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In This Issue

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In the last article we looked at what constitutes the 'Urban Forest', concluding that one of the simplest ways to start assessing this resource is to look at Canopy Cover.

In this article we will briefly explore what canopy cover means, the methods by which it can be assessed, and its uses.

Further reading is signposted within the article but also feel free to contact the author with any queries at: Kenton@treeconomics.co.uk

Using Canopy Cover for

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Introduction

Quantifying canopy cover has been identified by many authors to be one of the first steps in the management of the urban forest. For example, in James Schwab's book '*Planning the Urban Forest*', it states:

"The first step in reincorporating green infrastructure into a community's planning framework is to measure urban forest canopy and set canopy goals".

Canopy cover, which is often also referred to as tree canopy cover and urban canopy cover, can be defined as the area of leaves, branches, and stems of trees covering the ground when viewed from above. Canopy Cover is a two dimensional metric, indicating the spread of canopy cover across an area. It is not to be confused with Leaf Area Index (LAI), which is a measure of the number of layers of leaves per unit area of ground (although Canopy Cover studies can be used to estimate LAI).

Assessing canopy cover is popular because it is relatively simple to determine from a variety of means and it can be calculated at relatively little expense.

Measuring canopy cover has helped city planners, urban foresters, mayors and communities see trees and forests in a new way, focusing attention on green infrastructure as a key component of community planning, sustainability and resilience. It is an easy-to-understand concept that is useful in communicating messages about our urban forests with both the public and policy makers.

How can Canopy Cover be measured?

There are 3 main methods to obtain canopy cover data;

1. Field Work Surveys

This method requires surveyors to visit a number of sample plots and take direct measurements on the trees within them. The average Canopy Cover, along with its variability, can then be estimated for the entire area. The advantage of this method is that you can also collect additional data on tree species and tree size not normally available using the other methods. It is probably the most labour intensive, although it could be incorporated into an existing survey regime such as tree health and and tree safety inspections.

2. Random Point Method (using Aerial Photography or other remotely sensed data)

This method involves desk study of aerial imagery using a Geographical Information System (GIS). The method can be used to quantify tree cover by counting the relative number of random points in each area which are covered by trees. This is the principal used by i-Tree Canopy. Its quick, cheap and requires minimal training but only provides information on overall canopy at the chosen scale. It is however a very good starting point to start looking at canopy cover.

3. Area Method

This method involves using aerial imagery and digital mapping to determine the tree canopies using GIS, to calculate tree cover for given areas. This method can provide much finer detail at any chosen scale but depending on resolution the aerial imagery can be very expensive to obtain. Another disadvantage is that it is still very difficult to to get any information about other aspects of the trees such as the species, height and even numbers of trees when several individuals form a closed canopy. In some cases, trees can also be 'hidden' within the shadows of large buildings and a small proportion of shrubs may also be mistaken for trees.

Urban Forest Management

How do the methods compare?

There are few examples in the literature on directly comparing the methods described, although a study carried out by the City of Toronto (2008) used the 3 different methods which are reproduced in Table 1 below. The study concluded that [for its purposes] point sampling from aerial imagery was the most cost effective, whilst also recognising that [in this instance] it provided a conservative estimate compared to the other methods.

Method	Result (% tree canopy)
USDA Forest Service - automated classification of leaf on 2007 satellite imagery	28%
City of Toronto - 2008 i-Tree Eco study, ocular estimate of canopy cover (407 plots)	24%
USDA Forest Service - 9,998 point sample, manual interpretation of 2005 leaf-off aerial photos	19.9%
USDA Forest Service - 9,998 point sample, manual interpretation of 1999 leaf-off aerial photos	20.6%
City of Toronto Urban Forestry - small sample size, digitized manually from 2002 aerial photos with area estimates by land use	17.5%
University of Toronto - 2000 UFORE study, ocular estimates of canopy cover in 211 sample plots	20.5%

Table 1: Comparison of different methods for assessing canopy cover in Toronto. Source: Every Tree Counts - a portrait of Toronto's urban forest (2008).

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Fig 1: Australia's Urban tree canopy cover at a glance. Source: Where are all the trees?

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The Toronto experience shows quite a high variability in the different methods over a period of 8 years, although this does not necessarily mean that any one method is incorrect, just that it needs to be interpreted with consideration for the expected statistical accuracy.

What can Tree Canopy Cover tell us?

At a very basic level Canopy Cover provides a percentage figure of the amount of tree cover in a given area and could also indicate how much room there may be to plant more trees. However, do not be fooled! even this basic measurement can be implemented in a variety of different ways, with varying levels of sophistication and complexity.

Depending on how a project is set up Canopy Cover can be assessed at the individual property level, by ward or by borough, through to the city, county or even country scale.

Take for example the recent canopy cover league table completed by University of Technology, Sydney and 2020 Vision in Australia[1]. They are using the results of a country wide canopy survey (see fig 1) to benchmark and provide a baseline for their aspirations to increase their urban greenspace by 20% by 2020.

This example illustrates which cities have good canopy cover, those which are dominated by 'hard' surfaces and grey infrastructure and those where opportunities exist to increase canopy cover.

In many international canopy cover studies the mapping of existing tree cover levels and distribution has been used to set future targets. This is regarded as good practice by the US Conference of Mayors, the US Department of Agriculture Forest Service, and

many non-for-profit organisations including the Arbor Day Foundation (US-based), American Forest (US-based), the National Urban Forest Association (Australia-based) and the Trees and Design Action Group (UK-based).

In the US, American Forests offers some general guidelines for canopy goals based on climate conditions and land-use categories.

Although city wide figures are helpful, especially in country wide projects, tree cover is not uniform throughout a city. Generally canopy cover will change in relation to land-use, geography and other social and political factors.

fig 3 An example of infill from Perth, Australia with an obvious reduction in canopy cover. However, with canopy cover assessed at the parcel level, city planners can now seek to ensure that canopy cover levels are maintained or enhanced as a planning condition.

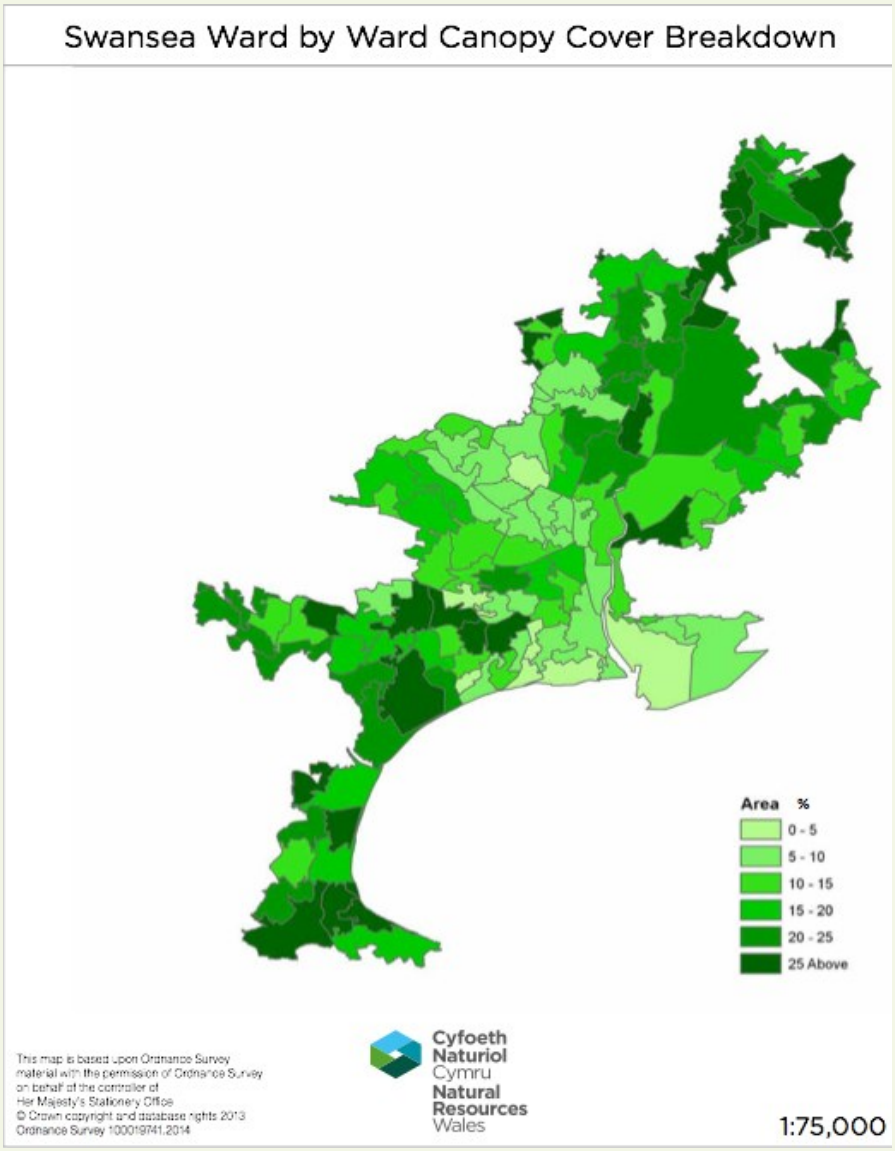

Fig 2: Canopy Cover by Ward for Swansea Wales. Source: Tree Cover in Wales' Towns and Cities 2014 © Natural Resources Wales

Illustrating this point are two separate studies carried out in the US[2] and the UK[3]. These have highlighted a trend where most of the canopy cover in urban areas is provided by residential areas, and also, that it is often the most deprived areas which have the least tree cover.

A land use approach was adopted by Natural Resources Wales, who have recently completed a canopy cover survey to look at the tree cover in all of its urban areas[4].

They have compared their tree cover for different land uses within a city as well as comparing overall canopy figures with other cities throughout the world. The results can be readily used to

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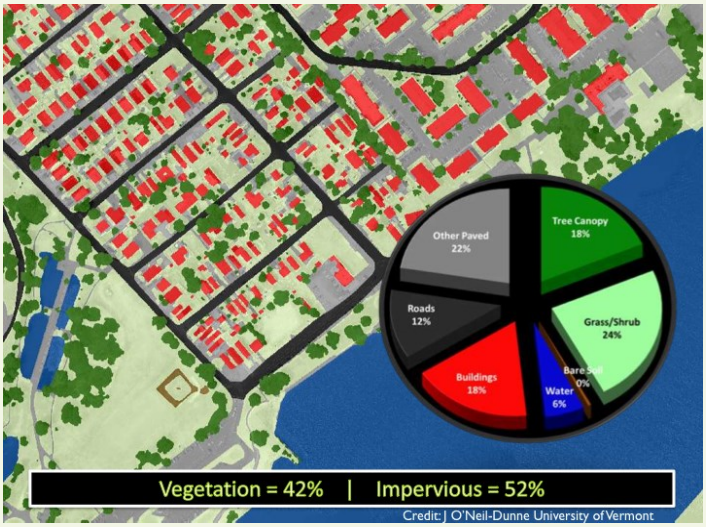

Fig 4: Tree cover and Urban Tree Canopy (UTC) potential at the parcel level. Image courtesy of J O Neil-Dunne, University of Vermont.

make comparisons between different cities, or between different parts of the same city (See fig 2). A study at this scale can help to target tree planting where tree cover is lower, delivering benefits to the areas that most need it.

The University of Vermont Spatial Analytics Laboratory have analysed the canopy cover at the parcel level for a growing number of cities in Virginia. At this scale it is possible to use the canopy mapping as a tool for maintaining or enhancing tree cover during development by requiring levels of canopy cover to be maintained or enhanced as a planning condition See Fig 3 overleaf.

This is a particularly important issue for many cities as the pace of development accelerates to keep up with the demand of evermore people moving into urban areas. Increasing demand for space often means that tree canopy is removed to make way for building and development, often on 'infill' (see fig 4). Yet it is the canopy cover which makes our towns and cities better places to live, providing important ecosystem services like urban heat island reduction and air pollution filtration. Therefore measuring canopy cover is crucial for establishing a baseline from which to monitor future progress.

Repeated measurements of Canopy Cover, for instance using historical aerial photographs or repeated surveys, can highlight changes in tree cover over time and space and there have been studies done in Wales, England (already cited) and the US[5]. Although some cities and towns showed an increase in canopy cover, the general trend has been a gradual reduction in the area of canopy, most probably due to the reasons described above.

Another way in which canopy cover can be used is to look at correlations between tree cover and environmental performance of an urban area. Canopy cover measurements can be used with other data such as crime rates, climate data or health and well being statistics to provide insight into how urban trees affect- and are affected by - various social and climatic factors.

Work in Manchester, UK[6] has assessed canopy cover at the ward level and has compared this with statistics on Acute Respiratory Disease and Mental Health. It found a positive correlation between tree cover and reduced rates of hospital admissions for these conditions. These relations are important and the Clean Air Act in the US recognises tree canopy management plans as part of State air quality management plans, based on the link between trees, ambient temperature and ozone levels.

Conclusions

Hopefully you've been given an insight into how assessing canopy cover can be used in a variety of ways for urban forest management. We really have only just scratched the surface of this fascinating subject. Thanks to

advances in Geographical Information Systems, the measurement of tree benefits and the sciences of Arboriculture and Forestry there has never been a better time to start using these tools to make our towns and cities better places to live by supporting decisions to get the right the right tree in the right place.

References

[1] *Where are all the trees?* Available at: http://202020vision.com.au/research

[2] *Connecting People with Ecosystems in the 21st Century: An Assessment of our Nations Urban Forests*. USDA Forest Service

[3] Trees in Towns II. Dept for Communities and Local Government, London

[4] *Tree Cover in Wales' Towns and Cities* Available at: http://naturalresourceswales.gov.uk/our-work/community-link-working-together-working-with-you/tree-cover-in-wales-towns-and-cities/?lang=en#.U9Yn9I5IlQ9

[5] Nowak and Greenfield (2012). Available at: http://www.itreetools.org/Canopy/resources/Tree_and_Impervious_Cover_change_in_US_Cities_Nowak_Greenfield.pdf

[6] Manchester Tree Audit 2. Available at: http://www.redroseforest.co.uk/web/images/stories/downloads/Valuing%20Manchester's%20Trees%20-%20Tree%

Google can serve as "entry-level GIS for urban tree managers"

Google's Fusion Tables web application can serve as a low-cost multi-user geographic information system (GIS) for urban forest managers, Canadian researchers have concluded.

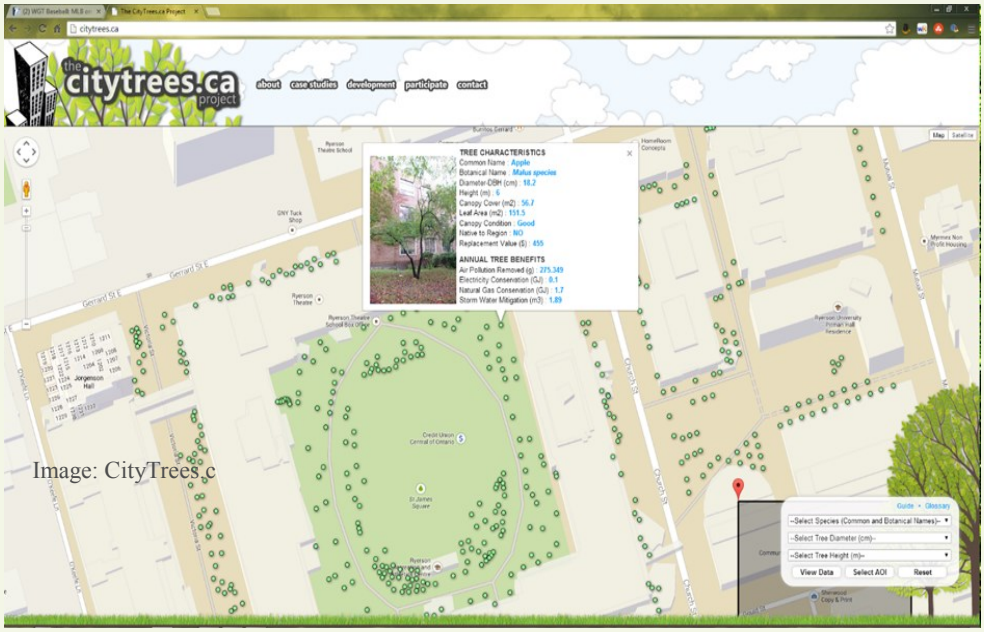

Image: CityTrees.c

"Google Fusion Tables provide cloud-based computing services for data management and easy user collaboration through the Google Maps interface," the team from Toronto's Ryerson University said.

"Fusion Tables are oriented toward smaller organizations that previously were unable to publish data online due to limitations of database knowledge and high cost of start-up."

An interactive web-based mapping platform, the CityTrees.ca project, tested the technology's ability to map trees on the university's campus, while query interface enabled users to narrow down the tree population by species, diameter, height, and location.

"We found that Fusion Tables performed well as a storage medium for our campus tree data, which could easily be explored through our creation of a JavaScript- enabled query tool," they concluded - describing their efforts as "a roadmap for small to medium-sized urban forestry organizations seeking to create interactive mapping applications".