

# NURSERY PAPERS

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## Mitigating Extreme Summer Temperatures with Vegetation

Recently, Dr Dong Chen and the team from Commonwealth Scientific and Industrial Research Organisation (CSIRO) and NGIA modelled the potential benefit of vegetation in reducing extreme summer temperatures in Melbourne CBD under different climate scenarios. Results showed that the cooling benefit of various urban forms and vegetation schemes may be in the range of 0.3°C to 2°C. The team also found that although Melbourne is projected to be warmer in 2050 and 2090, the relative benefit of urban vegetation will not change significantly. In this Nursery Paper, Dr Dong Chen details the rationale to this research and the results to date.

## Introduction

Around 85% of Australians live in urban areas with 64% in the eight capital cities (DSEWPac, 2011). Although the percentage of urban population has only increased slightly from several decades ago, the total Australian population has doubled in the past 50 years. Rapid urban population growth and development in Australian cities has transformed native environments to engineered infrastructure, accompanied with increased heat generation from anthropogenic activities and summer heat accumulation due to massive heat absorbing surfaces. This results in high temperatures in urban areas in comparison with rural areas, a phenomenon known as the urban heat island (UHI) effect. In Melbourne, previous researches reported UHI of a mean of around 2 to 4°C and as high as 7°C depending on the location, time of the year and day (Morris and Simmonds, 2000; Morris et al, 2001; Coutts et al 2010).

The situation of urban summer heat accumulation is likely to be further exacerbated with global warming. Climate change projections for Australia suggest an increase in the number of warm nights and heat waves which can pose significant threats to human health (Alexander and Arbalster, 2008). The most recent heat wave event in Melbourne during the summer in 2009 may have resulted in 374 excess deaths over what would normally be expected for the period: a 62% increase in total all-cause mortality and an 8 fold increase in direct heat-related presentations in the emergency departments (DHS, 2009).

The dual pressures from the increasing UHI effect and climate change presents enormous environmental challenges and requires urgent



collaborative efforts and combined measures from governments and communities. One strategy to mitigate extreme summer temperatures in the urban areas is the “cool cities” strategy (Luber 2008). The “cool cities” strategy reduces the urban heat island effect by promoting tree planting to shade buildings, to cool the ambient environment by evapotranspiration of vegetation and using reflective roof and paving surfaces to reduce heat accumulation due to solar radiation. In this study, the potential benefit of urban vegetation in mitigating extreme summer temperatures in Melbourne for 2009 (referred to as the present day) and for future climate in 2047, 2050 and 2090 were investigated using an urban climate model TAPM UCM developed by CSIRO (Thatcher and Hurley 2012).

### MELBOURNE 2009

2009 was one of the hottest summers in Melbourne since the keeping of records, which might have contributed to the extra deaths of about 374 people. In order to investigate the potential benefit of vegetation, simulation’s were carried out for 2009 with various urban and vegetation schemes in replacing the Melbourne CBD areas as listed in Table 1. In Table 1, the summer maximum temperature is the averaged summer daily maximum temperature (ASDM temperature) over December, January and February.

The vegetation and building coverage ratios of the generic urban type in Table 1 were based on measurements by Coutts et al (2007), while the vegetation and building coverage ratios of Melbourne CBD areas were estimated from Google Earth images. Considering the ASDM temperature, the following can be found:

- 1) Suburban areas are predicted to be around 0.5°C cooler than the CBD;
- 2) A relatively leafy suburban area may be around 0.7°C cooler than the CBD;
- 3) A parkland (such as grassland, shrub-land and sparse forest) or rural area may be around 1.5 to 2°C cooler than the CBD;
- 4) Doubling the CBD vegetation coverage may reduce 0.3°C ASDM temperature;
- 5) 50% green roof coverage of the CBD area may result in 0.4°C ASDM temperature reduction; and
- 6) ASDM temperature reduction of around 0.7°C may be achievable by doubling the CBD vegetation coverage and having 50% green roof coverage in the CBD area.

**Table 1 Predicted summer maximum temperature reduction in 2009 with various vegetation schemes**

Urban Type	Vegetation Coverage (%)	Green Roof (%)	Building Coverage (%)	Irrigation	ASDM Temperature (°C)	ASDM Temperature Reduction (°C)
Forest (low sparse)	100	0	0	No	25.7	-2.1
Shrub-land	100	0	0	No	25.8	-1.9
Grassland	100	0	0	No	26.1	-1.7
Urban (leafy)	49	0	40	Yes	27.1	-0.7
Urban (generic)	38	0	45	Yes	27.3	-0.5
CBD	15	0	65	Yes	27.8	0 (Reference)
CBD(with 1/3 Vegetation)	5	0	65	Yes	27.9	0.2
CBD(Double Vegetation)	33	0	58	Yes	27.5	-0.3
CBD(50% Green Roof)	15	50	65	Yes	27.4	-0.4
CBD(Double Vegetation + 50% Green Roof)	33	50	62	Yes	27.1	-0.7

Morris et al (2001) reported UHI observations of average around 1.3°C for Melbourne summers between 1972 and 1991. Simulation studies by Coutts et al (2008) also showed that day time UHI is in the range between 1 and 2°C. By reviewing a number of observation studies, Bowler et al (2010) summarised that, on average, an urban park would be around 1°C cooler than a surrounding non-green site, while 2.3°C cooler was reported when compared with a town or city further away. From these previous researches in the literature, it is believed that the predicted 0.5 to 2°C temperature differences in the ASDM temperatures between Melbourne CBD, suburbs, rural areas are reasonable.

### MELBOURNE 2047, 2050 and 2090

For modeling the benefit of vegetations in future Melbourne climate, it was assumed that the current Melbourne metropolitan boundary will be maintained in the next several decades. The future Melbourne climate was based on an A2 scenario using the GFDL2.1 model which is a coupled atmosphere-ocean general circulation model (AOGCM) developed in the United States (IPCC, 2007). Simulations were carried out for years 2047, 2050 and 2090 with various urban and vegetation schemes in the Melbourne CBD areas. The predicted ASDM temperatures and the reductions in the ASDM temperatures (CBD as the reference urban form) for the year of 2009, 2047, 2050 and 2090 are compared in Figures 1 and 2, respectively. Usually ten year simulations would be performed to estimate the climatology and the vegetation impact centered on 2050 and for 2090. Considering the large number of numerical experiments required, single simulation years such as 2047, 2050 and 2090 was used as random samples of the predicted future climate for 2050 and for 2090 in this study.

From Figures 1 and 2, it was found that although Melbourne is projected to be warmer in 2047, 2050 and 2090, the relative impacts on the ASDM temperature due to various urban forms and vegetation schemes in any particular future year are similar to those predicted in 2009. This is reasonable considering that the relative cooling effect of vegetation is mainly determined by vegetation types, shading and evapotranspiration rate. Since the current study assumes that the vegetation does not dry out with irrigation, the variation in rainfall for different years may have some, but not significant, effect on the evapotranspiration rate from vegetation.

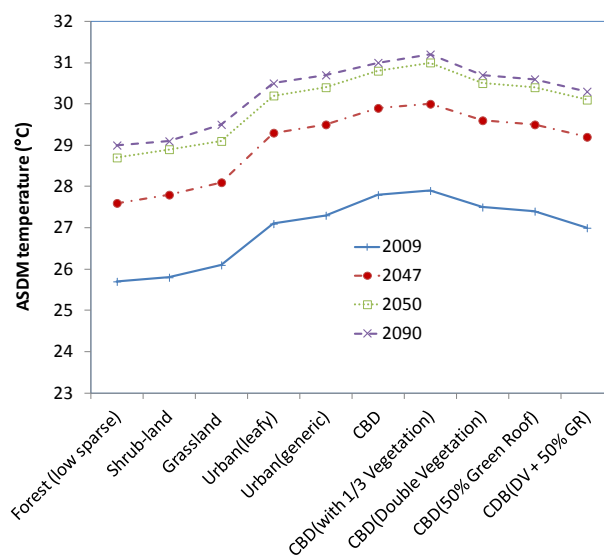


Figure 1 Predicted ASDM temperatures in 2009, 2047, 2050 and 2090 for different urban forms and vegetation schemes in Melbourne

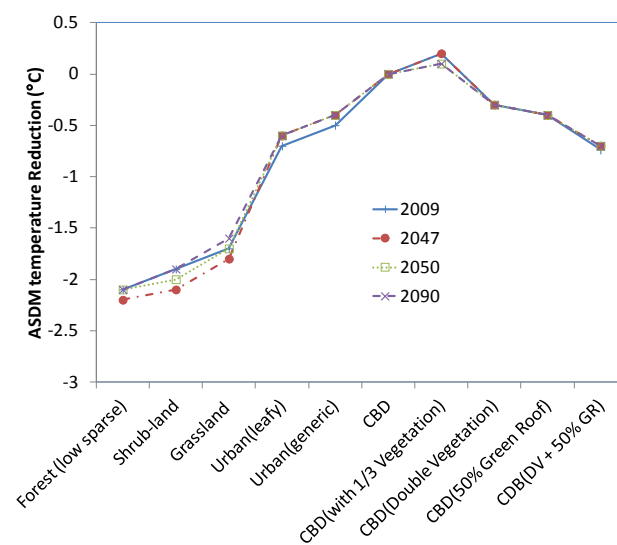
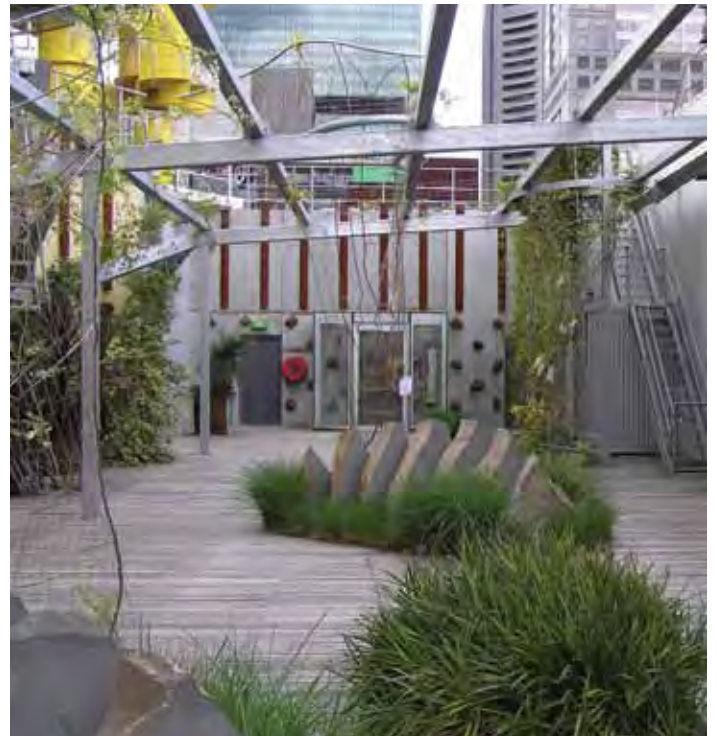


Figure 2 Predicted reductions in the ASDM temperature in 2009, 2047, 2050 and 2090 for different urban forms and vegetation schemes in Melbourne



Urban vegetation shades buildings and cools the environment through evapotranspiration.



## CONCLUSIONS

The potential benefit of urban vegetation in reducing extreme summer temperature has been investigated using an urban climate model in Melbourne in 2009, 2047, 2050 and 2090. Results show that in terms of the ASDM temperature, the cooling benefit of various urban forms and vegetation schemes may be in the range from 0.3°C with doubling the CBD vegetation coverage to around 2°C for forest parklands for present-day as well as future warming climate.

These cooling benefits of urban vegetation, if realized in practice, can contribute to the reductions in heat related mortality as well as other illness. Further studies are underway to quantify the benefit in reducing heat related mortality rate and extend the research to Sydney and Brisbane.

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