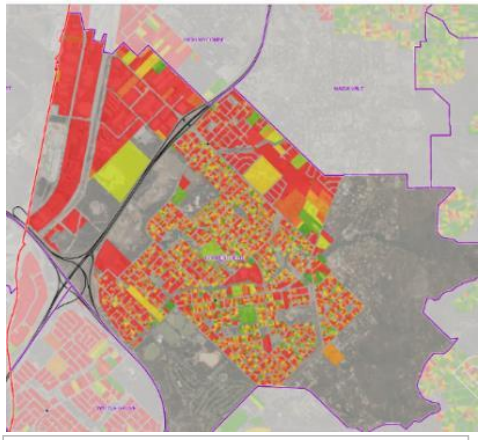
Suburb	Median Canopy Cover in Parks
Forrestfield	20-25%
High Wycombe	20-25%
Maida Vale	25-30%
Wattle Grove	10-15%

The mapping indicates that the City has been more successful in retaining tree canopy within public open space as new residential areas are developed, but not within residential lots and road reserves (Figure 8). This highlights the opportunity of conserving vegetation on roads and private land as potential key target areas for this strategy on the Swan Coastal Plain.

Case Study: Forrestfield: Urban Forest Canopy Mapping 2018
Median Canopy Coverage:

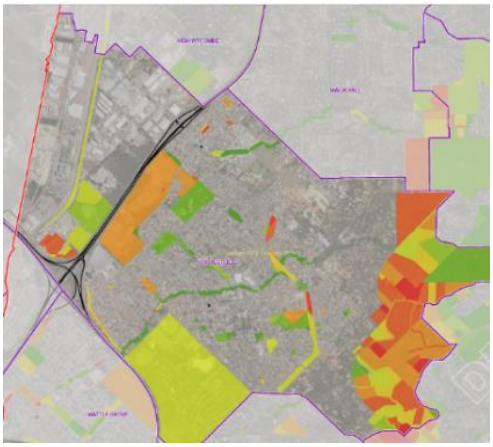
Roads	5-10 % canopy cover
Parks	20-25 % canopy cover
Street Blocks	5-10 % canopy cover

Canopy cover retention has been most successful in Parks and Reserves



Urban Forest Canopy Cover on **residential blocks** - Forrestfield

Urban Forest Canopy Cover on **roads** - Forrestfield



Urban Forest Canopy Cover in **parks** - Forrestfield

Figure 8 Case Study: Urban Forest Canopy retention in Forrestfield

Threats to the urban forest and opportunities for increases on the Swan Coastal Plain

Threats

Urban development - residential

Most of the planned urban expansion within the City is within the Swan Coastal Plain area. We can see from the current urban forest mapping, areas of higher residential development and density are likely to result in a reduction in urban forest. We can also see how this has occurred by comparing aerial photography over time (**Figure 9**).

2009 – 10-15 % canopy cover **2016 – 5-10 % canopy cover**

Figure 9 Example: Grouped Dwelling High Wycombe – increasing density (R60) has resulted in decreased urban canopy cover

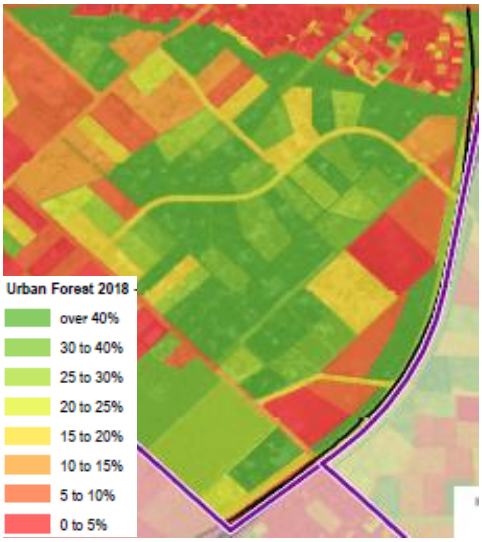
One of the most significant areas zoned for Urban Development but still to be realised is the Forrestfield North Development. The Forrestfield North Precinct Local Structure Plan (City of Kalamunda 2019 a) for this area was approved by the City in July 2020 and is awaiting determination by the Western Australian Planning Commission. The plan focussed on the opportunities the Forrestfield Airport Link would bring the area with movement towards the delivery of high-density residential housing, a new activity centre and commercial precinct surrounding the new train station.

This structure plan includes multiple conservation and local open space areas together with areas of

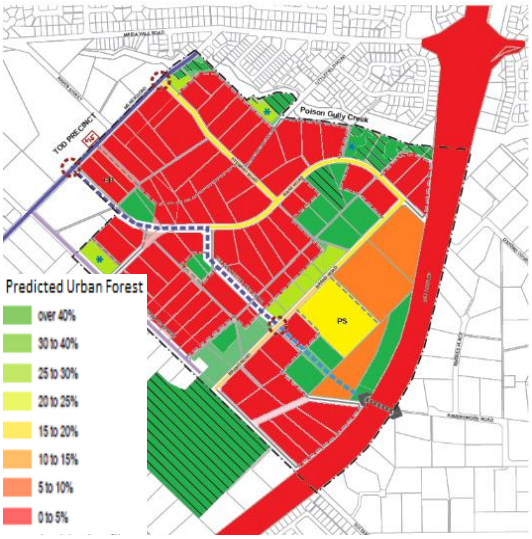
Medium (R40 – R60), Medium/High (R60-R80) and High (R80 to R100) residential density. It is likely that areas of native vegetation and trees will be retained in areas of public open space and conservation reserves (see Strategic Conservation Management Plan) with one objective of the plan to identify and retain significant trees.

However, even with those objectives there is significant risk of loss of the urban forest in the areas planned for residential development. This will impact upon the overall tree canopy cover and result in reduced amenity due to increase heating due to tree canopy loss (Figure 10).

Increasing residential density or changing land use from rural to residential also results in an increased road network which also contributes to the loss of urban forest.



Current Median Urban Forest Canopy Cover: 30-40%



Predicted Median Urban Forest Canopy Cover following realization of the planned development: 5-10% (based on current retention levels and draft structure plan)

Figure 10 Example: Predicted Urban Canopy Cover Change with Planned Development at Forrestfield North

Urban development - industrial

Canopy loss from urban development areas is not limited to residential areas and can also be observed in industrial development areas. Figure 11 shows the loss of vegetation in the western portion of the industrial area on the City's boundary in the Maddington-Kenwick Strategic Employment Area (MKSEA). This loss will likely continue as the area continues to undergo its transition from rural to an industrial precinct.

2017 – 15-20 % canopy cover

2019 – 0-5 % canopy cover (cleared area)

Figure 11 MKSEA aerial imagery comparison

Opportunities

Due to the already relatively high urban canopy cover retention in parks (**Table 1**), three key opportunities are identified for increasing urban forest on the Swan Coastal Plain:

1. Planting on street verges;
2. Working with landowners and developers to retain, and increase trees on private land; and
3. Improving tree retention or replenishment in industrial areas.

Street Verges

Urbanisation results in an increase of roads to service the higher population. On the Swan Coastal Plain area of the City of Kalamunda 16% of land is classified as 'roads' compared to 5% across the entire City.

Figure 12 identifies areas of low to high tree canopy coverage and demonstrates an opportunity to plant trees and increase tree canopy coverage within street and road verges to improve urban forest canopy on the Swan Coastal Plain.

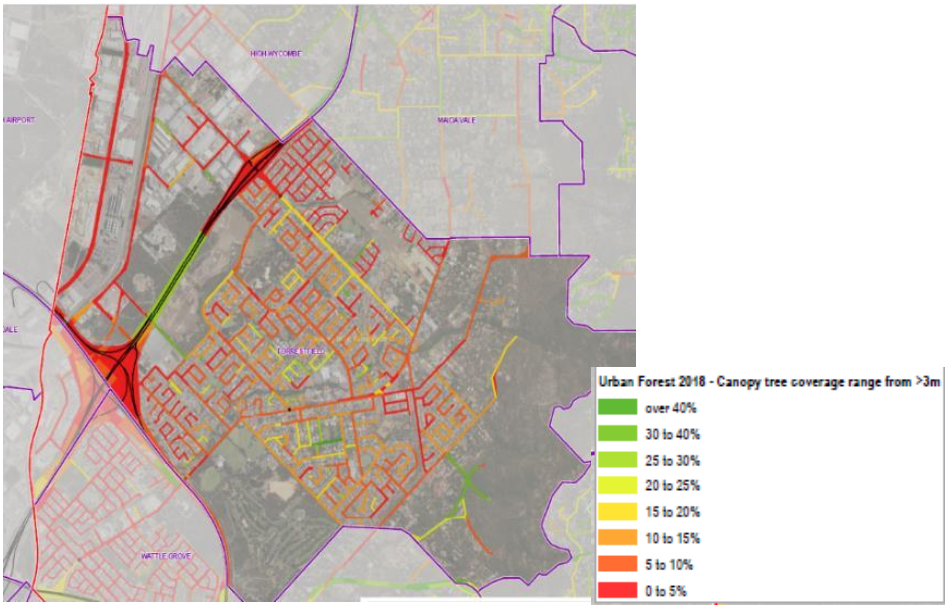


Figure 12 83% of roads in Forrestfield have less than 20% urban forest canopy cover (GHD, 2018)

It illustrates that over half of the land categorised as 'roads' in the Swan Coastal Plain area have less than 10% urban forest canopy cover, and 78% of the roads have less than 20%.

Seventy per cent of roads in Forrestfield, have less than 10% canopy cover, with 83% with having less than 20%.

It is not likely that this entire area can support vegetation, however, planting trees and native shrubs on a majority of street verges could increase amenity and shade, reduce heat effects, create more walkable neighbourhoods and support local biodiversity.

Targeting the City's street tree and shrub verge planting in this area will result in measurable increases in urban forest canopy over the life of the Urban Forest Strategy and improve the look and feel of this area. The City has a high degree of control over, and influence within, road reserves, meaning a higher likelihood of success and a measurable reward for effort.

Targeting tree and shrub verge planting should be combined with educational campaigns in the same areas to further increase the chance of success and community attachment to the planted trees.

For example, the City of Stirling provides letterbox information explaining the benefits of street trees. A similar campaign could be undertaken by the City of Kalamunda when undertaking streetscape improvements in targeted areas. Other initiatives to be considered include tagging trees with messages such as "a gift from the City" or including statistics about the tree, such as removal of pollutants or CO_2 from the atmosphere.

To improve the likelihood of increasing canopy cover in road reserves, the City can develop guides for planting in street verges and underneath power lines. The aim of these guides will be to:

- encourage private planting to supplement the City's street tree planting activities;
- increase diversity of plant species within the urban forest which will improve overall vegetation health by improving resilience against disease; and
- improve vegetation structure (improving habitat value and increasing visual amenity).

Private Land – residential

Approximately 1,701ha of land in the Swan Coastal Plain area is classified street blocks (largely residential and industrial land). The urban forest canopy cover on street blocks is generally low; 62% (or 1,048 hectares) of street blocks have less than 10% urban forest canopy cover, with 78% having less than 20% canopy cover.

The City of Kalamunda has limited control over what happens on private property, but it has the opportunity and willingness to work with residents to raise the profile of the importance of the urban forest. Educational campaigns, the provision of guides for planting in small gardens, courtyards and balconies, or participation in established tree planting programs like 'Verge Splurge'[6] are all ways the City can influence urban forest establishment and retention on private blocks.

There is also the opportunity to adapt existing programs, such as the *Plants for Residents,* to specifically target areas most devoid of urban forest canopy.

The City can also work with developers to improve canopy coverage in areas of new development and is the process of improving policy and statutory controls through the implementation of the *Environmental Land Use Planning Strategy* (ELUPS). This includes:

- retention of significant trees on development sites through the preparation of a Local Planning Policy (ELUPS action 8.2.4);
- investigate the implementation of a Natural Heritage register to register tree or natural areas of significant value (ELUPS 8.2.5);
- investigate opportunities to use the Local Planning Scheme to require rehabilitation of land adversely impacting neighbouring lands and caused by an act of non-compliance with planning approval (ELUPS 8.3.1); and
- investigate opportunities to incentivise protection of privately-owned natural areas (ELUPS 8.3.2).

Other options which will aid in the improvement of urban forest canopy on private properties in which the Urban Forest Strategy can investigate include:

- Investigate the provision of a condition of development for the requirement to plant trees on development sites where no trees are present (ELUPS 8.2.4)
- Investigate the provision for the requirement of tree bonds to prevent damage to retained trees during development (ELUPS 8.2.4)
- Investigate the provision for specifying planting requirements in car parks in industrial areas (Industrial Development Strategy 2018, action 1.1.1).

[6] Verge Splurge refers to a targeted street verge planting program

» Adopt a method in which to determine an empirical value of a tree (e.g. using the Helliwell system[7])

The City's current Local Planning Scheme No.3 requires that native vegetation is not damaged, destroyed or removed unless in accordance with relevant State legislation, acts, regulations and guidelines. The local planning policy for tree and vegetation protection can better define how trees and other vegetation should be retained (and replaced if necessary) and increased, particularly in the residential and urban development zones.

Private land – industrial

As highlighted in Figure 11, industrial development often results in loss of vegetation and urban forest. There are some mechanisms within the planning framework that require landscaping as a condition of development. The Forrestfield/High Wycombe Industrial Area Design Guidelines (Local Planning Policy 27) have been developed to oversee the development of a high standard, attractive, functional and sustainable industrial area. The design guidelines were reviewed and updated in 2019 and should be applied, where reasonable, to industrial development within the area. The design guidelines support streetscape landscaping, tree planting in car parks (one tree per four parking bays) and water sensitive urban design and should be applied to improve urban canopy cover in this industrial area to avoid the adverse impacts of urban canopy cover loss.

Industrial development may require some streetscape landscaping, but is often otherwise devoid of vegetation

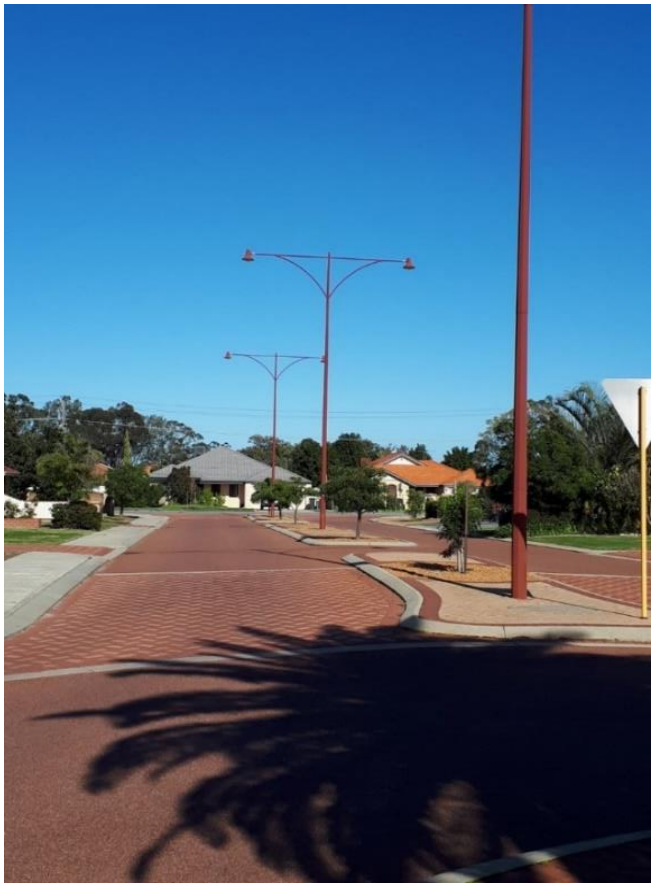
It is important that landscaping is a condition on development approvals, where possible, to systematically improve the level of urban forest in industrial areas and achieve the desired benefits such as shade and improved amenity. Through the implementation of the City's *Industrial Development Strategy* (City of Kalamunda 2018a), the City is developing a Local Planning Policy for all industrial areas to guide design and address modern industrial development standards.

[7] The Helliwell system calculates a tree's financial amenity value using several criteria including its life expectancy, canopy size, rarity and visual impact.

Monitoring and reporting

The City has undertaken street tree planting within the Swan Coastal Plain suburbs in recent years. This planting will be documented and monitored to track long-term viability of the trees. A replacement program will ensure the Urban Forest Canopy is healthy and actively growing. Photo monitoring photo points will be established to maintain a visual record of urban forest growth over time.

The DPLH has committed to publishing updated urban forestry mapping every two years. This mapping data could be obtained to track success of planting efforts and campaigns to improve canopy cover on private property.[8]



Street tree planting needs to be monitored to ensure success and capture the improvements in urban forest canopy levels. This street is mapped as having 0-5% canopy cover which should improve as planted trees mature.

[8] Although updated mapping will be available every two years, results may not be apparent until trees have had adequate time to reach a height of 3 metres or more.

1.8. Darling Scarp

The Darling Scarp area of the City of Kalamunda extends eastward from the eastern edge of the Swan Coastal Plain to the Darling Plateau and consists mainly as a moderately steep to very steep sloping escarpment.

This area is a historically significant part of Perth serving as a green backdrop to the Perth Metropolitan Area and entry point to the natural values of the Perth Hills.

Vegetation on the Darling Scarp face is often dominated by open woodland and shrubland. Kalamunda's wildflower season is a drawcard for city-dwellers, and its natural marri, jarrah and wandoo eucalypt stands are cherished by generations of residents and visitors.

Suburbs of the Darling Scarp for the purpose of this strategy include Lesmurdie, Kalamunda, Gooseberry Hill and Walliston[9]. These suburbs have been grouped according to landform, broad land use and development pressure.

Canopy cover is measured in in categories ranging from 0-5% to over 40%. The median canopy cover across all suburbs of the Darling Scarp is 30 to 40% canopy cover (greater than 3 metres). The over 40% category is the highest canopy coverage category by area in Kalamunda, Gooseberry Hill and Walliston. Canopy cover across the Darling Scarp area is shown in Figure 13.

The urban forest is integrated into development in the Darling Scarp Area

The Darling Scarp is the green backdrop to the Perth Metropolitan Area

[9] Walliston and eastern parts of Kalamunda, Gooseberry Hill and Lesmurdie would normally be associated with the Darling Plateau but has been included in the Darling Scarp Area based upon similar land use to each other.

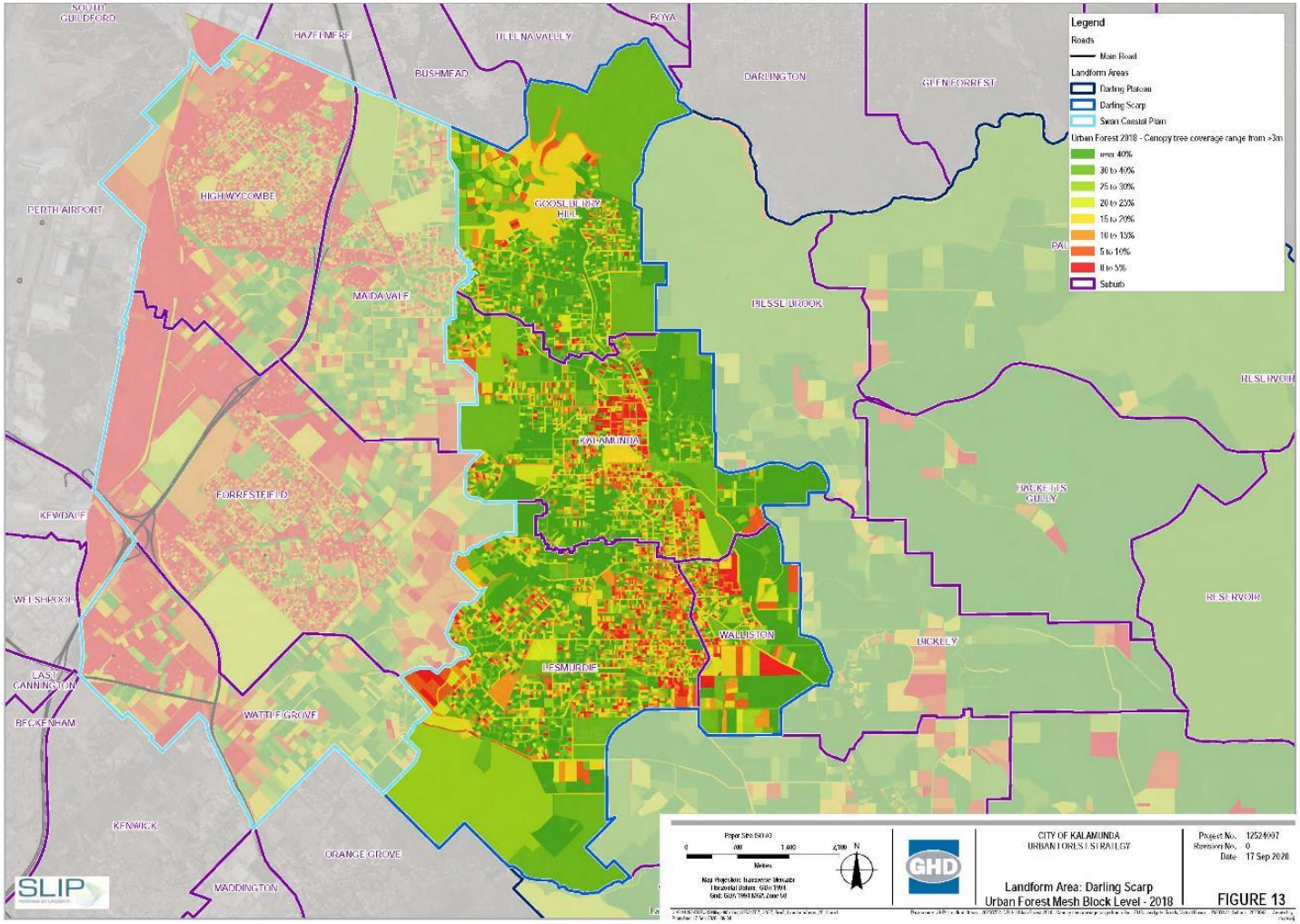


Figure 13 Urban Forest Canopy Cover on the Darling Scarp Area of the City of Kalamunda (GHD, 2020)

Reasons for differences in the urban forest canopy cover across the Darling Scarp Area

This area features large areas of Regional and National Parks together with well-established residential suburbs with generally low-density residential codes (mostly R5 and R10). Walliston also includes an established industrial area.

Lower residential densities are a result of historically more rural land use and geological constraints (which limit building capability and servicing). This is reflected in low increases in residential housing numbers over time (**Table 2**).

Table 2 Number of private dwellings by suburb on the Darling Scarp Area (ABS, 2016)

	Number of private dwellings			
Suburb	**2016**	**2011**	**2006**	**2001**
Kalamunda	3071	2947	2902	2791
Lesmurdie	3069	2958	2918	2885
Gooseberry Hill	1352	1442	1281	1240
Walliston	372	361	291	290

These elements combined have resulted in a high level of urban forest canopy retention across the area. Generally, residents in this area value the aesthetics and benefits a higher level of urban forest canopy provides.

Urban forest canopy cover is generally high across all broad land use categories, however, there are pockets of low canopy cover associated with Kalamunda Town Centre (where there is an urban centre with higher residential densities and servicing levels) and Walliston Industrial area (where we again see the trend of reduced vegetation due to industrial development – all industrial land in Walliston is mapped as having 0-5% canopy cover).

Threats to the urban forest and opportunities for increases in the Darling Scarp Area

Threats

Disease

Pests and diseases are most likely to impact areas with high canopy cover as they are more likely to spread where trees are closer together.

Marri Canker (*Quambalaria coyrecup*) and *Phytophthora cinnamomi* (dieback) are diseases that are known to negatively impact vegetation in the City. Marri canker is known to develop on Marri (*Corymbia calophylla)* and Red-flowering gum *(Corymbia ficifolia)* trees and cause decline in tree health

and ultimately death. Marri is a prominent species within the City and where urban forest is high, canker has the potential to spread quickly. Research suggests canker is often linked to stresses such as disturbance due to urbanisation (such as along roads, in parks, in remnant bushland on farms and on small rural blocks). Lower rainfall and increased temperatures are likely increasing the incidence of canker (Paap T, 2017).

The City participated in a project with the EMRC and Perth NRM in 2013 which mapped canker within Ledger Road Reserve and trialled treatment methods (Natural Resource Management Program, 2014). Unfortunately there is currently no proven treatment, however, the Centre of Excellence for Climate Change, Woodland and Forest Health (CoE) is looking at a number of possible treatments including application of fungicides and nutrients (Western Australia Local Government Association, n.d.)

Dieback causes root rot in susceptible plants reducing or preventing the uptake of water and nutrients leading to plant death. The pathogen can survive in resistant species and is unlikely to disappear irrespective of the absence of susceptible plant species. Dieback is more likely to impact on the City's vegetation within the City's local reserves dramatically altering plant communities and resulting in loss of plant habitats for marsupials, birds, reptiles and insects (Western Australia Local Government Association, n.d.).

In 2019, the City carried out its Dieback Protection Program at Kershaw Reserve (Lesmurdie), Hill Street Reserve (Gooseberry Hill) and Ledger Road/Nimbin Road Reserves (Gooseberry Hill), as well as mapping the incidence of dieback in 12 reserves which had not been interpreted before. The purpose of this program is to boost resilience of native trees to dieback infection and map extent of infection within Local Natural Areas throughout the city. (City of Kalamunda, 2019) These activities are currently part of ongoing operational programs.

Climate change

The impacts of climate change on the City of Kalamunda's urban forest may be serious and multiple. Rainfall patterns have changed significantly over the last 40 years (Climate Commission 2014) with Perth's rainfall reducing and average temperatures are increasing (Bureau of Meterology, 2020), which leads to greater evaporation. This results in less available surface water and lower groundwater recharge which has a negative impact on tree/vegetation health and survival. This resulting stress, especially in summer, leads to increasing plant death, less natural bush and woodland habitat, reduced amenity and increased impacts from urban heat islands. There is significant cost related to replacing the urban forest that dies due to climatic impacts. It currently costs the City approximately $700/tree to install and maintain a street tree through the first summer.

The impacts of climate change may also increase the impact of diseases as plants become more stressed due to heat and water deficiency and more susceptible to diseases.

Opportunities

Road Reserves

There are many roads within the Darling Scarp area that may offer opportunity to improve urban forest

canopy cover. Around 42% of roads (or 193 hectares) have less than 20% urban forest canopy cover (Appendix B). Not all areas can support vegetation, but planting trees on more street verges will increase amenity and shade, reducing heat effects, creating more walkable neighbourhoods as well as enhancing local biodiversity.

Targeting revegetation on road reserves will result in measurable increases in urban forest canopy over the life of the Urban Forest Strategy. The City also has a high degree of control and influence within road reserves, which will help improve likelihood of success and allow for monitoring.

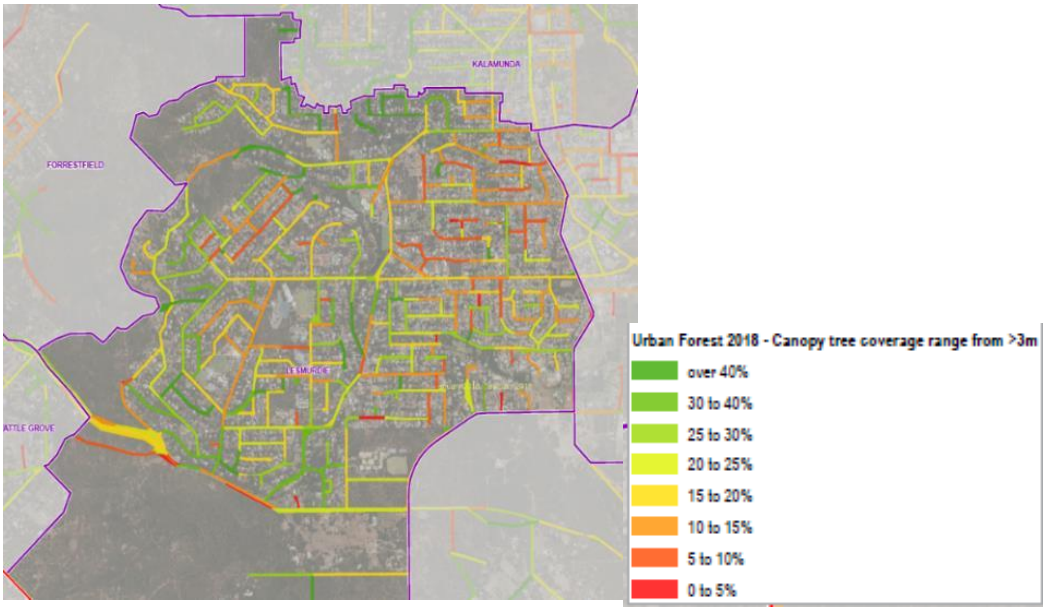


Figure 14 Canopy cover on road reserves Lesmurdie (DPLH, 2018)

Tree species diversification reduces the risk of tree mortality from diseases, fungal infections and pests. Increased species diversity lowers the risk of significant loss in any individual or group of species due to a particular pest or disease. Plants that are chosen now also need to have the resilience to tolerate hotter, drier conditions and potentially more severe storm events. The City is currently undertaking an audit of its street trees to assess attributes such as species composition, age and overall health. This information will be used to develop an ongoing replacement program that increases diversity and improves resilience over time.

Kalamunda Town Centre

Kalamunda Town Centre has significantly less urban forest canopy cover compared to the rest of the suburb. This reflects the commercial nature of the town centre and the effect of "infill" upon urbanisation with higher residential densities in close proximity to the townsite enabled by increased servicing.

Landscaping as part of improved urban design and working with residents to maximise canopy cover and other vegetation where appropriate, represents an opportunity to increase the urban forest in this area. This aligns with the Kalamunda Activity Centre Plan (City of Kalamunda 2019 b) and the associated Landscape Masterplan (City of Kalamunda 2018).

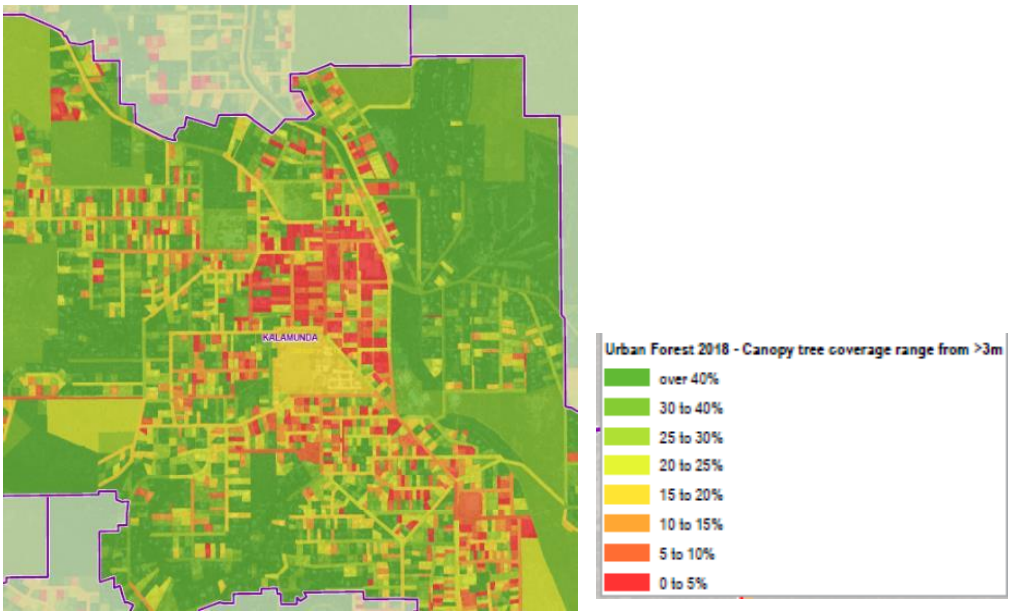


Figure 15 Kalamunda Town Centre has lower urban forest canopy cover compared to the rest of the suburb

Walliston Industrial Area

The Walliston Industrial Area has lower canopy cover compared to the rest of the suburb (generally 0 to 5% canopy cover). Improvements in streetscape and tree planting in parking areas will help improve this. Given the presence of City operations in this area, it represents an area where the City has some control over improving urban canopy cover and could be used to showcase improvements in industrial areas. The preparation of design guidelines could also be considered.

It is also important to ensure that landscaping is required as a condition of development approval, where reasonable (e.g. for screening and shading). Where development conditions are applied, it is also important to ensure compliance and enforce if necessary.

Private land – residential/street verges

While average canopy cover across the Darling Scarp area is higher than on the Swan Coastal Plain, areas with lower coverage exist and efforts are needed to conserve the existing urban forest canopy along streets and around houses. This will be aided by the significant tree register and tree retention policy being investigated in the Environmental Land Use Planning Strategy (City of Kalamunda 2019 b) and explored in action 8.3.2 of this strategy.

Monitoring and reporting

Monitoring canopy coverage on the Darling Scarp area over time is essential to ensure it is maintained. A key tool is urban forestry mapping updated every two years by DPLH. This mapping data should be obtained to compare the progress of urban forest maintenance and increase to the baseline levels of the 2018 data.

Mapping the presence of Marri Canker across the City is also prudent, using techniques such as remote sensing for key areas where canker is present so that management strategies can be developed. Partnerships with research institutions such as Murdoch University and the University of Western Australia can be explored to improve knowledge in this area. The City should continue its activities in mapping dieback, managing impacts of the pathogen and limiting its spread.

1.9. Darling Plateau

The Darling Plateau area of the City is the dominant landform, forming the eastern upland section of the City. Gently undulating slopes are dominated by native Jarrah and Marri forest zoned for conservation and agricultural land uses. Suburbs on the Darling Plateau include: Bickley, Canning Mills, Carmel, Hacketts Gully, Paulls Valley, Pickering Brook, Piesse Brook and Reservoir.

All suburbs in the Darling Plateau area have retained high levels of urban canopy cover, with all suburbs retaining a median 30 to 40% canopy cover or higher.

Reasons for the difference in urban canopy cover on the Darling Plateau

Large areas of the Darling Plateau area are reserved in Regional Parks, National Parks and State Forest, which has helped maintain high levels of canopy cover. Outside of the reserved areas, much of the zoned land is zoned for:

- Rural agricultural use, with the area known for its apple and stone fruit orchards
- Rural conservation/residential bushland, serving as a buffer to the regional and national parks

This has also contributed to a high level of urban canopy cover.

Areas with low canopy cover are associated with clearing for agricultural uses such as growing crops under 3 metres and grazing.

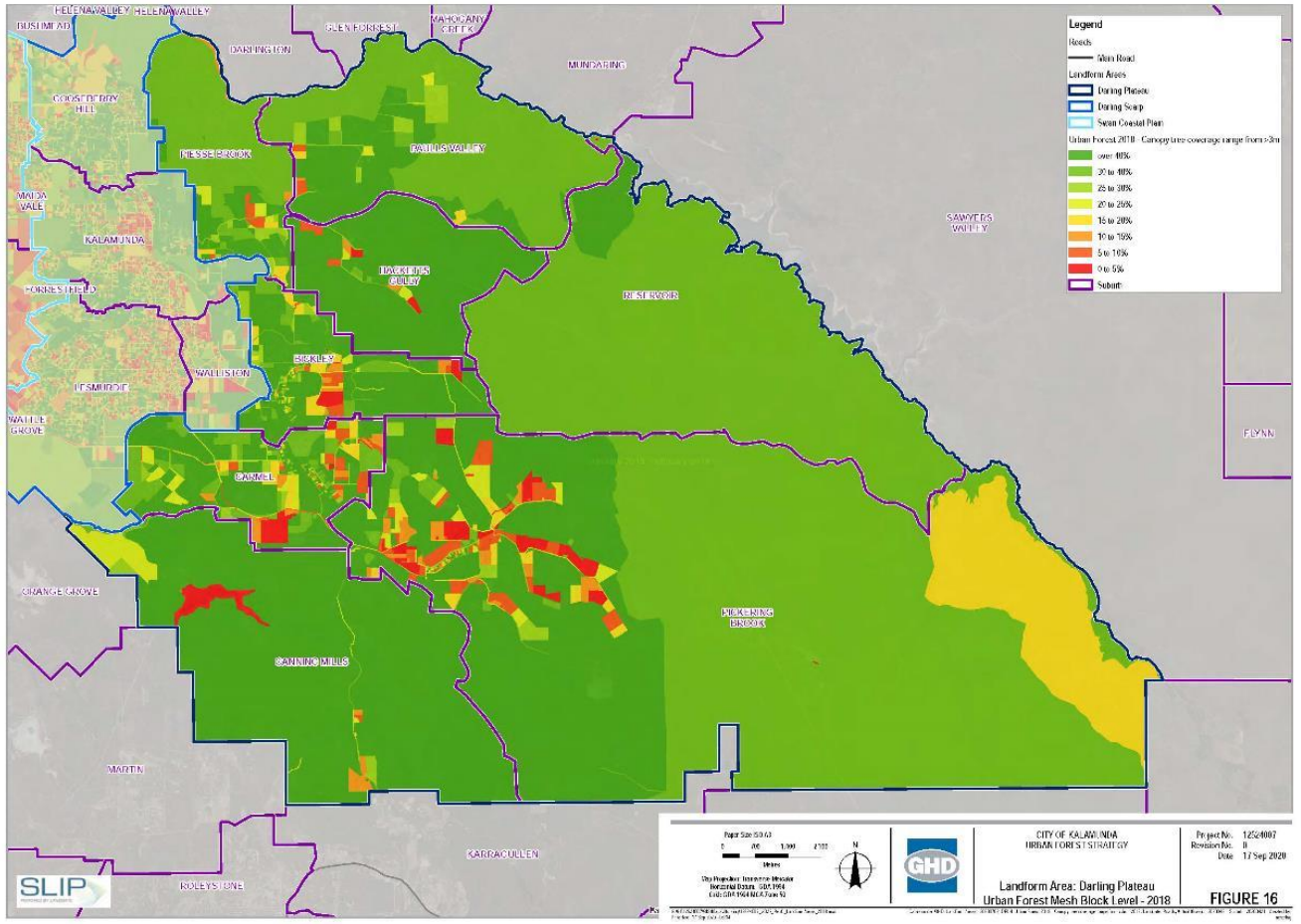


Figure 16 - Urban Forest Canopy Cover on the Darling Plateau Area of the City of Kalamunda (GHD, 2020)

Threats to the urban forest and opportunities for increases in the Darling Plateau area

Threats

Disease and climate change

Pests and diseases are most likely to impact areas with high canopy cover as they tend to spread where trees are closer together, including on the Darling Plateau (as described in section 0)

Marri Canker (*Quambalaria coyrecup*) and Dieback (*Phytophthora cinnamomi)* are diseases known to impact on vegetation in the City and in the National Parks of the Darling Plateau (Natural Resource Management Western Austalia, 2020).

Trees are more vulnerable to disease if they are stressed. The urban forest of the Darling Plateau faces likely stress through reduced rainfall and increased temperatures. This could translate into disease, loss of native vegetation and a reduction in agricultural productivity.

Disease impact (Crown decline) has been visible for decades in the local native species Wandoo (*Eucalyptus wandoo ssp. Wandoo), Jarrah (Eucalyptus marginate), Marri (Corymbia calophylla)* and Floodeed Gun (*Eucalyptus rudis).* Stresses due to climate change factors (increasing temp., decreasing rainfall) can only exacerbate these symptoms.

Clearing for agriculture

Much of this area is zoned for rural use and may lead to removal of urban forest. Given this is the intent of the rural zone, it may be difficult to avoid. It is, however, important that land use changes and new development are properly assessed so that conditions for replacing vegetation can be applied where reasonable to do so. Removal of vegetation for change of land use or development without approval should be actively pursued by the City, regardless of the requirements of the clearing regulations.

Development of a Local Planning Policy can also include requirements on rural land, such as designing development and crossovers around existing trees and fencing vegetation to protect it from livestock.

Opportunities

Much of the native vegetation in this area is managed by the State, however, there may be opportunities for the City to advocate for activities such as disease and vegetation health mapping which will help improve the likelihood that vegetation can be protected.

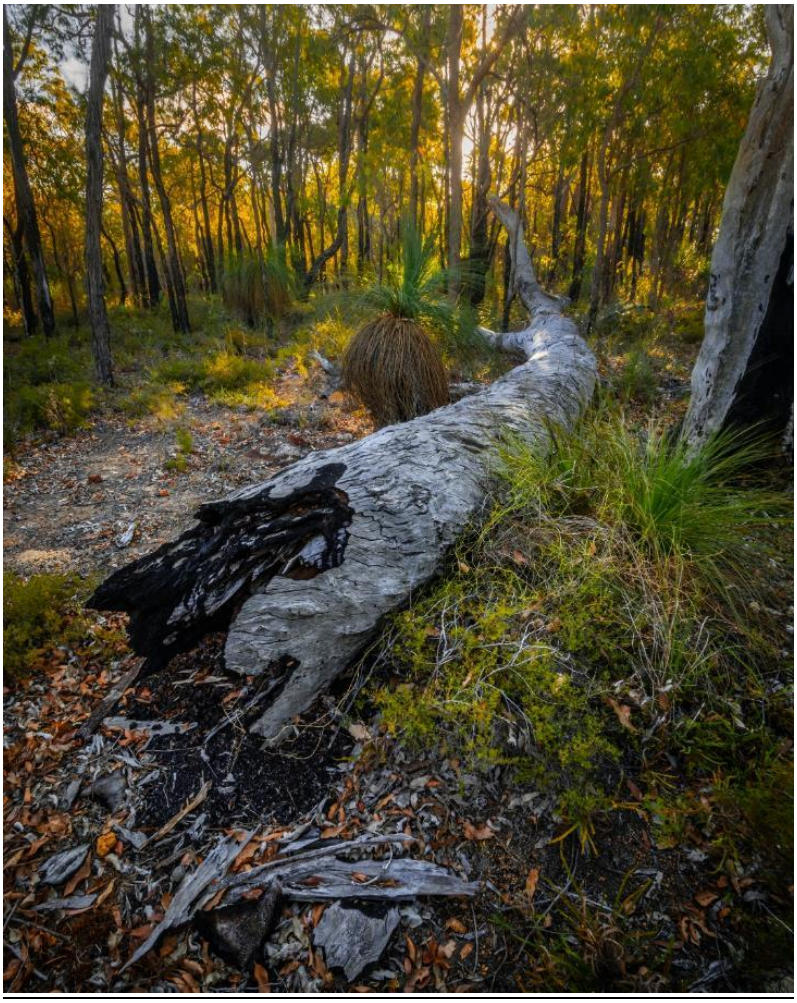
Planning controls

A Local Planning Policy which defines when vegetation is significant and requirements for replacement where trees and vegetation are removed can also be applied to agricultural land and may investigated in the implementation of the *Environmental Land Use Planning Strategy* discussed in section 8.3.2 of this strategy. This will enable expectations to be more clearly defined and conditioned as part of development approvals.

Monitoring and reporting

In the Darling Plateau area, it is important to monitor the urban forest canopy coverage over time to ensure that it is maintained. The DPLH has committed to publishing updated urban forestry mapping every two years. This mapping data should be obtained to ensure that the urban forest is maintained to the baseline established using the 2018 data.

Mapping the presence of Marri canker across this area is also likely to be of benefit. Use of techniques such as remote sensing could highlight key areas where canker is present so that management strategies can be developed and advocated for implementation by the State (where they apply to Regional and National Parks). Partnerships with research institutions such as Murdoch University and the University of Western Australia can be explored to improve knowledge in this area.



4. How do we increase our urban forest?

1.10. Goals

Swan Coastal Plain Area

- Increase canopy cover to an average of 20% with no net loss based on the 2018 baseline within residential lots and road reserves by 2028.
- Maintain current canopy cover within parks and reserves
- Retain at least 20% canopy cover within areas earmarked for, but yet to undergo, urban development
- Increase canopy cover in industrial areas to an average of 5 to 10% based on 2018 baseline by 2028

Darling Scarp Area

- Maintain overall canopy coverage with no net loss based on the 2018 baseline
- Increase canopy coverage in areas with less than 20% canopy cover (including the Kalamunda Town)
- Increase canopy cover in industrial areas to an average of 5 to 10% based on 2018 baseline by 2028

Darling Plateau Area

- Maintain overall canopy coverage with no net loss based on the 2018 baseline

1.11. Action plan

To achieve the goals to maintain and increase the City's urban forest canopy cover an action plan has been developed. High priority actions should be implemented within two years, medium priority within five years and low priority actions within 10 years.

Table 3 Action Plan

Strategy	Action	Landform Area	Priority
1. Increase planting on road reserves/ street verges	1.1 Seek Council endorsement of the Street Tree Masterplan (to be developed as part of *Environmental Land Use Planning Strategy*) to target planting in specific areas including non-discretionary street tree planting in road reserves with under 10% canopy cover and which show high urban heat island effects and poor visual amenity.	Swan Coastal Plain	High
		Darling Scarp	Medium
		Darling Plateau	Opportunistic
	1.2 Monitor street tree plantings where tree height is less than 3m and replace unsuccessful plantings.	Swan Coastal Plain	High
		Darling Scarp	High
		Darling Plateau	High
	1.3 Review and modify the *Plants for Residents* program to target more vulnerable areas (low levels of canopy cover) and increase verge planting.	Swan Coastal Plain	High
		Darling Scarp	High
	1.4 Develop a guide for planting on verges.	All	Medium
	1.5 Develop a guide for planting under powerlines.		Medium
	1.6 Consider expansion of the Friends Groups program to include streets in an 'Adopt a Street' style initiative to increase planting at a street scale.		Medium
	1.7 Identify areas where street trees have not yet been planted in accordance with an approved structure plan or development application, and ensure compliance.	Swan Coastal Plain	Medium
2. Increase species diversity within the City's streetscapes	2.1 Using information from the street tree audit to develop a program for replacing trees to improve diversity.	All	High

3. Increase planting within City managed parks and reserves with low levels of canopy cover	3.1 Target tree planting/revegetation within reserves with less than 20% canopy cover (unless natural vegetation is less than 3m).	All	High
	3.2 Consider additional community gardens.		Medium
	3.3 Explore potential external funding sources to increase planting within parks and reserves.		Ongoing
4. Maintain existing canopy cover within parks and reserves/road reserves	4.1 Continue the street tree planting program.	All	High
	4.2 Develop and implement the Street Tree Masterplan.		
	4.3 Continue commemorative tree program.		
	4.4 Continue to conduct regeneration, revegetation, weed control, disease and pest management activities in natural areas.		
	4.5 Continue to support Friends Groups to undertake works within local reserves.		
	4.6 Monitor vegetation health within parks and reserves, promptly replace unhealthy trees and vegetation at the end of life.		
	4.7 Monitor street trees, replace at end of life.		
	4.8 Undertake a review of all City-managed reserves (including reserve purpose) to identify opportunities to revegetate underutilised spaces, including increasing urban canopy through planting (combine with implementation of *the Local Biodiversity Strategy* and *Public Open Space Strategy*).	All	Medium
5. Increase planting on private property	5.1 Review and modify the *Plants for Residents* program to target more vulnerable areas (low levels of canopy cover) and increase planting in gardens, courtyards and balconies.	Swan Coastal Plain	High
		Darling Scarp	Medium
		Darling Plateau	Low
	5.2 Develop a guide for planting in small gardens, courtyards and balconies.	Swan Coastal Plain	High

		Darling Scarp	Medium
	5.3 Expand the community education programs to include urban forest.	All	High
	5.4 Explore potential partnerships to implement education programs.	All	High
6. Maintain trees and other vegetation on private property	6.1 Through the implementation of the *Environmental Land Use Planning Strategy* investigate the implementation of a local planning policy to address clearing of significant trees on private property.	All	High
	6.2 Through the implementation of the *Environmental Land Use Planning Strategy* incorporate a provision in the Scheme allowing the City to require rehabilitation of land where an owner or occupier has caused or allowed land to be cleared, managed or degraded in such a way as to cause environmental harm or to adversely affect the amenity of adjoining or nearby land.	Darling Scarp Darling Plateau	High
7. Maintain urban forest within areas earmarked for urban development	7.1 Through the implementation of the *Environmental Land Use Planning Strategy*, develop a local planning policy to support the retention of urban forest on newly created lots as part of structure planning, subdivision and development and require tree bonds to protect retained trees from damage during development. Where it is not possible to retain urban forest require replacement planting or contribution to Council (as specified in the local planning policy).	Swan Coastal Plain	High
	7.2 Require retention of urban forest within newly created local parks and road reserves during structure planning (whilst ensuring other POS needs are met).		High
8. Increase urban forest canopy in industrial areas	8.1 Monitor and review the Forrestfield/High Wycombe Industrial Area Design Guidelines	Swan Coastal Plain	High
	8.2 Through implementation of the *City of Kalamunda Industrial Development Strategy 2018*, develop a Local Planning Policy for all industrial areas to guide design and address modern industrial development standards and apply to Walliston Industrial area.	Darling Scarp	High

	8.3 Seek Council endorsement of the Street Tree Masterplan to target planting in specific areas including industrial areas which show high urban heat island effects, low canopy cover and poor visual amenity.	Swan Coastal Plain	Medium
	8.4 Implement the *Kalamunda Activity Centre Plan* which requires landscaping for all developments within the centre plan area and replacement/offset of trees worthy of retention as per the R-Codes.	Darling Scarp	Medium
9. Increase urban canopy cover in the Kalamunda Town Centre and surrounds	9.1 Monitor the implementation of action plan.	Darling Scarp	High
	9.2 Implement the Landscape Masterplan included in the *Kalamunda Activity Centre Plan*.		
10. Monitoring and reporting	10.1 In partnership with research institutions, undertake remote sensing to determine vegetation health across the City.	All	Ongoing
	10.2 Create a database to track the number of trees and vegetation planted and removed by the City on an annual basis.	All	Ongoing
	10.3 Monitor the success of the strategy in maintaining and improving urban forest cover in the City.	All	High
	10.4 Review and update the urban forest strategy mapping every 2 years (or as new data is released).	All	High
	10.5 Advocate the importance of an urban forest and promote the benefits it provides.	All	Ongoing
11.0 General	11.1 Create a dedicated urban forest team within the City.	All	Ongoing

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6. Appendix A:

1.12. Urban Forest Canopy data

Swan Coastal Plain Area

Table 4 Summary of urban forest canopy cover in the Swan Coastal Plain Area 2018

Canopy Coverage	Forrestfield (% area)	High Wycombe (% area)	Maida Vale (% area)	Wattle Grove (% area)
0 to 5%	30	37	7	25
5 to 10%	15	19	11	9
10 to 15%	14	13	11	11
15 to 20%	6	8	8	10
20 to 25%	16	5	13	9
25 to 30%	5	4	16	8
30 to 40 %	8	6	16	11
over 40%	5	9	16	17
Median coverage	10 to 15%	5 to 10%	20 to 25 %	15 to 20 %

Table 5 Urban Forest Canopy Cover by broad land use type in the Swan Coastal Plain Area 2018

	Forrestfield (ha)	High Wycombe (ha)	Maida Vale (ha)	Wattle Grove (ha)
Other Infrastructure	61.7	135.1	14.1	4.7
0 to 5%	45.5	48.0	0.0	1.2
5 to 10%	0.6	33.7	0.2	0.1
10 to 15%	10.3	32.5	13.6	2.1
15 to 20%	3.1	4.3	0.0	0.0
20 to 25%	1.5	0.5	0.0	0.2
25 to 30%	0.0	0.1	0.0	0.0
30 to 40%	0.2	0.0	0.3	1.0
over 40%	0.5	16.1	0.0	0.1
Parks	547.4	77.2	185.1	81.5
0 to 5%	14.4	5.3	5.3	15.8
5 to 10%	90.9	0.3	24.4	3.4
10 to 15%	119.4	3.3	3.3	32.4
15 to 20%	34.1	13.2	7.4	10.4
20 to 25%	184.2	10.1	37.5	3.7
25 to 30%	26.3	15.4	78.5	3.1
30 to 40%	59.4	14.2	10.3	3.7
over 40%	18.5	15.5	18.4	9.1
Roads	256.5	185.3	107.8	136.2

City of Kalamunda Urban Forest Strategy,

	Forrestfield (ha)	High Wycombe (ha)	Maida Vale (ha)	Wattle Grove (ha)
0 to 5%	97.8	71.4	11.1	53.3
5 to 10%	79.4	44.5	15.6	24.6
10 to 15%	36.3	32.9	24.4	7.4
15 to 20%	16.3	13.1	14.0	14.9
20 to 25%	8.3	9.1	17.5	16.4
25 to 30%	11.6	4.7	10.3	6.5
30 to 40%	5.7	6.4	6.2	8.6
over 40%	1.1	3.1	8.7	4.4
Rural	**175.8**	**108.9**	**302.6**	**369.4**
0 to 5%	1.0	7.2	7.0	18.3
5 to 10%	2.0	11.7	30.6	26.0
10 to 15%	14.2	11.2	27.9	30.0
15 to 20%	6.2	11.4	25.6	42.2
20 to 25%	31.3	2.2	33.7	35.7
25 to 30%	19.9	8.6	28.2	53.7
30 to 40%	48.5	15.1	79.9	62.4
over 40%	52.7	41.6	69.7	101.2
Street Block	**695.1**	**507.5**	**231.5**	**205.5**
0 to 5%	370.3	239.0	34.6	107.8
5 to 10%	93.0	103.0	25.7	17.1
10 to 15%	58.7	55.0	26.8	14.4
15 to 20%	52.5	39.0	22.5	10.1
20 to 25%	54.2	23.8	22.6	13.4
25 to 30%	22.8	10.7	20.8	4.4
30 to 40%	27.1	23.7	39.6	15.9
over 40%	16.5	13.4	38.9	22.4
Grand Total	**1736.5**	**1014.0**	**841.2**	**797.2**

Darling Scarp Area

Table 6 Summary of urban forest canopy cover in the Darling Scarp Area

Canopy Coverage	Gooseberry Hill (% area)	Kalamunda (% area)	Lesmurdie (% area)	Walliston (% area)
0 to 5%	1	4	3	8
5 to 10%	2	5	6	8
10 to 15%	4	5	8	6
15 to 20%	14	8	8	13
20 to 25%	6	8	8	6
25 to 30%	6	10	25	9
30 to 40 %	45	24	22	13
over 40%	22	36	23	46
Median coverage	30 to 40 %	30 to 40 %	25 to 30 %	25 to 30 %

Table 7 Urban Forest Canopy Cover by broad land use type in the Darling Scarp Area

	Gooseberry Hill (ha)	Kalamunda (ha)	Lesmurdie (ha)	Walliston (ha)
Other Infrastructure	0.2	0.9	0.0	4.7
0 to 5%	0.0	0.7	0.0	1.0
5 to 10%	0.0	0.0	0.0	0.2
10 to 15%	0.0	0.0	0.0	0.0
15 to 20%	0.0	0.0	0.0	2.4
20 to 25%	0.0	0.1	0.0	0.3
25 to 30%	0.0	0.0	0.0	1.6
30 to 40%	0.2	0.0	0.0	0.0
over 40%	0.0	0.1	0.0	0.1
Parks	396.0	336.0	550.7	100.4
0 to 5%	0.5	0.0	7.7	0.2
5 to 10%	3.9	5.8	14.7	0.0
10 to 15%	7.2	0.0	11.0	0.0
15 to 20%	76.9	6.5	8.1	0.0
20 to 25%	2.7	22.0	21.9	0.4
25 to 30%	2.3	38.3	261.9	5.4
30 to 40%	281.4	135.9	155.2	3.6
over 40%	21.6	127.4	77.8	91.1
Roads	103.1	143.3	163.9	48.7

	Gooseberry Hill (ha)	Kalamunda (ha)	Lesmurdie (ha)	Walliston (ha)
0 to 5%	0.1	0.9	2.8	1.3
5 to 10%	1.0	6.5	14.3	2.7
10 to 15%	9.7	19.6	30.9	6.3
15 to 20%	17.8	29.3	36.3	13.0
20 to 25%	16.3	19.4	28.3	5.1
25 to 30%	13.0	25.8	23.7	2.6
30 to 40%	26.1	26.3	15.2	8.2
over 40%	19.2	15.4	15.2	10.8
Rural	**114.3**	**19.2**	**45.1**	**115.8**
0 to 5%	0.0	0.0	0.0	3.2
5 to 10%	4.2	7.4	3.9	6.5
10 to 15%	4.4	1.0	2.2	10.3
15 to 20%	15.6	0.0	7.0	11.1
20 to 25%	11.5	0.5	2.2	10.0
25 to 30%	17.4	1.3	0.0	10.6
30 to 40%	31.6	0.0	3.8	21.3
over 40%	29.5	9.1	25.9	46.1
Street Block	**271.8**	**563.2**	**559.5**	**84.5**
0 to 5%	5.0	36.9	33.9	23.2
5 to 10%	8.9	31.4	46.7	17.8
10 to 15%	11.1	34.2	56.2	3.9
15 to 20%	16.8	45.7	58.5	19.3
20 to 25%	22.1	44.8	46.8	4.1
25 to 30%	24.6	44.0	48.2	12.1
30 to 40%	59.4	92.7	115.6	13.8
over 40%	128.8	233.6	187.4	13.6
Grand Total	**885.4**	**1062.6**	**1319.1**	**354.2**

Darling Plateau Area

Table 8 Summary of urban forest canopy cover in the Darling Plateau Area

Canopy Coverage	Bickley	Canning Mills	Carmel	Hacketts Gully	Paulls Valley	Pickering Brook	Piesse Brook	Reservoir
0 to 5%	3	2	3	1	0	1	0	0
5 to 10%	2	0	4	1	1	1	2	0
10 to 15%	2	1	4	1	0	1	2	0
15 to 20%	5	0	5	1	1	12	2	0
20 to 25%	2	3	5	0	1	1	2	0
25 to 30%	4	1	4	1	4	1	3	0
30 to 40 %	10	1	21	95	67	55	71	95
over 40%	72	93	53	0	28	28	19	5
Median coverage	over 40%	over 40%	over 40%	over 40%	30 to 40 %	30 to 40 %	30 to 40 %	30 to 40 %

Table 9 Urban Forest Canopy Cover by broad land use type in the Darling Plateau Area

	Bickley	Canning Mills	Carmel	Hacketts Gully	Paulls Valley	Pickering Brook	Piesse Brook	Reservoir
Other Infrastructure	0	3.3	34.9	22.5	7.9	118.4	0.0	3.5
0 to 5%	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0
5 to 10%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 to 15%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15 to 20%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20 to 25%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25 to 30%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6
30 to 40%	0.0	0.0	0.0	22.5	0.0	118.0	0.0	2.9
over 40%	0.0	3.3	34.9	0.0	7.9	0.0	0.0	0.0
Parks	321.1	3213.5	349.5	1119.5	1685.4	9445.4	782.8	3944.5
0 to 5%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
5 to 10%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10 to 15%	0.0	0.0	0.0	0.0	0.0	0.0	16.3	0.0
15 to 20%	0.0	2.0	0.0	0.0	0.0	1148.0	0.0	0.0
20 to 25%	0.0	94.9	7.8	0.0	1.8	0.0	10.7	0.0
25 to 30%	0.0	17.4	4.0	0.0	1.1	0.0	0.0	0.0
30 to 40%	5.4	13.9	68.1	1119.5	1299.6	5538.6	689.6	3760.8
over 40%	315.8	3085.3	269.5	0.0	382.8	2758.8	66.2	183.4
Roads	61.6	24.1	74.2	19.7	35.6	90.4	25.0	9.1

	Bickley	Canning Mills	Carmel	Hacketts Gully	Paulls Valley	Pickering Brook	Piesse Brook	Reservoir
0 to 5%	0.3	0.0	0.8	0.0	0.0	3.0	0.0	0.0
5 to 10%	0.0	0.0	4.8	0.0	0.0	1.6	0.0	0.0
10 to 15%	0.6	1.2	2.2	0.5	0.0	2.5	0.0	0.0
15 to 20%	2.9	1.1	4.3	0.6	0.0	11.8	0.1	0.0
20 to 25%	10.1	3.8	10.2	3.5	0.8	13.0	2.9	0.0
25 to 30%	3.8	1.4	12.0	9.1	5.3	10.2	5.7	0.0
30 to 40%	16.6	5.1	9.3	6.0	9.9	12.1	9.1	0.6
over 40%	27.3	11.4	30.5	0.0	19.6	36.1	7.2	8.5
Rural	**378.6**	**45.1**	**281.1**	**36.1**	**245.4**	**328.4**	**156.6**	**0.0**
0 to 5%	0.2	0.0	1.6	9.6	0.0	62.1	0.0	0.0
5 to 10%	1.3	2.0	1.2	14.2	0.0	64.4	1.7	0.0
10 to 15%	5.9	23.8	5.0	4.0	0.0	21.0	0.0	0.0
15 to 20%	10.8	0.0	9.7	8.2	0.0	23.9	7.7	0.0
20 to 25%	8.2	1.0	15.1	0.0	10.1	14.4	4.0	0.0
25 to 30%	12.0	12.2	4.0	0.0	65.6	31.0	19.9	0.0
30 to 40%	45.8	0.0	49.2	0.0	40.6	3.5	21.3	0.0
over 40%	294.3	6.0	195.2	0.0	129.0	108.1	102.1	0.0
Street Block	**224.9**	**0.4**	**422.7**	**19.9**	**55.3**	**475.0**	**59.1**	**0.0**
0 to 5%	25.4	0.0	38.1	0.0	0.0	71.1	0.0	0.0
5 to 10%	22.1	0.0	44.1	0.0	11.8	85.5	15.1	0.0
10 to 15%	14.9	0.0	39.2	3.6	1.4	54.3	4.6	0.0
15 to 20%	33.6	0.0	41.3	0.0	11.3	40.9	8.3	0.0
20 to 25%	3.1	0.0	23.6	0.0	0.0	74.3	6.6	0.0
25 to 30%	21.9	0.0	30.5	6.2	11.7	31.3	5.0	0.0
30 to 40%	28.6	0.0	114.3	10.1	0.0	51.8	5.5	0.0
over 40%	75.2	0.4	91.5	0.0	19.1	65.7	14.0	0.0
Grand Total	**986.2**	**3349.3**	**1162.4**	**1217.7**	**2029.6**	**10457.6**	**1023.6**	**3957.1**

1.13. Temperature Data

Table 10 Temperature correlation to urban forest canopy cover in the City of Kalamunda

Row Labels	BICKLEY	CANNING MILLS	CARMEL	FORRESTFIELD	GOOSEBERRY HILL	HACKETTS GULLY	HIGH WYCOMBE	KALAMUNDA	KEWDALE	LESMURDIE	MAIDA VALE	PAULLS VALLEY	PERTH AIRPORT	PICKERING BROOK	PIESSE BROOK	RESERVOIR	WALLISTON	WATTLE GROVE	(blank)	Grand Total
	Temperature (°C)																			
Other Infrastructure	-	-	26.7	36.4	30.7	27.7	35.5	30.7	32.9	-	31.3	28.7	-	28.2	-	25.6	30.1	37.8	-	34.3
0 to 5%	-	-	-	37.2	-	-	36.0	31.4	32.6	-	35.9	-	-	30.8	-	-	30.9	37.9	-	35.7
5 to 10%	-	-	-	37.7	-	-	35.6	-	34.8	-	35.9	-	-	-	-	-	30.2	39.1	-	35.7
10 to 15%	-	-	-	36.1	-	-	34.8	-	-	-	27.2	-	-	-	-	-	-	38.0	-	34.0
15 to 20%	-	-	-	36.5	-	-	34.7	-	-	-	-	-	-	-	-	-	29.4	-	-	34.3
20 to 25%	-	-	-	33.6	-	-	34.5	32.4	-	-	-	-	-	-	-	-	30.0	36.5	-	33.5
25 to 30%	-	-	-	-	-	-	34.5	-	-	-	-	-	-	-	-	25.6	30.3	-	-	30.1
30 to 40%	-	-	-	32.1	30.7	-	-	30.0	-	-	33.6	-	-	26.9	-	-	-	37.3	-	31.9
over 40%	-	-	26.7	35.6	-	27.7	32.7	29.8	-	-	-	28.7	-	-	-	-	29.4	36.9	-	30.4
Parks	26.4	23.3	27.2	34.4	32.0	26.9	33.4	30.1	-	31.4	33.9	26.7	-	26.5	27.8	27.4	28.7	36.8	-	31.3
0 to 5%	-	-	-	34.8	32.7	-	36.3	-	-	32.2	37.7	-	-	-	-	29.9	28.2	38.4	-	35.2
5 to 10%	-	-	-	33.4	32.6	-	32.7	32.5	-	31.4	34.3	-	-	-	-	-	-	38.7	-	33.5
10 to 15%	-	-	-	33.5	33.9	-	34.5	29.5	-	31.4	22.6	-	-	-	29.8	-	-	36.5	-	32.8
15 to 20%	-	27.3	-	33.9	32.7	-	35.2	31.0	-	32.3	33.9	-	-	-	-	-	-	36.3	-	33.5
20 to 25%	-	28.1	30.9	34.1	33.9	-	36.0	30.8	-	32.0	35.1	26.6	-	-	29.5	-	29.6	36.8	-	33.8
25 to 30%	-	26.4	29.4	35.5	33.4	-	28.9	31.3	-	31.3	32.8	27.1	-	-	-	-	30.0	35.4	-	31.7
30 to 40%	27.6	26.0	29.4	35.0	32.7	-	31.4	29.9	-	31.4	35.2	27.2	-	27.6	27.8	27.0	29.2	36.2	-	31.5
over 40%	26.2	22.9	26.7	35.6	31.3	26.9	35.2	29.4	-	31.1	34.2	26.4	-	26.3	27.5	26.6	28.3	35.4	-	29.8
Roads	28.1	24.7	28.7	36.5	32.0	29.6	36.3	30.5	37.7	31.2	35.2	28.0	35.5	29.5	28.0	20.1	29.1	37.3	-	33.7
0 to 5%	30.3	23.7	29.5	36.9	31.3	-	36.3	24.0	37.9	29.8	35.5	-	35.5	31.1	-	-	30.3	38.3	-	36.2
5 to 10%	-	-	29.7	36.4	32.9	-	36.6	31.8	37.9	31.4	35.0	-	-	30.2	-	-	30.2	37.3	-	35.4
10 to 15%	28.6	28.9	29.7	36.1	30.4	30.8	36.1	32.4	36.8	31.2	35.5	-	-	30.3	-	-	30.0	36.1	-	33.9
15 to 20%	29.1	26.4	28.3	36.4	33.1	-	34.8	31.8	37.3	31.8	34.9	-	-	30.9	30.6	-	30.1	35.9	-	33.0
20 to 25%	28.3	26.0	29.6	35.5	32.5	-	36.3	32.0	-	31.5	34.9	27.3	-	29.2	27.8	-	28.9	34.5	-	32.6
25 to 30%	28.7	24.9	28.6	35.2	32.0	29.6	36.1	30.8	-	31.5	34.7	28.9	-	29.9	27.6	-	29.7	34.6	-	32.0
30 to 40%	28.6	21.7	28.3	34.9	31.8	29.5	36.4	30.1	-	31.6	34.7	28.2	-	29.4	28.4	27.6	29.2	34.6	-	31.0
over 40%	27.2	25.4	28.0	35.2	31.4	29.6	36.3	29.6	-	30.6	35.8	27.6	-	28.4	26.5	17.6	24.7	34.7	-	30.0
Rural	27.5	27.7	28.4	34.4	34.6	30.8	35.3	29.5	-	31.8	35.4	28.4	-	29.4	27.7	-	28.4	35.0	-	32.7
0 to 5%	29.9	-	32.0	36.3	-	31.5	38.4	-	-	-	36.5	-	-	30.5	-	-	30.6	32.4	-	33.2
5 to 10%	28.6	28.0	29.2	35.1	35.2	30.1	37.2	32.2	-	33.8	34.0	-	-	30.2	31.6	-	30.8	38.0	-	33.8
10 to 15%	30.4	28.5	29.6	34.9	35.2	31.8	37.2	31.9	-	37.1	37.1	-	-	30.1	-	-	29.7	36.4	-	35.1
15 to 20%	29.3	-	29.2	34.9	34.9	-	36.1	-	-	33.9	36.3	-	-	28.5	29.8	-	30.0	36.0	-	34.6
20 to 25%	28.3	27.8	29.5	34.9	34.8	29.9	38.0	30.6	-	35.5	36.0	31.0	-	29.7	29.9	-	30.2	35.5	-	34.1
25 to 30%	28.9	26.6	28.5	34.7	34.7	-	35.1	28.7	-	-	35.5	29.6	-	28.5	29.1	-	30.0	34.5	-	33.3
30 to 40%	28.3	-	28.9	34.3	34.5	-	34.7	-	-	31.4	35.1	28.1	-	28.6	27.7	-	29.4	35.0	-	33.4
over 40%	27.1	27.2	27.8	33.6	33.8	-	34.1	28.4	-	30.5	34.6	27.8	-	27.9	27.2	-	25.7	34.3	-	30.7
Street Block	28.3	29.2	28.9	36.6	31.9	29.2	36.7	31.5	37.5	31.2	35.4	30.0	35.7	30.0	29.5	-	29.8	38.5	-	34.6
0 to 5%	31.6	-	31.7	36.8	32.5	-	36.8	33.4	37.6	30.9	36.3	-	36.2	31.2	-	-	30.1	38.6	-	36.8
5 to 10%	30.6	-	30.0	36.3	32.6	-	36.5	32.4	37.7	30.9	35.6	32.1	-	31.2	30.4	-	30.1	38.0	-	35.2
10 to 15%	29.8	-	29.5	36.4	32.6	30.2	36.5	32.2	37.5	31.1	35.3	30.4	-	29.5	31.2	-	30.1	38.0	-	34.7
15 to 20%	29.1	-	29.4	36.3	32.3	-	36.4	31.9	36.5	31.2	35.0	31.0	-	29.0	30.1	-	29.7	37.7	-	33.9
20 to 25%	28.2	-	29.0	36.4	32.1	-	36.5	31.8	35.0	31.2	34.9	-	-	30.0	30.6	-	29.6	37.2	-	33.5
25 to 30%	28.2	-	28.9	36.3	32.0	-	36.5	31.7	34.6	31.2	34.8	29.1	34.7	29.7	32.0	-	29.6	36.9	-	32.9
30 to 40%	27.6	-	28.9	36.2	32.0	29.1	36.4	31.6	-	31.3	34.3	-	-	29.9	28.8	-	29.6	36.0	-	32.6
over 40%	27.6	29.2	28.1	35.9	31.5	28.9	35.5	30.4	-	31.2	34.1	28.2	-	29.1	27.7	-	29.3	34.8	-	31.3
Water	-	24.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24.1
0 to 5%	-	24.0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	24.0
5 to 10%	-	25.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25.1
(blank)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26.0	26.0
(blank)	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	26.0	26.0
Grand Total	27.8	24.2	28.6	36.4	32.0	29.5	36.5	31.4	37.1	31.2	35.3	28.1	35.6	29.4	28.0	24.6	29.5	37.9	26.0	34.3

City of Kalamunda Urban Forest Strategy,

7. Appendix B

1.14. Urban Forest Canopy Mapping