



## **Shading Liveable Cities: exploring the ecological, financial and regulatory dimensions of the urban tree canopy.**

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## Executive summary

### Project justification

Provision of shade through the urban tree canopy is critical to resilience, health, social equity, urban amenity and child-friendly cities in a warming world.

Despite these benefits, tree cover remains uneven across metropolitan cities with those most vulnerable experiencing shade and cooling-deficits.

### Project aims

Recognising these uneven patterns of greening, this project aimed to:

- Identify the different actors involved in developing, maintaining and governing the urban canopy, and their roles and responsibilities;
- Identify challenges and opportunities in accounting for, and developing financial incentives and regulatory measures to underpin, the incorporation of tree canopies into urban development; and
- Pilot methods to integrate ecological and social data, in order to better understand variation in tree canopy cover in diverse suburbs.

### Method

The project used a mixed methods approach comprising:

- An online questionnaire completed by 50 local government officers from 15 Local Governments (LGs) in Melbourne. The questionnaire was divided into three sections to explore the boundaries of the urban tree canopy, in legal and spatial terms; government, developer and resident responsibilities in relation to the development and maintenance of the urban tree canopy; and questions about regulations and incentives for different groups to contribute to the development and or maintenance of the canopy. Both quantitative and thematic analyses of these data were undertaken.
- In-depth interviews with a sub-set of 14 officers from 5 Western Melbourne LGs and 2 state government divisions. This data set develops an understanding of the interactions between councils, developers and residents by exploring specific projects in detail. It focuses in particular on key strategies and programs in the Western Melbourne city councils of Hume, Brimbank, Moonee Valley, Hobsons Bay and Melton, and incorporates insights from state government (the Office of Living Victoria and the Metropolitan Planning Authority).
- A quantitative scoping study combining i-tree canopy analysis of the distribution of tree canopy cover over parts of Western Melbourne; with social and economic variables extracted from the 2011 Census and the AURIN portal.

I-tree Canopy software was used to generate 200 randomly generated points on 2012 aerial photographs in each of 96 ABS-defined Statistical Areas level 1 (SA1s). These data were disaggregated by coverage type and by public and private ownership. Using Geographic Information Systems (GIS), descriptive statistics, correlations, and regression models we explored spatial correlations between tree canopy; urban footprint; and social and economic variables. We modeled the relationship between local socio-economic variables and tree canopy; and between local tree canopy and sampled house prices when controlling for other characteristics.

- A stakeholder workshop with LGs, state government and utilities, and 'friends of' groups held in November 2014.

## Results

*Online surveys* found that:

- The governance of the urban canopy is complex, spanning a network of LGs, utilities, developers, state government planning authorities and residents. Together these actors develop and maintain canopy cover in different collaborative arrangements across public, private and shared spaces.
- Participants stressed that the financial costs of greening need to be considered in terms of the cost of buying trees, including labour to plant, repair and maintain trees, and meeting compliance costs. While these costs were top of mind for many participants, opportunities to value trees as assets were also identified.
- Despite the health, amenity and community benefits of the urban canopy, *most* trees are not protected by planning or environmental controls. While there are indirect incentives for developers to incorporate greening into development applications, and these had been advanced in growth areas in particular, the majority of participants also saw a role for stronger planning controls.
- The integrity of urban forest strategies was seen by most participants to depend on the activities of private landowners and residents. Some participants estimated that 70% of the canopy was located on private land. Despite this, resident values, perceptions and behaviours were seen to be mixed: around 65% of participants indicated residents were engaged in practices of care and stewardship for the canopy but 35% reported more ambivalent attitudes ranging from hostility (11%) to indifference (24%).

*In-depth interviews* revealed that:

- Significant innovation and experimentation in greening (between residents and councils, and councils and aligned authorities and organisations) is advanced at the local scale.
- Developers of smaller developments were nonetheless seen to be less knowledgeable and committed to public space greening than those on larger sites, highlighting a governance gap around smaller infill sites.



- While recognising the need for engaged community supporters, consultation processes were seen to potentially result in community and commercial interests voicing opposition or ambivalence to trees.
- Successful greening strategies included the City of Hume's 'model street' in Broadmeadows targeting lower socio-economic neighbourhoods and providing a tangible example of shading in cities generating community interest.

*GIS scoping* confirmed that:

- i-Tree data could be used to develop small area data about current tree cover within selected suburbs of Greater Western Melbourne, which was then successfully linked to small-area socio-economic data.
- Differences in tree canopy occur at multiple spatial scales. Within the study area, levels of tree canopy cover varied widely. The SA1 spatial units had an average total tree canopy cover of 17.44%, ranging from 4.5% to 29.2%.
- There were more marked differences between and within the four suburbs in public tree canopy cover – including public gardens and streets. Variation in private tree canopy cover – trees on private residential and commercial land – did not vary as widely.
- Spatial variation was evident between suburbs and within suburbs, and varied by property ownership. This carries important implications for program implementation.
- We modeled the strength of spatial relationships between key social, demographic and landscape location indicators with local variations in tree canopy cover. We found that:
  - Local variation in unemployment rate and population turnover correlated negatively and significantly with variation in tree cover, especially in public space. Other expected predictors of tree cover (income and education) were comparatively weak predictors.
  - Using individual house sale prices we applied a hedonic price modeling approach to explain property sale prices based on property characteristics (particularly size) and local characteristics, including tree canopy cover. We found that:
    - Tree canopy cover, position in the landscape and property characteristics (size and location) were able to explain 37% of the variation in sampled house sale prices.
    - The percentage of tree canopy cover in the area – its 'leafiness' – is a significant, and positive, contributor to house sale prices. If other characteristics were identical, a house sold in a local area with 30% tree canopy cover would sell for around \$150,000 more than one in a similar area with only 10% tree canopy cover.

## Conclusions

- While greening contributes to urban resilience, the value of trees nonetheless remains largely undocumented: they are often perceived as 'costs' or 'write-offs'. Responses indicate emerging interest in making the benefits of trees measurable, thus positioning the canopy as a core asset.
- Greening is advanced most effectively through situated practices and policies developed at the local scale. Variation in urban development processes means that greening strategies require flexible management and financial approaches that can support a range of collaborations across multi-scalar state and private actors.
- Despite the effectiveness of LG initiatives, resident values, perceptions and behaviours towards greening play a key role in shaping the development and maintenance of the canopy. This is because the largest proportion of the canopy occurs on private property. Developing a clearer understanding of resident perspectives through community-led greening projects would provide a better insight into how best to harness citizen support for greening.
- This study demonstrates the benefits of new initiatives, and concludes that a method for targeting areas of most need could be achieved through the use of an integrated data set matching ecological features of the canopy with social and economic features of its surrounds.
- It is anticipated that such data could be matched with qualitative analysis of more specific greening projects capturing personal and social outcomes for diverse communities. Together these mixed methods would provide a complete assessment of the benefits of greening, provide a better understanding of the social and economic values of the canopy, and recognise local councils' roles in the development of urban resilience.

## 1. Introduction and objectives

The provision of shade through the urban tree canopy is critical to urban resilience, health, social equity and child-friendly cities in a warming world. Trees help to minimise heat islands and so cool cities. Trees are also important and efficient carbon-converters through photosynthesis and a growing body of research emphasises the human health and well-being outcomes of human-plant interactions. Recognising these benefits, greening strategies and practices have proliferated through both local government and 'friends of' groups in many Australian suburbs. These include urban forest strategies, street tree policies, 'Adopt-a-tree' programs and the more routine greening practices by community groups and households, nature strips and public reserves. Despite these initiatives, tree cover remains extremely uneven across metropolitan cities. Comparative analysis of vulnerability and tree cover by location shows that those who are most vulnerable to extreme heat events (Loughnan et al. 2012) often live in those parts of cities that are most poorly shaded (ISF 2014).

The 'leafy suburb' is a selling point when it comes to real estate but the urban canopy takes on new significance in the context of warming for its capacity to shade and cool. In January 2009, some 374 people died in Melbourne prematurely due to successive days of 40 plus temperatures (Cooper 2009). Emergency access to nearby air-conditioned spaces during these extreme heat events is the most immediate solution to this significant public health problem. Longer term structural solutions should also be sought given the limited capacity of some groups in society to maintain private building air-conditioning and to access public air-conditioned spaces in and around extreme heat events. Heat mitigating urban design, better insulation, ventilation, and built-form and ecological shading of private and public spaces should be prioritised. Paradoxically, air-conditioning achieves temperature reductions by contributing more broadly to warming through the emission of carbon. Trees have the capacity to limit such extremes by absorbing carbon dioxide, while also increasing the proportion of shaded areas in cities (see Norton et al. 2015). Such areas can be important for many members of the community during warmer weather, including the very old and very young, as places to rest and recover. Shade also allows people to keep out and about in hot weather, connecting to other people and familiar faces on hot days within a shaded environment. Thus while city wide greening is seen to be an important strategy for resilient society, such strategies need to take into account patterns of social vulnerability and therefore need for socially-targeted greening and cooling.

One of the key findings of the '2020 report' (ISF 2014) is that only some of Melbourne's citizens enjoy shade. Residents living in some areas of the eastern suburbs and the CBD have high levels of canopy cover. The wealthier LGAs of Yarra and Stonnington are also well shaded. Areas of particularly low canopy cover include some western Melbourne LGAs, as well as growth areas across Greater Melbourne.

Recognising the critical role of tree cover in the context of urban resilience and vulnerability, the objective of the *Shading Liveable Cities* project was to better understand the different factors shaping the provision and maintenance of the urban tree canopy in suburban contexts. The specific aims of this project were to:

- Identify the different actors involved in developing, maintaining and governing the urban canopy, and their roles and responsibilities;
- Identify challenges and opportunities in accounting for, and developing financial incentives and regulatory measures to underpin, the incorporation of tree canopies into urban development; and
- Pilot methods to integrate ecological and social data, in order to better understand variation in tree canopy cover in diverse suburbs.

In addressing these aims, this report first draws on two new data sets. The first data set comprises on-line questionnaires completed by 50 participants from local government environment and planning departments in Melbourne and provides insight into the regulatory context in which the urban tree canopy is developed and maintained. These data have been used in the project to establish the boundaries of the urban tree canopy, in legal and spatial terms; identify government, developer and resident responsibilities in relation to the development and maintenance of the urban tree canopy; and explore how the urban tree canopy is currently financed in relation to housing and urban development processes. While this section of the report highlights the key role of local government and State government authorities in greening public spaces and new development, it also shows the strong perception among respondents of the role of residents as stewards of private property. As reported by some participants, private property accounts for the largest component of the canopy.

The second section of the report draws on a second qualitative data set generated out of in-depth, semi-structured face-to-face interviews. This data set develops an understanding of the regulatory and financial context of urban greening by exploring specific greening strategies and policies 'on the ground'. It focuses in particular on key strategies and programs in the Western Melbourne city councils of Hume, Brimbank, Moonee Valley, Hobsons Bay and Melton, and incorporates insights from state government (the Office of Living Victoria and the Metropolitan Planning Authority) into these accounts. This section identifies greening initiatives already in place and the way such strategies incentivise greening, as well as the limits of these approaches. This section of the report highlights the diversity of local council initiatives and the core concerns around urban development processes of infill and greenfield development. It nonetheless reveals different capacities among residents and developers to plan for and finance urban greening and highlights significant scope to achieve social resilience benefits from increased canopy cover. Results from the first two sections of the report show that efforts to increase canopy cover are working within a complex field of actors and public, private and shared spaces. Developing an evidence base from which to pursue and target effective programs, strategies, incentives and regulatory frameworks is therefore critical.

The third section of the report explores the potential to address this data gap by linking social and ecological data through GIS. It scopes the viability of using aerial photographs to estimate variation in tree cover by landuse combined with small area socio-economic and other data. The examples provided herein are drawn from three Local Government Areas (LGAs) in Western Melbourne. This scoping exercise is significant in testing the potential for data modeling that embraces the urban tree canopy as the outcome of interconnected social and ecological processes. This part of the report investigates the possibility of integrating social and ecological data to better understand the drivers as well as the impacts of uneven tree cover.

The final section of the report provides a summary of feedback received from the *Shading Liveable Cities* workshop held at the University of Melbourne with key stakeholders in November 2014. Stakeholders were recruited through the online survey, face-to-face interviews, and additional 'snowballing'. The aim of the workshop was to report on the findings of the scoping study, survey and interviews. The inclusion of an international speaker, Rebecca Salminen-Witt from 'The Greening of Detroit', provided international best practice insights and encouraged comparisons to be drawn between Melbourne and other urban contexts. An additional Australian keynote speaker, Dr Fiona Miller, focused stakeholder thinking on the links between heat stress on urban populations and the importance of cooling through canopy cover provision. A facilitated discussion sought stakeholder feedback about these insights and the project's data. The workshop tested the usefulness of these data to stakeholders *vis-a-vis* the opportunities and challenges of the day-to-day management and planning of urban forests in a warming world. The workshop recognised that a wide range of public and private actors and organisations must collaborate in the provision and maintenance of canopy cover.

## 2. Governing the urban tree canopy

The argument for increasing tree cover reflects growing consensus about the environmental and health outcomes of greening socially diverse cities in a warming world. However, the practice of developing and maintaining the urban forest (as an important component of greening) occurs through the combined actions of many organisations and individuals across public and private spaces. The maintenance of the canopy is also an ongoing process, that, in times of rapid urban development, can lead to both tree removal and new planting. In order to better understand the local contexts in which tree canopies are developed and managed, this part of the report draws on the views of 50 local council officers who participated in the on-line questionnaire. The questionnaire was promoted through Greening the West, and includes responses from council officers working in 15 different LGAs in Melbourne. The questionnaire was designed to establish more clearly the roles and responsibilities of particular groups and people in the provision and maintenance of the urban tree canopy; key issues concerning canopy cover; and the regulations, policies and incentives underpinning greening practices and behaviours. In order to consider geographical location and area of professional expertise, direct quotations are attributed to the department (as best discerned) and the council in which participants worked. No respondents are named, and position titles have been removed.

### 2.1 Actors and roles

One of the features of the urban forest is its occupation of both public and private space. In practice, the canopy crosses multiple property boundaries and enlists a wide range of stakeholders. To develop a clearer understanding of the different groups involved in managing and caring for the urban forest, this section reports on responses to the following question: *'Are different people responsible for different types of trees in your area or jurisdiction?' The results were used to develop the image in Figure 1, which shows the different actors involved in the development and maintenance of urban tree canopy by jurisdiction and property-type. It is important to note that the urban forest crosses many boundaries. This includes public and private space, and the further delineations of nature strips, median strips, parks, waterways, railway lines and utilities in public space, and types of private space, whether under development or home-owner's property.*

Figure 1 sets out these key actors and spaces. They comprise nine actors with different levels of authority based on property type or jurisdiction. This includes: **home-owners** who have responsibility over the trees on their own property, and to the nature strip; **local councils** that have responsibility over trees on nature strips, and some median strips in local roads, and median strips that are 'shared' with VicRoads on major roads, while council bushland management teams also look after the major wildlife corridors in their areas (sometimes assisted by **'friends of' groups**). Beyond these actors and jurisdictions, **developers** were seen to have major responsibility over greenfield sites, **water utilities** for trees on the beds and banks of waterways (Melbourne Water), **Vic Track/PT Victoria** for trees on rail corridors, and

**VicRoads** for trees on major roads. National parks are the responsibility of **Parks Victoria**, and **schools** are responsible for trees within their own boundaries.

Figure 1: The urban tree canopy: actors and spaces of governance



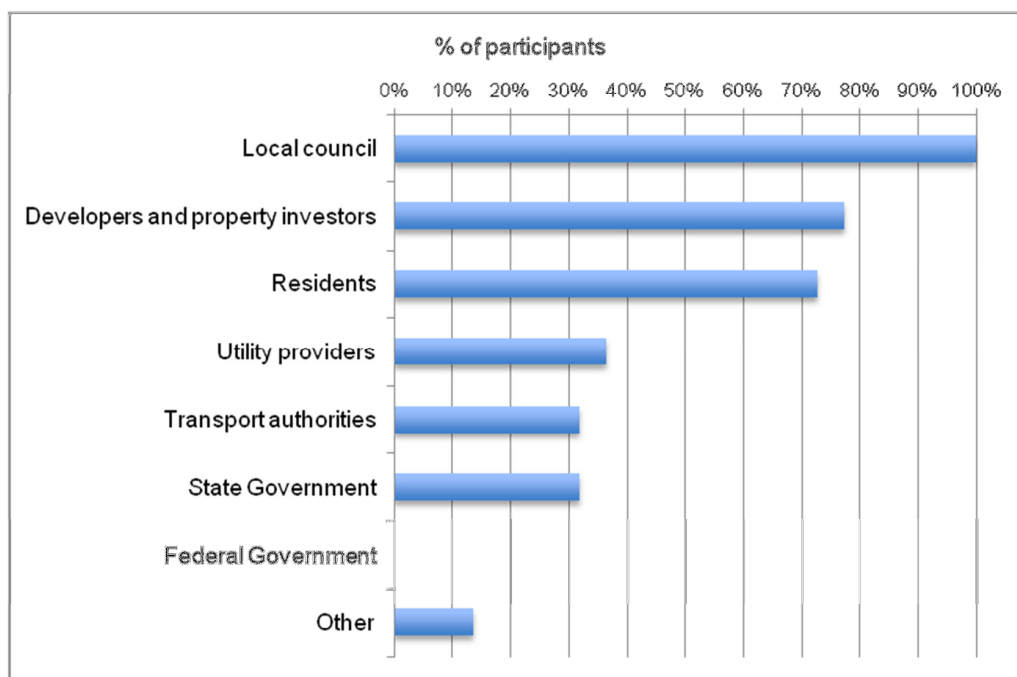
Source: Chris Cook

In order to gain a sense of who is most involved in developing and maintaining the urban canopy, participants were asked to identify the 'key people' involved in the provision and maintenance of trees in their jurisdiction. For all respondents, their jurisdiction referred to the LGA. This question comprised eight pre-determined options that participants were asked to select from: local council, residents, property investors, developers, utility providers, transport authorities, State Government and Federal Government. Recognising the preliminary nature of this study, participants were also invited to nominate other key people, with an option to select 'other' with a follow-up prompt 'please specify'. In this question, respondents were permitted to select more than one group. Six people did not respond to this question, and six nominated other groups not mentioned. Altogether 44 respondents generated 160 selections. Together these data provide a snapshot of the relative importance of different actors within the governance framework from the perspective of a majority local government sample.

As shown in Figure 2, all respondents to this question nominated local councils as playing a key role in the provision and maintenance of the tree canopy (100%). However it is significant that just over 75% of respondents also identified developers or property investors showing the significance of the commercial sector in the urban forest.

More than 70% of respondents also nominated residents as key people in providing and maintaining trees. While a smaller proportion of participants nominated utility providers and transport authorities, both were nominated by around a third of respondents respectively. Nearly a third of all respondents recognised the State Government as playing a key role. The Federal Government was not nominated by any participant. Six participants specified other groups who played a key role in the provision and maintenance of the trees, including contractors and 'friends of' groups.

Figure 2: Key people involved in the provision and maintenance of the urban forest (n=44 multiple responses permitted)



Together these data suggest that within local government boundaries, local councils, developers and residents are seen to be most involved in developing and maintaining the tree canopy, with utilities, transport authorities and the State government playing important but secondary roles. Moreover, the nomination of contractors and 'friends of' groups suggests additional actors are involved in stabilising the canopy, a point discussed further in subsequent sections. Overall these results suggest local government is operating within a network of local residents, State governments, and local and extra-local commercial actors that – like carbon control more generally (see McGuirk et al 2014) – tends to cohere through collaboration and situated practices rather than top-down approaches.

## 2.2 Key issues

With a clearer understanding of the relative significance of different groups within canopy governance, participants were asked to rank, in descending order of importance, key issues regarding the provision of trees in cities.



In this question four pre-determined options were available and, as before, participants could select 'other' where new issues could be specified. Forty-two participants responded to this question and sixteen nominated additional issues. The results, shown in Figure 3, highlight the significance of finance, regulations and residents as an intersecting set of issues in the provision of tree cover.

Figure 3: Key issues nominated by council workers regarding the provision of trees in cities

Issue Importance Ranking	First (%)	Second (%)	Third (%)	Fourth (%)	Fifth (%)
Financial considerations	13 (31)	13 (31)	8 (19)	5 (12)	3 (5)
Regulations	11 (26)	9 (21)	9 (21)	11 (26)	2 (5)
Resident Opinion	11 (26)	12 (29)	9 (21)	8 (19)	2 (5)
Water Supply	1 (2)	5 (12)	13 (31)	16 (38)	7 (17)
Other	6 (14)	3 (5)	3 (5)	2 (5)	27 (64)
<b>Total*</b>	42 (100)	42	42	42	42

\* 8/50 participants did not answer this question

Financial considerations were ranked as the top issue by the greatest proportion of participants (31%). However, regulations (26%) and resident opinion (26%) were both ranked by another quarter of participants respectively, as the most significant issue. Together these three issues accounted for 83% of all first-rankings. Considering both first and second rankings together, 50% of participants ranked resident opinion in these top two levels, slightly more than those nominating regulations (47%) in one of the two highest categories, but less than the 62% of participants who ranked 'financial considerations' in one of the two highest categories.

Staying with a consideration of these two highest ranking categories, water supply was more commonly seen to be less significant (14%) than finance, regulation or resident opinion. The seven respondents who ranked water issues first or second were employed in sustainability departments, landscape design, and parks, but nearly 70% of respondents rated water supply as a third- or fourth-ranked issue. Nine participants nominated other issues as the most, or next-most important issue (21%) including: space (above and below ground) (14%); climate change and heat island effects (5%), with individually nominated issues of vandalism, council attitudes, maintenance, communication, fire safety, habitat creation and liveability completing the series.

### 2.3 Financial considerations regarding trees

Mindful of the significance of financial issues in relation to the urban canopy we turn next to responses to the broad question '*what are the financial considerations of your organisation regarding trees?*'. This was an open-ended question designed to better understand the scope and nature of the financial considerations that local councils have in relation to the urban tree canopy. Of the 50 participants in the online survey, 37 answered this question.

In order to maintain both the depth and breadth of these data, multiple points made by the same person were coded. Overall 47 comments (generated from 37 participants) were coded. The coding framework was developed according to participants' key interpretations of the financial considerations of their organisation. As shown in Figure 4 these focused on i) the costs of the canopy to council (27/47), ii) the limits and uncertainties of funding (14/47), iii) other financial considerations (discussed in more detail below). The detail provided in these responses was used to build insight into the financial relationships in which the canopy is embedded. These data are set out in Figure 4 from which we develop three brief points below.

Figure 4: The financial considerations of local councils regarding trees

	n (%)
<u>i) Costs to councils</u>	27/47 (57)
Preparing site	
Tree stock and planting	
Maintenance	
Watering	
Pruning to clear powerlines	
Repair- flood or storm damage	
Repair- to buildings and roads caused by tree damage	
<u>ii) Funding context- limits and uncertainties</u>	14/47 (30%)
<i>'Limited yearly budget for tree planting, not adequate to address much lower canopy cover compared with other parts of the city' (Urban Design, Council not stated).</i>	
<i>'Once the Urban Forest Strategy was endorsed, it received funding for implementation for the first year. I think this was considerable reduced for the second year' (Darebin).</i>	
<i>'Can we now and in the future cover maintenance, replacement and liability costs that may be associated with trees' (Hepburn Shire)</i>	
<u>iii) Other financial considerations</u>	6/47 (13%)
<i>'Biodiversity Incentive program plants trees to offset carbon emissions from fleet' (Yarra Ranges Council)</i>	
<i>'Not according trees a monetary asset value' (Brimbank)</i>	
<i>'Developers are fined for removal or destruction of council street trees' (Planning, Darebin).</i>	

First, most participants (27 out of 37 people) reported the different financial costs incurred by councils of developing and maintaining the urban forest: these are not limited to the cost of buying trees but include labour to plant, repair and maintain trees, compliance costs. This is also a matter of achieving the best quality plants within given budgets, and appropriate species choices. Second, around a third of respondents made observations about the likelihood of ongoing funding for such activities. While in all cases council did allocate funding for urban trees, such funding was not seen as unlimited. Third, participants identified a range of other financial initiatives that, unlike the majority of responses where trees were understood in terms of their costs, saw trees in terms of a 'monetary asset value'.

These results suggest an emerging discussion about the financial return or benefit of trees. This may reflect the lack of data available around longer-term values, including social and economic values of urban forests. We pick up this question in the final research section of the report.

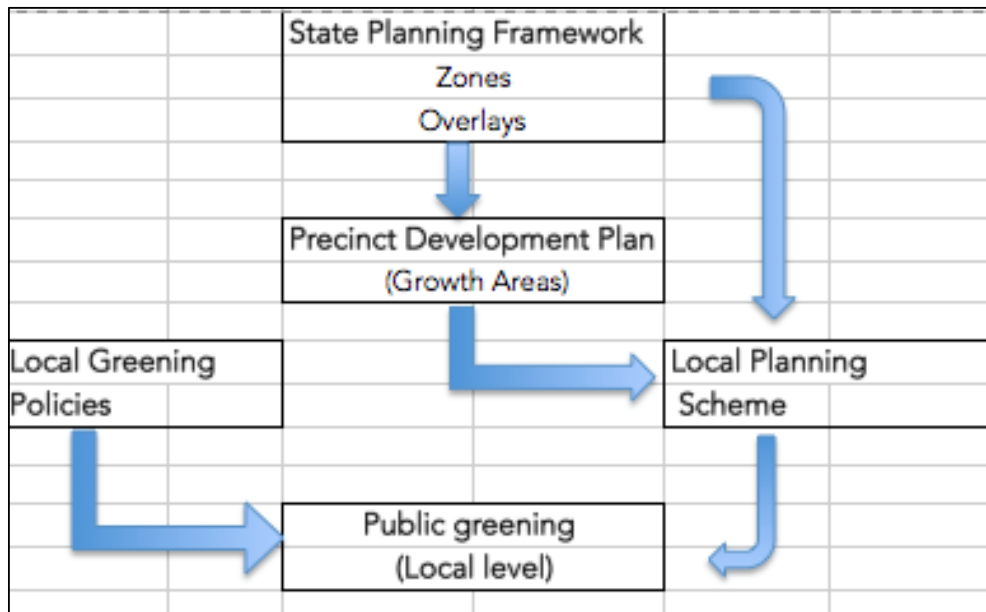
## **2.4 Regulatory controls: whose actions are regulated where?**

Regulations in planning and development, along with general controls around tree-removal, are important mechanisms governing how the urban canopy should be developed and maintained within specified areas and spatial units. In this report, regulations are defined as those controls developed with respect to legislation that bind different actors to particular behaviours and forms of conduct in relation to trees and their maintenance. This section of the report draws on the responses to two questions from the online survey: *'what are the relevant/regulatory frameworks?'* and *'are different people responsible for different types of trees in your area or jurisdiction?'*. Rather than documenting the most frequently mentioned responses, this section seeks to build an understanding of the legislation in spatio-temporal context. In doing so, it recognises that the canopy crosses property boundaries and jurisdictions with different actors responsible for trees within these spaces. In addition, the canopy itself experiences different temporalities: planting, growth, maintenance, removal and death to which legislation applies. Despite this, it is important to note that much of the urban forest is located on private property whose fortunes, as set out below, hinge on resident beliefs and behaviours.

### **2.4.1 Planning controls: overlays and development control plans**

Land use controls for LGAs in Melbourne are established in Local Planning Schemes (LPSs). The LPSs connect a number of State-wide planning instruments – such as zones and overlays – to specific units of land within a given municipality. Many zones and overlays contain controls over particular activities and objects within those boundaries. They specify prohibited and restricted uses, along with landuses and landuse practices that require permit applications. While as shown in Figure 5 the LPSs set the broad planning framework for the municipality, in most urban areas, most of the time, private land is excluded (the exception being when a development is proposed). In contrast, controls over the urban forest in public space, as well as guidelines and controls in relation to significant species in public and private space or groups of significant trees (where an overlay may apply), are informed by over-arching legislation including, for instance, the Flora and Fauna Guarantee Act 1988, Catchment and Land Protection Act 1994, Environment Protection and BioDiversity Conservation Act 1999, Road Management Act 2004, Planning and Environment Act 1987, and so on.

Figure 5: Regulatory framework for the governance of urban greening



Among participants in the online survey, the Vegetation Protection Overlay, Environmental Significance Overlay, Heritage Overlay, and Significant Landscape Overlay had been applied to only some parts of municipalities, to native trees only, often in non-urban areas. As summed up by one Open Space Co-ordinator (Hume): 'There is little or no protection for private trees nor public trees other than for native vegetation on larger parcels'. Similarly, Darebin reported that Clause 52.27 of their planning scheme (required a planning permit to remove native vegetation but that 'There are numerous exemptions to this policy and it is difficult to apply within an inner urban area particularly because the removal of native vegetation is not applicable for a site that has an area of less than 0.4 hectares' (Darebin).

#### 2.4.2 Discretionary controls

The LPS also includes discretionary controls where, for instance, the retention of trees, and the provision of a landscape concept plan with a development application is encouraged (Darebin) including garden settings, street trees, creeks, habitat for plants and animals and 'the retention of mature vegetation on the site'. The extent to which proponents (most typically developers) respond to such encouragement, and whether and how development approval proceeds more quickly (or more successfully) for proponents who do prioritise urban trees would be a reasonable test of how well discretionary controls and incentives are working in this space. These are important questions that are beyond the scope of this study. It is notable that the removal of native vegetation on mainly (but not only) rural land is not discretionary, while all other vegetation on urban land seems to be managed at the discretion of the proponent.

#### 2.4.3 Street trees: road setbacks, asset clearance, CCTV

In contrast to the discretionary nature of planning controls in relation to greening, the canopy itself is highly regulated relative to any intrusion it may make on other urban services. As summed up by one participant: 'there is too much going *against their planting* in terms of rules about setbacks from roads, clearance of assets, blocking of CCTV cameras etc.' (Council not specified). Powerline clearance was commonly mentioned, applying to trees on both public and private property.

#### 2.4.4 Greening targets and council policies

In addition to regulations and discretionary controls, are local councils' own greening targets, set out in policies with timeframes, budgets and assessment processes. Three mentioned in this study by City of Darebin were its goal of '25% total canopy coverage in the municipality' (Darebin), 'Greenstreets Streetscape Strategy', and the 'Darebin Urban Forest Strategy' (Darebin). Similarly, Monash was in the process of developing an urban forest strategy seen as an 'environmental road map supporting increasing canopy' (Monash). Participants from Brimbank also reported a Street Tree Policy.

#### 2.4.5 Private, urban space

In contrast to trees in public spaces, those in private space, are generally unregulated summed up by one participant as: 'Residents are responsible for their own trees, we have no protection' (Brimbank). The exceptions, were 'significant trees such as Red Gums' (City of Whittlesea; also mentioned by City of Casey). There are variations across LGAs, one participant from Banyule suggesting 'residents are responsible for trees in backyards and there are regulations and laws about removal of trees', (Banyule). More interventionist again were the cases of Yarra and Manningham, perhaps because of larger areas of land holding Environmental Overlays (Yarra and Manningham). Nonetheless, it appears that in most councils, most of the time, with the exception of native vegetation and some trees of historic value, 'there are not permit requirements or controls over private trees' (Hume City Council).

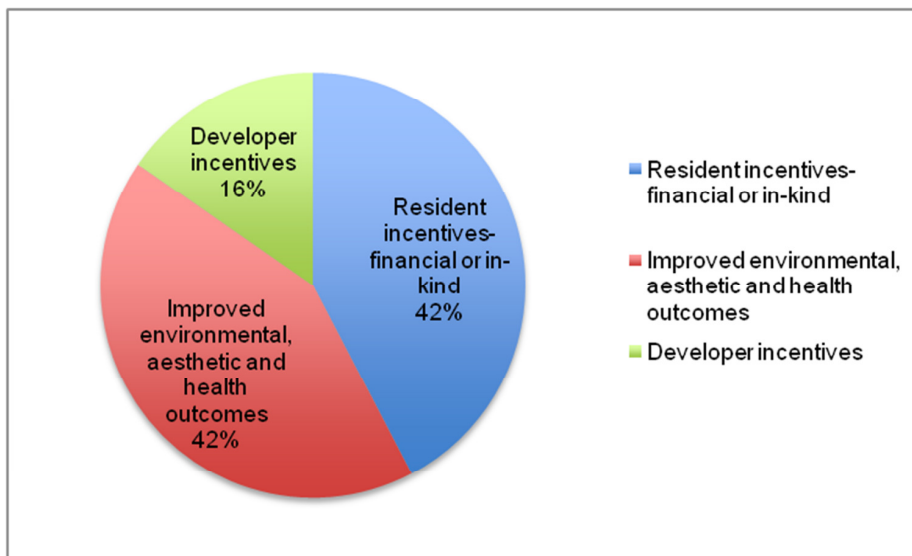
## 2.5 Incentives

Incentives can be seen as a supplement to regulations in encouraging desired behaviours. They can work through financial or in-kind support provided by one group to another, often funded by collectively generated revenues and in a state-community relationship. However broader outcomes – such as environmental sustainability and cleaner air – can also provide incentives for certain behaviours without direct economic benefit. Although accounting for these benefits would provide a stronger financial case for greening.

In order to gain a better understanding of the types of incentives used in relation to the urban forest, this section draws on responses to the question '*what incentives exist for the provision of trees in your area or jurisdiction?*' While thirty-five out of 50 participants responded to this question, two types of responses were excluded from analysis in this question, namely: i) those where one respondent from a given LGA maintained there were no incentives, and another participant from the same LGA identified incentives. In these cases, the former response was excluded. Second, responses where regulations were interpreted as incentives were discounted. This left a sample of 20 viable participants that, taken together, generated 26 'codable' comments given some respondents made more than one comment.

Incentives were divided into three categories: 'resident incentives – financial or in-kind', 'improved environmental/aesthetic/health outcomes' and 'developer incentives'. Figure 6 shows the relative significance of each: relationships with residents (11/26) and improved environmental outcomes (11/26) were most commonly reported, while incentives for developers were seen to be one way that the tree canopy could be incorporated into urban growth strategies. We explore these themes below.

Figure 6: Incentives for the provision of trees in LGAs selected councils (n=26)



First, participants were equally likely to nominate financial or in-kind incentives (42%) as the intrinsic values of urban greening (42%). Financial or in-kind schemes, however, often targeted *non-urban areas* including rural conservation zones, land covered by Environmental Significance Overlays, designated Wildlife Corridors, properties over 2 hectares in area (Yarra Ranges) and schools and rural land owners. Second, in terms of the intrinsic values of urban greening, these included: reducing the urban heat island, contributing to habitat creation and urban cooling, liveability, climate change mitigation, health improvements and making aesthetic improvements in neighbourhoods. Third, incentives for developers were identified (16%). These included the increased financial value of the property at the point of sale, and from a development assessment perspective, the likelihood of an improved assessment outcome. Specifically, applications with significant canopy coverage were more likely to be regarded favourably such that alternative design solutions may be approved 'where they result in the retention of a tree or the opportunity for deep root planting' (Darebin). Before exploring such opportunities for greening in the development process in more detail, the next section turns to the question of resident perceptions, values and behaviours.

## 2.6 At home with the urban forest: resident roles

Private space accounts for a greater proportion of the urban canopy than public space. As pointed out by one participant, residents are 'responsible for more than 70% of urban tree cover' (Hepburn Shire). However, as shown above, trees on private space are largely unregulated in terms of planting, maintenance and removal. Existing controls concern removal, but in relation to a small number and variety of significant trees.

The values, perceptions and behaviours of residents are therefore important factors in the health of the urban forest; residents' decisions to plant, maintain or remove trees can 'make or break' the stability and coherence of the urban canopy. Moreover, these decisions can unsettle or further enhance public space greening. In order to better understand resident values, perceptions and behaviours in the provision and maintenance of the urban forest, this section reports on responses by council officers to the question 'what role do residents play in relation to tree cover in your area?' Forty-one participants responded to this question, generating 70 codable comments that comprise the total responses for this question. The results are set out in Figure 7, providing testimony of the complex positions attributed to residents in relation to the urban forest.

Figure 7: Resident roles

Key roles	n-70 (%)
<p><b>i) Stewardship, private property</b></p> <p>'residents are responsible for maintaining their properties including front and rear gardens' (Darebin)</p> <p>'many residents value and care for their trees, in urban areas as keen gardeners' (Manningham).</p> <p>'residents contribute a large amount of canopy coverage within private land' (Darebin).</p> <p>'vegetation provision (maintenance and replacement) largely due to residents willingness to provide' (Monash)</p>	27 (39)
<p><b>ii) Stewardship, public spaces</b></p> <p>'Some residents will take "unofficial" responsibility for trees on their nature strips' (Maribyrnong)</p> <p>'Residents advocate for the retention of large trees when council or the state government wants to remove them' (Cardinia)</p> <p>'Selecting new trees for nature strips from a pre-approved list of about 30 street trees' (Monash)</p> <p>'There may be events of opportunistic planting by residents within road reserves or naturestrips' (Darebin).</p> <p>'MVCC has a Tree Management Strategy which is regularly reviewed and that is the community's main platform of influence and that document goes through a process of public consultation as part of those reviews' (Moonee Valley).</p>	18 (26)
<p><b>iii) Ambivalence</b></p> <p>'people don't seem to like gumtrees... they believe they are a danger to the public and properties and they drop leaves and limbs (making work for residents) (Casey).</p> <p>'There are very mixed opinions about tree cover' (Latrobe)</p> <p>'Some advocate for more tree cover (lower number) and other advocate to have them removed (greater number). People are scared they'll be impacted by a tree in someway (falling limbs, roots lifting pavement, damaging housing); the result of inappropriate species selection (especially the planting of very large Eucalypts close to housing)' (Brimbank).</p> <p>'An historical dislike of trees and the issues they cause such as blocked gutters and uneven footpaths' (council not specified)</p>	17 (24)
<p><b>iv) Active removal of trees</b></p> <p>'If there is a view impacted by trees residents will poison or remove public or private without question' (Casey)</p> <p>'A proportion of the trees are vandalized every year' (Whittlesea).</p> <p>'there is regular illegal tree removal for varying reasons and on varying scales-often bushfire is used as an excuse, or that a resident felt the need to "tidy up" In the more urban areas, tree removal often occurs because of perceived danger or "messiness"' (Manningham)</p>	8 (11)



As shown in Figure 7, participants identified four different 'resident roles'. The most commonly identified roles were connected to practices of stewardship, either at home (i) or in public spaces (e.g. nature-strips) (ii). While caring roles accounted for nearly 65% of total responses, further research is required to explore the nature of such stewardship because 'good cover relies on residents appreciating and selecting big trees, not just shrubs' (Department and council non-specified). The other 35% of responses recognised an ambivalence of residents towards trees (24%) often associated with the extra work of collecting and removing leaves and tree limbs, and the dangers that trees might present to property or person. A smaller proportion identified the persistence of vandalism (11%) that, while not widespread, was seen to be difficult to eliminate. Overall these data suggest that resident care for the canopy cannot be assumed: it can be seen to take too much work, produce unwanted risks or even compete with other home-values (such as views). While residents no doubt play an important role in the urban canopy, identifying and developing engagement strategies that enlist and inspire residents may in the end, be just as important as greening in public spaces.

## 2.7 Incorporating trees into urban development processes

Melbourne is set to grow to a population of 6 million by 2030. To meet housing demands urban development will occur through urban infill development and greenfield development. However, urban development trends shape the availability of space for planting: subdivisions can result in the removal of established trees for higher density dwellings, while the ratio of land to house has decreased over time. Water scarcity can also affect the urban forest and, in the Australian context, bushfire risk has seen many councils adopt intensive pruning to avoid the risks of worn powerlines sparking fires. A narrow palette of new trees is also now used to limit the height of trees that are as likely to be seen as fuel for fire as a cooling canopy. To better understand opportunities for incorporating greening in urban development processes within the Australian context, this section reports on the open-ended question: *'in your opinion, how could trees be better incorporated into urban development processes?'* Thirty-three out of fifty participants responded to this question, with most making more than one suggestion. In all, 52 comments were coded. The results are set out in Figure 8 and six key results discussed below.

Figure 8: 'How could trees be better incorporated into urban development processes?'

Suggestions	n=52 (%)
<p><u>i) Planning controls for...</u></p> <ul style="list-style-type: none"> <li>• a minimum number of trees by area or expected contribution of the development to the heat island effect (Maribyrnong; Planning, Casey)</li> <li>• a minimum provision of open space and planting (Manningham; City of Whittlesea; Cardinia) through the application of design and development overlays (DDOs) in the LPS</li> <li>• private space allocation for trees through ResCode (Cardina).</li> <li>• water sensitive urban design (City of Monash), including large commercial developments incorporating 'swales and ground level tree pits...whilst acting as a filtration system' (Darebin).</li> <li>• north and west shading to 'reduce summer heat' (Maribyrnong).</li> <li>• maintenance of all large trees (whether native or non-native) in major infrastructure projects (Council not specified), including 'local laws to protect existing vegetation on development sites' (Moonee Valley) or where trees are removed, planting opportunities 'retained' (Hume).</li> </ul>	18 (35)
<p><u>ii) Planning process improvement</u></p> <ul style="list-style-type: none"> <li>▪ earlier planning 10 (19)</li> <li>▪ internal council processes 5 (10)</li> </ul>	15 (29)
<p><u>iii) Resident engagement</u></p> <ul style="list-style-type: none"> <li>• 'buyers will lead developers' (Darebin)</li> </ul>	6 (12)
<p><u>iv) Making benefits of trees calculable</u></p> <ul style="list-style-type: none"> <li>▪ 'the full value of a tree needs to fully recognised - shade, aesthetics, climate, air quality etc. - so that their full value is included in decision making about whether to provide or maintain trees in urban developments' (Hume)</li> </ul>	5 (10)
<p><u>v) Design principles</u></p> <ul style="list-style-type: none"> <li>▪ 'softening hard landscaping to reduce the heat island effect' (Manningham);</li> </ul>	4 (8)
<p><u>vi) Linking greening and development contributions</u></p>	4 (8)

First, over a third of responses (35%) pointed to opportunities for stronger controls that set minimum standards around provision of canopy trees for shading in the development application stage (i). These included general suggestions: 'better planning rules' (council not stated); 'mandatory controls' (Darebin); 'stronger regulations such as State and Local Planning Provisions and Rescode' (Darebin). Other responses included detailed suggestions including: minimum numbers of trees relative to development area or to heat island effect of the development; open space allocation; building orientation; Water Sensitive Urban Design (WSUD); and private space allocation of trees through ResCode. Without such space, 'trees are not planted or are planted with insufficient space to grow' (Cardinia). Two respondents flagged compliance/ penalty systems (Maribyrnong City Council), and one respondent called for incentives for developers to include trees (council not specified).

Second, nearly a third of responses (29%) suggested trees needed to be considered earlier in the planning process (ii). Focusing on the entire planning and development process, participants suggested the development application process should begin with a consideration of the budget and

maintenance requirements for the urban tree canopy (City of Monash; Brimbank City Council; Hobsons Bay; Moreland); over the life of the tree (Moonee Valley). Similarly, trees 'need to be considered at the planning stage of infrastructure and incorporated into WSUD development and creative engineering solutions such as vaults, structural soils and permeable pavements' (Hume). As one participant noted, 'Trees are usually tucked into the gaps left after roads, paths, houses, etc. are planned. Trees should be higher in the list of priorities and given more space and better soils such as structural soils (Moonee Valley). At the other end of the development phase, there were indications that auditing processes at the point of completion and handover had seen better results depending on the selection and resilience of the plant stock used by developers (City of Monash; also mentioned by Latrobe City). Other suggestions related to developer engagement were information and fact sheets provided at the point of permit application. These information guides should explain requirements, the benefits of trees, and provide recommendations on species type for proponents (Maribyrnong).

Focusing on processes within council, suggestions looked to council's internal documentation and communication about the urban forest. These accounts recognised that councils were key actors in the governance of the urban canopy and positioned them as key sources of information and knowledge. Suggestions included greater communication between planning and environment departments to work collaboratively on 'choosing the right plant communities for developments, building approvals and landscaping' (Banyule). This was important particularly to ensure drought tolerant greening where preferences for indigenous plants were expressed (Environment Officer, La Trobe City Council) and being guided less by 'what's in vogue but what will succeed' (Manningham). Another participant emphasised the 'selection of more appropriate species to minimise problems with trees in the urban environment' (Greater Dandenong). Two participants also emphasised the importance of a 'significant tree register' (Darebin) seen as an important step in increasing the 'Statutory weight provided to trees.'

After planning controls and processes, resident engagement was the most common suggestion for incorporating trees into urban development (iii). Here, resident and home-owner engagement is seen to be vital 'as the buyers will lead developers' (Darebin City Council; also City of Hobsons Bay). One respondent flagged education, as a counter to resident fears (Brimbank) but others flagged the need to find out more about resident perceptions and values suggesting it was not an area that 'Council has taken a strong position on in the past' (Monash). One participant suggested 'wider education for folks looking to buy a property about the values provided by trees' (Darebin). Similarly, that 'the environmental and social value/benefit of trees could be better marketed to the community' (Parks, Moonee Valley).

A smaller group of participants (10%) also saw an opportunity for trees to be valued as assets, rather than 'write-offs' (Darebin City Council) Making the values of trees calculable was seen to be important in ensuring developers 'consider more trees as part of development proposals' (Moonee Valley). If such costing were undertaken, it would be possible, as one participant noted, to off-set tree removal. This was particularly the case where private trees are removed on smaller development sites. In this case, such removal should be

'costed and put into aerial bundling of power to improve the structure of street trees' (Moonee Valley).

Other aspects of the planning process related to design principles. These included 'softening' 'hard edges', increasing space available to large trees and designing streets to 'passively water trees' (Hume). Other suggestions were to plant trees 'cogniscent of view lines, fire risks and recreational users, as well as contributions to future biodiversity, whilst not threatening existing biodiversity values, especially grasslands and grassy understory components' (Hepburn). Finally, some respondents felt some proportion of development contributions should be earmarked for the provision of trees and two year maintenance costs (Maribyrnong City Council; Moreland; Moonee Valley). Others simply stated 'more funding' (City of Casey).

## **2.8 Conclusions: governing the urban tree canopy**

Overall, the results of the SLC online survey suggest that the provision of the tree canopy depends on a wide range of actors. Despite the significance of the urban canopy in terms of health, resilience and shading, only a small proportion of trees are protected. While there are indirect incentives for urban developers to incorporate greening into development applications, the majority of participants saw stronger planning controls as a key component of more effective greening. Still, the argument for stronger controls appears to be limited as long as the value of trees remains hidden: they are almost exclusively seen as 'costs' or 'write-offs'. Participant responses show an emerging interest in making the benefits of trees calculable, thus positioning the canopy as a core asset and important object of urban governance.

While Councils play a critical role in greening in public space and often provide guidelines for doing so in new development, the integrity of the urban forest ultimately hinges on the activities of private landowners and residents on whose beliefs and behaviours around 70% of the canopy depends. Accounts from council officers involved suggest resident values, perceptions and behaviours towards greening are mixed. Developing engagement processes that better enlist residents in the development and maintenance of the canopy seems to be a second key opportunity to enhance the urban forest. For instance, seven in ten local government officers saw residents as key people in the development and maintenance of the urban canopy. Resident opinion was also seen to be a significant issue by many participants and, notwithstanding rural-bias, many in-kind and intrinsic incentives are targeted towards or seen to benefit local residents.

With a clearer understanding of the regulatory and financial context in which the canopy is situated, the next section of the report explores the experiences of five councils 'on the ground' in Western Melbourne. The west is important since it experiences uneven tree cover, and proportionally less overall cover than eastern Melbourne (ISF 2014). These views are supplemented with an overview of canopy governance from the perspective of two key State Government authorities (the Metropolitan Planning Authority and the Office of Living Victoria).

### **3. Greening Greater Melbourne: policies and programs**

In this section we explore further the policies and programs of local governments as key actors in the provision of canopy cover. We also focus on Western Melbourne as an area of comparatively lower canopy cover, greater ecological challenges to growing large canopy trees, higher summertime temperatures and greater social diversity.

#### **3.1 Greening in public space**

It is more difficult to grow trees in the west of Melbourne due to the ecological conditions experienced in these areas. Street trees generally do not grow as quickly, nor do they achieve as large a canopy as their counterparts in other parts of Melbourne. While there is a significant sense that these conditions or constraints provide challenges for greening, for councils interviewed in this study, these ecological conditions are not seen as a reason to not attempt significant and strategic public space greening. This strength of purpose is matched by a sophisticated conceptualization of the urban forest canopy.

Councils are engaged both extensively and intensively with public space greening. Annual street tree planting in new streets, as well as 'gap' or 'infill' planting in already established streets, are in the order of 2,000-5,000 trees per annum in each of the five councils interviewed. Brimbank has additional funding to use tube stock plantings to bring this figure up to 10,000 trees across that city annually. Councils are increasingly adopting whole-of-city and canopy-minded approaches through the development of Urban Forest Strategies, tree audits and tree registers. This leads to increasingly detailed accounting and management from the scale of the whole-of-city urban forest, through precinct, suburb, neighbourhood, street and down to individual trees. Financial incentives in terms of grant money for councils seem relatively few, but include: the (Melbourne Water) Living Rivers Program (Hume), the (State Government) Ten Thousand Trees initiative (Brimbank), and the (Federal Government) Healthy Together Program (Hume, for limited community garden initiatives).

Particular attention is paid by councils to public space greening that is initially undertaken by greenfield and brownfield developers but ultimately 'inherited' by themselves. In growth areas such as Melton, developers near to match the numbers of trees planted by city councils through their programs. Councils have various policies and processes for managing the 'handover' of greenfield estate development from developers, especially around street trees, open space, and 'features' (such as stormwater treatment areas). Hume has a sophisticated multi-stage process, and a bond system, whereby the bond is retained by council if assets are not handed over in good condition. In Melton, council and developers explicitly share knowledge about what tree species are best for the area prior to developments taking place. For non-growth area councils, issues arise with smaller developers who are less committed to public space greening than larger developers (see below).

### 3.2 Resident engagement

In the majority of councils interviewed, residents engage in public space greening (mass tree-planting and regeneration) by way of their involvement in 'friends of' groups. For example, in Brimbank's Environmental Friends of Brimbank Group Directory, twelve 'friends of' groups are listed. They work in communities and neighbourhoods, river and creek systems (the Maribrynong River and Kororoit, Stony, Steele, Taylors and Jones creeks), grassland systems, and the Organ Pipes National Park. In Hobsons Bay, 'friends of' groups' tree planting and regeneration was also reported to be very significant. These activities are undertaken under direction from council (regarding location of trees and tree species to be planted). Another council (Moonee Valley) reported, however, that 'friends of' groups tended to be drawn from an ageing demographic, that younger people and families were less engaged (i.e. less able to be given lack of housing affordability and therefore work and time pressures).

Councils are attempting to encourage biophilia amongst their residents in numerous ways, including Adopt-a-Tree programs or Significant Tree Registers (which may include both remnant native and non-native tree species). Council officers are themselves vocal tree champions, and often engage in incidental education of residents as to the significant positive effects of trees. They also resist resident requests to remove trees. Councils generally have strict policy on the reasons why a tree might be removed – usually limited to direct endangerment of life or property. As one interviewee put it, "the days of the mantra 'if in doubt, pull it out' are long gone".

Perhaps as a result of this, the nature strip emerges as a space of contestation not only between council and resident (over issues of ownership, control, care and maintenance) but also as the contact zone between public and private greening. Nature strips are not private property (they're not owned by residents), but councils expect and encourage residents to maintain these spaces. This is certainly true for grassed nature strips, with councils expecting residents to mow these. In addition, some councils actively encourage residents to look after their street tree within the nature strip. For example, Hume has in the past dropped off a watering bucket and explanatory note, and Moonee Valley currently letter-boxes a card to the resident. This encouragement often relates to additional watering (additional to the watering that council has usually paid a contractor to do for 1-2 years to aid tree establishment), disease or pest attack, and also vandalism. The caring for street trees that council allows does not usually extend to pruning, for example, over which council prefers to retain expert control. Other forms of care or interference, however, are tolerated. In Hume, for example, it was reported that residents have grafted fruiting olive branches to non-fruiting street tree olive trees (see Figure 9).

Figure 9: Olive trees as street trees, City of Hume



### 3.3 Current opportunities and limits

According to the councils interviewed, concerted public space greening involves coordination across different departments, and council officers attribute their successes quite directly to this 'non-siloed' approach. Council departments or divisions such as Parks, Environment, Open Space, Urban Design, Sustainability, and (at times) Engineering or Capital Works, are often jointly involved in increasing tree canopy cover and public space greening.

Councils (and State Government) are recognising that the most significant health outcomes can be gained from increasing the amenity of 'passive open space' as opposed to 'active open space' like sports fields. It was agreed that while sports associations are vocal and well-organised and often get funding, for overall health outcomes funding would be better spent on 'passive open space' for the habitual and multi-aged, individual or small group users (see Figure 10). In many councils there are co-located initiatives around greening and open space, physical mobility (cycling and walking) and water management along linear reserves, creeks or other 'trails'. In one example from City of Brimbank, a 'whole of park' upgrade included the provision of a shelter, barbeque, toilets, drinking fountains, new tracks and 'a couple of hundred, if not more, trees' such that such areas become 'destination places and green' (Brimbank).

Figure 10: Planting in passive open space, City of Hobsons Bay.

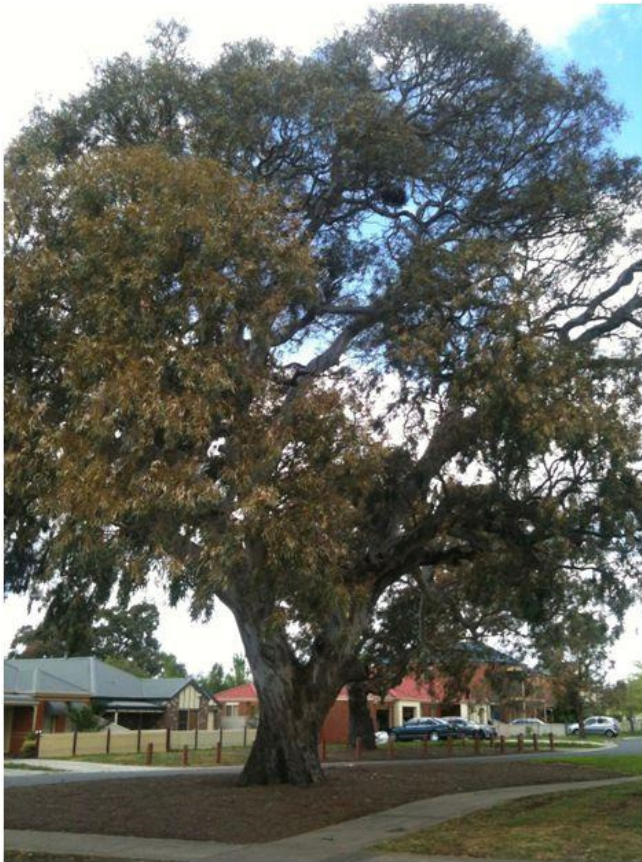


Greenfield or brownfield developers (discussed at Melton, Hume, Hobsons Bay, and also by OLV and MPA) are increasingly recognised as an internally heterogeneous group with varying degrees of knowledge about, and commitment to, lasting and appropriate public space greening. Overall, the more 'experienced' the developer, the better their approach to greening, including retention of existing vegetation (see Figure 11) and their willingness to provide open space, 'landscaping' and on-site stormwater treatment (required).

*'...[T]he large developers fundamentally are probably better equipped and better educated than the smaller ones, it's the smaller ones that tend to ... not get it. ...[T]he bigger ones ... they're going from development to development to development, so they have a brand they want to protect ... they're trying to do the right thing (Open Space Planning Coordinator, City of Melton).*



Figure 11: Remnant native trees in residential development, City of Hume



### 3.4 Concerns: a ground-eye view

Almost without exception councils interviewed for this study were concerned about the loss of existing trees in private space due to subdivision and infill development. There is also consensus recognition that this as a very difficult issue to address due to private property rights and the drive to greater urban density.

*So houses [are] being sold and a unit put at the back, so reducing the porous landscape, reducing the big okat tree in the back and increasing stormwater catchment ... the planning scheme just doesn't deal with – in a robust manner – the requirement for trees (Brimbank).*

There was a growing sense within some councils – that in order to halt the loss of trees in private space – a tree protection overlay may be warranted. It was recognised anecdotally that other councils ('bayside suburbs', i.e. in southeastern Melbourne) have such measures. Concerns were raised, however, about the possible workload for councils that such an overlay would create, and that it might be unpopular with residents, especially those whose land area and plans for subdivision were their 'retirement plan'. There was also a recognition and concern expressed regarding the trend in greenfield and brownfield developments toward larger houses on smaller blocks, leaving little space for new private space greening, and especially for greening with larger canopy trees.

In terms of heat and health, black roads, black roofs and roofs without eaves (necessitating the active cooling of houses) in new developments were also noted as being disadvantageous.

Council interviewees often reported residents' ambivalence towards trees. At its most extreme, this ambivalence can develop into 'biophobia' or 'dendrophobia' and be expressed in the form of tree vandalism, often in an attempt to retain parking space in front of residences, or responding to tree 'mess' like leaves, bark or fruit. This reported ambivalence of residents towards trees seems matched, however, by councils' own ambivalence about consultation or participation of residents. For some councils, consultations are considered prohibitively expensive and time consuming. Where consultation does occur (usually around larger upgrades of open space or activity centre areas) some council officers felt that outcomes for trees were diminished in the process. The point was made that both residents (and also commercial interests) in these areas are given an opportunity to voice opposition to trees being included in the ways in which Parks departments in councils would ideally have them. It was noted that investing in consultation (but also communication and education) might diminish tree 'invisibility' and also tree vandalism. There was an overall sense that more community engagement is needed and that how to best go about developing this was a key concern.

### **3.5 Successful programs and policies**

In summary, factors that are considered to assist local government in increasing tree-canopy cover include:

- a culture of consultation between different departments or sections within councils with the shared aim of increased greening;
- general support for trees across councils and an emerging view of trees as assets with multiple benefits rather than simply costs;
- policies that recognise that canopy cover must be planned and worked towards in terms of successive 'generational' achievements;
- the 'bundling' of mobility, amenity, compliance and greening initiatives in strategic and creative ways to maximize use of funds;
- greater coordination and consultation between local government and developers, and strong regulation of green 'asset' planting and eventual handover;
- local government support of and communication with 'friends of' groups with the shared aim of appropriate greening, especially in passive open space;
- programs that aim to 'have an intelligent conversation' about the benefits provided by trees with residents and ratepayers about greening in both public and private space, or that creative positive feelings and 'buy-in' by involving youth.

Figure 12: The Greening of Detroit: engaging (diverse) community

The Greening of Detroit provides a significant success story in terms of community engagement around greening. Over the last 25 years this organisation has been responsible for planting 85,000 trees across Greater Detroit, and regularly coordinates mass tree plantings (including street trees) almost entirely undertaken by community volunteers. As well as saving local government the labour costs that this planting would otherwise entail, 'The Greening' believes involving and training community volunteers works to foster community interest in and care for trees long after they have gone in the ground. 'The Greening' also engages in volunteer group coordination, adult and youth workforce training, environmental education for children, research into the 'ecosystem services' provided by their trees, park and greenway maintenance, and community-facilitated 'green' treatments for vacant land.

### 3.6 Future opportunities to increase canopy cover in Western Melbourne

In summary, the multiple opportunities to increase canopy cover include:

- a tree-protection overlay for significant canopy trees in private space;
- mechanisms by which developers contribute more significantly to canopy cover, indexed to their profit and/or to the canopy cover that is being lost to the development;
- the possible shift from private maintenance of front-of-house nature strips to public maintenance of centre median spaces;
- changes to the Code of Practice for the Coordination of Street Works that make better provision for street trees;
- high-level support and funding for canopy trees such as the recently-awarded '1 Million Trees' project (led by LeadWest);
- council tree 'champions' to develop a network of community tree 'champions' as a first step towards better community engagement beyond 'friends of' groups;
- community education around tree and urban canopy benefits, and further research on the best ways in which to conduct such education within diverse communities;
- possible involvement of community over contractors in street tree planting and maintenance to allow those funds to be committed to purchasing additional trees or other greening activities.

### 3.7 Social diversity and vulnerability to extreme heat events

This final section links the previous discussion of local government's efforts towards, and perceptions of, the urban tree canopy with issues of social diversity and particular groups' vulnerability to extreme heat events. The explicitly social dimensions of local government policies regarding trees and canopy cover are generally limited to: the view that trees benefit residents and that most residents appreciate trees for their visual amenity; an acknowledgement of the role of 'friends of' groups in planting, maintaining and advocating for trees; a recognition of the diverse responses of residents to trees in different spaces; some ambivalence towards residents or commercial stakeholders being consulted around changes to public space; and the view that residents who walk or cycle are enabled by better shading of pathways, whether for commuting, exercise or pleasure. On the question of vulnerability to extreme heat events, explicitly targeting tree provision towards lower socio-economic communities was only reported in two councils (Hobsons Bay and Hume). In Hume, a 'model street' was developed in a housing commission area of the suburb of Broadmeadows where a relatively wide nature strip allowed for the planting of Chinese elms, a significant-sized canopy tree. Anecdotally, this planting has promoted requests from residents in other (more affluent) parts of Hume city for similar street tree provision. In Hobsons Bay, a current street tree pathways project is deliberately being sited in an area of perceived social need, in the more socially diverse suburb of Laverton.

Given the established benefits of trees, and the recognition that canopy cover is both low overall (ISF 2014) and unevenly attained in Western Melbourne, a socially diverse area (as will be discussed in the next chapter), there is significant scope to attain social resilience benefits from efforts to increase canopy cover. By explicitly integrating social and ecological concerns within local government, and by educating, listening to, and involving a socially diverse constituency, the provision of tree canopy cover will in turn provide both ecological and social benefits. Furthermore, it might decrease ambivalence expressed by residents towards trees and councils' efforts.

The vulnerability of particular sectors of the community to extreme heat events in urban areas is a pressing issue for State and local government alike. The work of local government and communities around developing cooling local microclimates is underway, benefitting both public and private space. As well, and given the disproportionate risk of exposure of the young and the elderly to heat in their homes, public streets and playgrounds are a significant priority. In the next section, we begin the work of simultaneously considering the social and ecological dimensions of tree canopy cover. The aim of this study was to provide evidence of the relationship between social vulnerability and tree-canopy cover, and from this, a sense of socio-spatial vulnerability to extreme heat events. From this highly visual data we provide new rationales for renewed effort around this socio-ecological issue, based on community-consultative programs and policies. These would augment the vast, complex and effective work currently being undertaken by local governments 'on the ground'.

## 4. Spatially integrating social and ecological data

This scoping exercise combined tree canopy data derived from aerial imagery and geographical information systems, with economic and social indicators including from the 2011 Australian Bureau of Statistics (ABS) Census of Population and Housing. The goal was to explore the potential of integrating data from two distinctive fields of research: ecology and the social sciences. While both fields have developed nuanced and precise ways of measuring the natural and the social world respectively, the project brought these data and disciplines together. In particular the project aimed to examine the relationship between tree cover and social vulnerability, as well as the social benefits of greening, and the financial values of the tree canopy. From this perspective, the project builds on aspects presented in the previous two sections of this report by documenting the benefits of urban greening, and targeting greening strategies to address areas of social vulnerability.

### 4.1 Method for preliminary spatial analysis: small-area variation in tree canopy cover in Western Melbourne

Urban areas vary in their extent and type of vegetation, their extent of tree coverage, and hence their extent of shading from tree canopy. Differences in tree canopy occur at multiple spatial scales – with recent reports and projects such as “Where are all the Trees” (ISF 2014) and “Greening the West” in Melbourne highlighting a comparative lack of tree coverage in the city's western suburbs. Within broad regions, such as Melbourne's West, there are differences both between and within LGAs, and between and within suburbs. Programs to retain or increase urban tree cover may originate and be funded at the local government scale, but can be rolled out at the level of individual streets. Exploring spatial variations in tree coverage is thus relevant to exploring perceived drivers of change, the relationship between disadvantaged neighbourhoods and tree canopy within those neighbourhoods, and in providing baseline evidence against which to measure urban greening progress.

As part of the Shading Liveable Cities project we undertook a preliminary spatial analysis of the distribution of tree canopy cover over parts of Western Melbourne. This data was compiled at a relatively fine level of spatial detail – Statistical Area Level 1 (SA1s) – as defined by the Australian Bureau of Statistics (ABS) as the smallest spatial units for the release of Census data. SA1s have an average population size of 400 people. They are larger than the base unit for Australian standard Census geography – mesh blocks – but smaller than suburbs and local government areas. The preliminary analysis presented here is of 96 SA1s, across 4 local government areas. Given the resources required to collect spatial data on the distribution of tree coverage and shading at this level, the analysis is a relatively small selection of areas but is a “proof of concept” for larger-scale analysis of tree canopy data.

For each SA1, i-tree Canopy software was used to generate 200 randomly generated points on 2012 aerial photographs. In total the analysis is based on 19,343 randomly generated points within the sampled small areas. Researchers classified the randomly generated sample points into 21 categories – based on 7 main categories of tree, grass, soil, water, impervious roofs surfaces, and impervious ground surfaces. These were further categorised by broad categories of land ownership and use – public land, private commercial land, and private residential land. This generated data with which to map tree canopy in terms of variation between areas, relationships to other land uses, and their associations with other spatial variables. Using SA1 boundaries allows merging with social and economic variables from other spatial datasets including the ABS Census.

The dataset gives a view of current tree cover within selected suburbs of Greater Western Melbourne. These data are disaggregated by coverage type and by public and private ownership. In this section of the report we detail the study area and method; map variation in tree coverage at different spatial levels; and demonstrate the linking of small-area tree canopy data to socio-economic and property data.

## 4.2 Study area and units

The West of Melbourne is known to having generally low levels of tree canopy. The 2020 Vision Report (ISF 2014) similarly applied i-tree analysis at the level of LGA, and highlighted LGAs with lower than 20% and 10% tree canopy. Most Western Melbourne municipalities were in this category. While useful for highlighting broad challenges; the scale of LGA is not suited for helping to target, prioritise and plan within a LGA, which is typically the government level at which intervention and strategy can respond. The maps at Figure 13 show LGA level tree canopy data from the 2020 Report – with Western Melbourne LGAs, at this level of aggregation, having less than 10% canopy cover. On the right, SA1 boundaries are overlaid to illustrate the finer level of spatial detail that can be offered through the approach piloted here.

There are 96 small areas (SA1s) in the pilot study area. These are across four suburbs (SA2s) – Laverton (11); Seddon-Kingsville (19); Williamstown (34); and Yarraville (32). The suburbs are across three LGAs: Hobsons Bay with Williamstown and part of Laverton; Wyndham with part of Laverton; and Maribyrnong with Yarraville and Seddon-Kingsville. Relationships between SA1s, suburbs, and LGAs are shown at Table 1.

Williamstown was selected for being likely to have a larger and more established tree canopy, and for having likely variations within older and more recently developed areas. Laverton is a partly industrial suburb, selected because it has undergone recent development in parts and is likely to be the site of a future investment in urban greening. Seddon-Kingsville and Yarraville both have a mix of industrial and residential areas, and are undergoing infill redevelopment particularly in areas closer to the Melbourne CBD. Overall the sampled suburbs offer a mix of land use and development types. A map showing the spatial units is shown at Figure 14.

Table 1: Study area – small areas (SA1s) by suburb and local government area

Suburb	Local Government Area	Number of Small Areas (SA1s)
Laverton	Wyndham (part); Hobsons Bay (part)	11
Seddon-Kingsville	Maribyrnong	19
Williamstown	Hobsons Bay	34
Yarraville	Maribyrnong	32
<b>Total</b>		<b>96</b>

Figure 13: LGA level data overlaid with SA1 boundaries (based on ISF 2014)

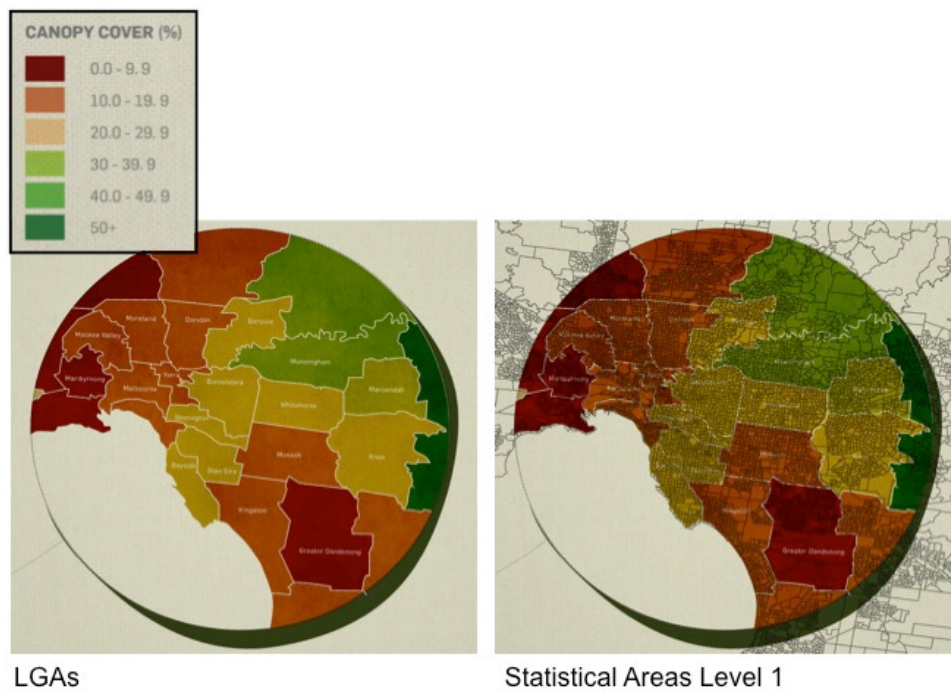
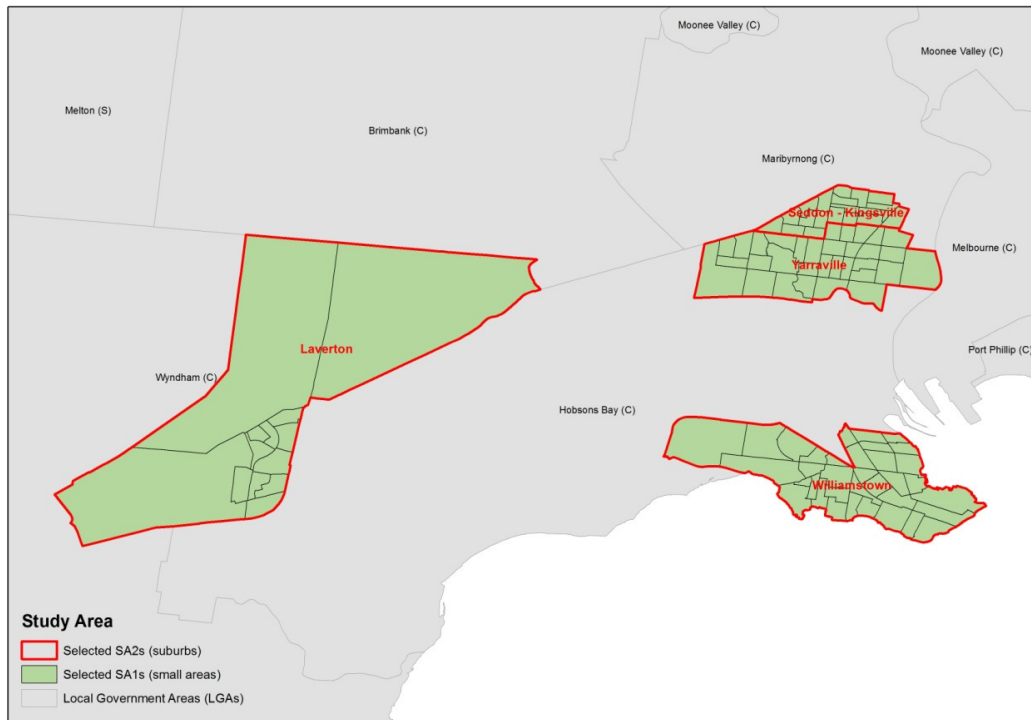


Figure 14: Quantitative study area and spatial units



### 4.3 Tree Canopy Data collection

i-Tree Canopy is free software developed by the USDA Forest Service ([www.itreetools.org](http://www.itreetools.org)). It uses Google Maps aerial photography and then generates random points within user-defined spatial areas on those aerial images. Users then categorise the randomly generated sample points into land use categories, building a database with which to estimate tree coverage by area.

The analysis here is based on i-Tree Canopy analysis of 2012 Aerial Photographs, with 96 SA1s as the defined areas. There were 200 random points generated per SA1 area. We trialled the sensitivity of different point collection numbers, and determined 200 points per area as offering acceptable error margins. In total, researchers categorised 19,343 randomly generated points across the sample area, applying 21 categories of tree coverage.

These categories are based on 7 main land surface categories: tree, grass, soil, water, impervious roofs surfaces, and impervious ground surfaces. These were further categorised according to land ownership and use: public land, private commercial land, and private residential land. Identification of public and private land, and commercial versus residential land, was made using zoning and cadastral maps. The land use and shading categories and their relationships are shown at Figure 16. As the diagram suggests, the point data may be aggregated into coverage type (tree, grass, soil, water, roof impervious, ground impervious); or into ownership type; or can be explored at the level of specific categories. These are as follows:



- Tree/shrub over Private impervious
- Tree/shrub over Public impervious
- Tree/shrub over Private pervious (grass soil gravel)
- Tree/shrub over Public pervious (grass soil gravel)
- Grass Private
- Grass Public
- Soil/gravel Private
- Soil/gravel Public
- Water Private
- Water Public
- Roof impervious Private
- Roof impervious Public
- Ground impervious Private
- Ground impervious Public

Some level of uncertainty with identifying and classifying the random points on aerial imagery is unavoidable. Researchers generated additional sample points where identification was not possible. Other difficulties experienced in data collection and coding included the size and quickly changing zoning and land use status of parts of Laverton. The Laverton area is being redeveloped from commonwealth land to residential, and includes areas of ambiguous public or private land. In addition, drier areas were at times difficult to classify as soil or grass; alleyways were difficult to classify as grass or impervious; and several properties were ambiguous in terms of being public or private land. The distinction between public and private is relevant to exploring drivers of tree coverage – private ownership or public management – however, this distinction is the more prone to error. Identifying tree canopy points was comparatively simple. The example at Figure 15 shows a tree canopy over impervious ground – in this case, a public road.

Figure 15: Example of data collection in i-tree Canopy

The screenshot displays the i-Tree Canopy v6.1 web interface. At the top, there is a navigation menu with buttons for Home, About, Applications, Utilities, Resources, Support, and News. A search bar and login/register options are also present. The main content area is divided into two sections:

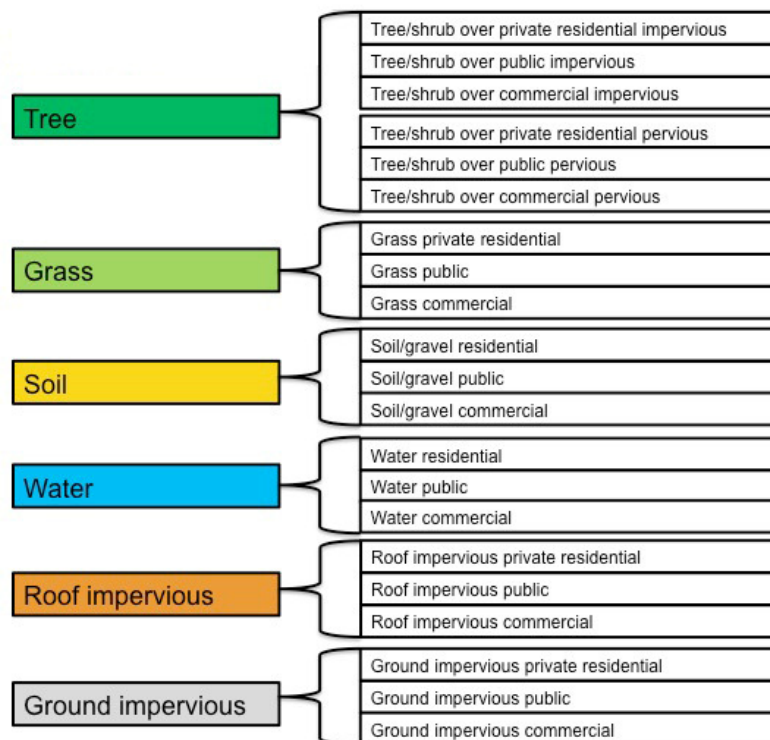
**Map Section:** A Google Map showing a street labeled "Charles St". A vertical line is drawn across the map, indicating a survey transect. The map includes standard Google Maps controls like zoom in/out and pan.

**Data Section:** A bar chart titled "i-Tree Canopy v6.1 Percent Cover (±SE)" shows the percentage of cover for various tree species. The y-axis ranges from 0 to 50. Below the chart is a table with the following data:

Id	Cover Class	Latitude	Longitude
201	Tree/shrub over private residenti	-37.80625	144.88519
202	Tree/shrub over private residenti	-37.80647	144.88893
203	Tree/shrub over private resident	-37.80601	144.88616

Below the table, there is a "Save Your Data" section with a "Save Data" button and the text: "Save Early. Save Often. Don't lose your project data!".

Figure 16: Land use and shading categories for data collection



#### 4.4 Initial Results: Variation in tree canopy between suburbs and between public and private land

Initial analysis of the results indicates that even within the Western Melbourne study area, levels of tree canopy cover vary widely at the small area level. Previous research has shown that Western Melbourne LGAs have, at the aggregate level, very low levels of tree canopy cover relative to Melbourne overall and to Australian cities generally – typically less than 20% and sometimes less than 10%.

Consistent with these findings, across each of the suburbs in the pilot study area, small areas (SA1s) had an average total tree canopy cover of 17.44%. However, it is notable how wide the range of this canopy cover was – some SA1s had total tree canopy cover as low as 4.5% and others as high as 29.2%. Spatial variation was evident between suburbs – on average Williamstown areas had tree canopy cover of 18.79%, compared to 14.76% in Laverton. Spatial variation was also evident within suburbs - each of the sample suburbs had SA1s with relatively low coverage (although all SA1s in Williamstown were 10% or higher and all in Laverton were less than 20%). The widest variation in total tree canopy coverage was in Yarraville.

A key finding is thus that spatial scale matters – that canopy cover varies considerably at the local level. This carries important implications for program implementation.

There were more marked differences between and within the four suburbs in public tree canopy cover – including public gardens and streets. In Williamstown some SAIs have as much as 24% public tree canopy cover; and similarly in Yarraville as high as 16%. In Laverton and in Seddon-Kingsville by contrast only 11% of public land comprised tree canopy cover. This may reflect differences in public green space area; differences in public street tree planting; or differences in the style of public landscaping (grass and shrubs versus trees).

Variation in private tree canopy cover – trees on private residential and commercial land – did not vary as widely across the study area. On average, Seddon-Kingsville had 13.14% tree canopy over private land; compared to lower proportions in Laverton (9.45%), Yarraville (9.7%) and Williamstown (10.26%).

Figure 17: Tree canopy cover (% of SAIs) by Suburb

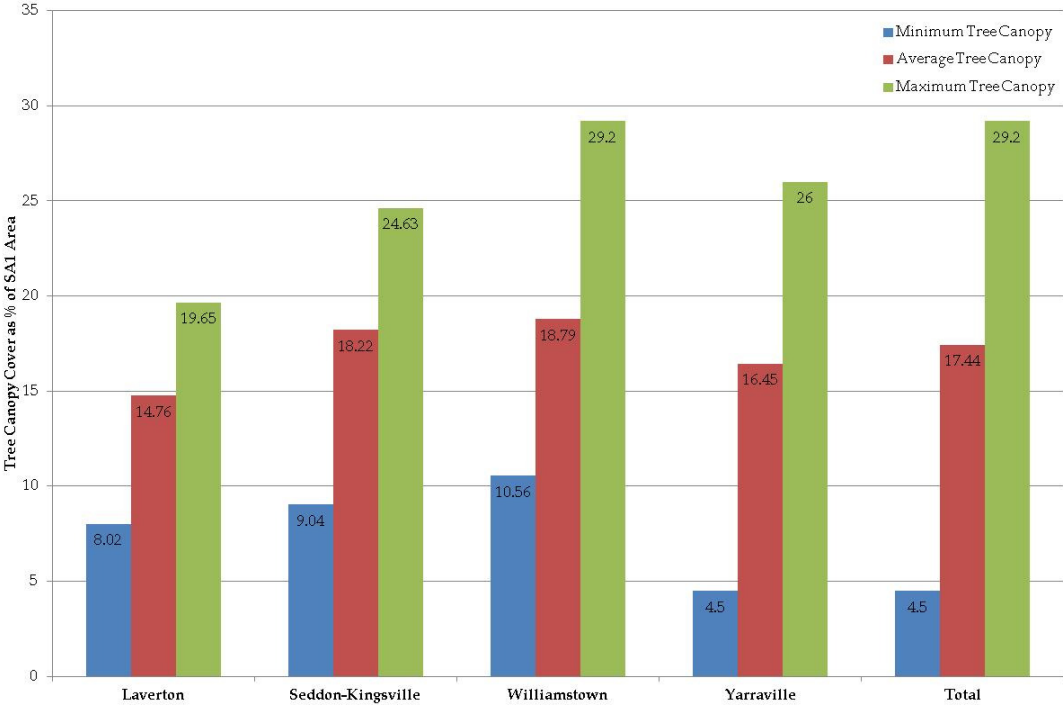


Figure 18: Public tree canopy cover (% of SA1s) by Suburb

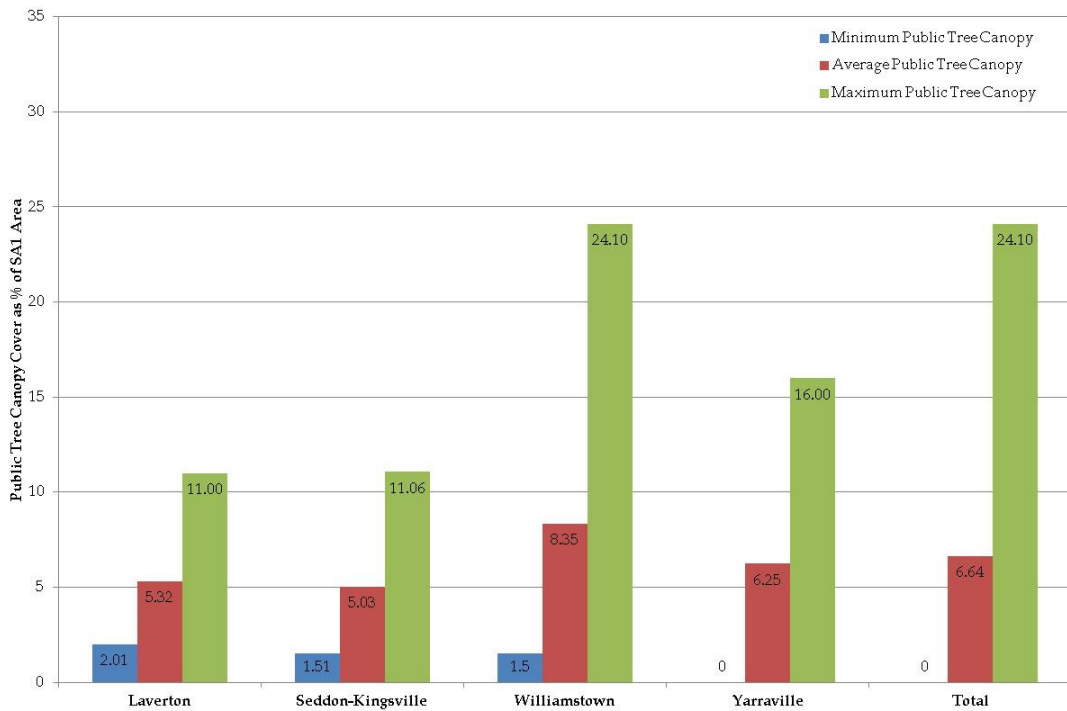
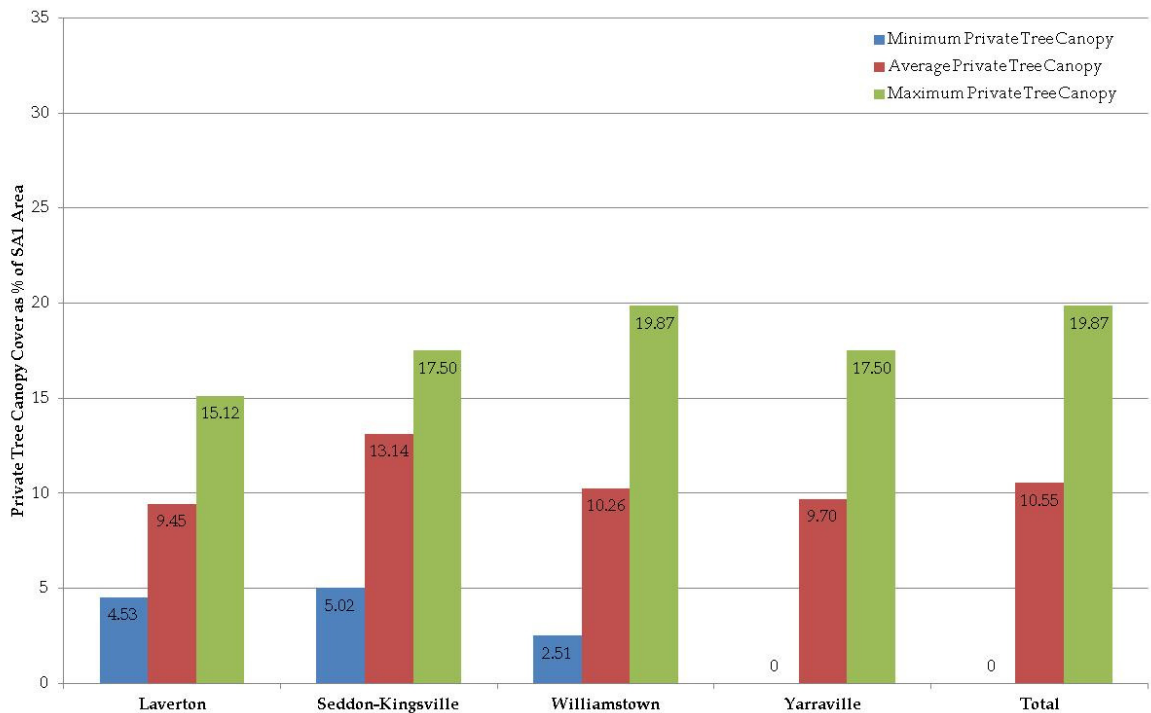


Figure 19: Private tree canopy cover (% of SA1s) by Suburb



#### 4.5 Initial Results: Spatial distribution of tree canopy

The suburb of Laverton, as noted, presented difficulty in data collection and coding – much of its area is under redevelopment away from Commonwealth owned industrial or military uses, toward residential use. Parts to the East (within Hobsons Bay) are more established residential areas –with quite low tree canopy cover. Large parts of Laverton have below 10% tree canopy cover, in part because so much of the area is comprised of soil and grass (the latter accounting for on average 33% of small areas in Laverton). Distribution of total tree canopy across Laverton is mapped at Figure 20 and the share of ground cover is in the graph at Figure 24. Compared to the other suburbs, Laverton has relatively low proportions of impervious ground (21%) and roof (20%) surfaces.

By contrast the suburb of Williamstown contains areas of very high tree canopy – the older, central areas along the railway line; and a newly developed area to the west (Figure 21). More commercial areas along the shoreline are lower in canopy cover. Parts of Williamstown are noticeably 'leafy' and have nearly 30% tree canopy cover, much of it, as noted, from public trees – street trees and gardens. The average tree canopy cover for small areas in Williamstown is 19%. Williamstown also had comparatively high proportions of impervious ground (27%) and roof (26%) surfaces (Figure 25). There were no parts of Williamstown with lower than 10% tree canopy cover, although private canopy cover was low in parts.

The suburb of Yarraville encompasses a mix of urban land uses, and consequently a patchwork pattern of tree canopy cover (Figure 22). In the far West of the suburb are industrial areas adjoining the highly industrial area of Brooklyn – home to former and current landfills, food processing facilities, and other low amenity land uses. These parts of Yarraville are low in tree canopy cover (below 10%) and also expected to undergo residential redevelopment in coming years. In the East of Yarraville, along the Yarra River, are also comparatively industrial areas with low tree canopy cover. The central parts of Yarraville (the so-named 'village') have very high canopy cover in part through the presence of gardens and street plantings.

The suburb of Seddon-Kingsville is the most inner-city of the study area and is comparatively highly developed (Figure 23). On average at the small area level a high proportion, 37%, of area is impervious roof surface; and 30% is impervious ground surface (Figure 23). The average tree canopy cover in the area was 18%. Most canopy cover was over private land rather than public.

Figure 20: Tree canopy coverage by SA1, Laverton

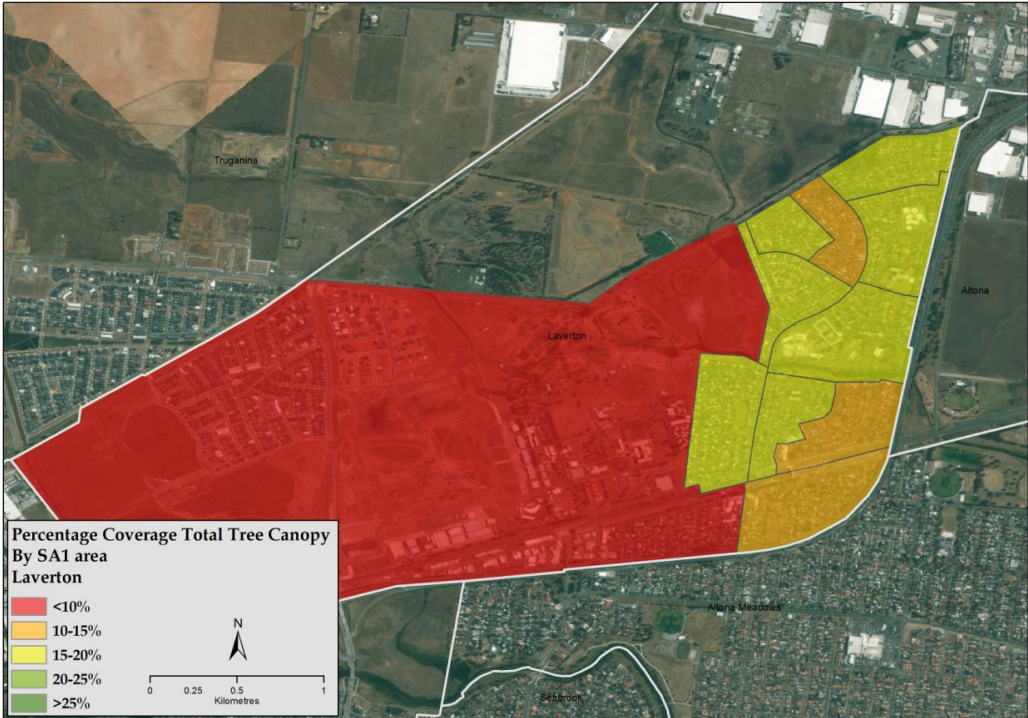


Figure 21: Tree canopy coverage by SA1, Williamstown

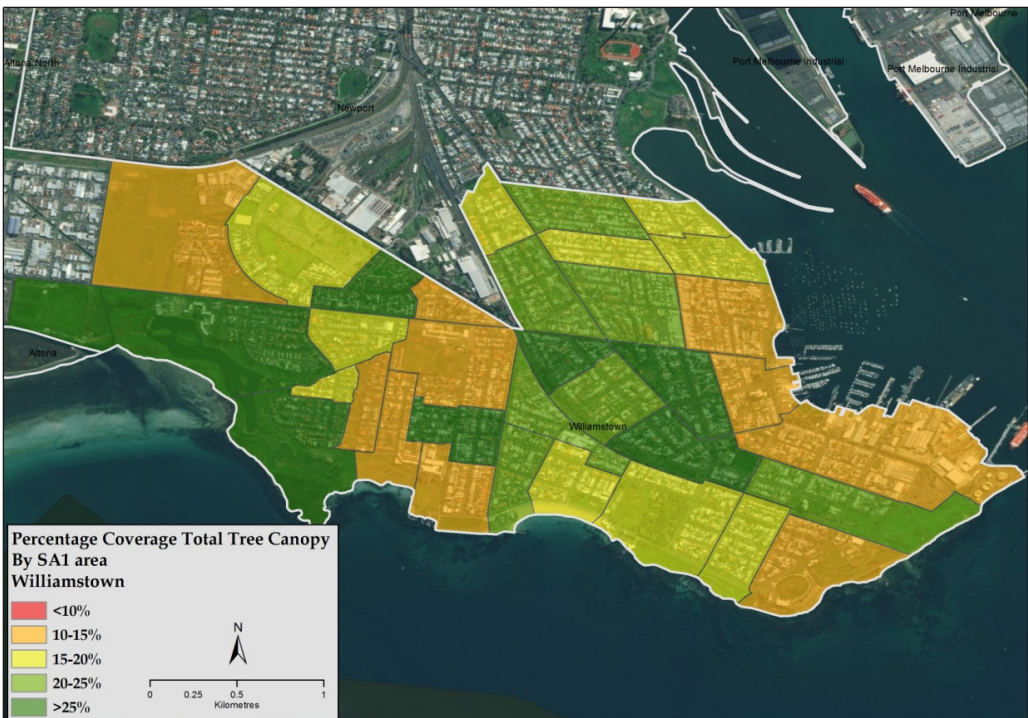


Figure 22: Tree canopy coverage by SA1, Yarraville

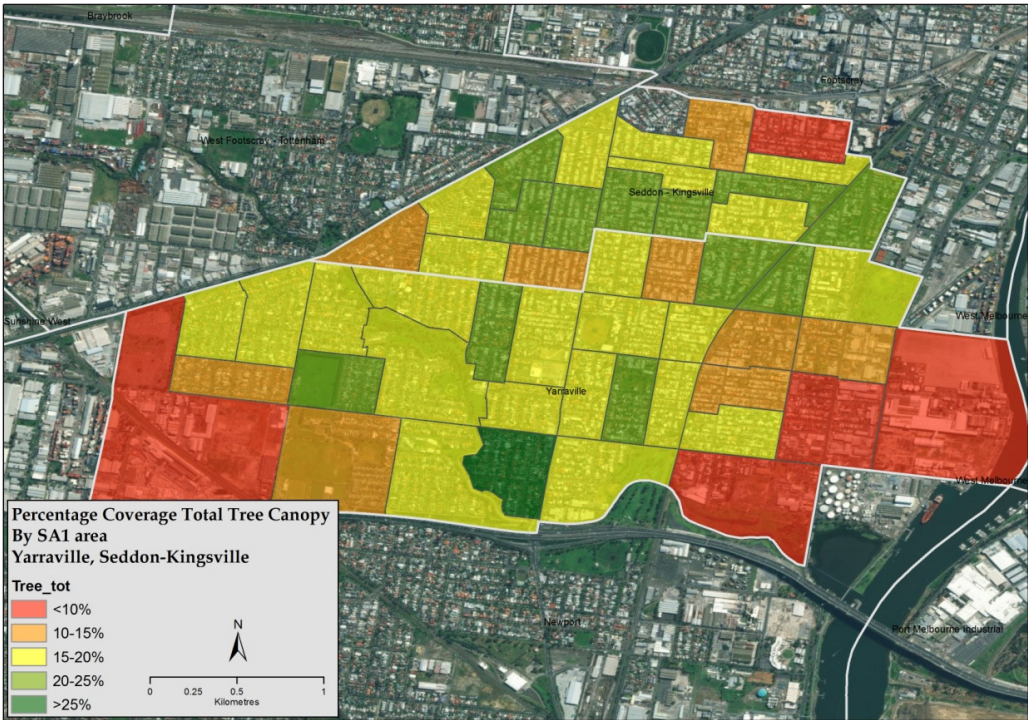


Figure 23: Tree canopy coverage by SA1, Seddon-Kingsville

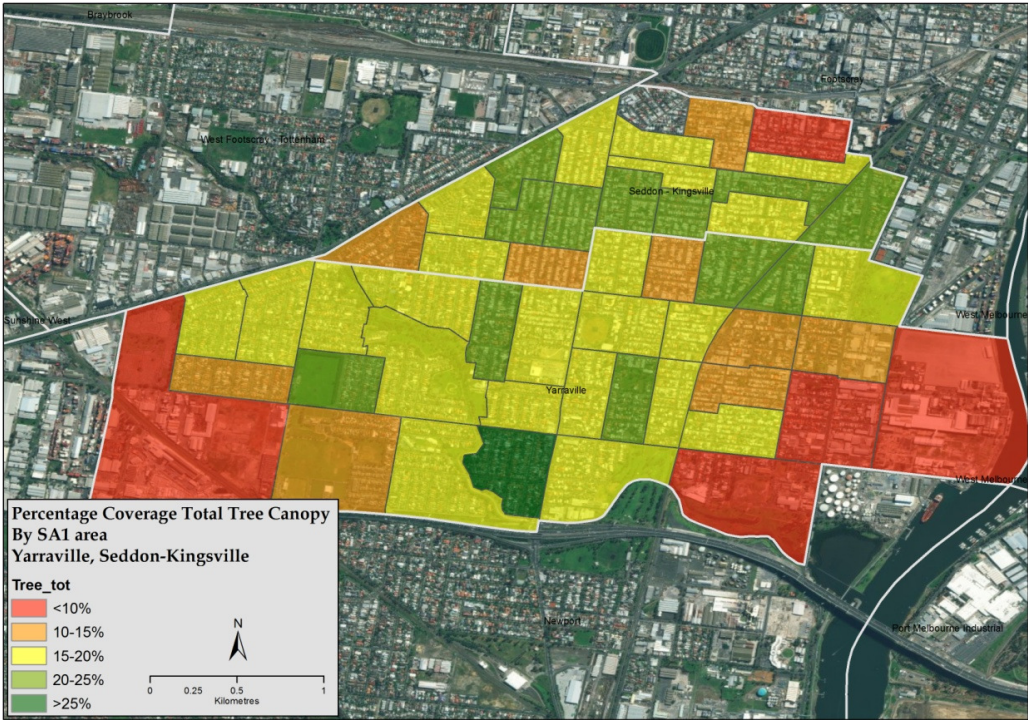




Figure 24: Laverton by average share of ground cover (SA1s)

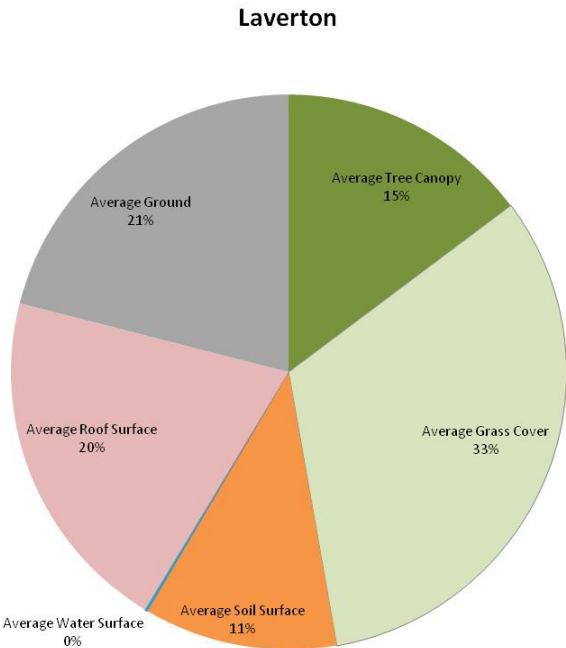


Figure 25: Williamstown by average share of ground cover (SA1s)

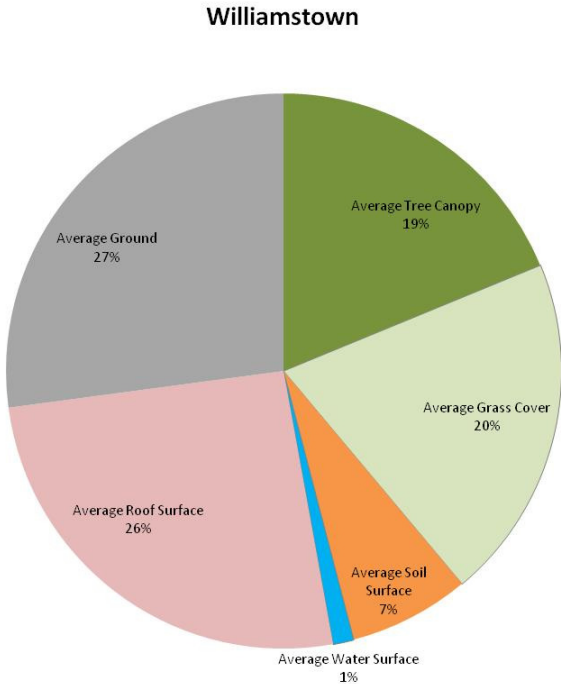


Figure 26: Yarraville by average share of ground cover (SA1s)

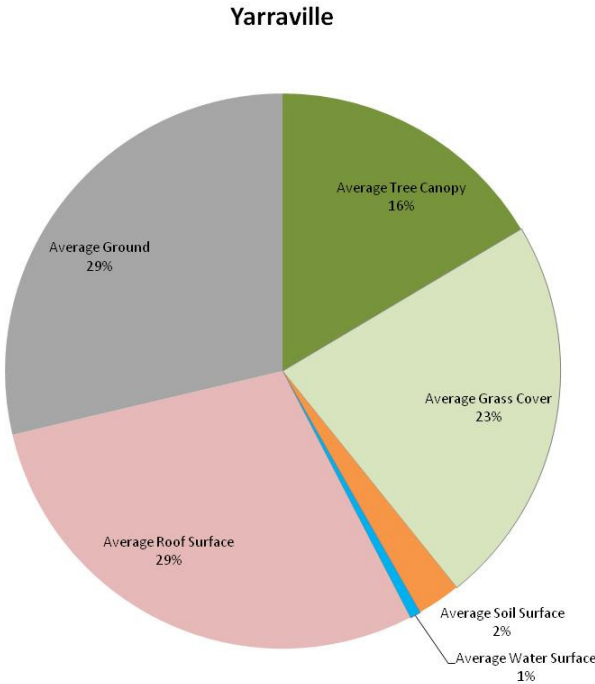
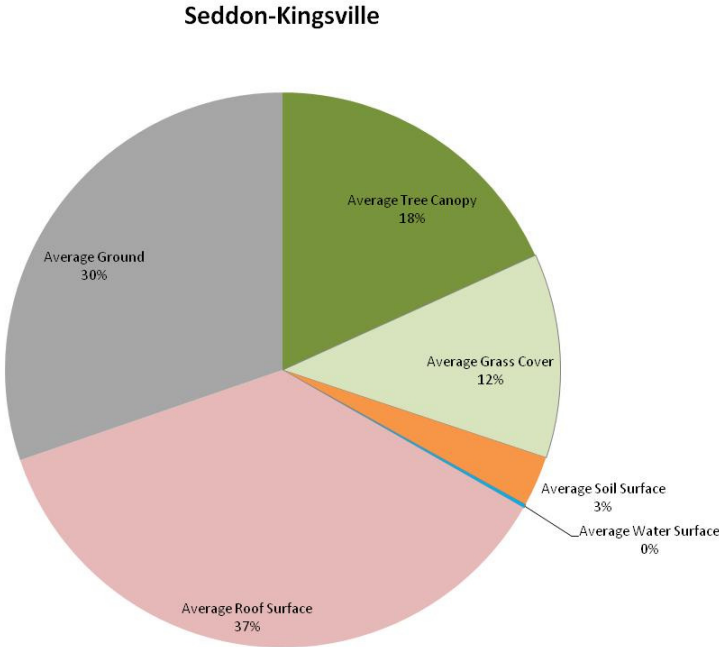


Figure 27: Seddon-Kingsville by average share of ground cover (SA1s)



## 4.6 Method: Socio-economic predictors and spatial variation in urban tree canopy

To explore spatial variation in tree canopy cover further we combined the small area (SA1) canopy data with social and economic variables extracted from the 2011 Census. Using descriptive statistics and correlations, we explored spatial correlation between measures of tree canopy; urban footprint; and social and economic variables.

Our principle question was – at the small area level, to what extent are socio-economic factors associated with higher levels of tree canopy cover? Can we predict tree canopy cover at the small area level by social and demographic factors? In exploring this question, we controlled for the extent to which socio-economic factors are also associated with differences in development and density. We also took into account measures of basic differences between areas such as distance to the Melbourne CBD and distance to the shoreline (waterfront areas traditionally being more desirable).

We tested for the relationship between socio-economic variables and total tree canopy; private tree canopy; and public tree canopy. This analysis does not comment on causality, only correlation. However, it provides insights into the extent to which tree coverage varies spatially. Two theories may apply – one, that socio-economic resources (education, property ownership, income) lead to successful influence on public tree planting investment as well as to higher investment in planting on private property. Second, that the relative 'leafiness' of an area attracts higher housing prices and, in turn, residents of differing socio-economic makeup.

In the analysis we removed very low population SA1s. The core dataset is 91 SA1 across the three sampled suburbs in Western Melbourne. Variables are as follows (Table 2).

### **Dependent variables (tree coverage)**

- Total tree cover
- Private residential tree cover
- Public tree cover
  
- **Socio-economic data**
  - Percentage tertiary educated
  - Median household income
  - Percentage homeowners – dwellings owned or mortgaged
  - Unemployment rate
  - Labour force participation rate
  - Overseas born who arrived in last 5 years
  - Migration – moved in last 5 years
  
- **Density and development data**
  - Population density
  - Household density
  - Vehicle density
  - Percentage of higher density housing

- **Landscape and location**
  - o Distance from CBD
  - o Distance from ocean

#### 4.7 Results: Tree coverage correlations

Total tree cover is, unsurprisingly, significantly correlated to: Private tree cover (positive) and public tree cover (also positive) (Table 2). Total tree cover has a significant negative correlation to the distance to the Melbourne CBD: that is, the further from the CBD, the lower the total percentage of tree cover. It has a significant negative correlation to the unemployment rate: that is, the higher the unemployment rate, the lower the total tree cover. Total tree cover is significantly negatively correlated to areas with high proportions of recent overseas migrants; and to areas where a high proportion of the population had moved within the last 5 years. Other variables did not have a significant correlation (Table 2).

Private tree cover is, unsurprisingly, significantly correlated to total tree cover. It has a negative correlation to public tree cover: suggesting that areas with higher private tree canopy actually have slightly less public tree canopy. The only other variables significantly correlated to private tree cover were measures of population and dwelling density: which were significant and positive. The higher the density of development, the higher the level of tree cover in the area. This may be partly understood by considering that grass cover is negatively associated with density: lower density areas in the sample had more lawn, but less tree cover. In addition, the measure of density used is fairly basic: total population and total dwellings, divided by the area size. The other measure of density used – higher density housing (housing other than detached dwellings) as a percentage of dwellings – was not significantly associated with any tree measure (Table 2).

Public tree canopy cover was significantly related to total tree canopy, and had a negative correlation to private tree canopy as noted. Public tree canopy was significantly negatively correlated to the distance to the coast: in the sample, areas further from the ocean had lower public tree cover. Public tree cover was significantly negatively correlated with the unemployment rate: areas with higher unemployment had lower public tree coverage. Public tree canopy was negatively correlated with areas with high rates of recent migration, and was negatively correlated with measures of population and development density (Table 2).

Other correlations within the SA1 dataset included distance to CBD, which is negatively correlated to median household income: meaning that the further from the CBD, the lower the median income. Distance to CBD was positively associated with higher unemployment (more distant areas had higher unemployment); negatively correlated to labour force participation (more distant areas had lower labour force participation); negatively correlated to tertiary educated (more distant areas had lower percentages of tertiary education); negatively correlated to higher density housing (less higher density housing further from the CBD); positively correlated to overseas

migration (higher proportions of migrants further from the CBD); and negatively correlated to density (lower density further from the CBD).

Owner occupation was significantly positively correlated to higher median incomes; to lower unemployment rates; higher rates of tertiary education; lower proportions of higher density housing; and lower proportions of recent migrants.

Median household income was significantly correlated to the distance from the CBD and coast (negative – incomes lowered with distance from CBD and coast); to owner occupation; lower rates of unemployment; and higher rates of tertiary education.

Table 2: Pearson correlations: Statistical Local Areas in sample (n=93) by tree coverage, socio-economic, and development data

	Total tree cover	Private tree cover	Public tree cover	Distance to CBD	Distance to Coast	% Owner occupied	Median hhold. income	Unemp. Rate	Labour Force Part.	% Tertiary Educated	% Higher Density Housing	% OS Arrivals <5 years	% Moved <5 years	Pop. Density	Dwelling Density
Total tree cover	1.000	<b>.545**</b>	<b>.640**</b>	<b>-.205*</b>	-0.157	0.181	0.095	<b>-.377**</b>	-0.028	0.181	-0.055	<b>-.280**</b>	<b>-.316**</b>	0.141	0.104
Private tree cover		1.000	<b>-.287**</b>	-0.113	0.158	0.014	-0.021	-0.127	0.075	0.132	-0.165	-0.121	-0.113	<b>.558**</b>	<b>.523**</b>
Public tree cover			1.000	-0.098	<b>-.305**</b>	0.194	0.125	<b>-.294**</b>	-0.122	0.077	0.078	-0.197	<b>-.259*</b>	<b>-.335**</b>	<b>-.350**</b>
Distance to CBD				1.000	<b>.409**</b>	-0.169	<b>-.367**</b>	<b>.705**</b>	<b>-.534**</b>	<b>-.706**</b>	<b>-.299**</b>	<b>.697**</b>	0.152	<b>-.375**</b>	<b>-.407**</b>
Distance to Coast					1.000	<b>-.273**</b>	<b>-.400**</b>	<b>.375**</b>	-0.108	<b>-.311**</b>	<b>-.379**</b>	<b>.429**</b>	<b>.252*</b>	<b>.241*</b>	<b>.256*</b>
% Owner occupied						1.000	<b>.687**</b>	<b>-.424**</b>	<b>.240*</b>	<b>.314**</b>	<b>-.438**</b>	<b>-.449**</b>	<b>-.601**</b>	-0.116	<b>-.236*</b>
Median household income							1.000	<b>-.536**</b>	<b>.600**</b>	<b>.655**</b>	-0.144	<b>-.378**</b>	<b>-.260*</b>	0.079	-0.041
Unemployment Rate								1.000	<b>-.420**</b>	<b>-.674**</b>	-0.101	<b>.524**</b>	0.172	-0.203	-0.182
Labour Force Participation									1.000	<b>.737**</b>	0.069	<b>-.231*</b>	0.167	<b>.357**</b>	<b>.353**</b>
% Tertiary Educated										1.000	0.090	<b>-.361**</b>	-0.016	<b>.405**</b>	<b>.390**</b>
% Higher Density Housing											1.000	-0.052	<b>.357**</b>	0.006	0.093
% OS Arrivals <5 years												1.000	<b>.609**</b>	-0.200	-0.168
% Moved <5 years													1.000	0.047	0.130
Population Density														1.000	<b>.969**</b>
Dwelling Density															1.000
Car Density															

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

## 4.8 Model Results: Tree Coverage

We developed ordinary least squares linear regression models on from three measures of tree canopy cover at the small area (SA1) level:

- Total tree canopy cover (%)
- Private tree canopy cover (%)
- Public tree canopy cover (%)

These predictive models comprise socio-economic variables at the SA1 level as drawn from the 2011 Census; as follows:

- Median household income
- Tertiary education (% of adults 15+)
- Recent migration (people who moved within the last 5 years)
- Owner occupation (% of dwellings owned or mortgaged)
- Unemployment rate

In addition, measures of density, landscape and location were integrated, as follows:

- Distance to CBD
- Distance to coast
- Population density (population divided by SA1 size in square kilometres)
- Higher density housing (dwellings other than separate houses, as % of dwellings)

The predictive models were developed in four stages (Table 3), progressively adding measures of socio-economic status, then density and finally landscape location. Adjusted R Square values for each iterative version of the model are shown in Table 3. These models predict a relatively small amount of variance in tree cover at the small area level. Overall, the models - comprising socio-economic variables, combined with some locational characteristics - explain between 22% and 31% of the variation in tree coverage at the SA1 level.

Using only tertiary education and median household income as explanatory variables, offers no significant prediction of tree canopy cover (Table 4). By adding the variable of recent migration, model 2 becomes moderately significant (Table 4). Recent migration is negatively associated with total tree coverage and public tree coverage; and tertiary education is positively associated with total tree coverage and private tree coverage.

The third predictive model includes unemployment rate, which is a significant predictor. An increase in unemployment rate significantly decreases total tree coverage and public tree coverage.

The fourth version of the predictive model also includes distance measures of landscape location. Distance to CBD is a moderately positive factor (increased distance increases tree cover and private tree cover), although the correlation overall between CBD distance and tree coverage is negative (Table 4).

The key finding from these developed models is that local variation in unemployment rate correlates significantly with variation in tree cover. Population turnover, and higher unemployment rates, are strongly and negatively associated with tree coverage; this is particularly true for public tree coverage. Other predictors of tree coverage – higher socio-economic status including income and education – are comparatively weak predictors. The relationship between unemployment and public tree coverage, and population turnover and public tree coverage, points to the importance of community engagement and people's secure tenure in place.

Table 3: Adjusted R square values, models of tree canopy coverage at SA1 level

Model	Adjusted R Square		
	Total trees	Private trees	Public trees
1 - Median household income, tertiary education	.012	.016	-.006
2 - Median household income, tertiary education, recent migration (5 years), owner occupation	.112	.023	.031
3 - Median household income, tertiary education, recent moves (<5 years), owner occupation, unemployment rate	.200	.014	.103
4 - Median household income, tertiary education, recent moves (<5 years), owner occupation, unemployment rate, distance to coast, distance to CBD, population density, higher density housing	.218	.311	.258



Table 4: Coefficients, models of tree canopy coverage at SA1 level

		Total trees		Private trees		Public trees	
		Coeff.	Sig	Coeff.	Sig	Coeff.	Sig
1	(Constant)	14.751	.000	9.489	.000	5.104	.005
	% Tertiary Educated	0.058	.133	0.059	.066	-0.002	.949
	Median household	0.000	.764	-0.002	.174	0.001	.347
2	(Constant)	22.929	.000	13.288	.006	9.760	.057
	% Tertiary Educated	<b>0.086</b>	.025	<b>0.070</b>	.036	0.016	.658
	Median household	-0.002	.244	-0.002	.175	0.000	.992
	% Owner occupied	0.005	.938	-0.005	.932	0.010	.873
	% Moved <5 years	<b>-0.211</b>	.006	-0.090	.176	<b>-0.127</b>	.076
3	(Constant)	33.849	.000	14.820	.011	18.758	.002
	% Tertiary Educated	0.009	.827	0.059	.137	-0.047	.245
	Median household	-0.002	.276	-0.002	.184	0.000	.896
	% Owner occupied	-0.035	.575	-0.010	.856	-0.023	.693
	% Moved <5 years	<b>-0.204</b>	.006	-0.089	.182	<b>-0.121</b>	.078
	Unemployment	<b>-0.801</b>	.002	-0.112	.622	<b>-0.660</b>	.006
4	(Constant)	31.674	.000	6.618	.193	24.036	.000
	% Tertiary Educated	0.052	.326	0.000	1.000	0.059	.205
	Median household	-0.003	.079	-0.002	.215	-0.002	.327
	% Owner occupied	-0.051	.444	0.031	.544	-0.083	.153
	% Moved <5 years	<b>-0.213</b>	.008	-0.060	.330	<b>-0.165</b>	.017
	Unemployment	<b>-1.041</b>	.000	<b>-0.313</b>	.159	<b>-0.759</b>	.003
	Distance to CBD	<b>0.364</b>	.105	<b>0.259</b>	.141	0.191	.328
	Distance to Coast	-0.320	.404	-0.144	.632	-0.200	.549
	Population Density	0.002	.167	0.002	.099	0.000	.821
	Dwelling Density	-0.005	.265	-0.001	.828	-0.004	.266

Note: bold text indicates statistical significance.

## 4.9 Model Results: House Prices

We also applied a final modelling approach, this time based on individual house sale prices in the sampled regions. These models are hedonic price models – attempts to explain property sale prices based on property characteristics and characteristics of the local area; including tree canopy cover.

We extracted unit-record house sales from the Australian Property Monitors (APM) dataset from the Australian Urban Research Infrastructure Network (AURIN), and matched these by location to the SA1s in the i-Tree dataset. The sample of house prices comprises 782 houses sold in 2011. The data is limited to houses – not units or apartments, or vacant land.

Using descriptive statistics and correlations, we explored the relationship between the house sale price; and its locational characteristics including levels of local tree canopy cover (total, public, and private); when controlling for other common predictors of house price (location and size).

The property characteristics variables are as follows:

- Distance to CBD (of the SA1)
- Distance to Coast (of the SA1)
- Number of bedrooms
- Number of bathrooms
- Number of car parking spaces
- Size of property in square metres

The local area socio-economic characteristics included from the SA1 of the property sales are as follows (2011 Census):

- Median household income
- Tertiary education (% of adults 15+)
- Recent migration (people who moved within the last 5 years)
- Owner occupation (% of dwellings owned or mortgaged)
- Unemployment rate
- Population density (population divided by SA1 size in square kilometres)
- Higher density housing (dwellings other than separate houses, as % of dwellings)

The local area tree canopy measures are as follows:

- Total tree canopy cover of SA1 (%)
- Private tree canopy cover of SA1 (%)
- Public tree canopy cover of SA1 (%)

The models were run in three stages. Firstly using local tree canopy variables, then adding property characteristics, and then finally adding the socio-economic characteristics. Adjusted R Square values for each version are shown at Table 5.

Tree canopy cover could explain (correlated with) very little of the variation in house prices. However, including tree cover in combination with landscape location and property characteristics, this second model is able to explain around 37% of house price variation (Table 5). Including the additional local socio-economic variables (model 3) increases this to explain around 40% of variation in house prices in the sample areas in 2011.

On its own, total tree coverage in an SA1 is positively associated with house prices within that SA1, with each percentage increase in tree canopy cover adding \$22,019 to sale prices. A model that includes distance to CBD, distance to coast, and property characteristics still has local tree coverage as having a positive correlation with individual house sale prices. Within the studied area, increasing distance from the CBD decreases house sale price by between \$7,284 per kilometre; whereas increasing distance from the coast rapidly decreases house sale prices by \$112,339 per kilometre. Other property characteristics – bedrooms, bathrooms, and parking spaces – each added positively to property prices as expected (Table 6).

Adding socio-economic variables of the area to these predictive models is significant, although the value added is small compared to other property characteristics. In this last version of the model, each additional percentage of local tree coverage adds \$7,455 to house sales, holding other significant characteristics (location, bedrooms, bathrooms, parking spaces) constant. Holding these constant, local socio-economic characteristics are also significant to house sale prices in the study area, with tertiary education and owner occupation adding to prices; and unemployment rates significantly detracting from sale prices. The models for private tree canopy cover and for public tree canopy cover give very similar results, although the price contribution of local public trees is slightly higher.

Overall the results for the sample of 782 house sales in the sample areas in 2011 show as expected that proximity and property size are the main determinants of variations in house prices. Holding these constant, however, local socio-economic characteristics are still significant – particularly unemployment rates, which significantly reduce sale prices. The percentage of tree canopy cover in the area – its 'leafiness' – is also a significant, and positive, contributor to house sale prices. If other characteristics were identical, a house sold in a local area with 30% tree canopy cover would sell for \$149,115 more than one in a similar area with only 10% tree canopy cover.

Table 5: Adjusted R square values, models of house prices

Model	Adjusted R Square		
	Total trees	Private trees	Public trees
1 -% Tree coverage of SA1	.0823	.0004	.0860
2 -Tree coverage, distance to CBD, distance to coast, bedrooms, bathrooms, parking, lot size	.3706	.3621	.3710
3 - Tree coverage, distance to CBD, distance to coast, bedrooms, bathrooms, parking, lot size, owner occupation, median household income, tertiary education, moved <5 years, unemployment rate, population density, higher density housing	.4063	.4023	.4041

Table 6: Coefficients, models of house sale prices at property level

		Total trees		Private trees		Public trees	
		Coeff.	Sig	Coeff.	Sig	Coeff.	Sig
1	(Constant)	308,382.62	.000	655,053.89	.000	525,111.71	.000
	Tree coverage	<b>22,019.48</b>	.000	<b>3,697.09</b>	.254	<b>26,084.94</b>	.000
2	(Constant)	708,782.99	.000	829,992.23	.000	789,083.71	.000
	Tree coverage	<b>7,955.19</b>	.001	<b>2,792.21</b>	.305	<b>9,325.71</b>	.001
	Distance to CBD	<b>-7,284.80</b>	.012	<b>-8,461.40</b>	.005	<b>-9,796.00</b>	.001
	Distance to Coast	<b>-112,339.85</b>	.000	-	.000	<b>-106,469.72</b>	.000
	Num. bedrooms	<b>44,438.98</b>	.001	<b>49,248.39</b>	.000	<b>49,480.28</b>	.000
	Num. bathrooms	<b>33,246.11</b>	.084	<b>30,498.36</b>	.115	<b>30,049.16</b>	.117
	Num. parking	<b>14,778.15</b>	.146	<b>16,776.59</b>	.101	<b>14,714.01</b>	.148
	Lot size	0.07	.405	0.05	.493	0.06	.475
3	(Constant)	344,100.95	.056	497,982.15	.003	433,140.12	.012
	Tree coverage	<b>7,455.76</b>	.006	<b>5,149.62</b>	.117	<b>6,686.29</b>	.030
	Distance to CBD	<b>3,227.22</b>	.578	<b>4,837.90</b>	.406	<b>5,515.64</b>	.333
	Distance to Coast	<b>-86,483.53</b>	.000	<b>-88,614.63</b>	.000	<b>-89,047.23</b>	.000
	Num. bedrooms	<b>68,033.37</b>	.000	<b>67,938.53</b>	.000	<b>69,433.53</b>	.000
	Num. bathrooms	<b>15,942.71</b>	.400	<b>16,058.83</b>	.398	<b>13,832.84</b>	.466
	Num. parking	<b>15,032.40</b>	.136	<b>14,620.35</b>	.149	<b>15,780.22</b>	.119
	Lot size	-0.01	.860	-0.02	.841	-0.01	.870
	Med HHold inc.	<b>59.33</b>	.194	<b>43.16</b>	.340	<b>45.79</b>	.310
	% Tertiary Educ.	<b>598.22</b>	.643	<b>839.01</b>	.517	<b>515.98</b>	.691
	Moved <5 years	<b>99.07</b>	.447	<b>-15.24</b>	.900	<b>52.36</b>	.681
	% Owner occupied	<b>1,801.41</b>	.259	<b>1,835.96</b>	.252	<b>1,892.41</b>	.236
	Unemployment rate	<b>-23,530.89</b>	.005	<b>-29,409.21</b>	.000	<b>-28,018.00</b>	.000
	Population density	<b>-8.32</b>	.448	<b>-16.51</b>	.190	<b>3.28</b>	.783
	% Higher density housing	<b>1,949.46</b>	.014	<b>1,991.48</b>	.014	<b>1,625.82</b>	.042

Note: bold text indicates statistical significance.

## 5. Stakeholder perceptions: challenges, opportunities and future research

On November 6 2014, the SLC project hosted a one-day stakeholder workshop. In the morning of this workshop a number of presentations were made, including those by an international guest speaker, Rebecca Salminen Witt from the organisation 'The Greening of Detroit' (USA) (see Figure 12), and an Australian social resilience and heat expert Dr Fiona Miller (Macquarie University, Sydney). As well, preliminary results of the SLC research project were presented. In the afternoon of the workshop, a group discussion was facilitated. This discussion allowed the SLC team to gain further input regarding the key challenges around the incentive and regulations affecting tree-canopy cover (particularly vis-à-vis the morning's research presentations). These challenges were articulated in response to four key topics: regulation and protection for trees in development controls, codes or schemes; engaging vulnerable communities around the issue of public space trees; trees in private space; and greenfield and in-fill development and trees. The late afternoon discussion centered on the question of future research, and on how to develop research opportunities between the SLC team and participating stakeholders.

### 5.1 Challenges and opportunities across key areas

A lack of regulation and protection for trees in development controls, were very important and involved many overlapping issues were found to be relevant. It was recognized that regulation and provision at the PSP-level should provide for trees prior to development occurring, for example through the clustering of services underground, or the mandating a minimum number of trees per development area. It was also acknowledged by stakeholders that additional effects of greening – such as better public health (e.g. with access to green public space) or protection of property (e.g. with stormwater management) – could add further impetus towards tree regulation and protection. It was recognised that 'landscape design' was at times an afterthought within the development process, and also often an exercise in aesthetics or beautification rather than liveability. Canopy rating tools (for both residential and commercial areas) and 'green credential' or 'liveability credential' point-of-sale information were also discussed, as mechanisms for linking the provision and protection of trees in local areas and house and/or land offers that buyers seek. The influencing of buyers was suggested as an on mass influence on developers. The point was made, however, that equity must be consistently considered so as to avoid a situation in which only the rich can afford a cooler home.

Engaging vulnerable communities around the issues of trees in public space was considered in terms of the inability of communities' to cope with unexpected change (such as extreme heat events). Some stakeholders felt that expectations had changed considerably and that far more was expected of local government in terms of services than councils could deliver.

Others felt that information sharing was necessary to build community engagement, but that this information sharing was not occurring. It was recognised that community membership varies significantly, and that many community members are time-poor and hard to engage outside of work hours, and community engagement and education initiatives would need to be mindful of this. Nature strips as a contact zone between public and private space emerged in this discussion as a possible place to initially engage residents.

The key issues discussed in relation to trees in private space were ones of cultural and behavioural change, the potential for regulating in favour of private space trees, and additional roles for local government. There was an acknowledgement that many factors were affecting tree canopy cover in private space, including the reduction of average lot size, larger house sizes, in-fill development, and the move toward 'zeroscaping' private gardens (which results in water saving but also less vegetation). There were suggestions that councils could play a 'showcasing' role (either directly or indirectly by supporting local area 'demonstration houses') and/ or a basic information-sharing role around tree selection, planting and maintenance for residents (a 'talk backyard trees with your local council' event). Guidelines for which effective and appropriate planting could be developed based on existing and future research, which may allow for tree to be planted in locations that have previously been considered too small. The need to in some way incentivise significant tree retention, and new tree planting was discussed, as was the need for education to combat 'biophobia' or 'dendrophobia'.

## **5.2 Possibilities for future research**

Stakeholders present at the workshop reiterated that policy change requires evidence-based research. There was strong emphasis that this kind of research creates the opportunity for collaborative and well-informed discussion. It was generally felt that universities could have a role in researching best practices around tree canopy cover. It was also suggested that creating metrics for shading is be useful for assessment, planning and monitoring progress over time.

At the community-level, stakeholders saw a role for research to document existing success stories. It was reported that park upgrades were currently being studied in relation to how people now use and perceive these spaces (post-upgrade). It was argued that data around the planning and implementation of greening projects would be useful, as would longitudinal studies around sustainability and maintenance of greening or tree provision initiatives. An additional nominated focus for research in this discussion was one of interaction in well-planned green spaces.

At the level of the individual, stakeholders perceived a need for research that describes and explains what makes (different) individuals care about trees and how to engage most effectively with diverse communities, as well as for research that qualified and quantified the feelings people have when they experience the urban forest.

## 6. Conclusions

There is little doubt that greening contributes to urban resilience but in most local councils in Melbourne, the urban forest is not generally as valued as a *financial* asset. Rather it is seen as a cost. Thus, there appears to be an opportunity to explore mechanisms for measuring the wider social and economic benefits of greening.

Despite the effectiveness of many LG-led greening initiatives, resident values, perceptions and behaviours towards greening play a key role in shaping the development and maintenance of the canopy. This is because the largest proportion of the canopy occurs on private property. Developing a clearer understanding of resident perspectives through community-led greening projects would provide a better insight into how best to harness citizen support for greening.

While this flags opportunities for locally-led greening in socially diverse suburbs, it also raises questions about how best to document the impacts and capture the benefits of existing and future greening programs. This is especially the case as greening often competes with other aspects of urban development and open space management.

This study shows that capturing the benefits of such initiatives, as well as targeting areas of most need, could be achieved through the use of an integrated data set matching ecological features of the canopy with social and economic features of its surrounds, potentially allowing for the socio-ecological prioritising of small areas within municipalities.

Socio-ecological data for four sample suburbs in Western Melbourne in this study showed that variation in tree canopy cover exists at smaller scales than is usually considered (e.g. within suburbs within LGAs). Taking into account this small area variation, it was found that high population turnover and unemployment were strongly and negatively associated with tree coverage; particularly public tree coverage, and that better canopy cover contributed significantly to house sale prices.

It is anticipated that integrated social and ecological data could be matched with qualitative analysis of specific greening projects capturing personal and social outcomes for diverse communities. Together this would provide a more complete assessment of the benefits of greening, situating local councils at the forefront of urban resilience.

This study also calls for new forms of community participation in order to facilitate the engagement of a diverse population in the urban forest.

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