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Valuing the urban forest in Sydney

Any grower can tell you the price of a tree but how many can tell you the value that trees offer to the community?
The objective of the project "Understanding the carbon and pollution mitigation potential of Australia's urban forest" was to test and improve methodologies for evaluating the ecological and social value of the urban forest. In this nursery paper Dr Marco Amati of La Trobe University explains how this was done along two major highways in Sydney.

Valuing the urban forest in Sydney

The urban forest holds a particular role in the Australian urban landscape. A mixture of remnant, native and exotic trees, it exists at once as an expenditure for local authorities while providing a range of unquantified benefits such as habitats for wildlife, air pollution removal and flood prevention. Despite its prominence as an identifier for an urban area or as the backdrop in the lives of urban residents, the urban forest continues to be undervalued as part of the policy process. The aim of this project was to contribute to the development of tools that help value the urban forest, while seeking an understanding of the feelings of residents towards urban trees.

Current planning policies and recent research work highlight the urgency of this task. For example, the current 'Draft Metropolitan Strategy for Sydney' outlines that by 2036 Sydney's population is expected to reach 6 million, an increase of 1.7 million since the 2006 ABS Census, which means Sydney will need to provide 770,000 more homes than in 2006 (NSW Government, 2013). Much of this development will be suburban infill and redevelopment at higher density leading to potential losses of green space. At the same time, research on housing has described how houses in all capital cities in Australia are getting larger and backyards are disappearing (Hall, 2010). The twin drivers of 'densification' through policy and preference work against the well-documented positive impacts that green spaces and especially trees can have on the sustainability of suburban areas. Trees and green spaces can reduce the need for storm water provision, prevent floods and save on air conditioning, mitigating greenhouse gas emissions and improve biodiversity (Stone and Rodgers, 2001).

While a great deal of research exists internationally on urban forests, little work has been undertaken to ensure that this research is appropriate to Australian conditions, which include soils with a uniquely low nitrogen content and frequent drought conditions. A model for the city of Canberra was developed by Cris Brack, one of the researchers in this study (Brack, 2002). Some postgraduate level research has been performed to evaluate the use of the US model STRATUM on street trees in Melbourne, funded by the NGIA. The City of Melbourne has applied i-Tree to its local government authority (LGA) area. CITYgreen and UFORE are two of the most well known models for calculating carbon benefits of tree canopy cover. UFORE's models have been incorporated into i-Tree and the package has been recalibrated to Australian conditions. 'i-Tree' can estimate tree composition, carbon sequestration and storage potential, storm water benefits, air pollution mitigation capability, energy savings and related economic benefits (US Forest Service, 2012). It requires field sample tree data to be collected from a number of sample plots or all plots distributed across the study area. So far the suitability of these packages to Australian conditions remains an ongoing topic of investigation.

Method:

Our study focused on two corridors both 400 m wide: 11 km along the Parramatta Road and 19 km along the Pacific Highway, with both cutting through a variety of different suburbs in Sydney. Figure 1 shows a map of the overlapping study areas. The area shaded in blue shows the area of hyperspectral data collected, the area inside the red line shows the area of LIDAR data collected, the black lines show the area for the sample sites used in the i-Tree component of the study.

Post-graduate students Shi-Hsien Yung and Angela Maria Gomez used the i-Tree methodology to measure trees and model the benefits that derive from the canopy throughout most of 2012. At the same

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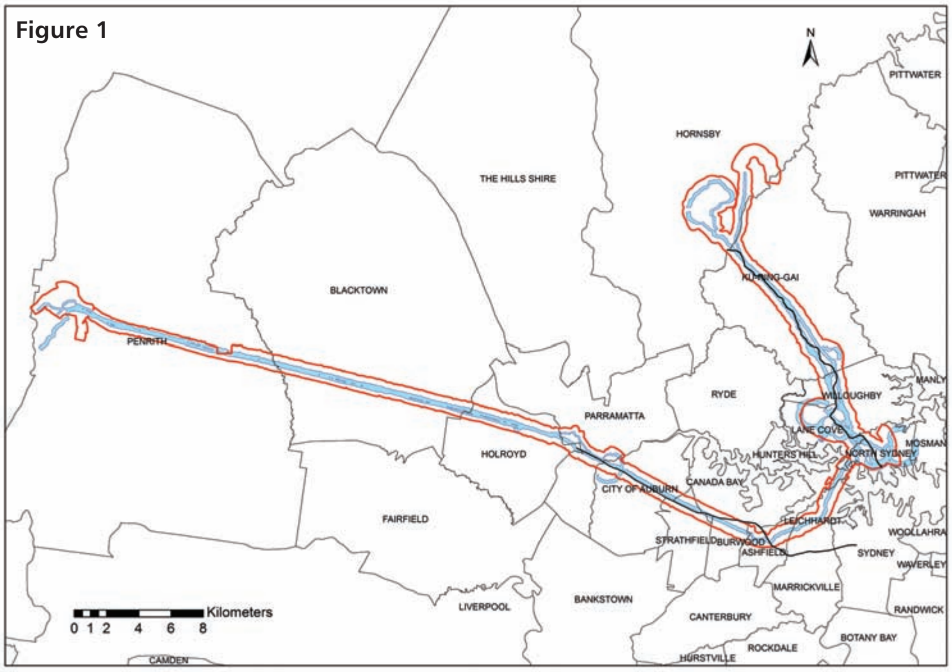
time another student, Mingzhu Wang scheduled an aerial survey of the roads. The survey collected Light Detection and Ranging (LiDAR) and hyperspectral data of the ground surface and canopy. The LiDAR system scans the ground with a radar pulse to a very high degree of accuracy (Figure 2). This data was initially analysed with the help of the company DiMAP in Perth. Subsequently, Mingzhu used the data to identify the shape and extent of the canopy cover and employed a GIS to model the impact that the canopy would have on reducing the solar radiation on building and roofs. This research is ongoing and is part of her PhD project at Macquarie University.

Lastly, during the final quarter of 2012 and the first half of 2013 another post-graduate student, Natalia Saldarriaga, designed and conducted a postal response survey of 1500 residents on their views about the trees in North Sydney and Parramatta LGA areas. The aim of her survey was to identify and evaluate the positive and negative attitudes of residents' towards trees and their willingness to plant and manage trees on their private land according to their socio-economic situation. She received a response rate of 8-19%. This research is an ongoing project as part of a Masters of Philosophy at the University New South Wales, and Natalia will undertake a second survey with council officers responsible for the management of trees along the two transport corridors used in this study.

Figure 1



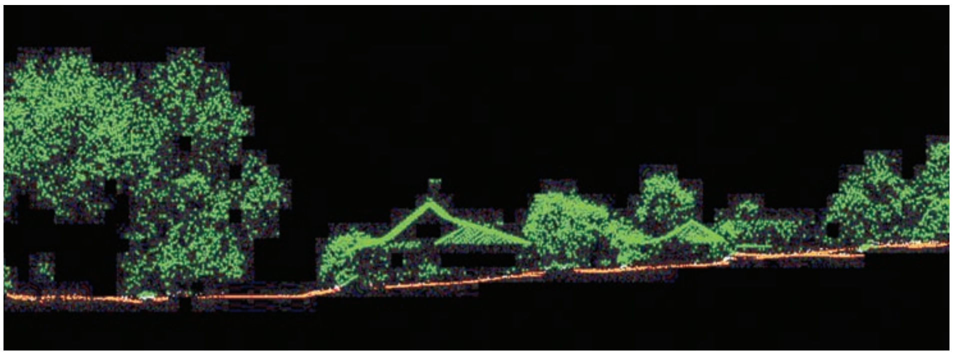
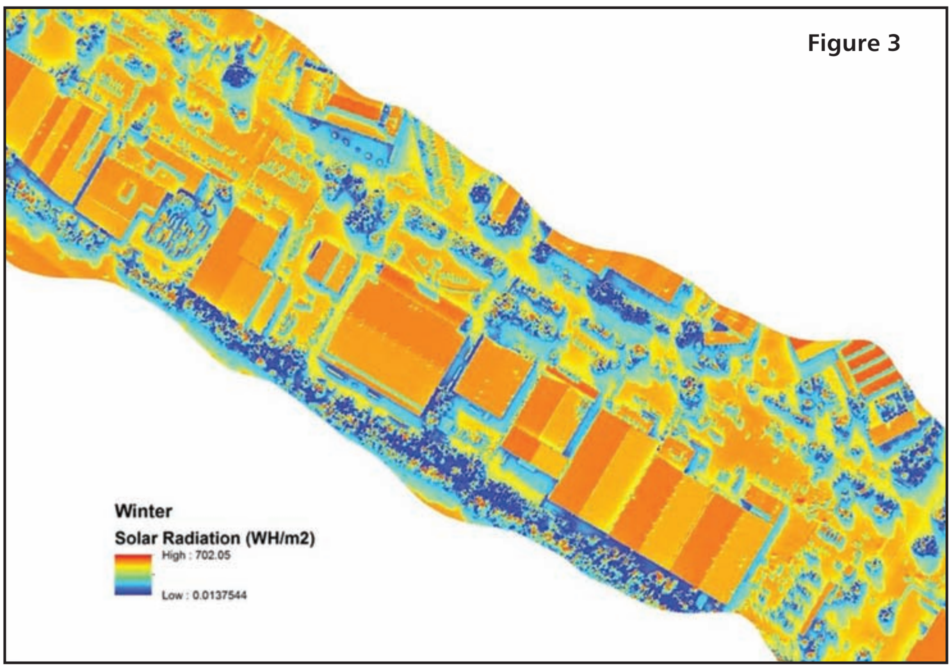


Figure 2

Figure 3



Results:

The i-Tree data shows that the Pacific Highway has a much larger coverage of trees when compared with Parramatta Road (40.3% versus 14.2%). This means that at a basic kilometre-by-kilometre comparison, the Pacific Highway performs better on all of the variables looked at. I-Tree enables the estimation of a variety of parameters related to the ecological value of the canopy. For example, the canopy along the Pacific Highway is estimated to remove 11 tonnes of air pollution per year. This is equivalent to $5,200 per year. The total value of ecological services delivered by the canopy along the Pacific Highway is $97,700 per year and is $18,100 along the Parramatta Road. For the Pacific Highway the lion’s share of this value is delivered by the savings on building heating and cooling at $55,700 per year whereas for the Parramatta Road, carbon sequestration comprises the most important function at $13,200 per year.

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More surprisingly, the results showed that the urban forest along the Pacific Highway corridor is also adding more value per tree to the urban environment than its Parramatta Road counterpart. It is in the areas of pollution removal and building energy savings (and therefore avoided carbon emissions) where the biggest differences between both sites are seen. According to i-Tree the trees along the Pacific Highway are 1.7 times more effective at removing pollution when compared to those along Parramatta Road. Building energy savings delivered by a tree on average are 5 times higher for the Pacific Highway than for the Parramatta Road.

A large amount of data is produced from the i-Tree software that can also show differences between sites. Firstly, the most prevalent species along the Pacific Highway is *Syagrus romanzoffiana* (Queen Palm) which typically has a sparse canopy. The model within i-Tree, however, calibrates the importance of this tree by adding the percent leaf area and the species percentage. This means that trees such as the third most-prevalent species, *Eucalyptus saligna* (Sydney blue gum), which are larger and have a denser canopy and a higher leaf area, contribute proportionately more to pollution removal and building energy savings (cf. Saunders et al., 2011).

In general, the institutional, recreational and other (IRO) land uses are where the greatest density of trees is found (112 trees/ha along the Pacific Highway and 92 trees/ha for Parramatta Road). It is in these schools, parks and other open spaces such as hospital grounds where trees are able to flourish and where a large amount of control can be exerted on planting and maintenance by government authorities. Along the more urbanised Parramatta Road corridor, trees on IRO lands constitute islands of native vegetation. The IRO tree density here is significantly higher than for residential land uses (92 trees/ha compared with 42 trees/ha residential), whereas along the Pacific Highway the residential tree density is comparable to the IRO tree density (both around 110 trees/ha). A consideration of the land use is important since this will affect the overall management of the urban forest canopy.

These initial comparisons of the two roads are reinforced by the results from the LiDAR and hyperspectral data. Mingzhu Wang compared the average solar radiation in WH per square meter (WH/m^2) modelled for the whole area when trees are to be included and when they are removed. As Figures 3 and 4 show the data when modelled can clearly show the detail in the reduction of the solar radiation that i-Tree cannot. At the peak of summer for example the trees along Parramatta Road can reduce the solar radiation from a potential radiation of 7136.7 WH/m^2 to 6424.5 WH/m^2 as seen in Figure 5.

An area where a difference between the two roads cannot be seen is in the attitude of residents of North Sydney and Parramatta local government areas towards the trees. Despite some differences in the characteristics of respondents along both corridors, both show a striking similarity in their responses. Groups along both roads cite beauty as the most common reason to value trees, followed by a tree's role in environment processes. The aesthetic value judgement also plays out in the response

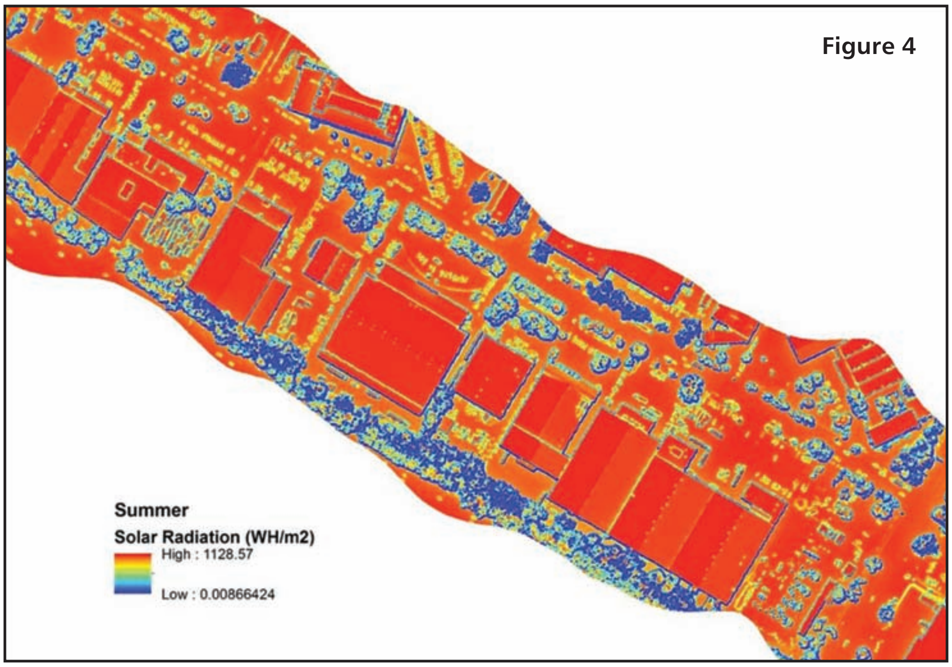

Figure 4

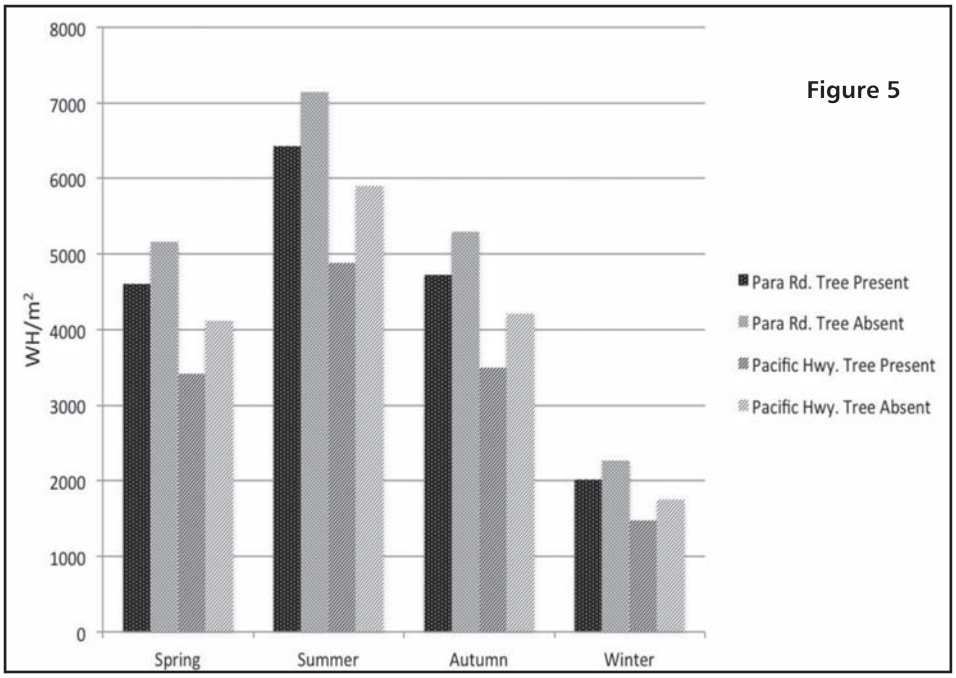

Figure 5

towards the view of trees as a problem - for which the most popular answer was that they are unattractive. This indicates that respondents are highly sensitive to the aesthetics of different trees.

Discussion

A key contribution of this study is to show the difference between LiDAR and i-Tree methodologies for measuring trees in the urban environment. The i-Tree methodology requires relatively low levels of technological input but does require a certain degree of expertise to measure trees, collect samples and input data accurately. i-Tree certainly provides more complete information than the LiDAR hyperspectral components. It would be impossible to calculate the amount of stored carbon in the tree using airborne LiDAR for example. The modelling that i-Tree uses to calculate the value of the tree canopy is peer-reviewed and has been developed over many years. The outputs provided in dollar terms certainly proves a powerful argument for the use of the tool in policy work. On the other hand, we would argue that the LiDAR technique has enormous potential moving forward. The technique does not require a stratified random sample that i-Tree uses. i-Tree's sampling technique is based on 19th century methods and the LiDAR method makes full use of the latest technology. LiDAR can also provide a much more accurate picture of the shape and height of the canopy, allowing accurate modelling of the shading on nearby buildings as we have shown. This modelling could also be performed for the canopy's impact on pollution removal. Further work is required to bring this work to the same level of policy relevance as i-Tree, but the basis for advances is stronger being based on actual measurements as opposed to the allometric calculations that form the basis of i-Tree. Furthermore, rapid development in the use of drones for carrying out LiDAR surveys, suggests that this technique will become cheaper in the future. The possibilities of mapping the trees using LiDAR and hyperspectral data also open up the potential to map other aspect of the tree canopy, for example the distribution of different groups of trees. Finally, it is important to note that both techniques could be used in a complementary way. LiDAR could be used to measure the heights of the trees making the field survey for i-Tree quicker and cheaper.

In conclusion, this project sought to improve the valuation and monitoring of the urban forest – a crucial resource as cities adapt to climate change in the future. The work moving forward will be of relevance to policy makers and planners by highlighting the ecological value of the services that the urban forest provides and showing how valued this green infrastructure is by the community in two very different areas of Sydney.

Further Information

This project was funded by the nursery industry levy with matched funds from the Australian Government through Horticulture Australia Limited (HAL). Other team members included: Sumita Ghosh (University of Technology Sydney), Phil McManus (University of Sydney), Krishna Shrestha (University of New South Wales), Cris Brack (Australian National University), Anthony Kachenko, (Nursery and Garden Industry Australia), Shih-Hsien Yung (University of Technology Sydney), Mingzhu Wang (Macquarie University), Natalia Saldarriaga (University of New South Wales) and Angela Maria Gomez (Macquarie University). Further details can be obtained in the final report for the project: Amati, M. Ghosh, S. Shrestha, K. McManus, P. Brack, C. Kachenko, A. Wang, M. Yung, S.-H. Saldarriaga, N. Gomez, A. M. (2013) *Understanding the carbon and pollution mitigation potential of Australia's urban forest: final report* Horticulture Australia Ltd: Sydney.

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