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A comparison of the ameliorating effects of native and exotic street trees on surface heat retention at dusk

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ABSTRACT

Urbanisation results in a host of adverse environmental conditions often associated with an increase in temperature. Increasing urban vegetation, particularly street trees, may help alleviate higher temperatures as street trees play an important role in providing shade. We compared the potential for exotic and native street trees to help reduce surface temperatures in urban climates. The surface temperature of asphalt surrounding (or adjacent to) 6 species of street trees (3 exotic and 3 native) at 8 sites each were recorded using a FLIR Infrared camera on hot and normal temperature days. Surfaces under native trees exhibited lower temperatures when compared to exotic trees (lower by 2 °C). This suggests that there are some characteristics of native vegetation such as the density of shade or air flow that influence the surface temperature. Our study suggests that native vegetation is more efficient at ameliorating increased urban temperatures. Further work should identify the mechanisms by which street trees influence surface temperatures.

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1. Introduction

In 2012, a report released by The United Nations, Department of Economic and Social Affairs indicated that 52% (3.6 billion) of the world's population now inhabit urban areas. This number is set to increase to 6.3 billion by 2050. Urbanisation causes a change in climate, defined as the Urban Heat Island (UHI) effect where temperatures tend to be higher than surrounding rural areas (Oke et al., 1991) Understanding how well different vegetation helps to alleviate UHIs, will enable the development of urban vegetation that maximises thermal benefits in cities (Scott et al., 1999; Zhang et al., 2009).

While other factors affect UHIs, surface change is the predominant influence (Memon et al., 2008). Urban surfaces, such as asphalt, concrete and tiles, have higher thermal properties (emissivity and conductance) than the surrounding rural and natural surfaces, such as soil and vegetation. Higher heat retention leads to, not only higher temperatures during the day when surfaces are actively being heated by the sun, but also higher temperatures at night (Jongtanom et al., 2011). In an urban environment, surface temperature modulates atmospheric temperature by influencing the air that is in contact with it. This interaction influences the energy exchange from buildings, affecting the internal climate of buildings (Guan, 2012; Kikegawa et al., 2003; Kolokotroni et al., 2012), creating diverse and erratic microclimates (Colombo et al., 1999; Giridharan et al., 2004) and affecting the comfort and wellbeing of people living in the city (Tomlinson et al., 2011; Frumkin, 2002; Mills, 2009).

Decreases in the intensity of UHIs may be achieved by increasing the albedo of urban surface materials (Santamouris et al., 2011; Taha, 1997; Taha et al., 1988), increasing urban vegetation cover (Akbari et al., 2001; Shashua-Bar and Hoffman, 2003; Tsiros, 2010), reducing anthropogenic heat (Ferreira et al., 2010; Taha, 1997), and altering city structure design (Shashua-Bar and Hoffman, 2003). However, it is widely accepted that increased vegetation is the most cost effective and beneficial way of combating UHIs in developed cities (Santamouris et al., 2011). Asides from counteracting the UHI effect by evaporative cooling and shading, Increasing vegetation also reduces runoff from trees, carbon dioxide (CO_2) and noise pollution, increases the wellbeing of inhabitants and raises economic value of real estate (Payton et al., 2008). Shade trees reduce surface temperatures during the day by restricting the amount of incident light hitting the surface (Scott et al., 1999); however, there have been no studies investigating if this reduction in surface temperature during the day translates to lower heat retention at night/dusk. The early night (dusk) is a critical time when surfaces have accrued the quantity of heat from the day which determines the intensity of the UHI at night. Furthermore, different species of trees may have different capacities to influence the UHI, through tree architecture and physiology (Feyisa et al., 2014). We investigated differences among tree species in influencing heat retention of surfaces by investigating temperatures of surfaces at dusk.

Exotic tree plantings are often used in cities as shade trees to improve aesthetics and reduce temperatures (Feyisa et al., 2014). In Australia, *Liquidambar* spp. and *Platanus* spp. are common species due to their large deciduous leaves and canopies which are excellent at providing shade during summer and sunlight during winter. Australian native vegetation is perceived to be less effective at providing shade as leaves are often small, narrow and sclerophyllous. However recent findings by Feyisa (2014), found that natives eucalypts are extremely effective at shading and cooling surrounding areas. Native vegetation provides added benefits of enhancing biodiversity by supporting native insect and bird species (Ikin et al., 2013). We measured surface temperatures of asphalt in both shaded and unshaded areas, on hot and normal days, under three native and three exotic tree species in order to identify the effectiveness of tree species in reducing surface temperature retention at dusk.

2. Methods

2.1. Study area and species sampled

This study was conducted in the metropolitan area of Wollongong, NSW, Australia (34°25′59″S, 150°52′59″E; population > 290,000). The region experiences low seasonal temperature variability (mean summer range 17.1–24.6 °C; mean winter range 9.3–17.5 °C) and uniform precipitation