Urban Heat and Tree Mapping Viewer

Frequently Asked Questions

Version 2.0

Government of South Australia

Department for Environment and Water

Contents

Background

The Urban Heat and Tree mapping Viewer displays a number of spatial layers derived from thermal imagery, multispectral imagery and LiDAR (Light Detection and Ranging) datasets captured over the entire metropolitan Adelaide region over a number of separate projects undertaken from 2016 to 2022.

The Department for Environment and Water (DEW) created the Urban Heat and Tree Mapping Viewer in 2019 to enable the public, practitioners and state and local government staff to view the datasets in a meaningful, accessible way. It has been used as an effective educational and research tool since its inception.

The datasets and the spatial layers derived from them are outlined in the table below (What data can I view on the web portal?).

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's green spaces, vegetation and built environment.

By using tools like the Urban Heat and Tree Mapping Viewer to explore and understand the data we collect, we can better coordinate how to manage vegetation to ensure the liveability of Adelaide continues for years to come.

The Viewer displays a variety of layers that provide in-depth ways of understanding how urban heat, the built environment and tree canopy are related across the Adelaide region.

What data can I view on the web portal?

Data Product	Format	Initial Capture	2022 Capture	Change Detection Dataset
Thermal imagery	Raster	2016 – 2018	✓	N/A
Urban Heat Islands	Raster	2017 - 2018	✓	N/A
Tree Canopy Boundaries (>3m) – horizontal extents of trees >3m	Vector	2018 - 2019	✓	✓
Tree Canopy Heights (CHM) (>3m)	Raster	2018 – 2019	✓	N/A
Vegetation Greenness (NDVI) – measure of vegetation health	Raster	2018	✓	N/A
Tree canopy coverage by unit area (% cover per 100m x 100m)	Raster	2018 – 2019	✓	✓
Permeable vs Impermeable Surfaces	Raster	2018 – 2019	✓	N/A
Building Footprints (horizontal extents of buildings)	Vector	2018 - 2019	✓	✓
Green space extents	Raster	2022	✓	N/A

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

The spatial layers contained in the Viewer can be switched on and off to display the extents of metro Adelaide's urban forest and built structures, as well as thermal imagery and urban heat islands.

A great place to start is to zoom into your local neighbourhood, house, workplace or school. Turn on the **2022 Tree Canopy Boundaries (>3m)** layer to view the trees or the **2022 Vegetation Greenness (NDVI)** layer to view the actively growing vegetation.

Then turn on the **2022 Urban Heat Map** layer to see the temperature difference over a range of surface types, including areas of vegetation or buildings. From this you can see how much trees and other green spaces contribute to cooling their local area, or the impact of dark coloured roofs and roads.

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

Yes, if your house / business / school falls within the metropolitan Adelaide study area. 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.

What is LiDAR?

LiDAR (Light Detection and Ranging) is a remote sensing method that scans the surface of the Earth. It does this using a device installed in a light aircraft which fires laser pulses and records the time taken for the laser to reflect off surface features and return to an on-board sensor.

This creates a highly accurate point cloud which is used to make a digital three dimensional images 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 horizontal boundaries. LiDAR has many other uses in emergency response, civil engineering projects, hydrodynamic modelling and shoreline mapping.

What counts as tree canopy for the purpose of the datasets?

For the purpose of studies relating to urban forests and tree canopy, a tree is classified as vegetation ≥3m height. This is the height at which trees begin to provide shading and cooling benefits to their immediate environment.

Vegetation between 2–3m has also been captured to map of the extents of emerging trees, shrubs and other mid-storey vegetation, however this is not included in the measurement of tree canopy.

How is canopy cover measured through LiDAR?

LiDAR produces a highly accurate point cloud of the Earth's surface, including features such as trees and buildings. Using a mix of automated and semi-automated, machine learning processes, the results of which are quality checked by human operators, LiDAR points are classified by the feature they have captured.

From this point cloud, the following three dimensional spatial layers can be generated:

- Digital Surface Model (DSM) representing the ground **and** surface features.
- Digital Elevation Model (DEM) representing bare ground only
- Canopy Height Model (CHM) representing the tree canopy ≥3m height

The horizontal and vertical extents of the tree canopy can be derived from the CHM. A two dimensional spatial layer, displaying the horizontal extents of tree canopy, is extracted from the CHM. From this layer the total area (m^2 or Ha) is measured and the proportion of tree cover can be calculated at various scales (eg. LGA, suburb, 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 based on the principle that well-nourished, irrigated, actively growing plants reflect a different ratio of red and near-infrared light to plants that are stressed or "less healthy". Stressed or dead vegetation reflects comparatively more red light than healthy vegetation which gives them a yellow appearance.

What is 'Green Space' for the purpose of this study and dataset?

Trees are only part of the story. Actively growing vegetation less than 2m height also provides cooling, amenity and biodiversity benefits. Green spaces include backyards, parklands, sports ovals and reserves. For the purpose of this study, 'Green Space' is any area of actively growing vegetation, identified either through LiDAR or NDVI classification. They represent opportunities for people to be outdoors and connect with nature and areas where healthy vegetation is providing cooling benefits.

Vegetation ≤ 2m height is identified using NDVI, vegetation ≥ 2m is identified using the LiDAR point cloud.

Where are the green spaces in my neighbourhood?

For the purpose of this survey, Green Spaces are defined as areas of actively growing vegetation. Vegetation over 2m tall was mapped using LiDAR. Vegetation less than 2m tall was mapped using the multispectral imagery. Therefore, the Green Space layer in the Viewer does not describe the extents of public parks, it describes where vegetation is actively growing and providing a cooling benefit to its surrounds. This not only includes public parks but also backyard lawns and trees.

What is a permeable / impermeable surface?

A permeable surface is a ground surface that allows water to pass through, such as bare soil and grass. Impermeable surfaces including pavements, concrete and roads do not allow water to pass through. Buildings, tree canopy and other elevated features overhanging roads and other impermeable surfaces have been identified and classified as impermeable surfaces.

The Permeable vs Impermeable Surface layers are a result of an automatic, semantic classification of permeable and impermeable surfaces using 4 band (Red, Green, Blue, Near-infrared) multispectral imagery and LiDAR. The analysis classifies the layer into:

- Impermeable: impermeable surfaces (includes roads, buildings and trees overhanging impermeable surfaces)
- Permeable: permeable surfaces (includes bare ground, vegetation and trees overhanging permeable surfaces)
- Water bodies: ocean, lakes, rivers, dams and large pools

Where are the trees in my neighbourhood?

Turn on **2022 Tree Canopy Boundaries layer (>3m)** to view the horizontal extent of tree coverage or the **2022 Canopy Height Model (>3m)** to view height of trees in your own backyard, street or neighbourhood. Either navigate to your neighbourhood using the pan and zoom tools or enter an address in to the Search tool.

How do trees offset the effects of urban heat?

When you compare the canopy layer with the Heat Maps, you can see how vegetation provides a localised cooling effect on hot days. Trees provide cooling to their local area through shading and evapotranspiration.

What has changed between data captures?

With the data captured 2022 you can view how Adelaide's metropolitan landscape has changed. For the areas where LiDAR was captured between 2018 and 2019, tree canopy and building footprint data from both captures have been directly compared to produce change detection datasets. You can see where vegetation has grown and where it has been removed. You can also see where buildings have been built, extended or removed.

Results of the thermal imagery capture and urban heat island analysis cannot be compared between captures. The imagery and derived analysis is a snapshot of the environmental, physical and climactic conditions at the time of capture.

When was the thermal imagery collected?

During both surveys thermal imagery was collected at ~3,000 metres altitude from an aerial thermal sensor during the day and night. Capture windows were identified to provide days with clear skies, no haze and light winds.

To better enhance the presence of any urban heat islands (UHI) the original thermal imagery captures ensured that acquisition took place after two or more consecutive days of hot weather. Thermal data was collected over the Regional Climate Partnership areas in three separate projects between February 2016 and March 2018.

The majority of the 2022 capture was undertaken between January and March 2022. Unfortunately the ongoing La Nina conditions caused ongoing cool, cloudy weather. Due to the precision of the thermal imaging camera (sensitive to temperature differences of 0.1°C) the urban heat island effect can effectively be captured at lower temperatures on clear, calm days. Thermal imagery during 2022 was therefore captured on much cooler days than previous captures.

Deteriorating weather conditions in March 2022 meant that data capture was halted with 80% capture complete. Suitable weather conditions were experienced in early January 2023 and the data capture was completed.

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 impermeable, meaning less moisture is available to assist with cooling. Healthy trees and shrubs, and irrigated grass cool their local environment through shading and evapotranspiration. The increase in impermeable surfaces and the associated loss of vegetation in developed cities 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. This effect exacerbates the impacts of heatwaves where heat is absorbed by surfaces and buildings during the day and is radiated back into the atmosphere long after sunset. This impacts the health and wellbeing of residents through disrupted sleep patterns and increased need for air-conditioning.

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. Areas were also identified as having ‘extreme’ urban heat islands where temperatures were > 3°C or >4°C above average.

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 m x 2 m pixel displays an average measurement of surface temperature within that area.

LiDAR was collected with an average point density of 8 points per m^2 in 2018 – 2019 and 12 points per m^2 in 2022. The Canopy Height Models processed from the LiDAR data have a spatial resolution of 0.5 metre x 0.5 metre, which means the smallest area of canopy cover measurable on-screen is 0.5m^2.

Data Collection and Classification

Raw LiDAR data is collected as a point cloud made up of billions of points measuring the height of features on or near the ground. The point cloud is processed using a range of automatic classification steps applying Machine Learning / Artificial Intelligence (ML / AI) techniques to classify each point into a class or category which describes the type of feature that point represents. Classes include Building, Ground and High and Low Vegetation.

Automated LiDAR analysis can make errors in classification. For example, water towers and stobie poles being classed as trees, or water in coastal environments affecting height measurements for mangrove vegetation. However, the results of the automated classification undergoes quality assurance by a human operator who either applies a semi-automated classification process or undertakes a level of manual classification to reach the specified level of accuracy for ground, building and vegetation classes.

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

The overall findings of the 2022 capture provide an accurate snapshot of tree canopy greater than three metres in height covering 17% of the metropolitan study area.

Across the metropolitan study area, the majority of tree canopy is on residential land (37%), reserves (15%) and Roads (14%).

Canopy cover change detection analysis is possible in areas where LiDAR has been captured twice (noting that the 2022 capture footprint is larger than the combined 2018-19 captures). In a direct comparison of these areas, canopy cover has increased from 14.5% to 18.3%.

As these captures represent only two data points, 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, and social vulnerability and how it has changed over the five year period between captures. You can download the reports for the metropolitan Adelaide region here for more information.

What are the limitations of the LiDAR study?

- The LiDAR data represent snapshots of conditions and features present at the time of capture.
- Trees are measured 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 canopy 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).
- During the 2018-19 captures data was only captured over the built up areas in Playford and Gawler LGAs, therefore results from these locations are not representative of the entire council area. In these LGAs change detection analysis has only been carried out for the areas which have been captured twice.

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 for an entire area or interest.

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, direct 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 do councils and state government use the data?

Councils 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 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 will be used as a new tree canopy baseline, against which data captures in the future can be compared 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?

2016 – 2018 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 (in association with Spatial Scientific 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

2018 – 2019 Tree Canopy Mapping

DIT (Department for Infrastructure and Transport) 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.

Permeable vs Impermeable Mapping

Green Adelaide and DEW engaged Aerometrex Pty Ltd to analyse the LiDAR and multispectral aerial imagery captured in 2018 and 2019 to create a layer describing surface permeability and impermeability across the Adelaide metropolitan region.

Aerometrex Pty Ltd used a sematic classification consisting of two stages:

1. Using an end to end trained Feature Pyramid Network on four band (Red, Green, Blue, Near-infrared) aerial imagery and raster derived products from LiDAR to classify ground surfaces as either permeable or impermeable,
2. Classification of above ground features to either permeable or impermeable using a rules based classification approach see the figure below).

If you would like to know more about the methodology used and results, please access the report produced by Aerometrex.

2022 Urban Heat, Tree Canopy, Green Spaces and Built Spaces Project

In 2021 Green Adelaide partnered with the metropolitan councils of Adelaide, DEW, DIT and Preventive Health SA to repeat and expand the LiDAR, multispectral and thermal captures. The intent of the project was to build on the expertise of councils and Regional Climate Partnerships, to replicate the previous methodology as much as possible and to capture all datasets in a narrow time window.

As a result the 2022 capture provides for the first time:

- Contiguous tree canopy, urban heat and built environment datasets across the entire metropolitan Adelaide region
- Datasets that (as much as possible) reflect conditions in a specific data capture window.
- Datasets which were captured using comparable methodologies to enable change detection analysis for tree canopy and building footprints (in areas which were captured twice)

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

The 2022 dataset and capture footprint are considered the baseline against which progress will be measured through future LiDAR data captures.

Following the partnership model of the 2022 capture, future data capture and analysis projects would be undertaken in a collaborative, coordinated way between state and local governments. Undertaking multispectral and LIDAR capture and analysis on a regular cycle, using consistent capture and analysis methodologies, will allow for ongoing assessment of the effectiveness of tree canopy and urban environment management policies and practices. Analysis and comparison of aerial thermal imagery captures is limited as each flight is a snap shot of the environmental conditions (temperature, humidity, wind etc). Acquisition of satellite thermal imagery will be investigated as a potential alternative which will enable detection of trends over time. This method will not however enable small scale viewing or analysis of surface types and local area affects. There are many benefits of working together to capture and analyse spatial data, including significant cost savings, and the ability of multiple stakeholders to use of the data – for example in measuring and modelling urban development and tree loss over time. This approach also ensures that there is a consistent methodology and result for the entire metropolitan Adelaide region.

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

For more information on how Green Adelaide is working to create a cooler, greener, wilder, more climate resilient city visit their website.

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

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