TECHNICAL

NURSERY PAPERS

October 2011 Issue no.8

Estimating the benefits of Australian Street Trees using i-Tree Stratum - A Pilot Study

Abstract

A US software package called i-Tree STRATUM designed to quantify the physical and economic benefits of street trees was trialled by University of Melbourne in a study of two Melbourne city councils, the central City of Melbourne and the newer City of Hume on the cities outskirts. This research was made possible by direct funding from Nursery and Garden Industry Australia (NGIA) through the Nursery Industry Research & Development Levy. The study was designed as 'proof-of-concept' for the use of i-Tree STRATUM in an Australian context. The research was undertaken by Tom Fairman, a student from the 'Masters of Forest and Ecosystem Science' program at the university of Melbourne who reports in this Nursery Paper on the results of his research.

Study Design

i-Tree STraTum model

i-Tree STRATUM (Street Tree Resource Analysis Tool for Urban Forest Managers) is a model developed by the United States Department of Agriculture (USDA) Forest Service. It is a user-friendly software package to assist communities or urban forest managers describe and quantify the environmental benefits of their trees in comparison to the costs of their management (McPherson et al, 2005). The model can quantify physical benefits such as carbon sequestered in kilograms or electricity savings in gigajoules (GJ), by using local economic values, placing a dollar-value on these savings as to provide cost-benefit analysis of the urban street tree population.

Selection of climatic zone

As the software is currently only set up to model tree growth and development in US climate zones, one of the 16 built-in climate zones had to be selected as being most similar to Melbourne's climate. The selection process was performed through a statistical consideration of street tree species presence and abundance, number of days requiring supplementary heating or cooling and annual precipitation.

Figure 1 City of Hume's Crestmont Terrace with native *Eucalyptus* street trees established sometime between 1997 and 2000 (upper pane). City of Melbourne's iconic Elm trees on Royal Parade between Carlton and Parkville (lower pane).

Nursery & Garden Industry Australia

• Your Levy at Work •
The production and distribution of Nursery Papers is funded jointly by your Nursery Industry Levy and the Commonwealth Government via Horticulture Australia Limited

HAL Know-how for Horticulture™

Melbourne local government authorities

To represent the City of Melbourne, the two suburbs of Carlton and North-West (NW) Melbourne were selected. These are dominated by deciduous European species such as elms, planes, ash and poplars (Figure 1, Table 1). For the City of Hume which lies roughly 20-30 km north of the Melbourne CBD, two suburbs selected were Broadmeadows and Craigieburn which have largely developed over the last 40 years. These suburbs are dominated by native species and a younger average tree age (Figure 1, Table 1).

Selection of street segments for analysis

Street segments equal to between 3% and 6% of the total street length in these suburbs should be sampled to obtain a sample that represents the total street tree population to within a 10% standard error (USDA Forest Service, 2006). As the population of Carlton and NW Melbourne is 25,049 this required 6% of the total street length to be sampled. The population of Broadmeadows and Craigieburn is 120,571 which required only 5% of total street length to be measured. ArcMap and ArcCatalog were used to manipulate GIS maps of Melbourne and Hume to select random segments of available streets for this study.

Generic and specific data collection

i-Tree STRATUM requires generic default data on climate and unit costs for electricity, natural gas, carbon, average house value, as well as suburb specific data on tree species, stem diameter, city population, size and costs associated with urban forest management (Table 2). For the collection of field data, a PDA was used to record species names and stem diameter at a stem height of 1.3 m. City and suburb information and estimates of costs associated with management of the urban forest were obtained through interviews with street tree managers in both Local Goverment Authorities.

Table 1. Species composition of Melbourne City and Hume City and the measured tree number and street length measured as compared to total street length.

City of Melbourne	%	City of Hume	%
Platanus x acerifolia	33.8	*Eucalyptus species*	27.8
Ulmus americana	20.7	*Fraxinus species*	10.7
Tristaniopsis laurina	10.1	*Eucalyptus leucoxylon*	8.9
Eucalyptus species	8.5	*Callistemon salignus*	5.9
Celtis australis	4.9	*Callistemon viminalis*	3.8
Quercus palustris	4.7	*E. polyanthemos*	3.6
Acer species	4.2	*Melaleuca styphelioides*	3.6
Melia azedarach	4.0	*Robinia pseudoacacia*	3.6
Acer platanoides	2.3	*Hakea suaveolens*	3.7
Eucalyptus citriodora	2.1	*Quercus palustris*	2.3
Other Species	4.7	Other Species	26.9
Total trees measured (#)	426		661
Street length measured (km)	3.8		8.5
City wide street length (km)	61.9		163.5
street tree density (tree/km)	105		104

Table 2. Key characteristics of the City of Hume and Melbourne.

City information	City of Hume (Broadmeadows & Craigieburn)	City of Melbourne (Carlton & NW Melbourne)
Total Municipal Budget	$171,000,000	$306,726,891
Population (human)	120,571*	25,049*
Total Land Area (km^2)	18.2	6.2
Average Sidewalk Width (m)	1.5	2.5
Total street length (km)	163.5	61.9
Average street width (m)	4.8	25.0

**= Australian Bureau of Statistics (www.abs.gov.au)*

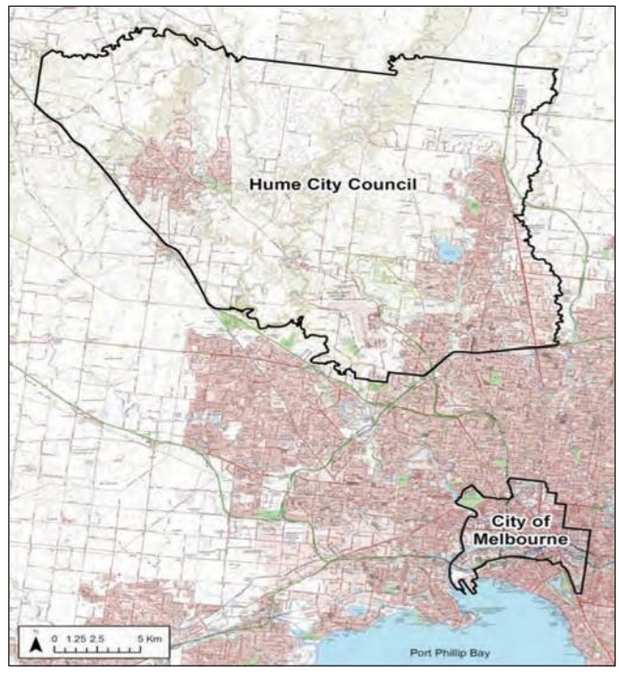

Figure 2. Location of the two city councils selected for the study.

Study Results

Figure 3 shows what an average tree in these two councils contribute in terms of aesthetic, energy savings, stormwater, carbon and air quality benefits. After aesthetic value (increased property value) energy savings accounted for the highest benefit value. In physical terms and across the whole street tree population, street trees in the City of Melbourne saved 2,292 GJ of electricity (cooling) and 1,321 GJ of natural gas (heating) due to shading benefits. In the City of Hume, street trees saved 4,397 GJ of electricity and 3,243 GJ of natural gas.

However, these benefits must be weighed against the costs involved in managing a street tree population (Figure 5).

Figure 3. Monetary value for each tree, on a per tree scale in the city of Hume and Melbourne

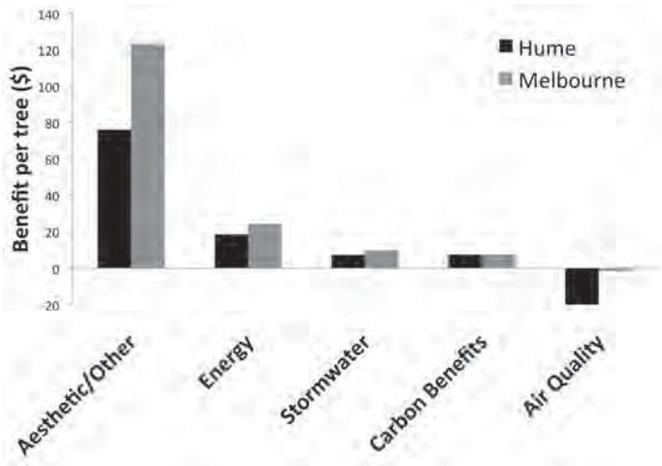

Figure 4. Plane trees (Platanus acerifolia) in the City of Melbourne are estimated to intercept $7,346 worth of air pollutants every year.

For 'newer' suburbs, such as those in Hume, the cost of maintaining a population of trees is less because of the younger age of the trees. For older populations of larger trees, such as those in the City of Melbourne, there is greater cost involved, particularly in pruning in addition to pest and disease management. This model can assist managers in assessing the changing costs involved in maintaining a street tree population over time, depending on age and size of the population (Moore, 1993).

Figure 5. Monetary costs involved for managing a single tree in the city of Hume and Melbourne

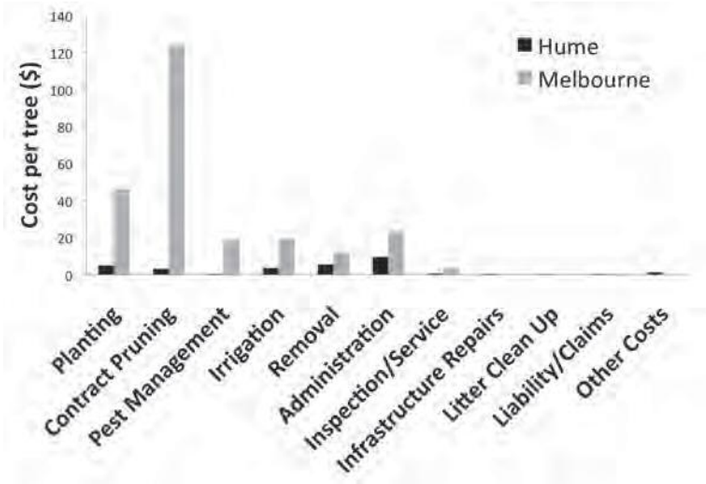

Table 3 shows the respective benefits and costs for each tree in the differing suburbs. Whilst the street trees in the Melbourne have greater benefits, this is outweighed by the higher costs involved in their management and maintenance.

Table 3. Benefit-Cost Analysis of street trees in the City of Hume and Melbourne.

City Information	City of Hume (Broadmeadows & Craigieburn)	City of Melbourne (Carlton & NW Melbourne)
Total Benefits ($ per tree)	$89.0	$163.1
Total Costs ($ per tree)	$30.9	$247.1
Cost-Benefit Ratio	2.88	0.66

Significance of findings

This 'proof of concept study' of the USDA developed i-Tree STRATUM model has allowed one of the first valuations of street trees in south-east Australia.

The model showed that for the environmental benefits estimated, such as carbon sequestration, water retention, energy saving, aesthetics and air pollution removal, the population of street trees in two suburbs of the City of Melbourne provide ecosystem services equivalent to approximately $1 million dollars, where as those in the City of Hume have a value of approx $1.5 million dollars. On an individual scale, the trees in the City of Melbourne provide ecosystem services valued at $163 per tree, and in Hume at $89 per tree.

Caution should be taken when interpreting the model outputs and results. As stated, this has been a 'proof of concept study' for the use of this USDA model and it may not correctly estimate the benefits of some of the tree species used in Australian streetscapes.

A salient example of this is the negative benefits ascribed to eucalypt street trees in Hume. The emission of volatile organic compounds (VOCs) from Eucalypts when combined with industrial pollution (vehicle exhausts, factories) and higher temperatures typical of the urban landscape can lead to enhanced photochemical smog formation (Nowak, 2002). i-Tree STRATUM estimates that in Hume, this effect has a deleterious effect on air quality, in the order of a $20 cost per tree (figure 3). However, in the low pollution environment typical of Australian suburbs smog formation is not likely to be an issue.

Furthermore, i-Tree STRATUM uses a number of growth formulas derived from American natural forest and plantation research, rather than from urban environments (McHale *et al*, 2009). Hence, estimates of tree growth and biomass allocation may not fairly represent what is observed in an Australian urban and single tree environment. As such, future research should directly assess the growth, biomass allocation and environmental benefits of street trees and other trees in an Australian urban context. Regardless, this study has illustrated the data requirements and simplicity of applying the i-Tree STRATUM model, whilst further emphasising the numerous environmental, monetary and aesthetic benefits that urban trees provide.

Acknowledgements

This nursery paper was written by Thomas A. Fairman & Dr. Stephen J. Livesley and derived from a research project titled 'Using STRATUM to estimate the benefits of street trees in Melbourne, Victoria'.

The authors thank Dr Anthony Kachenko and the Nursery & Garden Industry Australia for funding and support, Jason Summers of the Hume City Council, Ian Shears and Oliver Pohl at the City of Melbourne for assistance and the delegates and organisers of the U21 International Conference for Sustainable Cities for the Future at which a early draft of this research was presented.

Cited Literature

McHale, M.R., Burke, I.C., Lefsky, A., Peper, P.A. & McPherson, E.G. 2009, *Urban forest biomass estimates: is it important to use allometric relationships developed specifically for urban trees?* Urban Ecosystems, Vol. 12, No. 1.

McPherson, J.R., Simpson, S.E., Peper, E.G., Maco, P.J. & Xiao, Q. 2005, Municipal Forest Benefits and Costs in Five US Cities, Journal of Forestry, Dec. 2005

Moore, G. 1993, *Arboriculture*: *An Australian* Perspective, Journal of Arboriculture, Vol. 19, Issue 2 ,

USDA Forest Service, 2006, iTree Streets User Manual, available from www.itreetools.org

Nowak, D.J., 2002, *The Effects of Urban Trees on Air Quality,* USDA Forest Service, Syracuse NY, USA

Compiled and edited by Matthew Carroll, NGIA Industry Communications; banner photography by Anthony Tesselaar.

Published by NGIA, PO Box 907 EPPING NSW 1710.