Urban Heat and Tree Canopy Mapping: Frequently Asked Questions

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Background

Despite global efforts to reduce greenhouse gas emissions, impacts from climate change are inevitable. Adapting to climate change involves planning and action by individuals, communities and businesses to cope with the challenges and opportunities.

In an urban context, heat, tree canopy cover, water, biodiversity and urban design are particularly relevant for maintaining the wellbeing, liveability, resilience of local communities.

In South Australia we are fortunate to have locally based plans and initiatives that support communities, business and individuals in adapting to, and mitigating the economic, social and environmental impacts of climate change. Find out more about how Regional Climate Partnerships are progressing climate action in these areas and contact your local group to see how you can get involved.

The Government of South Australia's 30-Year Plan for Greater Adelaide (2017 Update) specifies a target for green cover to increase by 20% across metropolitan Adelaide by 2045. To help meet this target, the Government of South Australia and 18 local governments have partnered to understand our urban heat and tree canopy cover across the Adelaide metropolitan area. This data is available to be viewed via an online mapping portal.

This mapping tool consists of two main datasets captured from fixed wing aircraft: 1) Heat mapping derived from thermal imagery, and 2) tree canopy height and coverage from LiDAR across the metropolitan Adelaide region. Thermal imagery was captured between 2016 – 2018 and LiDAR was collected in 2018 and 2019, providing a baseline against which future measurements can show changes in urban heat and tree canopy cover over time.

Abbreviations used:

- UHI – Urban Heat Islands
- LiDAR / LIDAR - Light Detection and Ranging
- LGA - Local Government Association
- DEW - Department for Environment and Water
- DIT - Department for Infrastructure and Transport (formerly the Department for Planning, Transport and Infrastructure)
- GIS - Geographical Information System

What's the purpose of this mapping tool?

Adelaide's climate and weather patterns are changing. To adapt to these changes and continue to thrive, we need to understand our region in new ways. By using tools like this mapping suite, we can better coordinate how to use and manage water and vegetation to ensure the liveability of Adelaide continues for years to come.

This mapping tool displays a variety of layers that provide in-depth ways of understanding how urban heat, tree canopy and social vulnerability are related across the Adelaide region. More data added in the future will allow us to see patterns in urban heat and tree canopy over time.

What data can I view on the web portal?

- **Heat Maps:** captured 2016 – 2018 in °C
- **Social Vulnerability and Heat Islands:** day and night
- **Tree Canopy Boundaries:** captured in 2018 and 2019 (for trees > 3 metres in height)
- **Tree Canopy Heights**: based on a digital canopy or canopy height model captured in 2018 and 2019 (for trees >3 metres in height)
- **Vegetation Greenness**: Normalised Difference Vegetation Index (NDVI) as a measure of tree health from 20cm multispectral aerial imagery captured in 2018
- **Tree Canopy Coverage by Unit Area:** captured in 2018 and 2019. This data indicates the percent cover of tree canopy > 3 metres in height in a 100 metre x 100 metre area.
- **Building Footprints:** vectorised horizontal extent of LiDAR point cloud which have been classified as a building
- **Contextual spatial layers:** Administrative boundaries, cadastral information, land use and topographic overlays

What is a meaningful way of viewing the data on the map?

Turn on **Tree Canopy Boundaries layer (>3m) 2018/2019** to view the extent of tree coverage and the **Tree Canopy Heights (>3m) 2018/2019** to view height of trees in your own backyard, street or neighbourhood.

When repeat data has been added in the coming years, you will be able to see where vegetation has grown and where it has been removed.

Compare the canopy layer with the **Heat Maps** to see how vegetation provides a localised cooling effect on hot days.

Finally, look at the **Vegetation Greenness (NDVI) Sept 2018** – Normalised Difference Vegetation Index (NDVI) to assess vegetation greenness as an indicator for plant health.

If you need some help navigating the maps and choosing layers, take a look at our user guide.

We hope that once you have spent some time using this tool to understand the relationships between these layers and identifying areas that need more trees, you will be motivated to take action at your local level to help make your neighbourhood more resilient to urban heat.

Can I see my house / business / property on this map?

Yes, if your area of interest falls within greater metropolitan Adelaide you can either zoom closer to find the location on the map or to find a specific property you can type the address into the Search area.

When was the thermal imagery collected?

Thermal imagery was collected at ~3,000 metres altitude from an aerial thermal sensor during the day and night. To better enhance the presence of any urban heat islands (UHI) acquisition took place after two or more consecutive days of hot weather.

Thermal data was collected over the following Regional Climate Partnership areas:-

- Resilient South: 22 February 2016
- Adapt West: 9 February 2017
- Resilient East: 10 March 2018
- Northern Adelaide (City of Salisbury): 10 March 2018

What is an urban heat island?

The urban environment is characterised by built structures, activities and materials which have replaced natural surfaces. Artificial surfaces such as roads, footpaths and buildings store and accumulate heat which can affect temperatures at the local scale. These surfaces are also impervious, meaning less moisture is available to assist with cooling. This, in turn, leads to an increase in the minimum and maximum temperatures of a city compared with surrounding or less developed areas and is known as the 'urban heat island' effect.

For the purposes of this project, heat islands were defined as a 125m^2 area where the temperature measured at least 2°C higher than average temperatures for the study area. Hot spots were 2m^2 areas where the temperature measured at least 2°C higher than average temperatures for the study area, which allowed the impacts of specific land uses to be identified.

What is LiDAR?

LiDAR (also written as LIDAR) stands for Light Detection and Ranging, which is a remote sensing method that uses laser reflections of ground and other surfaces of the Earth to provide high resolution topographic mapping.

These reflections are used to make a digital three dimensional image of objects on or near the ground, such as buildings, roads and trees.

The resulting data can be used to model tree canopies, including tree heights and canopy boundaries. LiDAR has many potential uses in emergency response, civil engineering projects, hydrodynamic modelling and shoreline mapping.

What counts as a ‘tree’ for the purpose of this study and dataset?

It is common practice for vegetation picked up in such analysis to be called a tree when it is above 3 metres tall – especially when it comes to distinguishing between shrubs and trees.

While LiDAR can identify vegetation under 3 metres in height for the purpose of this study vegetation greater than 3 metres was used. This includes small areas of hedges and other non-tree vegetation over 3 metres in height. Therefore, smaller trees, shrubs and grasses were not included in the ‘tree’ canopy detection and reporting.

Data for vegetation between less than 3 metres also exists but was not used in this analysis.

How is canopy cover measured through LiDAR?

The area of canopy cover measured includes trees and vegetation over 3 metres in height detected with LiDAR. The online map presents this data in a 2D view of the canopy cover boundary from above.

Within the boundary there is vegetation over 3 metres in height, and the area within the boundary has been measured to provide figures for canopy cover at the time of data collection. This is a vector measurement that allows the proportion of tree cover to be calculated at various scales (e.g. LGA or Unit Area).

What is NDVI?

The **Normalised Difference Vegetation Index or NDVI** (Rouse Jr. *et al.* 1974) was developed as an index of plant "greenness" and attempts to track photosynthetic activity. It has since become one of the most widely applied vegetation indices. It is also based on the principle that well-nourished, living plants absorb red light and reflect near-infrared light. As plants become stressed or "less healthy" the proportion of red light / near infra-red light changes. Stressed or dead vegetation absorbs comparatively less red light than healthy vegetation.

How accurate is the thermal and LiDAR data?

Spatial Resolution

Thermal imagery has been collected over the Adelaide metropolitan region with a spatial resolution of 2 metres. Each 2 metre x 2 metre pixel is an average of temperature within that area.

LiDAR was collected with an average point density of 8 points per m^2. The digital canopy model processed from the LiDAR data has a spatial resolution of 1 metre x 1 metre, which means the smallest area of canopy cover measurable on-screen is $1m^2$. Small overestimations in tree canopy data can occur where the tree canopy boundary is measured in one square metre pixel, but does not actually fill that entire space. This is a well-understood limitation of this geospatial method and does not invalidate the data.

Data Collection and Classification

Automated LiDAR analysis can make errors in classification. For example, water towers and stobie poles being marked as trees, or, tide levels affecting height measurements for mangrove vegetation. However, these inaccuracies can be managed within an acceptable margin of error given acceptable sample sizes and thorough data classification processes are used. If you would like to know more about the LiDAR data collection and analysis methodology, you can download the report for the Adelaide metropolitan region here, alternatively you can contact Aerometrex Pty Ltd directly.

What are the key findings of the LiDAR analysis so far?

The overall findings provide an accurate estimate of tree canopy greater than three metres in height representing 24% of the metropolitan study area, and this ranged between local governments from 10% in City of Port Adelaide Enfield up to 49% in City of Mitcham.

Across the metropolitan study area, the majority of tree canopy is on private land. However, as a proportion, private land actually has the least canopy cover (20%) compared to streets (24%) and other public land (31%).

As only one 'snapshot' in time of data is available, no trends or patterns can be deduced as yet. Results analysis will become more telling once more data is collected in the coming years.

For now, the tool provides a strong visual comparison between canopy cover, urban heat, vegetation health, hotspots and social vulnerability.

You can download the report for the metropolitan Adelaide region here for more information.

What are the limitations of the LiDAR study?

- The LiDAR data was captured at a point in time in 2018 and 2019.
- Trees are measured here as three metres tall or over, which is common practice to distinguish between tree and shrubs, used in other cities including Perth, Melbourne and Sydney. This study excludes smaller trees and all vegetation less than 3 metres tall from the analysis.
- Tree trunks are not located in the canopy boundary layers, therefore council trees providing cover over private land may be recorded in private land assessments (and vice versa).
- In the Playford and Gawler LGAs data was only collected over built-up areas, therefore results from these locations are not representative of the entire council area.

How has tree canopy coverage previously been measured?

The first assessments of Adelaide's urban tree canopy used the i-Tree Canopy method. This method uses statistical analysis of random points in a satellite image to estimate vegetation cover. These estimates were used to inform targets for the 30-Year Plan for Greater Adelaide.

The first assessment of Adelaide's urban tree canopy used 2013 satellite imagery with i-Tree Canopy, which informed the nationwide study Benchmarking Australia's Urban Tree Canopy (Jacobs et al., 2014). Greener Spaces Better Places used this study in their 2014 report Where Are All the Trees?, which informed the baseline for the urban tree canopy target in the 30-Year Plan for Greater Adelaide.

Estimated trends were established from satellite imagery taken in 2013 and 2016 and analyses of urban heat.

Since region-wide LiDAR data has become available in 2018 it is now the primary assessment method being used as it provides a more accurate measure of tree canopy cover.

How do i-Tree Canopy surveys compare to LiDAR canopy models?

LiDAR and i-Tree Canopy assessments calculate the coverage of trees in fundamentally different ways and their results should not be compared against each other.

i-Tree produces a statistical estimate of tree canopy coverage by extrapolating data from randomly-selected set of points across a study area. The points are manually classified (by the human eye) for their vegetation type (tree, grass, road etc).

In contrast, LiDAR measures the three-dimensional form of every tree in a study area, from which the coverage of those trees can be calculated (with limitations defined by the LiDAR resolution).

While both methods are valid ways to quantify trees in an area, LiDAR can be used to precisely assess coverage as each tree is measured directly.

How will councils and State Government use the data?

Councils can use this data in their own mapping systems alongside other datasets. These may include 3D tree canopy and digital terrain models, contours, GIS layers of building footprints, canopy extent, canopy height, heat maps, social vulnerability, street activation, development applications and stormwater systems.

These datasets can help councils and the State Government improve decision-making, refine policies and target investment and action. For example, identifying where new street trees, vegetation and water sensitive urban design initiatives could provide the greatest benefit for communities, and identifying where building footprints have changed.

The data is intended to be used as a new tree canopy baseline, against which data captured in future years can be used to track progress towards the 30-Year Plan for Greater Adelaide (2017 Update) target to increase green cover by 20% by 2045.

Who was involved in the urban heat and tree canopy mapping project?

Urban Heat Mapping

Thermal imagery, processing and the delivery of urban heat island and social vulnerability were undertaken by the following councils and Regional Climate Partnerships:

- Resilient South (Cities of Marion, Mitcham, Holdfast Bay and Onkaparinga)
    - ArborCarbon Pty Ltd undertook the collection and analysis for Resilient South.
- Adapt West (Cities of Charles Sturt, Port Adelaide Enfield and West Torrens)
    - Imagery was acquired by Airborne Research Australia, analysed and reported by EnDev Geographic and Seed Consulting Services Pty Ltd
- Resilient East (Campbelltown City Council, Cities of Adelaide, Burnside, Prospect, Norwood Payneham & St Peters, Tea Tree Gully, Unley and the Town of Walkerville) and City of Salisbury
    - Imagery was acquired by AeroScientific, analysed and reported by EnDev Geographic and Seed Consulting Services Pty Ltd

Tree Canopy Mapping

DIT commissioned Aerometrex Pty Ltd to capture LiDAR over a study area of metropolitan Adelaide in April 2018 as part of the 3D Adelaide project.

In 2018, the City of West Torrens and City of Charles Sturt co-invested in a project with DIT, DEW and Aerometrex Pty Ltd to develop a tree canopy model using the 2018 LiDAR data, which enabled the development of the tree canopy map for these areas.

Additional areas were captured in October - November 2019 in collaboration with DEW, DIT and local governments through the Regional Climate Partnerships.

In 2020, the Regional Climate Partnerships (involving 16 councils), DEW and DIT co-invested to translate the LiDAR data into a tree canopy and digital terrain models.

Participating Councils included those in:

- Resilient East (Campbelltown City Council, Cities of Adelaide, Burnside, Prospect, Norwood Payneham & St Peters, Tea Tree Gully, Unley and the Town of Walkerville)
- Resilient South (Cities of Marion, Mitcham, Holdfast Bay and Onkaparinga)
- Adapting Northern Adelaide (Cities of Salisbury and Playford)
- City of Port Adelaide Enfield
- The Town of Gawler.

Aerometrex Pty Ltd undertook the analysis.

Is there intent to repeat the thermal and LiDAR capture to track progress?

Thermal imagery coordinated through DEW and Green Adelaide Landscape Board in partnership with local government is expected to be acquired over the entire Adelaide metropolitan area in the next few years. Thermal imagery captured day and night plus other imagery datasets (e.g. hyperspectral to improve vegetation classification) will become a baseline dataset for comparison against future datasets. In this way mitigation efforts can be monitored for their efficacy reducing severity and number of urban heat islands.

The tree canopy coverage targets as set from the 30-Year Plan targets will be reviewed in light of this new baseline later in 2020. It is intended that progress against these targets can be accurately assessed once further LiDAR data sets are collected in coming years.

Any future data capture and analysis projects would be undertaken in a collaborative, coordinated way between state and local governments. Undertaking thermal and LIDAR capture and analysis on a regular cycle, using consistent methodologies, would allow for ongoing assessment of the effectiveness of tree canopy management policies and practices.

There are many benefits of working together to capture and analyse spatial data, including significant cost savings, and the variable use of the data – for example in measuring and modelling urban development and tree loss over time.

Where can I find more information regarding urban heat, climate change, liveability, canopy cover and urban green space management in SA?

Links to reports on Urban Heat for each of the Regional Climate Partnerships or tree canopy coverage metrics over metropolitan Adelaide can be found here, or you can visit the Regional Climate Partnerships website for more details on how we're adapting to make our communities more resilient to climate change impacts.

For information specific to your regional climate partnership, visit:

- Resilient East (Campbelltown City Council, Cities of Adelaide, Burnside, Prospect, Norwood Payneham & St Peters, Tea Tree Gully, Unley and the Town of Walkerville)
- Resilient South (Cities of Marion, Mitcham, Holdfast Bay and Onkaparinga)
- Adapting Northern Adelaide – (Cities of Salisbury and Playford)
- Adapt West (Cities of Charles Sturt, Port Adelaide Enfield and West Torrens)
- Town of Gawler

More information

For further information on climate resilient communities, visit the Department for Environment and Water's *Adapting to climate change* web page:

https://www.environment.sa.gov.au/topics/climate-change/programs-and-initiatives/adapting-to-climate-change