Trees and temperature

A well established body of evidence supports the role of trees in temperature modification. This section of the plan details the science behind the cooling benefits of trees and documents some of the research findings and applications to urban policy and practice in warming Australian cities.

The temperature under the shade of a medium to large sized tree can be several degrees cooler than ambient temperature. Trees reduce land surface temperatures by absorbing radiant heat from the sun and shading the spaces beneath or adjacent (depending on the time of day and angle of the sun). Trees reduce ambient temperature through evaporative cooling.

By mitigating excess urban heat, tree canopy cover and its shade can play a critical role in reducing both heat related health costs and summer home cooling costs in the subtropics.

Shade

A direct relationship exists between areas shaded by trees and cooler land surface temperatures (Ali-Toudert & Mayer 2007; Kurn et al. 1994, Shashua-Ba et al. 2010). Street trees can help manage the impacts of heat, especially in densely populated communities and along popular pedestrian routes. Studies have confirmed that older and younger members of our communities are the most vulnerable to extreme heat. UV exposure during a person's first eighteen years of life is also the most critical for cancer causing skin damage (Norton et al. 2013; Kimlin and Guo 2012).

Shading homes and buildings also reduces heat gain during hotter days. In South East Queensland trees provide the greatest shade benefit when planted on the east and west sides of homes and alongside east-west orientated streets (Norton et al. 2015). In the summer months high angled sun on the south side of buildings is also a priority for shading (Doick and Hutchings 2013).

Cooling

Trees not only provide shade but also cooling. The process causing trees to cool the surrounding air is termed evapo-transpiration and occurs while a plant is photosynthesising (converting sunlight to usable energy). The by-product is cooling of the leaf surface (evaporative cooling) which effects a reduction in the temperature of the surrounding air. The denser the tree canopy, the greater the surface area from which evaporative cooling can occur.

Rainforest species provide more cooling benefits on account of their leaf size, leaf arrangement and higher water use than low water users such as eucalypts (gum trees) which have adapted strategies to slow or halt evapo-transpiration (and as such conserve water use) as a response to drought.

Large single specimens of broadleaved species have the potential to provide greater cooling benefits than a group of smaller trees with sparser canopies and less total leaf surface area (City of Melbourne, 2012).

Brisbane City Council targeted 'shade hungry' footpaths along popular pedestrian routes in their ‘Neighbourhood Shade-ways’ program developed in 2006/07. On a summer day, surface temperatures of tree shaded pathways were found to be up to seven degrees cooler than unshaded pathways (National Urban Forest Alliance 2014). Temperature differentials of between 14.1 °C and 18.7 °C have been forecast beneath clusters of shady trees in heat wave conditions in Adelaide (Thom et al. 2016). While McPherson et al. (2009) reported that the interior of cars in tree shaded car parks can be between twenty-two and twenty-eight degrees cooler than car parks without trees.

Trees can significantly improve thermal comfort and relief from summer heat stress at the street and local neighbourhood scale (Norton et al. 2013).

The urban heat island effect

Temperatures in urban areas are significantly higher than in undeveloped or rural areas due to the ‘heat island effect' where hard surfaces high in thermal conductivity and heat storage capacity and low in reflectivity not only increase ambient temperature but also retain heat (Norton et al. 2013).

Urban areas are hotter than rural areas as an outcome of vegetation removal and a higher volume of impervious surfaces and buildings to permeable spaces. Highly urbanised areas tend to get hotter because of the lack of breeze. The heat is exacerbated by hard surfaces reducing water availability for trees and lowering rates of evaporative cooling. Structured drainage systems also deplete soil moisture levels (Norton et al. 2015). Heat production from cars and air conditioners, and air pollutions also contribute to the 'urban heat island effect'. Built up areas are generally two degrees hotter than rural areas. International research indicates that localised temperature increases associated with the urban heat island effect already exceed those predicted by climate change models over coming decades (Grimm et al. 2008; McCarthy et al. 2010).

A key driver of the ‘urban heat island effect’ (especially with reference to private land) is new or replacement tree planting not keeping pace with the amount of vegetation removed as a part of the urban consolidation process. The problem is exacerbated by replacement of permeable surfaces with non-permeable surfaces, which in turn require even more trees for natural shade and cooling.

The City of Melbourne has estimated that one of the many benefits of a plan to increase tree canopy cover from twenty-two to forty percent by 2031 (predominantly on public land) is a forecast reduction of up to two degrees in average daytime summer temperature (NGIA 2012).