The Canopy Cover of England's Towns and Cities: baselining and setting targets to improve human health and well-being

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Abstract

Evidence shows that the negative impacts upon human health of urbanisation, such as increased exposure to heat stress and elevated levels of air pollution, are in part caused by the removal of vegetation relative to rural environments. Consequently, trees and the wider green infrastructure of a city are advocated as a cost-effective sustainable remedy. Trees also contribute to human well-being by softening the urban aesthetic and offering a focal point for human social interaction.

Within the UK, there is a knowledge gap with respect to the numbers of trees in towns and cities. Anecdotal evidence for England and research from Wales suggests that tree numbers and therefore canopy cover is falling.

City-wide tree canopy cover is a useful indicator of the extent of tree presence across a city. Its assessment can be simple, fast and highly reproducibly. Repeat observation could be a cost-effective means of monitoring tree populations, setting targets and tracking effectiveness of planting programmes.

Presenting the canopy cover of 283 towns and cities of England this report provides a landmark baselining of England's urban canopy. With reference to Scottish, Welsh and international cities a minimum canopy cover target of 20% for UK towns and cities (15% for coastal locations) is then recommended. The study used the ‘random-point method’ and includes reflections on this methodology in comparison to area-based approaches, associated errors and their implications in setting (and monitoring changes towards) future urban canopy cover targets.

Key Words Tree canopy cover; Urban forest management; i-Tree tools; Ecosystem service provision; Monitoring

Introduction

Properly managed forests and trees in urban and peri-urban environments make important contributions to the planning, design and management of sustainable, resilient landscapes - they help make cities safer, more pleasant, more diverse and attractive, wealthier and healthier (FAO, 2016). Indeed, the international literature on the positive human health impacts of urban trees is vast, as demonstrated in recent reviews (Davies et al., 2017; Nature Conservancy, 2016). Within the UK, however, there is a knowledge gap with respect to the numbers of trees in towns and cities, and of their species, age composition and health. The level of canopy cover required to deliver meaningful benefits in UK towns and cities is also unknown.

Tree canopy cover (TCC), also referred to as urban canopy cover or urban tree cover, can be defined as the area of leaves, branches, and stems of trees covering the ground when viewed from above (Grove et al., 2006). TCC is a land-cover class and is a two dimensional metric, indicating the spread of canopy cover across a given area irrespective of what other land-cover classes may lie underneath. While related to leaf area index (LAI) it is not the same; LAI is a plant-based metric and is the area of leaf surface per unit area of ground. However, TCC is an easily accessible measure that can be used to estimate some ecosystem services directly or through other related measures such as LAI (Korhonen, 2006).

Research suggests that even moderate increases in canopy cover within cities can aid adaptation to the adverse effects projected under a changing climate (Gill et al., 2007). Yet a baseline value for many of the UK’s towns and cities is not known. Nor is it known whether canopy cover is changing and, if it is, whether it is increasing or decreasing. Anecdotal evidence suggests a decreasing trend in canopy cover over past decades (for example Britt and Johnston, 2008; NRW, 2016; Moffat, 2016; UFWACN, 2016). In Wales, the loss has been quantified: some 7,000 (or 20%) large trees (>12 m crown diameter) were lost between 2006 and 2013 across 220 urban areas (NRW, 2016). This widespread loss is despite the wealth of research on the social, environmental and economic benefits of trees and green infrastructure, and the promotional literature (Woodland Trust, 2012; UFWACN, 2016) and best practice guides (for example, TDAG, 2012) that have ensued with the aim of increasing awareness, support and funding for urban forests. The lack of evidence on TCC poses a problem to the maintenance of urban canopy cover, as well as to local and national target-setting.

Quantifying TCC is a first step in the management of the urban forest (Schwab, 2009). With a suitable and relatively simple classification scheme, TCC can tell us how much tree cover there is and how much room there may be to plant more trees. Furthermore, tailoring assessments to district or ward level can inform strategic planning and policy creation (Rodbell and Marshall, 2009; McPherson et al., 2011). Canopy cover is also an easy-to-understand concept that is useful in communicating positive messages about urban forests. Given that the benefits of trees have been ineffectively communicated to urban communities and their politicians for several decades (Moffat, 2016) adoption of such a metric could be useful in advocating an increase in urban tree cover.

Given the wide ranging benefits of urban trees, and the suitability of TCC for communication to citizens and politicians, it is unsurprising that some authorities have set targets for total canopy cover. For example, Greater London has a target to increase TCC to 25% by 2025 (GLA, 2011); the city of Bristol aims to increase TCC to 30% (target date not specified; TreeBristol, 2012); Wrexham, Wales: TCC to 20% by 2025 (WCBC, 2016) and Plymouth City Council has proposed a 20% TCC target by 2034 (Rogers and Handley, 2017). Targets are however still rare and, to this end, a vision for England's urban forests to "thrive and expand" has been published (UFWACN, 2016). In support of this Vision, Forestry Commission England commissioned research to measure the canopy cover for English towns and cities, to act as a baseline from which to develop goals and monitor progress. The results of that research are reported through this conference paper. Over and above the general aim of supporting the Vision, there is a specific need for UK canopy cover data to:

- inform on the appropriate level of TCC to deliver the benefits of trees to UK cities
- inform decision making on the setting of canopy cover targets
- provide a baseline from which to measure changes in TCC quantity and progress towards targets
- substantiate the tree management policy of those towns and cities where such policies exist, and
- inform the preparation of such policies where they do not yet exist.

There is also a need to increase open access of UK canopy cover data (including via the www.urbantreecover.org web resource).

The aims of this research therefore were to:

- assess for the first time the canopy cover of 265 towns and cities of England and present them alongside 18 English towns that have already published a baseline,
- provide a comparison to major settlements in Scotland, Wales and international cities, and
- review the scientific and international literature for guidance on setting canopy cover targets for England's urban areas.

Methodology

The study comprised two studies and a literature review. The first study used i-Tree Canopy (www.itreetools.org) and comprised both a main study to assess the TCC of

265 towns and cities of England and seven major cities of Scotland and a sub study to determine the impact of boundary definition on the TCC result obtained. The second study used an area-based approach to determine TCC as well as the i-Tree Canopy approach in order to compare the two methods. The two studies and the literature review are detailed further below.

Point-based assessments (i-Tree canopy)

Free-to-use, i-Tree Canopy is an online point-based canopy cover assessment tool. Sample points are randomly generated within a defined study area and reviewed in Google maps using the i-Tree Canopy programme. Resolution is defined by the Google map image quality and the sample point marker – represented by a yellow cross (+). Each sample point is viewed and allocated to one of a pre-defined list of cover types by the assessor who is able to zoom in/out to obtain a clearer view of the location, land-use and any vegetation present. In this study, two cover types were used: tree, non-tree.

The more sample points assessed the greater the accuracy of the estimate. i-Tree recommend 500-1,000 sample points depending on the area of the study location. For this study, 400-1,000 sample points were chosen. Due to their small area, 400 points was chosen as the starting point for towns of <600 ha (e.g. Lichfield, Staffordshire). Where the standard error (s.e.) was >2% after the initial 400, a further 100 points were assessed. 500 points were used for towns of 600-10,000 ha (unless otherwise stated below) (the largest town in this category was Leicester at 8,870 ha), 1,000 points for cities >10,000 ha (namely, Birmingham, Manchester, Tynemouth, Liverpool and Leeds), and 3,000 points for Greater London (ca.104,400 ha).

Study area

In the main study, the study boundary of each town/city was defined according to GB's OS 1:625,000 Urban polygon dataset. This dataset includes communications and water features, settlement administration boundaries and coastline. This dataset has been superseded, for example by the OS MasterMap and the ONS built-up area (BUA) dataset. However, alternative datasets required detailed reconfiguration to be useful to this study. For example, the BUA dataset excludes parks and greenspaces and these would have had to be incorporated in order to accurately determine the canopy cover across each town or city.

In the sub-study, the analysis was repeated for the 26 mostly densely populated English cities (plus Glasgow, Scotland and Cardiff, Wales) based upon local authority boundaries (OS Boundary-Line October 2015 dataset,1:10,000 scale). Where these included marine areas, the boundaries were modified to exclude them, ensuring that the result was proportional to land area only (non-marine waterbodies were retained). In this study, 500 points were initially sampled. Where s.e. was >1.5% a further 100 points were assessed, then a further 100 points, etc., until the s.e. was <1.5%; a maximum of 800 points were required.

Tree canopy cover

This study is concerned with tree canopy cover, rather than vegetation cover or total canopy cover which encompasses trees and shrub cover. This distinction is important because depending on the quality of the aerial imagery available it can be difficult to differentiate between a tree and a shrub (Nowak and Greenfield, 2010). Guidance was therefore developed and given to assessors to determine 'what is a tree?' If the cross fell on the shadow from a tree, non-tree was selected. If the cross fell on an ornamental tree in a garden, tree was selected; if on a garden hedge, non-tree was selected; if on a hedgerow e.g. along a road, the assessor scaled by zooming in and out on the map – if it was just a hedgerow, non-tree was selected, but if it fell on a dominant tree growing within a hedgerow, tree was selected. Where the cross fell on a canopy within waste-land/scrubland, the scale was again assessed to differentiate between a tree and a bush. The primary objectives were to count only trees not shrubs (woody plants with multiple stems) and to be consistent. It is possible that juvenile trees may have appeared 'shrub-like' in the aerial photograph and therefore were discounted, especially where the image quality was poor or where further confidence in sizing could not be achieved via scaling. Consistency was obtained via interaction and agreement between the assessors on test case study areas. Data consistency was assured through cross-comparison of assessors, wherein they were determined to be consistent if results were each within the recorded standard error.

Area-based assessments

To highlight the impact of methodological approach on the TCC assessment, an area (ward) based approach was also applied (after Goodenough et al., 2016). In this sub-study, the National Tree Map™ (NTM) was purchased from Bluesky International Ltd for Wycombe District, Buckinghamshire. The NTM seeks to identify (map) all trees and bushes in England and Wales over 3 m in height using stereo aerial photography, Digital elevation models and hydrological models. Using a geographic information system (GIS), the NTM was overlaid on a map of Wycombe District and the TCC of a randomly selected sub-set of 14 of the 28 wards was assessed. The TCC of each ward was also determined using the i-Tree Canopy methodological approach described above, using 350-500 points per ward. An initial 350 points were surveyed, increments of 50 points were then added until the standard error either stabilised or was <2% (the range in s.e. of the final results was 1.82-2.38%). The study allowed comparison of TCC determined via the NTM with that determined by i-Tree Canopy assessment.

Literature review

A search of the international academic and grey literature was performed (of Google, Google Scholar and www.itreetools.org/resources/reports.php) to gather and collate TCC baselines and targets from international studies.

Results

Canopy cover assessment of English towns and cities

The results of the i-Tree Canopy assessments of the 265 towns and cities of England are presented in Appendix A. TCC of an additional 18 English towns are included (and labelled accordingly) for completeness, providing a total of 283. These 18 towns are listed on www.urbantreecover.org - their TCC has been determined using a range of techniques including i-Tree Eco, Proximitree, LTOA Canopy, LiDAR survey and individual town surveys. The TCC results for seven Scottish cities and Cardiff, Wales are presented in Appendix B.

Canopy cover across England ranged from 3.25±0.89% in Fleetwood, Lancashire to 45.00± 2.22% in Farnham, Surrey. The mean TCC of England's towns and cities was 16.4%; Petersfield, Hampshire with 16.2±1.65% TCC sits on this mean average point. The median TCC of England's towns and cities was 15.8%; Morecambe, Lancashire with 15.8±1.63% TCC sits on this median point.

Table 1 presents summary statistics of the TCC of England's towns and cities. The majority (62%) of the towns and cities have 10-20% TCC, while only eight locations have in excess of 30% TCC. A relationship between extent of TCC and urban area size was not found. Of the forty locations with less than 10% TCC, thirty were coastal locations; the only coastal towns with more than 10% TCC were Accrington, Burntwood, Dewsbury, Heywood (near Rochdale), Leighton Buzzard, Little Thurrock, Newark on Trent, Rochdale, Swindon and York. The average TCC of coastal towns was 13.7%; this increases to 13.9% if the definition included all towns within 1 km of the coast.

'Insert Table 1 "Summary statistics of the tree canopy cover of 283 towns and cities of England" here'

The mean TCC of England's towns and cities (16.4%) was lower than the average of the seven Scottish cities analysed (17.9%). It was also lower than the TCC of Cardiff, Wales (21.0; Appendix B) although approximately equal to the Welsh mean urban tree cover estimated in 2013 at 16.3% (NRW, 2016). The range in England's urban canopy cover is similar to that reported for the towns and cities of Wales (2.8%-30%; NRW, 2016). NRW also reported that TCC was not related to town size but to regional landscape - being higher in the South Wales Valleys and noticeably lower in most coastal towns.

Impact of boundary definition on canopy cover assessments

The TCC of the 26 most densely populated local authorities in England estimated in the sub-study to determine the impact of study area on TCC assessment are also shown in Appendix A. In most cases the results were within the quoted standard errors indicating that, for these boundary definitions, the area assessed did not have a statistically significant impact on the result obtained. There were a number of exceptions: TCC assessed using the 625k urban area boundary definitions were 4.0-4.8 percentage-points higher than figures assessed using the local authority boundaries of Liverpool, Luton, Manchester, Plymouth and Southend-on-Sea. For Coventry the difference was 7.8 percentage-points (Appendix A). The boundary definition of the area under investigation is putatively the cause, the adopted approach and the low frequency of the anomaly rule out other probable considerations. Indeed, for Coventry, local authority boundary area is noticeably larger and encompasses sparsely planted agricultural area and for Liverpool, the land area under the jurisdiction of the City Council is 2,660 ha smaller (or 80% of the urban area) and excludes a number of wooded areas included in the urban 625k definition. In both these cases, the TCC result would thus be lower when assessed using the local authority boundary area.

The impact of boundary definition is also reflected in the comparison of i-Tree Canopy and i-Tree Eco results (see Appendix A). Of those UK locations that have conducted an i-Tree Eco study four were also assessed in this study. For Petersfield, Hampshire and Glasgow, Scotland the i-Tree Canopy result plus/minus the standard error shows overlap with the TCC reported in i-Tree Eco and this is expected as the area studied was the same in each case. However, while the same boundary was adopted for the i-Tree Canopy assessment of Greater London the result was substantially higher (19.6±0.72%) than reported in the 2015 i-Tree Eco study (13.6%). For Edinburgh, Scotland the i-Tree Eco study reported a lower TCC (17.0%) than the i-Tree Canopy methodology (19.6±1.26%) even though it covered an area ca. 25% larger. However, the difference is not as substantial as observed when comparing the two London studies. The potential for the i-Tree Eco project to have under-estimated London's TCC is acknowledged by its report (Rogers et al., 2015: p29).

These results indicate that boundary choice can impact TCC results and should be driven by the overriding question: "what is the tree canopy cover in the urban land-classes of a given local authority", compared to "what is the tree canopy cover in a given local government jurisdiction".

A comparison of a point-based and an area-based assessment

The TCC of 14 of Wycombe District's 28 wards was assessed using the point-based and area-based assessment methodologies. The absence of an estimate of sampling error for the area-based methodology means that a valid statistical comparison between the two approaches cannot be made. However, the standard error estimate of the point-based assessment can be used to indicate possible divergence of the two methodologies. For example, for two wards the point-based estimate of TCC plus the standard error was lower than the estimate returned by the area-based approach (wards Disraeli and Micklefield, data not shown). For six wards, the average minus the standard error was higher that the area-based assessment result, sometimes substantially so (data not shown). In the other eight cases, the average plus/minus the standard error overlapped with the comparative area-based result. While this method of comparison is not statistically robust, the divergence of the results for more than half of the wards indicates a clear lack in consistency and comparability between the two approaches.

International canopy cover

The literature review sourced nineteen international examples of published urban tree cover baselines and future targets. Many were for US cities. For example, targets to increase TCC to 40% from the current cover of 20-30% (e.g. Baltimore 20% and Leesburg 27%) and 30-40% (e.g. Guelph 30% and Washington DC 35%). Boston has a target TCC of 35% (from a baseline of 29%). Annapolis (baseline 41%) and Columbia (baseline 43%) have targets to increase TCC to 50% and 56%, respectively. Each of these cities aims to achieve their target between 2031 and 2036 (except Boston and Guelph: target year of 2020). A comparison to England is interesting: many of the international examples have a baseline >20% TCC (with targets to increase) whereas in England over 75% of towns and cities have a canopy cover of <20%.

The remainder of the international targets are summarised in Table 2. The minimum TCC target is 20% and a target between 25% and 35% is commonplace. The highest international TCC target is 40%, for both Melbourne, Australia and Toronto, Canada. The targets are typically for 20- to 25-year intervals which represents an annual increase of 0.2 to 0.8% (average 0.4% per year). Two of the Australian targets also included composition targets: Melbourne targets include ≤5% of any one species, ≤10% of any one genus, ≤20% of any one family, and >90% of tree population healthy by 2040.

'Insert Table 2 "Canopy cover and canopy cover targets for some U.S., European and Australian cities, as reported in the international literature" here'

Discussion

The Trees in Towns II study of England's urban trees revealed an estimated TCC of 8.2% (Britt & Johnston, 2008). The current assessment places average TCC across England's towns and cities at 15.8%. These figures could be interpreted as showing that urban TCC across England has almost doubled in one decade, however methodological differences make comparison difficult and together the two studies raise an important question: what is the actual trend in urban TCC across England?

In recent years a growing body of evidence has made it clear that trees are a cost-effective way of bringing a wide range of benefits to the environment, individuals and society as a whole (TDAG, 2011; Ulmer et al., 2016; Davies et al., 2017) and that trees as part of the wider green infrastructure are an important component of climate change adaptation strategies (Handley & Gill, 2009; Wilson et al., 2015; UFWACN, 2016). Two further questions remain: what is the appropriate level of TCC to deliver meaningful benefits to UK cities? And, given that it's unclear whether cover is currently increasing or decreasing, what is a realistic date to attain the selected target?

Challenges in setting a tree canopy cover target

Initial challenges to target setting typically include the questions: what is the baseline, what is the recommended level of TCC, and what is achievable locally given available resources and planting space? Studies like that conducted for Cambridge City Council (Wilson et al., 2015) and the West Midland's Urban Tree Air Quality Score (Donovan et al., 2010) are useful as they suggest TCC targets based upon a local baseline, assessment of plantable space and from the perspective of what has been achieved across different land-uses locally. This approach addresses the challenges of baseline and plantable space and gives a certain confidence that a target should be attainable based on local precedent. However, it does not address whether the TCC target could or should be higher. Similarly, the Wycombe District study (Goodenough et al., 2016) offers a relatively fast and therefore pragmatic ward-level assessment and through interrogation to the index of multiple deprivation (IMD) and similar metrics sets a target based upon apparent trends. However, such an approach assumes a certain causality that is, in all probability, erroneous. For example, lower hospital admission rates from wards with higher TCC may be a consequence of the socio-economic status of people from these wards rather than TCC per se. In many international TCC studies the mapping of existing tree cover levels and distribution has been used to set future targets. Indeed, this is regarded as good practice by the US Conference of Mayors, the US Department of Agriculture FC and various non-for-profit organisations (Rogers, 2014). Local context, geography and landscape can impact suitability for planting however and therefore some US cities have taken the approach to look at what space is available to plant and then set the canopy goal (Locke et al., 2013). In the absence of scientific reasoning or strong evidence connecting TCC to context-aware health and well-being outcomes, this approach again draws solely from what may be spatially achievable. Research is required to inform the optimum TCC for a town/city and whether this changes with size of urban area, geography, landscape or climate, for example. It should also investigate maximum as well as minimum levels of TCC required for healthy urban populations.

Learning lessons from abroad: what do international studies suggest the appropriate canopy cover for UK towns and cities to be?

The TCC metric is becoming widely used internationally as a means to describe the current extent of the urban forest and to set future targets (Table 2). Methods used internationally are the point- and area-based methods in approximately equal measure (Table 2) because of their ease of repeatability; ground survey methods are less commonly used for this purpose. The difference in methodological sampling approach constrains the read-across between international cities with respect to their TCC, however there is commonality in target setting. International targets are typically made for 20 to 25 year intervals and range from 0.2 to 0.8% increase per year. The more detailed targets tend to incorporate age and species diversity, land-use, and social and economic priorities, highlighting a thought-out strategy and action plan. Other cities (not presented in Table 2) had tree planting targets which can be useful in generating political support and public engagement; for example, Greater Manchester ‘City of Trees’ aims to plant three million trees over the next 25 years (Bell, 2017). However their impact on TCC can be hard to quantify, not least because survival rates to maturity are rarely assessed or assured.

The lowest target TCC from the international studies was 20% for Frederick, Maryland USA, and Copenhagen, Denmark from baselines of 14 and 16% respectively, and 23.5% for Sydney, Australia (with a longer term target for 27% by 2050). These studies set a precedent for a minimum 20% TCC in the UK purely on a like-for-like basis. However, the cities also bear some commonality to UK cities with their similar climates and based upon their size – at 59.9 km^2 (23.1 sq. miles) and a population of 70k Frederick (Wikipedia, 2017a) has approximately the same size as Kingston-Upon-Hull, Yorkshire and the same population as Ashford, Kent. Additionally, Copenhagen with a population of 610k in an urban area of 86.4 km^2 (Wikipedia, 2017b) has a similar footprint to Leicester and a similar population size to Glasgow, Scotland (600k in 2014).

The majority of the US cities had a target of (or close to) 40%, a consequence of the American Forests 1997 recommendation (quoted in: Kenney et al., 2011). However, in recent years there has been a move away from a single city wide target towards targets based upon specific objectives (such as reducing surface stormwater flow or providing urban cooling); targets therefore include land-use and social economic priorities, age and species diversity and require a strategic delivery approach (American Forests, 2017).

What are the issues to performing a canopy cover assessment and achieving a canopy cover target?
This study has highlighted differences between desk-based methodologies, and between the field (i-Tree eco) and desk-based (i-Tree canopy and GIS area-based) approaches. Field-sampling by expert arborists of a stratified sample area - such as adopted in i-Tree Eco studies and the West Midland’s Urban Tree Air Quality Score (Donovan et al., 2010), provide the most comprehensive and statistically robust estimates of TCC. However, such approaches are time consuming and very expensive in comparison to these desk-based approaches, and provide much more information than is purely required for quantifying TCC.

Choice of boundary definition is an important factor to consider when assessing TCC (see Results section). While this study, for practical reasons, used the 625k urban area boundary definition, towns and cities may wish to resurvey to establish their baseline according to preferred boundary descriptions or local need, for example based on their current urban footprint or including neighbouring areas earmarked for development. They should also consider the nuances of the different methodologies: inclusion of shrub cover or not – this will impact on the potential to do follow up quantification of ecosystem service delivery; staffing expertise - the area based approach requires staff knowledgeable in GIS, whereas i-Tree canopy requires no particular specialism and can be undertaken easily following a small period of time to read the online user guide; cost - the difference in the cost of the two assessment methodologies (the area-based approach also required purchase of the NTM); and statistical confidence – an estimate of statistical error is required to demonstrate confidence in the result provided and any associated trend. Either way, once a particular approach has been selected commitment to consistent and repeat application is vital; mixing methods would lead to serious error in trend analysis.

A TCC target that is city-wide and not targeted at specific wards or land-uses poses a number of challenges. It can be delivered in such a way that does not optimise or diversify benefit delivery. For towns and cities that have a green belt (or similar designation), planting schemes can be targeted within this land. However, with comparatively lower populations than the urban centres, planting here offers fewer benefits on a per capita basis. Canopy increase targets could equally be met by preserving the existing tree stock and allowing natural growth. As the canopies increase so will total canopy cover, although such increases will be constrained by tree loss/removals, natural wastage and damage by pests and disease. Such an approach, however, also fails to address social equity. Targets based on land-use based assessments (as in Cambridge) or ward (as in Wycombe and Torbay) are more likely to align the provision of ecosystem services with indicators of social inequity. It will be important that such approaches are underpinned by a robust baseline and a commitment to repeat canopy cover surveys using a consistent approach. Both the i-Tree Canopy and the area-based GIS canopy cover assessments employed in this study can be applied at ward level across an average sized city in about one person-week by a suitably skilled person.

Species diversity and placing the right tree in the right place are important considerations when planting to achieve a TCC increase as these allow resilience to be built into the urban forest (Hale et al., 2015). Knowing the composition of the existing urban forest in terms of species and age structure, condition and appropriateness to location (and therefore life expectancy) can inform such decisions. Given that private ownership of trees can be as little as 24-35% in some cities (including Glasgow and Wrexham) but as high as 71-75% in others (including Torbay and Edinburgh) (Doick and Davies, 2016), TCC baselining studies should be complemented by a field study (e.g. an i-Tree Eco study) in order to inform planning for the future (see www.itreetools.org for further details or www.forestry.gov.uk/fr/itree for UK specific examples).

With the wide range of considerations and stakeholders involved in urban forest management, TCC targets should be set both within local planning policy and within a formal urban forest management strategy. Targets should have a target date, an action plan and a commitment to monitor, review and update. The policies should inform on which tree species to plant. They should also prioritise wards and/or land uses, as discussed above, and should protect the existing tree canopy by enforcing best practice, codes of practice and statutory controls in the care, maintenance and protection of trees (TDAG, 2012). Given that the average lifespan of a typical urban tree is estimated to be 32 years (Moll and Ebenreck, 1998), changes in the age profile of the urban forest should also be modelled to at least 50 years distant in order to understand and plan for the likely impact on total TCC of tree planting and loss. Finally, the strategy will need to focus on partnerships with institutions and guidance advising residents on how they can best protect and look after their tree stock, schemes to assist in management and maintenance, and support future tree planting amongst the different ownership groups.

Canopy cover targets for the UK: key messages for decision-makers

This paper has summarised existing targets and identified some of the key questions and challenges of city specific TCC targets: they require a baseline; they can inform and substantiate tree management and urban sustainability policies; and they provide a language and a simple metric for communicating to citizens about their local authority's management of the local urban tree resource.

The results of this study suggest that:

- an average TCC of 20% should be set as the minimum standard for most UK towns and cities, with a lower target of 15% for coastal towns;
- towns and cities with at least 20% cover should set targets to increase cover by at least 5% (i.e. above the ±2% tolerance of i-Tree Canopy) within ten to 20 years (depending on what is achievable against their baseline); and,
- targets and strategies for increasing tree cover should be set according to the species, size and age composition of the existing urban forest, based upon a ward/district level and land-use assessment.

Note to the Editor

This study adopted an internationally recognised methodology for canopy cover assessment. Other techniques are available, some of which have been discussed herein. Read across to other methodologies cannot be guaranteed, may not be possible, or may require the design of a specific research methodology. In this context, a lack of *direct* comparability is acknowledged between this study and the Official Statistics due in spring 2017 that will report on the tree cover outside of NFI Woodlands, including all small woodlands, groups of trees and lone trees in Great Britain. The Official Statistics methodology uses a representative sample field survey and desk mapping of aerial photography, to cover rural and urban areas by country and region. There will be no statistics for individual towns or cities. These two studies adopt different geographic realms of interest and different methodological approaches. Users are recommended to consider which approach best matches their needs when determining which result(s) are most applicable.

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Table 1. Summary statistics of the tree canopy cover of 283 towns and cities of England.

Canopy Cover	Number of Towns	Size of urban areas evaluated (km^2)			
		Mean	Median	25th Percentile	75th Percentile
under 10%	40	11.6	8.3	5.0	15.7
10-20%	175	24.5	10.7	6.9	19.9
20-30%	60	26.9	10.2	7.0	16.4
over 30%	8	9.1	9.0	8.3	10.0

Table 2. Canopy cover and canopy cover targets for some U.S., European and Australian cities, as reported in the international literature.

Town/city and country	Existing TCC in % (and year of	Target TCC (and	Method and comment	Source

	assessment)	year)		
Geelong, Australia	14 (2012)	25 (30 years)	i-Tree Canopy; excludes rural roadways and rural land	City of Greater Geelong Urban Forest Strategy
Melbourne, Australia	22 (2012)	40 (2040)	GIS based; whole city jurisdiction area.	City of Melbourne Urban Forest Strategy 2012-2032
Sydney, Australia	15.5 (2008)	23.5 (2030) & 27.1 (2050)	GIS based; whole city jurisdiction area.	City of Sydney Urban Forest Strategy 2013
Frederick, USA	14 (2007)	20 (2038)	GIS based method	http://forestsforwatersheds.org/urban-tree-canopy/
New York City, USA	24 (un known)	30 (2030)	GIS based, Whole city jurisdiction area. 30 by '30 project	A Report on New York City's Present and Possible Urban Tree Canopy
Portland, USA	26 (2010)	33 (un known)		http://www.portlandonline.com/portlandplan/?a=288088&
Toronto, Canada	20 (2005)	30-40 (2060)	Both point and GIS based methods used. States 5-10-20 rule for diversity is nearly always met already by current trees	Every Tree Counts: A Portrait of Toronto's Urban Forest
Vancouver, Canada	18.6 (2010)	28 (2030)	GIS based, Whole city jurisdiction area	City of Vancouver Urban Tree Canopy Assessment
Barcelona, Spain	25 (un known)	30 (2037)	Includes large forested area (excluding this existing UTC may be 15%)	European forum on Urban Forestry discussion
Copenhagen, Denmark	16 (2015)	20 (2025)	i-Tree Canopy, areas in Copenhagen that are owned by the City	Urban Nature in Copenhagen Strategy 2015-2025 Tree planting target

of Copenhagen, apart from green municipal areas.

Appendix A

The i-Tree Canopy coverage of 265 towns and cities in England (assessed according to the methodology described for the 'main study'). Historical canopy cover records listed on the www.urbantreecover.org web resource are provided also [in square brackets], with their year of assessment. The 26 English cities investigated in the sub-study on the impact of boundary definition on canopy cover assessment are listed and identified with an asterisk (i-Tree Canopy*).

Country	Town	% Tree cover (± Std Error)	Source	Year of survey
England	Abingdon	16.3 (± 1.84)	i-Tree Canopy,	2016
England	Accrington	6.3 (± 1.21)	i-Tree Canopy,	2016
England	Aldershot	22.8 (± 1.87)	i-Tree Canopy,	2016
England	Amblecote	15.0 (± 1.60)	i-Tree Canopy,	2016
England	Amersham	30.3 (± 2.06)	i-Tree Canopy,	2016
England	Andover Down	14.4 (± 1.57)	i-Tree Canopy,	2016
England	Ashford	18.8 (± 1.75)	i-Tree Canopy,	2016
England	Ashington	16.2 (± 1.65)	i-Tree Canopy,	2016
England	Avonmouth	9.8 (± 1.33)	i-Tree Canopy,	2016
England	Aylesbury	13.0 (± 1.50)	i-Tree Canopy,	2016
England	Banbury	14.6 (± 1.58)	i-Tree Canopy,	2016
England	Barnsley	19.2 (± 1.76)	i-Tree Canopy,	2016
England	Barrow In Furness	7.6 (± 1.19)	i-Tree Canopy,	2016
England	Basildon	23.0 (± 1.88)	i-Tree Canopy,	2016
England	Basingstoke	15.8 (± 1.63)	i-Tree Canopy,	2016
England	Bath	20.0 (± 1.79)	i-Tree Canopy,	2016
England	Bedford	14.0 (± 1.55)	i-Tree Canopy,	2016
England	Beeston	14.6 (± 1.58)	i-Tree Canopy,	2016
England	Beverley	12.5 (± 1.65)	i-Tree Canopy,	2016
England	Bexhill	12.8 (± 1.49)	i-Tree Canopy,	2016

England	Bicester	13.4 (± n/a)	i-Tree Canopy,	2016
England	Billericay	23.0 (± 2.10)	i-Tree Canopy,	2016
England	Billingham	10.0 (± 1.34)	i-Tree Canopy,	2016
England	Bingley	20.8 (± 1.82)	i-Tree Canopy,	2016
England	Birkenhead	19.4 (± 1.77)	i-Tree Canopy,	2016
England	Birmingham	19.0 ± 1.48 [23.0 ± n/a]	i-Tree Canopy*, i-Tree Canopy	2016, 2012
England	Birmingham (Greater)	21.2 (± 1.29)	i-Tree Canopy[1]	2016
England	Bishop Auckland	12.4 (± 1.47)	i-Tree Canopy,	2016
England	Bishops Stortford	24.2 (± 1.92)	i-Tree Canopy,	2016
England	Blackburn	11.6 (± 1.43)	i-Tree Canopy,	2016
England	Blackpool	4.4 (± 0.92) [6.0 ± 1.06]	i-Tree Canopy, i-Tree Canopy*,	2016, 2016,
England	Blyth	8.0 (± 1.60)	i-Tree Canopy,	2016
England	Bognor Regis	10.8 (± 1.39)	i-Tree Canopy,	2016
England	Bolton	14.0 (± 1.55)	i-Tree Canopy,	2016
England	Boston	5.4 (± 1.01)	i-Tree Canopy,	2016
England	Bournemouth	[16.4 ± 1.40]	i-Tree Canopy*,	2016
England	Bournemouth & Poole[2]	15.7 (± 1.22)	i-Tree Canopy,	2016
England	Bracknell	27.6 (± 2.00)	i-Tree Canopy,	2016
England	Bradford	11.2 (± 1.41)	i-Tree Canopy,	2016
England	Braintree	17.4 (± 1.70)	i-Tree Canopy,	2016
England	Brentwood	26.2 (± 1.97)	i-Tree Canopy,	2016
England	Bridgwater	7.2 (± 1.16)	i-Tree Canopy,	2016
England	Bridlington	5.8 (± 1.16)	i-Tree Canopy,	2016
England	Brighouse	19.4 (± 1.77)	i-Tree Canopy,	2016
England	Brighton	14.4 (± 1.57) [12.0 ±	i-Tree Canopy, i-Tree	2016, 2016

[1] In the case of the i-Tree Canopy survey carried out in 2016 using the urban area boundary: this urban area extends over a significantly larger area than just the city of Birmingham, it encompasses also Dudley, Sandwell, Solihull, Walsall and Wolverhampton.
[2] Includes Bournemouth and Poole as one contiguous urban area.

		1.45]	Canopy*,	
England	Bristol	18.6 (± 1.52) [17.0 ± 1.42] [14.0 ± n/a]	i-Tree Canopy, i-Tree Canopy*, Bristol Tree Survey	2016, 2016, 2009
England	Bromsgrove	13.4 (± 1.52)	i-Tree Canopy,	2016
England	Burnley	14.8 (± 1.59)	i-Tree Canopy,	2016
England	Burntwood	9.8 (± 1.48)	i-Tree Canopy,	2016
England	Burton Upon Trent	13.8 (± 1.54)	i-Tree Canopy,	2016
England	Bury	12.4 (± 1.47)	i-Tree Canopy,	2016
England	Bury St Edmunds	21.2 (± 1.83)	i-Tree Canopy,	2016
England	Caldecotte	12.3 (± 1.64)	i-Tree Canopy,	2016
England	Cambridge	19.0 (± 1.75) [17.1 ± n/a]	i-Tree Canopy, Proximitree	2016, 2014
England	Cannock	13.4 (± 1.52)	i-Tree Canopy,	2016
England	Canterbury	23.0 (± 1.88)	i-Tree Canopy,	2016
England	Canvey Island	7.8 (± 1.34)	i-Tree Canopy,	2016
England	Carlisle	9.4 (± 1.31)	i-Tree Canopy,	2016
England	Castleford	15.8 (± 1.63)	i-Tree Canopy,	2016
England	Catterick Garrison	29.6 (± 2.04)	i-Tree Canopy,	2016
England	Chatham	14.0 (± 1.55)	i-Tree Canopy,	2016
England	Chelmsford	13.8 (± 1.54)	i-Tree Canopy,	2016
England	Cheltenham	12.8 (± 1.49)	i-Tree Canopy,	2016
England	Chesham	16.8 (± 1.87)	i-Tree Canopy,	2016
England	Chester	14.6 (± 1.58)	i-Tree Canopy,	2016
England	Chester Le Street	14.0 (± 1.73)	i-Tree Canopy,	2016
England	Chesterfield	16.2 (± 1.65)	i-Tree Canopy,	2016
England	Chichester	14.2 (± 1.56)	i-Tree Canopy,	2016
England	Chorley	18.0 (± 1.72)	i-Tree Canopy,	2016
England	Clacton On Sea	8.2 (± 1.23)	i-Tree Canopy,	2016
England	Clay Cross	16.0 (± 1.83)	i-Tree Canopy,	2016
England	Coalville	13.3 (± 1.70)	i-Tree Canopy,	2016
England	Colchester	18.8 (± 1.75)	i-Tree Canopy,	2016

England	Congleton	23.8 (± 1.90)	i-Tree Canopy,	2016
England	Consett	10.8 (± 1.55)	i-Tree Canopy,	2016
England	Corby	18.0 (± 1.72)	i-Tree Canopy,	2016
England	Coulby Newham	17.0 (± 1.68)	i-Tree Canopy,	2016
England	Coventry	20.6 (± 1.81) [12.8 ± 1.49]	i-Tree Canopy, i-Tree Canopy*,	2016, 2016
England	Crawley	20.4 (± 1.80)	i-Tree Canopy,	2016
England	Crowborough	28.6 (± 2.02)	i-Tree Canopy,	2016
England	Darlington	16.0 (± 1.64)	i-Tree Canopy,	2016
England	Dartford	16.6 (± 1.66)	i-Tree Canopy,	2016
England	Darwen	14.0 (± 1.73)	i-Tree Canopy,	2016
England	Deal	11.0 (± 1.40)	i-Tree Canopy,	2016
England	Derby	13.0 (± 1.50) [10.6 ± 1.38]	i-Tree Canopy, i-Tree Canopy*,	2016, 2016
England	Dewsbury	9.6 (± 1.32)	i-Tree Canopy,	2016
England	Doncaster	12.2 (± 1.46)	i-Tree Canopy,	2016
England	Douglas	20.4 (± 1.80)	i-Tree Canopy,	2016
England	Dover	29.2 (± 2.03)	i-Tree Canopy,	2016
England	Droitwich Spa	27.0 (± 1.99)	i-Tree Canopy,	2016
England	Dudley	[16.2 ± 1.50] [20.5 ± n/a]	i-Tree Canopy*, i-Tree Canopy	2016, 2015
England	Dunstable	14.8 (± 1.59)	i-Tree Canopy,	2016
England	Durham	17.4 (± 1.70)	i-Tree Canopy,	2016
England	Eastbourne	16.0 (± 1.64) [15.9 ± n/a]	i-Tree Canopy, i-Tree Canopy	2016, 2011
England	Eastleigh	22.0 (± 1.85)	i-Tree Canopy,	2016
England	Ellesmere Port	15.6 (± 1.62)	i-Tree Canopy,	2016
England	Exeter	18.8 (± 1.75) [23.0 ± n/a]	i-Tree Canopy, i-Tree Canopy	2016, 2013
England	Exmouth	17.4 (± 1.70)	i-Tree Canopy,	2016
England	Farnham	45.0 (± 2.22)	i-Tree Canopy,	2016
England	Fleet	32.8 (± 2.10)	i-Tree Canopy,	2016

England	Fleetwood	3.3 (± 0.89)	i-Tree Canopy,	2016
England	Folkstone	16.8 (± 1.67)	i-Tree Canopy,	2016
England	Formby	17.0 (± 1.68)	i-Tree Canopy,	2016
England	Frimley	36.6 (± 2.15)	i-Tree Canopy,	2016
England	Gainsborough	12.3 (± 1.64)	i-Tree Canopy,	2016
England	Gloucester	13.6 (± 1.53)	i-Tree Canopy,	2016
England	Gosport	11.6 (± 1.43)	i-Tree Canopy,	2016
England	Grantham	17.4 (± 1.70)	i-Tree Canopy,	2016
England	Gravesend	10.8 (± 1.39)	i-Tree Canopy,	2016
England	Great Malvern	30.0 (± 2.05)	i-Tree Canopy,	2016
England	Great Yarmouth	10.4 (± 1.37)	i-Tree Canopy,	2016
England	Greater London	19.6 (± 0.72) [21.9 ± n/a] [13.6 ± n/a]	i-Tree Canopy, LTOA Canopy, i-Tree Eco	2016, 2012, 2015
England	Grimsby	7.6 (± 1.19)	i-Tree Canopy,	2016
England	Guildford	21.2 (± 1.83)	i-Tree Canopy,	2016
England	Halifax	18.8 (± 1.75)	i-Tree Canopy,	2016
England	Harlow	19.0 (± 1.76)	i-Tree Canopy,	2016
England	Harpenden	24.4 (± 1.92)	i-Tree Canopy,	2016
England	Harrogate	21.0 (± 1.82)	i-Tree Canopy,	2016
England	Hartlepool	8.6 (± 1.25)	i-Tree Canopy,	2016
England	Hastings	23.4 (± 1.89)	i-Tree Canopy,	2016
England	Hatfield	20.0 (± 1.79)	i-Tree Canopy,	2016
England	Havant	10.8 (± 1.39)	i-Tree Canopy,	2016
England	Haywards Heath	25.6 (± 1.95)	i-Tree Canopy,	2016
England	Heanor	17.4 (± 1.70)	i-Tree Canopy,	2016
England	Hemel Hempstead	22.6 (± 1.87)	i-Tree Canopy,	2016
England	Hereford	15.4 (± 1.61)	i-Tree Canopy,	2016
England	Hertford	23.6 (± 1.90)	i-Tree Canopy,	2016
England	Heswall	22.6 (± 1.87)	i-Tree Canopy,	2016
England	Heywood	8.3 (± 1.38)	i-Tree Canopy,	2016
England	High Wycombe	17.8 (± 1.71)	i-Tree Canopy,	2016

England	High Cliffe	15.8 (± 1.63)	i-Tree Canopy,	2016
England	Hinckley	9.5 (± 1.47)	i-Tree Canopy,	2016
England	Hitchin	13.8 (± 1.54)	i-Tree Canopy,	2016
England	Hoddesdon	15.0 (± 1.74)	i-Tree Canopy,	2016
England	Hooe	11.0 (± 1.54)	i-Tree Canopy,	2016
England	Horsham	22.7 (± 1.79)	i-Tree Canopy,	2016
England	Hoylake	6.6 (± 1.23)	i-Tree Canopy,	2016
England	Hucknall	10.3 (± 1.52)	i-Tree Canopy,	2016
England	Huddersfield	21.8 (± 1.85)	i-Tree Canopy,	2016
England	Hull	13.4 (± 1.53) [9.0 ± 1.28]	i-Tree Canopy, i-Tree Canopy*,	2016, 2016
England	Ilkeston	17.8 (± 1.71)	i-Tree Canopy,	2016
England	Ipswich	11.0 (± 1.40)	i-Tree Canopy,	2016
England	Keighley	18.6 (± 1.79)	i-Tree Canopy,	2016
England	Kendal	12.5 (± 1.65)	i-Tree Canopy,	2016
England	Kettering	13.2 (± 1.51)	i-Tree Canopy,	2016
England	Kidderminster	20.6 (± 1.79)	i-Tree Canopy,	2016
England	Kings Lynn	12.8 (± 1.49)	i-Tree Canopy,	2016
England	Kirby	11.5 (± 1.60)	i-Tree Canopy,	2016
England	Kirkby In Ashfield	12.5 (± 1.65)	i-Tree Canopy,	2016
England	Leatherhead	22.3 (± 1.63)	i-Tree Canopy,	2016
England	Leeds	17.4 (± 1.20)	i-Tree Canopy,	2016,
England	Leicester	15.2 (± 1.41) [13.7 ± 1.40]	i-Tree Canopy, i-Tree Canopy*,	2016, 2016
England	Leigh	16.6 (± 1.66)	i-Tree Canopy,	2016
England	Leighton Buzzard	7.4 (± 1.17)	i-Tree Canopy,	2016
England	Letchworth Garden City	20.6 (± 1.79)	i-Tree Canopy,	2016
England	Leyland	12.4 (± 1.47)	i-Tree Canopy,	2016
England	Lichfield	10.7 (± 1.53)	i-Tree Canopy,	2016
England	Littlehampton	12.8 (± 1.49)	i-Tree Canopy,	2016
England	Little Thurrock	9.0 (± 1.43)	i-Tree Canopy,	2016

England	Liverpool	16.2 (± 1.17) [12.2 ± 1.46]	i-Tree Canopy, i-Tree Canopy*,	2016, 2016
England	Loughborough	12.0 (± 1.45)	i-Tree Canopy,	2016
England	London	for London, see Greater London		
England	Lowestoft	12.8 (± 1.49)	i-Tree Canopy,	2016
England	Luton	17.8 (± 1.71) [13.0 ± 1.50]	i-Tree Canopy, i-Tree Canopy*,	2016, 2016
England	Lymington	12.0 (± 1.61)	i-Tree Canopy,	2016
England	Lytham St Annes	7.0 (± 1.28)	i-Tree Canopy,	2016
England	Macclesfield	18.4 (± 1.73)	i-Tree Canopy,	2016
England	Maghull	13.2 (± 1.51)	i-Tree Canopy,	2016
England	Maidenhead	17.8 (± 1.71)	i-Tree Canopy,	2016
England	Maidstone	13.0 (± 1.50)	i-Tree Canopy,	2016
England	Manchester	21.1 (± 1.30) [17.0 ± 1.42] [15.5 ± n/a]	i-Tree Canopy, i-Tree Canopy*, Red Rose Forest Survey	2016, 2016 2007
England	Mansfield	16.2 (± 1.65)	i-Tree Canopy,	2016
England	Margate	10.2 (± 1.35)	i-Tree Canopy,	2016
England	Middlesbrough	11.0 (± 1.40) [11.4 ± 1.42]	i-Tree Canopy, i-Tree Canopy*,	2016, 2016
England	Morecambe	15.8 (± 1.63)	i-Tree Canopy,	2016
England	Neston	14.2 (± 1.56)	i-Tree Canopy,	2016
England	Newark On Trent	8.4 (± 1.24)	i-Tree Canopy,	2016
England	Newbiggin By The Sea	5.5 (± 1.14)	i-Tree Canopy,	2016
England	Newbury	22.0 (± 1.85)	i-Tree Canopy,	2016
England	Newcastle Upon Tyne	10.6 (± 1.38) [10.4 ± 1.37]	i-Tree Canopy, i-Tree Canopy*,	2016, 2016
England	Newcastle Upon Tyne (inc Tynemouth)	14.7 (± 1.42)	i-Tree Canopy,	2016
England	Newport	18.2 (± 1.73)	i-Tree Canopy,	2016
England	Newport Pagnell	13.2 (± 1.51)	i-Tree Canopy,	2016

England	Newton Aycliffe	13.6 (± 1.53)	i-Tree Canopy,	2016
England	North Holmwood	34.3 (± 2.12)	i-Tree Canopy,	2016
England	Northampton	17.4 (± 1.70)	i-Tree Canopy,	2016
England	Northwich	16.2 (± 1.65)	i-Tree Canopy,	2016
England	Norwich	18.6 (± 1.74)	i-Tree Canopy,	2016
England	Nottingham	15.2 (± 1.61) [14.0 ± 1.42]	i-Tree Canopy, i-Tree Canopy*,	2016, 2016
England	Nuneaton	12.0 (± 1.45)	i-Tree Canopy,	2016
England	Old Felixstowe	7.6 (± 1.19)	i-Tree Canopy,	2016,
England	Ormskirk	14.4 (± 1.57)	i-Tree Canopy,	2016
England	Oxford	16.6 (± 1.67) [21.4 ± n/a]	i-Tree Canopy, i-Tree Canopy	2016, 2015
England	Penrith	14.2 (± 1.75)	i-Tree Canopy,	2016
England	Peterborough	17.2 (± 1.69)	i-Tree Canopy,	2016
England	Peterlee	7.4 (± 1.17)	i-Tree Canopy,	2016
England	Petersfield	16.2 (± 1.65) [15.1 ± n/a]	i-Tree Canopy, i-Tree Eco	2016, 2016
England	Plymouth	21.4 (± 1.84) [17.4 ± 1.43]	i-Tree Canopy, i-Tree Canopy*,	2016, 2016
England	Pontefract	15.3 (± 1.80)	i-Tree Canopy,	2016
England	Portsmouth	8.0 (± 1.21) [8.0 ± 1.21] [14.7 ± n/a]	i-Tree Canopy, i-Tree Canopy*, i-Tree Canopy	2016, 2016 2015
England	Potters Bar	14.4 (± 1.73)	i-Tree Canopy,	2016
England	Preston	14.6 (± 1.58)	i-Tree Canopy,	2016
England	Ramsgate	14.0 (± 1.55)	i-Tree Canopy,	2016
England	Reading	18.4 (± 1.73) [18.6 ± 1.47]	i-Tree Canopy, i-Tree Canopy*,	2016, 2016
England	Redcar	8.0 (± 1.36)	i-Tree Canopy,	2016
England	Redditch	25.4 (± 1.95)	i-Tree Canopy,	2016
England	Reigate	27.8 (± 2.00)	i-Tree Canopy,	2016
England	Retford	13.3 (± 1.68)	i-Tree Canopy,	2016
England	Rochdale	7.8 (± 1.20)	i-Tree Canopy,	2016

England	Rotherham	15.6 (± 1.62)	i-Tree Canopy,	2016
England	Royal Leamington Spa	14.8 (± 1.59)	i-Tree Canopy,	2016
England	Royal Tunbridge Wells	33.7 (± 2.12)	i-Tree Canopy,	2016
England	Rugby	13.2 (± 1.51)	i-Tree Canopy,	2016
England	Runcorn	23.2 (± 1.89)	i-Tree Canopy,	2016
England	Ryde	17.8 (± 1.71)	i-Tree Canopy,	2016
England	Salisbury	19.8 (± 1.78)	i-Tree Canopy,	2016
England	Sandwell	[12.6 ± 1.48]	i-Tree Canopy*,	2016
England	Sawley	13.4 (± 1.52)	i-Tree Canopy,	2016
England	Scarborough	16.4 (± 1.66)	i-Tree Canopy,	2016
England	Scunthorpe	10.8 (± 1.39)	i-Tree Canopy,	2016
England	Sheerness	4.3 (± 1.01)	i-Tree Canopy,	2016
England	Sheffield	16.2 (± 1.25)	i-Tree Canopy,	2016,
England	Shrewsbury	22.0 (± 1.85)	i-Tree Canopy,	2016
England	Sidmouth (Sid Vale)	[23.0 ± n/a]	i-Tree Eco	2014
England	Sittingbourne	14.8 (± 1.59)	i-Tree Canopy,	2016
England	Skegness	9.3 (± 1.45)	i-Tree Canopy,	2016
England	Skelmersdale	27.8 (± 2.00)	i-Tree Canopy,	2016
England	Slough	13.8 (± 1.54) [14.2 ± 1.42]	i-Tree Canopy, i-Tree Canopy*,	2016, 2016
England	South Lancing	9.8 (± 1.48)	i-Tree Canopy,	2016
England	South Moor	17.0 (± 1.68)	i-Tree Canopy,	2016
England	Southampton	19.8 (± 1.78) [22.8 ± 1.48] [20.4 ± n/a]	i-Tree Canopy, i-Tree Canopy*, LiDAR Survey	2016, 2016, 2013
England	Southend-on-Sea	15.6 (± 1.62) [11.0 ± 1.40]	i-Tree Canopy, i-Tree Canopy*,	2016, 2016
England	Southport	9.0 (± 1.28)	i-Tree Canopy,	2016
England	St Albans	26.8 (± 1.98)	i-Tree Canopy,	2016
England	St Helens	19.8 (± 1.78)	i-Tree Canopy,	2016
England	Stafford	14.0 (± 1.55)	i-Tree Canopy,	2016

England	Stanford-Le-Hope	9.4 (± 1.31)	i-Tree Canopy,	2016
England	Stevenage	17.6 (± 1.70)	i-Tree Canopy,	2016
England	Stockton-On-Tees	17.0 (± 1.68)	i-Tree Canopy,	2016
England	Stoke-On-Trent	[14.7 ± 1.44]	i-Tree Canopy*,	2016
England	Stoke-on-Trent & Newcastle-Under-Lyme[3]	16.0 (± 1.64)	i-Tree Canopy,	2016
England	Stratford-Upon-Avon	19.2 (± 1.76)	i-Tree Canopy,	2016
England	Strood	22.4 (± 1.86)	i-Tree Canopy,	2016
England	Stroud	28.6 (± 2.02)	i-Tree Canopy,	2016
England	Sunderland	9.2 (± 1.29)	i-Tree Canopy,	2016
England	Sutton In Ashfield	13.3 (± 1.70)	i-Tree Canopy,	2016
England	Swadlincote	17.8 (± 1.71)	i-Tree Canopy,	2016
England	Swindon	8.0 (± 1.21)	i-Tree Canopy,	2016
England	Talke	21.0 (± 1.82)	i-Tree Canopy,	2016
England	Tamworth	16.6 (± 1.66)	i-Tree Canopy,	2016
England	Taunton	14.6 (± 1.58)	i-Tree Canopy,	2016
England	Telford	25.2 (± 1.94) [12.5 ± n/a]	i-Tree Canopy, i-Tree Canopy	2016, 2012
England	Thetford	25.2 (± 1.94)	i-Tree Canopy,	2016
England	Tonbridge	28.5 (± 2.02)	i-Tree Canopy,	2016
England	Torbay	[12.0 ± n/a]	i-Tree Eco	2011
England	Torquay	15.8 (± 1.63)	i-Tree Canopy,	2016
England	Wakefield	23.4 (± 1.89)	i-Tree Canopy,	2016
England	Wallasey	9.8 (± 1.48)	i-Tree Canopy,	2016
England	Walsall	[13.0 ± 1.50] [17.3 ± n/a]	i-Tree Canopy*, i-Tree Canopy	2016, 2012
England	Warrington	16.8 (± 1.67)	i-Tree Canopy,	2016
England	Washington	17.4 (± 1.70)	i-Tree Canopy,	2016
England	Waterfoot	26.0 (± 1.96)	i-Tree Canopy,	2016

[3] The urban area of Newcastle-under-Lyme also includes the city of Stoke-on-Trent.

England	Waterlooville	22.2 (± 1.86)	i-Tree Canopy,	2016
England	Watford	18.2 (± 1.73)	i-Tree Canopy,	2016
England	Wellingborough	14.2 (± 1.56)	i-Tree Canopy,	2016
England	Welwyn Garden City	26.6 (± 1.98)	i-Tree Canopy,	2016
England	Weston-Super-Mare	11.6 (± 1.43)	i-Tree Canopy,	2016
England	Weymouth	9.8 (± 1.33)	i-Tree Canopy,	2016
England	Whitehaven	12.4 (± 1.47)	i-Tree Canopy,	2016
England	Whitstable & Herne Bay	16.0 (± 1.64)	i-Tree Canopy,	2016
England	Wickford	20.6 (± 1.81)	i-Tree Canopy,	2016
England	Widnes	10.8 (± 1.39)	i-Tree Canopy,	2016
England	Wigan	18.0 (± 1.72)	i-Tree Canopy,	2016
England	Winchester	27.4 (± 1.99)	i-Tree Canopy,	2016
England	Windsor	15.8 (± 1.63)	i-Tree Canopy,	2016
England	Woking	33.2 (± 2.11)	i-Tree Canopy,	2016
England	Wokingham	27.4 (± 1.99)	i-Tree Canopy,	2016
England	Wolverhampton	[12.4 ± 1.47]	i-Tree Canopy*,	2016
England	Worcester	14.6 (± 1.58) [21.9 ± n/a]	i-Tree Canopy, i-Tree Canopy	2016, 2015
England	Workington	12.4 (± 1.47)	i-Tree Canopy,	2016
England	Worksop	12.5 (± 1.65)	i-Tree Canopy,	2016
England	Worthing	15.8 (± 1.63)	i-Tree Canopy,	2016
England	Yeovil	16.6 (± 1.66)	i-Tree Canopy,	2016
England	York	9.8 (± 1.33)	i-Tree Canopy,	2016

Appendix B

The i-Tree Canopy coverage of seven Scottish cities and Cardiff, Wales. Those assessed according to the 'main study' methodology are listed as i-Tree Canopy, those assessed according to the 'sub study' methodology are identified by an asterisk (i-Tree Canopy*).

Scotland	Aberdeen	10.0 (± 1.34)	i-Tree Canopy,	2015

Scotland	Dundee	17.8 (± 1.71)	i-Tree Canopy,	2015
Scotland	Edinburgh	19.6 (± 1.26); 17.0 (± na)	i-Tree Canopy, i-Tree Eco	2015, 2015
Scotland	Glasgow	14.9 (± 1.13) [13.5 ± 1.40] [15.0 ± n/a]	i-Tree Canopy, i-Tree Canopy*, i-Tree Eco	2015, 2016, 2015
Scotland	Inverness	21.0 (± 1.82)	i-Tree Canopy,	2015
Scotland	Perth	22.2 (± 1.86)	i-Tree Canopy,	2015
Scotland	Stirling	20.0 (± 1.79)	i-Tree Canopy,	2015
Wales	Cardiff	[21.0 ± 1.44]	i-Tree Canopy*,	2016