CRC for
Water Sensitive Cities

The climatic benefits of green infrastructure

Research shows that green infrastructure can reduce urban heat and increase thermal comfort. However this cooling effect is highly localised and needs to be implemented widely across a neighborhood to drive local-scale cooling. The cooling effect of green infrastructure has been found to extend for a distance approximately equal to the width of the feature.

Urban heat and why it matters

When cities and towns are constructed, hard impervious surfaces and buildings replace vegetation and soil. This leads to the development of unique urban climates that are typically hotter than natural landscapes. Higher urban temperatures are caused by many factors including reduced shading, abundance of materials that absorb heat, reduced evapotranspiration and waste heat from infrastructure and vehicles. Urban heat can add several degrees to the background air temperature of cities during a heat wave.

Excessive temperature has a negative impact on people and infrastructure, particularly during prolonged heat waves. Indeed, heat waves take more lives in Australia each year than any other natural disaster. Model projections suggest that in the future average air temperatures will increase across much of Australia, and that the frequency, intensity and duration of heat waves will also increase.

Research shows that local features including surface materials, building proximity and shape, presence and type of vegetation and the prevalence of water in the landscape interact to influence urban heat.

Measuring urban heat

Human Thermal Comfort (HTC) is a term used to describe a person's satisfaction with the surrounding thermal conditions. Various metrics can be used as indicators of HTC including:

Measure	Benefits
Land surface temperature	Easiest to measure but not necessarily well correlated to HTC
Air temperature in spaces occupied by humans i.e. above the surface	Moderately resource intensive to measure but more relevant to HTC
Universal Thermal Climate Index (UTCI)	Good measure of HTC but highly resource intensive to monitor

Reducing urban heat

Research shows that vegetation, especially trees, can effectively mitigate urban heat. To achieve human health and comfort benefits, it is particularly important to reduce temperatures during heat waves.

The amount of cooling provided by vegetation is influenced by multiple factors including tree health and water availability. Trees provide maximum HTC benefits when they have access to water during heat waves.

The impact of isolated trees on urban heat

Research shows that isolated trees improve HTC benefits below and immediately downwind of the tree canopy.

A study of a single isolated tree in Melbourne Cemetery showed that on very hot days in 2014, the air temperature below the tree canopy was 0.6 to 1.2 degrees cooler than immediately upwind of the tree.

A study of isolated, single street trees in Melbourne's CBD found that

- during a heat wave in 2012 the UTCI was "strong" under the tree canopy and "very strong" out in the open; and
- during warm, sunny conditions, the mean daytime air temperature was up to one degree cooler under the tree canopy compared to out in the open.

The impact of tree-lined streets on urban heat

Research shows that tree-lined streets can have better HTC than streets without trees. However the street tree type and placement is important to provide maximum daytime shading whilst allowing the heat to escape at night.

The air temperature in two residential streets in East Melbourne was measured during 2011 to 2013.

Australian Government
Department of Industry, Innovation and Science
Business Cooperative Research Centres Programme

The study showed that during hot daytime conditions, the air temperature in a tree lined street was 0.2 to 0.9 degrees cooler than in an equivalent street with little canopy cover.

The air temperature in Bourke Street (Melbourne CBD) was measured at the same time as the residential streets. Bourke Street had a tree canopy of 31% and tall buildings on both sides of the street. The buildings provided daytime shade, which lowered daytime heat stress, but trapped night-time heat and radiation causing the night-time the air temperature to be 4.8 degrees warmer than the residential street with 45% canopy cover.

The impact of stormwater treatment and harvesting on urban heat

Vegetated stormwater treatment systems reduce air temperature by retaining water in the urban landscape and increasing soil moisture. This promotes healthy vegetation which provides evapotranspiration and shade.

Vegetated stormwater treatment systems can play a critical role in mitigating urban heat by providing irrigated urban vegetation. Systems that incorporate trees provide the most urban cooling. Regular tree watering ensures that vegetation remains healthy, with full canopies that provide shade and sufficient water to support tree canopy transpiration.

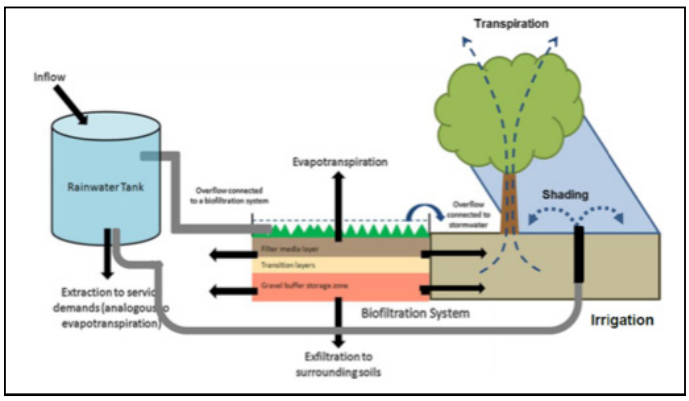
Optimal microclimate benefits are provided when vegetation has access to water for evapotranspiration during times of high urban heat. Irrigation harvesting or saturated zones in treatment systems can be used to provide irrigation water during these times.

Irrigation has a significant impact on **land surface temperature** although this does not always translate to an impact in **air temperature**. A City of Port Phillip study showed that during a heat wave in February 2012, the average daytime surface temperature for irrigated grass was 5 degrees cooler than non-irrigated grass and 6 degrees cooler than roads. Other studies have shown that the daytime air temperature in streets with non-irrigated trees is lower than the air temperature in parks with irrigated grass (but no trees). This indicates that the shade from the trees had a larger impact on the air temperature than the reduced land surface temperature from irrigation.

The impact of green roofs and walls on urban heat

Research shows that while green roofs have many benefits including reducing stormwater runoff volume, they are not effective at improving HTC:

- ✗ Green roofs that are not irrigated provide the same HTC as traditional roofs.
- ✓ Irrigated green roofs have a similar HTC to highly reflective white roofs.
- ✓✓ Collecting rainfall runoff from white roofs and using the harvested rainwater to irrigate ground level vegetation will provide greater HTC benefits than irrigated green roofs.
- ✓✓✓ Green walls provide a larger benefit than green roofs as they reduce daytime heat build up in street level hard surfaces.



Biofiltration systems can be designed to cool cities by enhancing evapotranspiration, supporting trees and providing irrigation. (source: Burns et al, 2012)

Further reading

Coutts, A. Tapper, N. Loughnan, M. Demuzere, M. Broadbent, A. Motazedian, A. White, E. Phan, T. Thom, J. Gebert, L. Pankhina. D. (2015) Determine the microclimatic influence of harvesting solutions and WSUD at the micro-scale: Presented as FREQUENTLY ASKED QUESTIONS. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities

Coutts, A. Loughnan, M. Tapper, N. White, E. Thom, J. Broadbent, A. Harris, R. (2014) The impacts of WSUD solutions on human thermal comfort. Melbourne, Australia: Cooperative Research Centre for Water Sensitive Cities

Burns, M. Fletcher, T. Walsh, C. Ladson, A. Hatt, B. (2012) Hydrologic shortcomings of conventional urban stormwater management and opportunities for reform. Landscape and Urban Planning, 105, 230-240.

Further information

Level 1, 8 Scenic Blvd
Monash University, Clayton
Victoria 3800, Australia

info@crcwsc.org.au

www.watersensitivecities.org.au

@crcwsc

CRC for
Water Sensitive Cities