Chapter 25
A Spatio-Temporal Decision Support System for Designing With Street Trees

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ABSTRACT

This article describes how tree species and spacing is an integral part of street design. 3D modelled trees have traditionally been computationally prohibitive to use within precinct scaled urban design models, thus, tree choices in street design are typically limited to database or 2D representations limiting engagement with spatio-temporal issues. This article provides an overview of urban design tree modelling and technology emerging outside of the discipline, then proposes an urban tree decision support system (DSS) drawing from advances in computational botany, entertainment industries and light engineering. The DSS is tested at both street and precinct scale using two case studies. The results demonstrate it is now feasible to integrate detailed 3D trees into urban design models allowing rapid scenario testing of tree placement, species selection, size, alongside the visual and solar impact of these choices. The proposed DSS promotes consideration of spatio-temporal characteristics of trees and a greater level integration of tree choices in the urban design process than previously possible.

INTRODUCTION

From Aesthetics to Green Infrastructure

Street trees can have a tremendous impact on the quality of public spaces relative to cost (Moore, 2009) and the choice of street tree species, their arrangement and spacing are an integral part of street design in many cities built or renewed during the 19^{th} century (Nadel, Oberlander, & Bohm, 1977). Trees have been used in urban street design to provide symbolic definition between streetscape uses, visual mark-

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ers for specific human activities and streetscape enclosure (Lawrence, 2008). Urban street trees have also become a valuable visual and physical connection for urban residents with nature (Beatley, 2011).

While these visual and symbolic uses are still important design considerations, in recent years there has also been a growing recognition of the ecosystem services trees contribute to urban environments (Ely, 2009; Young, 2010). These functional contributions include mitigation of the Urban Heat Island Effect through surface shading (Lindberg & Grimmond, 2011), air temperature cooling through evapotranspiration (Shashua-Bar, Tsiros, & Hoffman, 2010), grey water filtration (Gómez-Baggethun & Barton, 2013), pollution filtration (Maher, Ahmed, Davison, Karloukovski, & Clarke, 2013), noise attenuation, reduction of pedestrian UV exposure and thermal comfort (Parisi, Kimlin, Wong, & Wilson, 2001, 2000).

This shift in the perception of urban trees from a purely aesthetic consideration to both aesthetic and infrastructural or structural consideration, strengthens the argument for their continued inclusion in cities (Mullaney, Lucke, & Trueman, 2015). For heavily constrained urban sites, trees provide the highest 'green plot' ratio of all vegetation types taking up a comparatively small amount of valuable urban real-estate (compared with lawn for example), for a high return in heat mitigation, water sensitive urban design (WSUD), aesthetics and ecology, making them ideal for inclusion in urban systems (Ong 2003). However, the complicated and competitive spatial and climatic environment of more heavily developed sites increases the need to model, quantify and advocate for the microclimatic benefits provided by trees (Oke, 1988). Urban densification is associated with increasing percentages of impervious surfaces, exacerbating the impact of heat in cities (Mullaney et al., 2015).

Melbourne, Australia, for example, is getting bigger, denser and hotter (Metropolitan Planning Authority, 2014). Melbourne's heat issues are intensified in urban streets with large areas of unshaded, dark, impermeable pavements such as the most frequently found asphalt and bluestone (Nakayama & Fujita, 2010). The shading of these surfaces is possibly the most substantial contribution trees could make to heat mitigation particularly areas of low and mid-rise density (Coutts, 2014; Mohd Sanusi, 2015).

In addition, Melbourne is experiencing increased extreme weather events including prolonged and intense heat waves (Bureau of Meteorology, 2013) and altered precipitation patterns (Akompab et al., 2013) which are affecting the range of plants which can be successfully grown as street trees (Mitchell, O'Grady, Hayes, & Pinkard, 2014). In Melbourne, a large proportion of the current tree stock has reached the end of its useful life expectancy due partially to environmental damage and partially to consistent planting age, requiring a substantial renewal over the coming decade (Shears, 2009).

With this major tree-stock renewal challenge, comes a unique opportunity to reconsider not only the kinds of street tree pallets that may be more suitable to the local climate, but also reconsider design and decision-making processes involving trees to increase engagement with spatial and temporal implications. There is potential to redesign the structure and layout of some streets to maximise the ecosystem services and heat mitigating functions trees can provide within the street environment if they are strategically located and afforded with optimal growing conditions (Bolund & Hunhammar, 1999; Dobbs, Kendal, & Nitschke, 2014; Escobedo, Kroeger, & Wagner, 2011).

In order to avoid unsatisfactory or status quo tree species and positioning during this renewal period, sophisticated decision support and visualisation tools capable of garnering public support for tree decisions will be required (Dobbs et al., 2014). Traditional 2D modelling (plan, section and elevation drawings), usually employed for communication of street tree choices, lack integration of science based information and will not be adequate for the challenging and complex decision making required (Escobedo et al., 2011).

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