www.oxford.gov.uk

OXFORD CITY COUNCIL

Oxford i-Tree Canopy Cover Assessment

2015

i-Tree

Treeconomics

DAVEY

Forest Research

The Authors

Kenton Rogers and Anne Jaluzot, Treeconomics

Project Manager

Kevin Caldicott, Oxford City Council

Acknowledgements

Kieron Doick, Forest Research
Cleaner, Greener Executive Board - Oxford City Council
Oxford University
Westgate Oxford Alliance

This assessment was carried out by Treeconomics

Contents

Summary

This study estimates tree canopy cover in Oxford using aerial imagery and a random point technique using the i-Tree Canopy software tool. Estimates of canopy cover for each ward, as well as the city total were calculated. The results provide a snapshot of current tree canopy cover and a baseline for comparison with future surveys. Classifications were made for overall tree canopy cover and where no tree canopy cover was present other key land use categories were defined.

The classification of 7939 random points across the city estimated Oxford to have over 21 percent of canopy cover (trees, woodland, shrubs) and over 48 percent green cover (areas including grass etc).

This estimate provides a baseline for tree canopy cover of **21.4** percent with 95 percent confidence intervals.

Using aerial images is just one method to estimate tree canopy cover. Importantly, the i-Tree Canopy method used in this study is low cost and easily repeatable. Following this study it is recommended that Oxford repeats and monitors aerial image analysis of canopy cover on a 5-10 year basis across Oxford and within its wards. We also recommend that Oxford work towards obtaining, drawing or calculating more detailed canopy cover maps that can be used within a GIS system to observe other trends and patterns.

Oxford compares favourably with other towns and cities (see table 1 below) that have completed canopy surveys, although urban tree cover in the UK is generally lower than that found in continental Europe and the US.

City	% Tree cover	Source
Birmingham	23.00	i-Tree Canopy Survey 2012
Exeter	23.00	i-Tree Canopy Survey 2013
London	21.90	forestry.gov.uk/pdf/ltwf_highlights.pdf
Oxford	21.40	i-Tree Canopy Survey 2015
Walsall	17.30	i-Tree Canopy Survey 2012
Edinburgh	17.00	i-Tree Survey 2012
Wrexham	17.00	i-Tree Survey 2014
Eastbourne	15.90	i-Tree Canopy Survey 2011
Manchester	15.50	2007 Red Rose Forest survey
Glasgow	15.00	i-Tree Survey 2014
Bristol	14.00	Bristol Tree Survey 2009
Telford	12.50	i-Tree Canopy Survey 2012
Torbay	12.00	i-Tree Survey 2011

Table 1: Canopy cover comparison

Urban Tree Cover

Measuring tree cover has helped city planners, urban foresters 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 the public, policy makers and other stakeholders.

The importance of vegetation in urban areas has long been recognised (e.g. Oke 1982, Huang et al 1987, Nowak et al 2010). For example, vegetation provides shading, evaporative cooling and rainwater interception (Gill et al 2007). It has a strong influence on a number of factors including energy demand, air quality and noise pollution, biodiversity, mitigation of the urban heat island effect (UHI), human health and well being.

Quantifying tree canopy cover has been identified by many authors (Britt and Johnston, Escobedo, Nowak, Schwab) to be one of the first steps in the management of the urban forest.

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

James Schwab, Author, Planning the Urban Forest.

Canopy cover, which is often also referred to as tree canopy cover, urban tree 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).

It is important to note that in using the interpretation of aerial images to ascertain a canopy cover the estimate will include the canopy cover of both trees and shrubs. It is difficult or impossible to differentiate between trees and shrubs using aerial photography and so it must be borne in mind that the canopy cover figures presented here include both trees and shrubs.

Methodology

i-Tree Canopy was used to interpret aerial images across Oxford using 7939 random points. This overall picture was built up by analysing the 24 wards (see fig 1) that make up Oxford, allocating between 300 and 600 plots to each ward until a satisfactory standard error for canopy cover was reached. This was typically between .2 and 2.4% depending on land use.

Classification of Land Use followed the Land Use and Land Classification Guidelines (Version 4.4) published by the Office of the Deputy Prime Minister (ODPM 2006), with the exception of the inclusion of the 'Nature Reserves' classification, a land use of particular interest to Oxford which covered agricultural areas managed for conservation. The land classes assigned and their descriptions are provided in table 2 (below). Furthermore, tree cover is given as a percentage which occurs across all land uses.

i-Tree Canopy is a quick and simple method to obtain statistically valid estimates for canopy cover and other land uses based on the point method. Its simplicity, low cost and ease of use means that it has certain limitations over other more expensive methods. For example, i-Tree Canopy is not spatially explicit and so there is no 'geo-referenced' layer for use in GIS applications. Furthermore, as values are calculated 'on the fly' it cannot be enquired like a database. For example, if we wanted to find out the tree cover within Agricultural or Residential land uses then a new survey would be required.

Further technical information on i-Tree canopy is included in Appendix 1.

Cover Class	Abbreviation	Description
Agricultural	Ag	Farmed land including; Fields, pasture, crops and bare earth
Tree Cover	T	All trees and shrub cover on any land or cover class and including Orchards and Scrub
Nature Reserve	NR	As per the areas delineated on the map provided by OCC
Water and Wetland	Wtr	Canals, rivers, marshland and inland water
Parks and Gardens	Prk	Other greenspace including private gardens, tennis courts etc
Transport	Trns	Road and rail network
Residential	Res	Private dwellings and multi occupancy
Industrial, Institutional and Commercial	Ind	Shops, offices, universities, govt buildings, warehouses etc
Vacant Lots	Va	Derelict land and building sites

Table 2: Cover class descriptions

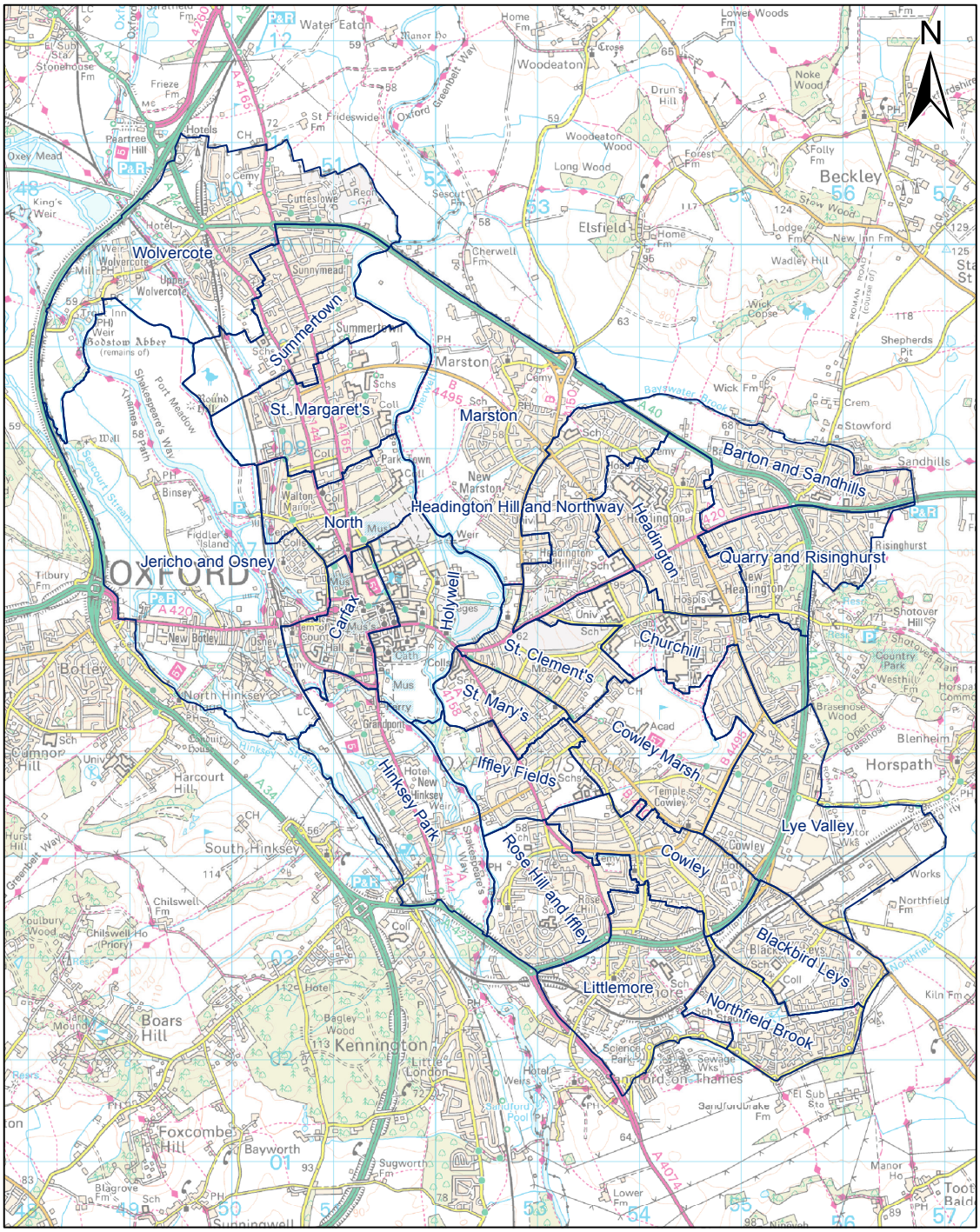
Notes:

Where the aerial image shows a roof top it is not always possible to distinguish between commercial and residential - e.g when there are multiple apartments on floors above a shop. Where possible this was cross-referenced with Google Streetview; when there was a shop present it was classed as 'industrial and commercial'.

Driveways in front of houses are classified as 'residential'.

Hard surfaces such as paths, parking areas and tennis courts within parks were defined as 'parks and gardens' even though the actual point was not technically a 'greenspace'.

Oxford City Wards



District Ward

Scale: 1:50,000 (A4)

www.oxford.gov.uk
OXFORD CITY COUNCIL

Fig 1: Oxford wards

Results

Total canopy cover in Oxford is estimated at 21.4 percent across the city.

On a ward by ward basis canopy cover ranges from 11.4 to 30 percent. Canopy cover was highest in Headington and Headington Northway at 29 and 30 percent respectively. Canopy cover was lowest in Lye Valley and Jericho Osney at 11.4 and 13 percent.

A full list of the canopy cover by Ward is given in Figures 2 and 3 (below). Fig 4 (below) gives percentage ground cover estimates for each land use category.

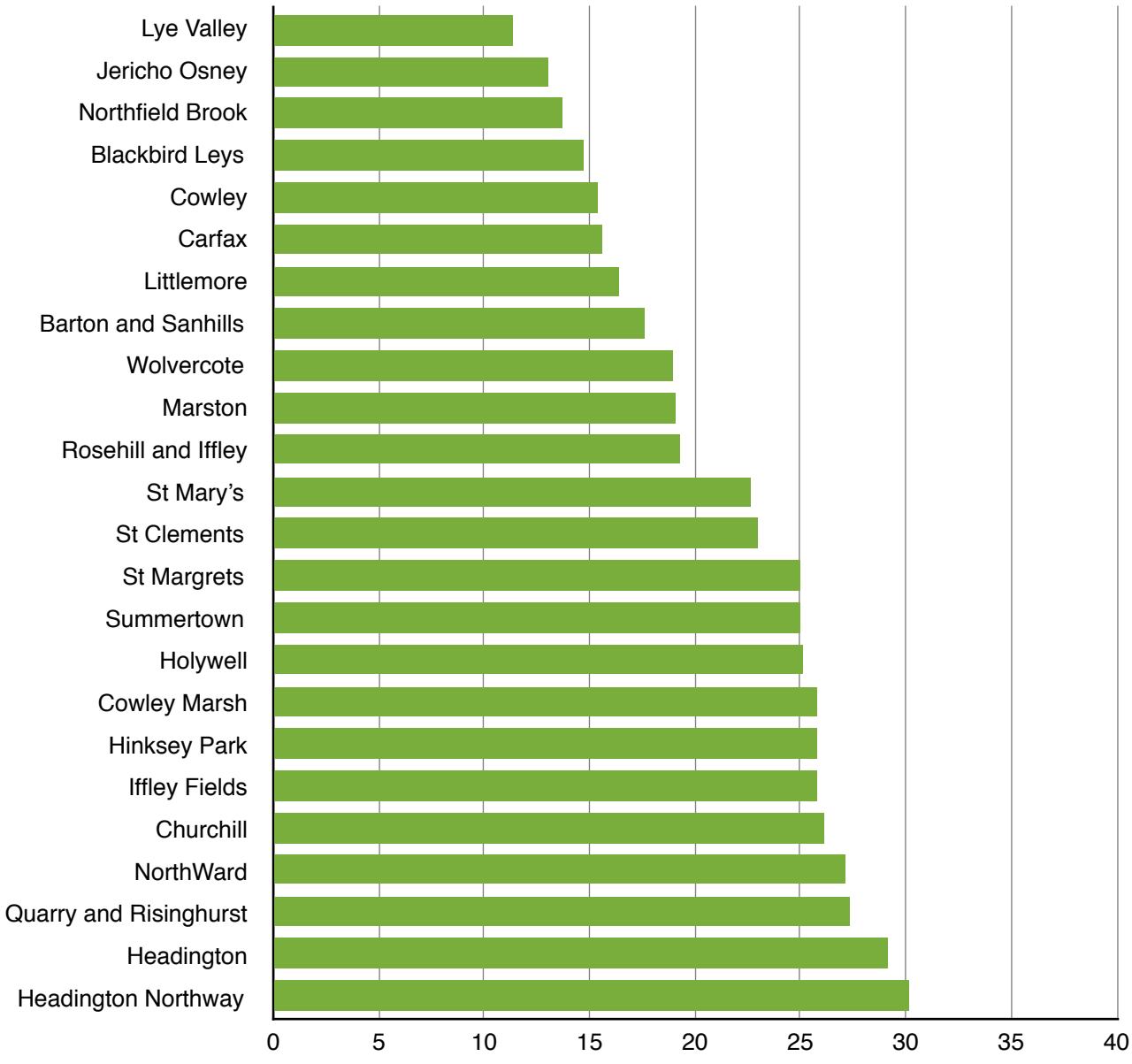


Fig 2: Canopy cover by ward

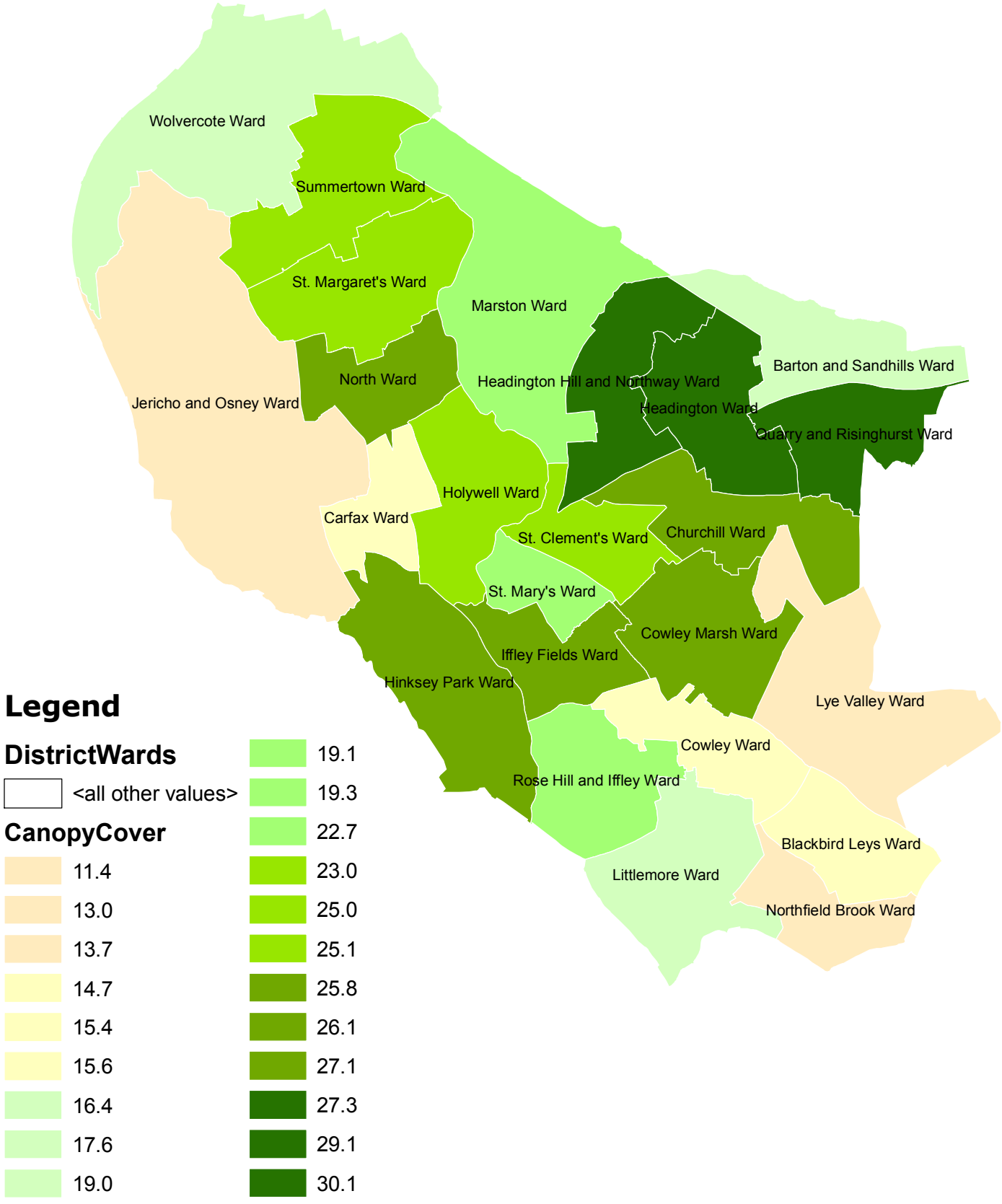


Fig 3: Canopy cover percentages by ward

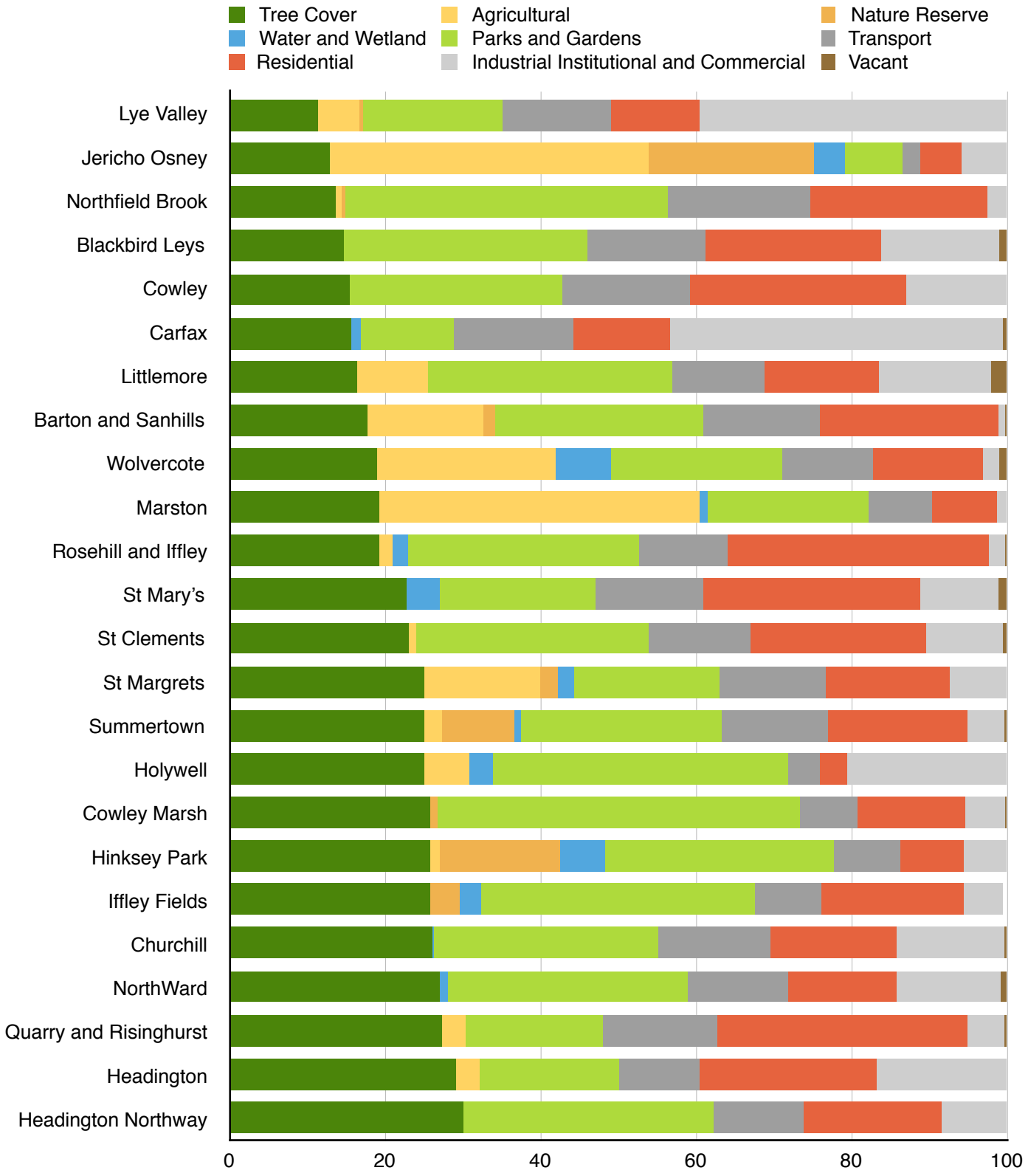


Figure 4: Land-use % by ward

Generally, it is the areas in the southern part of Oxford (Cowley, Littlemore, Lye Valley, Blackbird Leys and Northfield Brook) that present the lowest canopy cover within the study.

Areas with higher canopy cover include Headington, Northway, Quarry and Risinghurst, located in the middle and east of the study area. These areas also have lower Industrial, Commercial and Institutions coverage.

Jericho ward in the North West also has low canopy cover at 13% but also contains the largest proportion of other greenspace. Total percentages and the equivalent area in hectares are given in table 3 below.

How does Oxford compare to other areas with regard to its canopy cover?

Comparison with cities is an interesting exercise but should be made with caution as there are many attributes of a city which will effect urban forest structure and function. Furthermore, other studies listed in the comparison table (see fig 5 below) have used a variety of different methods to assess canopy cover. Studies that have carried out i-Tree Eco assessments also have tree population data available which is also included, although Oxford does not have a figure yet. Nonetheless, these figures can be very helpful in providing a rough benchmark for Oxford.

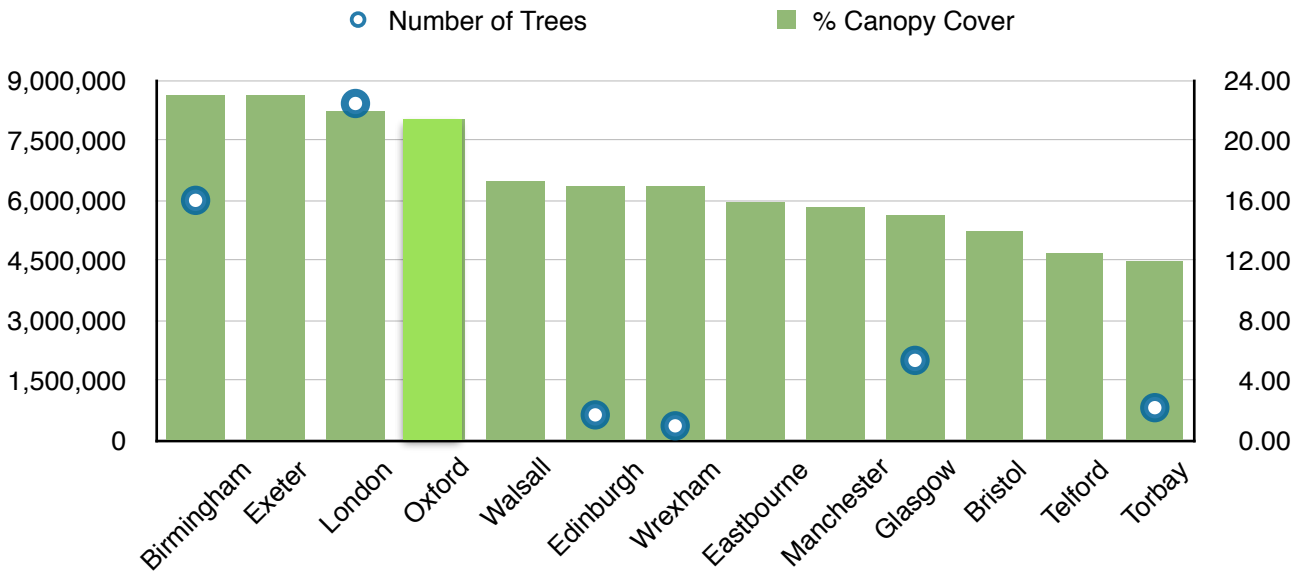


Fig 5: Percentage of Canopy Cover and Tree numbers (where available)

Canopy Cover		Agriculture		Nature Reserve		Water		Parks Gardens		Transport		Residential		Industrial Institutional Commercial		Vacant	
%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha	%	Ha
21.4	974.9	7.0	320.2	2.3	105.6	1.5	67.2	26.7	1215.3	11.9	544.8	17.8	811.7	11.0	502.8	0.4	17.0

Table 3: Total % and area estimates for Landuse across Oxford

Recommendations

This preliminary study presents basic data on the canopy cover found in Oxford on a ward by ward basis. It also establishes a baseline which can be used to monitor future progress or in further research, for example the data could be used to study the relationships between tree cover and house prices, flooding or social deprivation (where data exists). These relationships are often very useful in making the case for retaining or increasing canopy cover.

More specifically the following recommendations are also suggested.

1. Undertake a iTree Eco phase 2 'bottom-up' survey of trees within the Oxford City Council administrative area in order to:

    I. Provide more detailed information on the structure and composition of the urban forest such as the species present, the size and age (structural diversity) and health of the trees to inform and facilitate planning of future planting and maintenance activities to ensure that current canopy levels can at least be sustained, if not improved where appropriate;
    II. Quantify and estimate the value the benefits trees are delivering;
    III. Provide an evidence base for a comprehensive tree strategy.

2. Prepare a comprehensive tree strategy for public and privately owned trees which will:

    I. Describe the nature and extent of the urban forest that exists within Oxford and provide a vision for the urban forest that is needed in the future, together with an action plan for delivery and monitoring;
    II. Set canopy cover targets for key land uses and/or geographic areas as well as for the whole of Oxford;
    III. Monitor canopy cover as a key performance indicator for management of the urban forest;
    IV. Identify and prioritise action through planting and management to ensure that tree cover is maintained, sustained and improved where this is appropriate;
    V. Describe the role of trees within the landscape setting of Oxford.

3. Also to consider in relation to 1 and 2 above:

    I. Obtain canopy cover shape files from remotely sensed data to establish better resolution of data for spatial planning of available planting space for future planting. Publicly accessible lands (e.g., streets, parking lots, schools, parks) provide good opportunities for maximising air quality, energy savings, and aesthetic benefits;
    II. Assess canopy cover in relation to other relevant contextual ward level data to help prioritise action and develop a rationale for doing so. Datasets to investigate could include:
        - Index of Multiple Deprivation (IMD)
        - Specific public health Key Performance Indicators (eg obesity)
        - Air quality
        - Urban heat island
        - Surface water flooding;
    III. Collect data on the role of trees within the landscape setting of Oxford including important view cones.

Appendix I i-Tree Canopy Technical Notes

i-Tree Canopy Technical Notes

This tool is designed to allow users to easily and accurately estimate tree and other cover classes (e.g., grass, building, roads, etc.) within their city or any area they like. This tool randomly lays points (number determined by the user) onto Google Earth imagery and the user then classifies what cover class each point falls upon. The user can define any cover classes that they like and the program will show estimation results throughout the interpretation process. Point data and results can be exported for use in other programs if desired.

There are three steps to this analysis:

1) Import a file that delimits the boundary of your area of analysis (e.g., city boundary). Many standard boundary files can be located on websites such as ESRI's Census 2000 TIGER data site (http://arcdata.esri.com/data/tiger2000/tiger_download.cfm) and the US Census Cartographic Boundary Files site (http://www.census.gov/geo/www/cob/bdy_files.html). Data from these sites will require some minor processing in GIS software to select and export a specific boundary area polygon.
2) Name the cover classes you want to classify (e.g., tree, grass, building). Tree and Non-Tree are the default classes given, but can be easily changed.
3) Start classifying each point: points will be located randomly within your boundary file. For each point, the user selects from a dropdown list the class from step 2 that the point falls upon.

The more points that are interpreted, the more accurate the estimate.

Credits

The concept and prototype of this program were developed by David J. Nowak, Jeffrey T. Walton and Eric J. Greenfield (USDA Forest Service). The current version of this program was developed and adapted to i-Tree by David Ellingsworth, Mike Binkley, and Scott Maco (The Davey Tree Expert Company).

Limitations

The accuracy of the analysis depends upon the ability of the user to correctly classify each point into its correct class. Thus the classes that are chosen for analysis must be able to be interpreted from an aerial image. As the number of points increase, the precision of the estimate will increase as the standard error of the estimate will decrease. If too few points are classified, the standard error will be too high to have any real certainty of the estimate. Information on calculating standard errors can be found below. Another limitation of this process is that the Google imagery may be difficult to interpret in all areas due to relatively poor image resolution (e.g., image pixel size), environmental factors, or poor image quality.

Calculating Standard Error and Confidence Intervals from Photo-Interpreted Estimates of Tree Cover

In photo-interpretation, randomly selected points are laid over aerial imagery and an interpreter classifies each point into a cover class (e.g., tree, building, water).

From this classification of points, a statistical estimate of the amount or percent cover in each cover class can be calculated along with an estimate of uncertainty of the estimate (standard error (SE)). To illustrate how this is done, let us assume 1,000 points have been interpreted and classified within a city as either "tree" or "non-tree" as a means to ascertain the tree cover within that city, and 330 points were classified as "tree".

To calculate the percent tree cover and SE, let:

N = total number of sampled points (i.e, 1,000)
n = total number of points classified as tree (i.e., 330), and
p = n/N (i.e., 330/1,000 = 0.33)
q = 1 – p (i.e., 1 - 0.33 = 0.67)
SE = √ (pq/N) (i.e., √ (0.33 x 0.67 / 1,000) = 0.0149)

Thus in this example, tree cover in the city is estimated at 33% with a SE of 1.5%. Based on the SE formula, SE is greatest when p=0.5 and least when p is very small or very large (Table 1).

Table 1. Estimate of SE (N = 1000) with varying p.

p	SE
0.01	0.0031
0.1	0.0095
0.3	0.0145
0.5	0.0158
0.7	0.0145
0.9	0.0095
0.99	0.0031

Confidence Interval

In the case above, a 95% confidence interval can be calculated. "Under simple random sampling, a 95% confidence interval procedure has the interpretation that for 95% of the possible samples of size *n*, the interval covers the true value of the population mean" (Thompson 2002). To calculate a 95% confidence interval (if N>=30) the SE x 1.96 (i.e., 0.0149 x 1.96 = 0.029) is added to and subtracted from the estimate (i.e., 0.33). The result is a 95% confidence interval between 30.1% and 35.9%.

SE if n < 10

If the number of points classified in a category (n) is less than 10, a different SE formula (Poisson) should be used as the normal approximation cannot be relied upon with a small sample size (<10) (Hodges and Lehmann, 1964). In this case:

SE = (√n) / N

For example, if n = 5 and N = 1000, p = n/N (i.e., 5/1,000 = 0.005) and SE = √5 / 1000 = 0.0022. Thus the tree cover estimate would be 0.5% with a SE of 0.22%.

References

Lindgren, BW and GW McElrath. 1969. Introduction to Probability and Statistics. Macmillan Co. London
Hodges, JL and EL Lehmann. 1964. Basic Concepts of Probability and Statistics. Holden-Day, Inc. San Francisco.
Thompson, S. K. 2002. Sampling, second edition. John Wiley and Sons, Inc., New York, New York.

Bibliography

Britt, C., Johnston, M (2008). Trees in Towns II - A new survey of urban trees in England and their condition and management. Department for Communities and Local Government, London.

Escobedo, F., Nowak, D (2009). Spatial heterogeneity and air pollution removal by an urban forest. Landscape and Urban Planning, 2009 Vol. 90 (3-4) pp. 102-110.

Gill, S., Handley, A., Ennos, A., Paulett, S (2007). Adapting cities for climate change: the role of green infrastructure. Built Environment 33 (1), 115-133.

Huang, Y.J., Akbari, H., Taha, H., and Rosenfeld, A.H. (1987) The potential of vegetation in reducing summer cooling loads on residential buildings. Journal of Climate and Applied Meteorology 26 pp. 1103-1116

i-Tree Canopy (2013). 'i-Tree software suite v5' [Online] Available at: http://www.itreetools.org/resources/manuals.php [Accessed: Feb 12 2015].

Nowak, D., Hoehn, R., Crane, D., Stevens, J., Leblanc F. (2010). Assessing urban forest effects and values, Chicago's urban forest. Resource bulletin NRS-37. USDA Forest Service, Radnor, PA.

Oke, T.R. (1982) The energetic basis of the urban heat island. Quarterly Journal of the Royal Meteorological Society 108 pp. 1-24

ODPM (2006) National land use database: Land use classification. Office of the Deputy Prime Minister, London.

Rogers, K,. Hansford, D., Sunderland, T., Brunt, A., Coish, N., (2012) Measuring the ecosystem services of Torbay's trees: The Torbay i-Tree Eco pilot project. Proceedings of the ICF - Urban Tree Research Conference. Birmingham, April 13-14.

Schwab, J. (2009) Planning the Urban Forest: Ecology, Economy, and Community Development. USDA Forest Service, NewYork.

Trees in the Townscape (2013). The Trees Design Action Group. [Online] Available at: www.tdag.org.uk/uploads/4/2/8/0/.../tdag_treesinthetownscape.pdf [Accessed: Feb12 2015].