Urban Forestry & Urban Greening 116 (2026) 129221

Contents lists available at ScienceDirect

Urban Forestry & Urban Greening

journal homepage: www.elsevier.com/locate/ufug

Original article

Which trees matter most? The role of private garden trees and woodland cover for 3–30-300 success in seven English cities

Eleanor S. Smith [a,*], Christopher Fleet [b], Arjan S. Gosal [c], Stuart King [d], Hannah Walker [e], Ian Willey [a], Catherine E. Scott [a]

[a] Institute for Climate and Atmospheric Science, School of Earth and Environment, University of Leeds, Leeds, UK
[b] National Library of Scotland, Edinburgh, UK
[c] School of Geography, Faculty of Environment, University of Leeds, Leeds LS2 9JT, UK
[d] School of Mathematics and Maxwell Institute for Mathematical Sciences, University of Edinburgh, Edinburgh, UK
[e] Forest Research, Alice Holt Lodge, Farnham, Surrey GU10 4LH, UK

ARTICLE INFO

Keywords:
3–30-300
Canopy cover
Greenspace
Urban Forests
Urban Trees
Tree equity

ABSTRACT

The 3–30–300 rule is a tool to evaluate access to trees and greenspaces and is gaining popularity in Europe but not yet in the UK. We calculate a 3–30–300 score per building to measure success at the rule in the local authority areas of seven English cities, examining how overall canopy cover and where the canopy is situated (e.g. woodland, street, private garden) influence performance. We find that a maximum of 2.1 % of buildings in the locations studied meet all three rules. Land use analysis indicates that increasing the density of trees in private gardens and increasing woodland cover are the most important factors for improving performance at the 3-tree and 30 % components in UK neighbourhoods. These recommendations should be applied to UK urban areas to improve overall performance at the 3–30–300 rule and increase access to trees and their benefits. We also explore how sensitive the results of the 3–30–300 analysis are to methodological choices by comparing results of network and line-of-sight analyses to simple buffers for the 3-tree and 300 m components of the rule, finding that more simple methods result in higher 3–30–300 scores and therefore suggest better 3–30–300 performance.

1. Introduction

Trees and greenspaces provide an essential slice of nature within an otherwise stark built environment. They are however not simply an important component of a city's aesthetics but also provide benefits ranging from improving health to mitigating climate change impacts, as well as providing habitats for nature and supporting biodiversity. Access to these benefits is not distributed equitably across urban populations yet many approaches measuring tree coverage, such as canopy cover, fail to capture this; here, we explore the use of the 3–30–300 rule as a possible and effective metric for assessing access to these benefits and identifying areas for improvements.

1.1. English urban canopy cover targets

Canopy cover, 'the layer of leaves, branches, and tree stems that cover the ground when viewed from above' (Grove et al., 2006), is frequently used to quantify the presence of, and changes in, tree and woodland coverage. In England, cities are setting ambitious targets to meet and exceed the minimum standard of 20 % suggested by The Urban Forestry and Woodland Advisory Committee Network (UFWACN, 2018). For example, Manchester aims to increase canopy cover from 18.8 % to 21.8 % by 2050, requiring approximately 64,000 additional large trees (Manchester City Council, 2023). In York, the target is to attain 13 % urban canopy cover by 2050, not meeting the 20 % goal but increasing from a much lower 10.8 % in 2022 (City of York Council, 2024). In Leeds, the canopy target is 33 % by 2050, approximately doubling the 17 % canopy cover recorded in 2020 (Leeds City Council, 2020).

Canopy cover estimates are valuable tools for quantifying tree and woodland coverage and change, and increased canopy cover is likely to indicate enhanced access to trees and greenspaces. However, for the same canopy cover, most trees could be confined to one location, with the rest of the area having little tree cover, or there could be an even distribution of trees across the whole region. These city-scale percentages therefore fail to capture where there is an inequitable distribution

* Corresponding author.
E-mail address: ee21ess@leeds.ac.uk (E.S. Smith).

https://doi.org/10.1016/j.ufug.2025.129221
Received 22 July 2025; Received in revised form 14 November 2025; Accepted 4 December 2025
Available online 5 December 2025

of trees.

1.2. Tree and greenspace equity and access

There are many approaches to measuring tree and greenspace equity and access, however existing measures have limitations. Greenspace access can be measured on a city-wide scale, where greenspace provision is calculated per capita, on a neighbourhood scale, or on an individual building scale. Mears and Brindley (2019) identified great variation in the methods used to calculate greenspace equity between studies and make methodological recommendations to encourage consistency, including using a network analysis to measure distance to greenspace as opposed to straight line distances, so that proximity is not overestimated.

The Gini index was originally developed to measure economic inequality (Gini, 1912) but since 2011 (Jenerette et al., 2011) has increasingly been used to examine equality in access to trees, greenspaces and their benefits (Martin and Conway, 2025). The Gini index, applied to variables such as distance to greenspace and canopy cover, gives a quantitative measure of inequality and allows comparison across cities if reported consistently. Here, equality is measured as opposed to equity. Equality generally measures how evenly tree and greenspace features are distributed, aiming for equal opportunities for everyone. Equity goes a step further and considers factors such as air pollution, heat severity and income, aiming to prioritize tree and greenspace access where it may be more needed by offering varying levels of support to achieve a fairer outcome. However, the result of the Gini index is a single value which means we are unable to identify how greenspace and urban trees vary spatially across a city and are therefore unable to identify priority areas. Martin and Conway also report finding 10 variations in the Gini index equation used and, in some cases, the equation is not reported at all. This reduces the comparability of results, along with other methodological steps which vary between studies.

Other statistical approaches can be taken to assess inequality in tree benefits. Using inequality indexes, including the Gini index, Nyelele and Kroll (2020) found that ecosystem services from urban trees are inequitably distributed across different socio-demographic subgroups within census blocks in the Bronx, New York (USA). Wei (2024) used tree planting data from Seattle (USA) dating from the 1950s along with house sale prices and found that street trees generate a higher increase in house prices in lower income areas.

In the UK, Sales et al. (2023) conducted a citizen science assessment of the canopy cover of all urban wards. Data was collected by volunteers using the i-Tree Canopy tool (i-Tree, n.d) whereby points are randomly generated within each ward boundary and viewed over a Google Maps satellite image. Each point was classified as either a tree or non-tree, allowing a canopy cover estimation for each ward. In England, canopy cover ranged from 0 % in one London ward to 80.4 % in a ward in the east of England, highlighting the inequality in canopy cover. Comparison to deprivation indices in England also showed that wards with lower canopy cover were more likely to be deprived. Similarly, Friends of the Earth (2023), alongside Terra Sulis, identified that local authority areas containing a higher proportion of the 10 % most deprived neighbourhoods nationally are more likely to have lower tree cover than those with fewer socially deprived neighbourhoods. Their findings show that Surrey Heath with 0 % deprived neighbourhoods recorded a canopy cover of 36.1 %, while Hartlepool with 38 % deprived neighbourhoods had a canopy cover of 5.7 %. In 2020, a corresponding link was found between greenspace deprivation and poverty in England (Friends of the Earth, 2020).

Despite the abundance of work in this area, and the evidence of tree and greenspace inequity, there is no standard tool for measuring access to trees and greenspaces. The tree equity score developed by American Forests, a conservation organisation in the United States of America (American Forests, 2024) presents a possible solution to this problem which has been adapted for the UK in partnership with The Woodland Trust. The tree equity score for each neighbourhood relies on a measure of the existing canopy cover along with other factors such as air pollution and heat disparity and highlights priority areas for tree planting (Tree Equity Score UK, 2024).

However, the tree equity score does not consider greenspaces, which are an important part of urban green infrastructure. Additionally, the calculation of each score uses a target canopy cover, and the score is higher if an area is closer to this target. Within the tree equity tool, target canopy covers are reduced where there is a higher population density. This is based on the likelihood of reduced planting area, rather than evidence of reduced need in areas with higher population density. The tree equity score also does not consider how accessible the canopy is.

The 3–30–300 rule is a recent recommendation (Konijnendijk, 2023) and is based on the same concepts of improving access to trees and greenspaces. Although relatively new, this approach has become popular, particularly in Europe (Nieuwenhuijsen et al., 2022; Owen et al., 2024) and offers a straightforward standard for examining tree and greenspace access while addressing limitations in existing measures.

1.3. 3–30-300

The 3–30–300 rule recommends that every house, school, and workplace has a view of 3 trees, that there is 30 % canopy cover in each neighbourhood and that each building has a public greenspace within 300 m. It thus combines canopy cover and both visual and physical access to trees and greenspaces into one assessment. Assessing visual access to three trees represents a measure of eye-level greenness visibility, more closely resembling what humans experience at ground level, while assessing canopy cover provides a top-down approach, more simply indicating how much greenness is present in an area (Labib et al., 2021). Visual access allows nature watching and the enjoyment of watching trees change throughout the seasons, both of which have been shown to improve wellbeing (O'Brien et al., 2014) and also contributes to stress recovery (Brown et al., 2013). Physical access encourages exercise (Han et al., 2013) and social interaction (Coley et al., 1997) and can also bring other advantages such as shade from trees to provide cooling (Speak et al., 2020) and physical health benefits such as air purification (Davies et al., 2017). Initial work suggests that meeting the rule is linked with better mental health (Nieuwenhuijsen et al., 2022) and reduced urban flooding (Vesuviano et al., 2024).

Browning et al. (2024) assess the strengths and weaknesses of several methods and datasets to determine the most suitable process to evaluate each component of the rule. For the 3-tree rule Browning et al. find window view analyses and questionnaires most suitable, high resolution land cover maps for the 30 % rule, and urban greenspace maps combined with a network analysis for the 300 m rule. However, despite these recommendations, depending on the size of the area under examination and computational power available, it may be necessary to apply buffers around buildings to determine their access to three trees and greenspaces within 300 m which Browning et al. suggest as simple and faster approaches.

Konijnendijk (2023) proposes the 3-tree component as a proxy for visible greenspace. In the report, Konijnendijk explains that a minimum canopy area may be set, citing 25 m^2 as an example, based on Kluck et al. (2020) who find that large trees provide a greater cooling effect than smaller trees. If using the buffer method to determine the view of 3 trees from each building, Konijnendijk proposes using a 30 m buffer. Evidence from other works suggest that improved mental health is associated with living within 100 m of a high density of street trees (Marselle et al., 2020), and having greenspace within 50, 100, 300 and 500 m of people's homes is associated with decreased redemptions of antidepressant prescriptions (Stenfors et al., 2024) suggesting that other buffer distances could be used.

The 30 % canopy cover requirement is based on evidence linking this level of canopy cover to improved sleep and mental health (Astell-Burt and Feng, 2019; 2020) and is measured on a neighbourhood scale. In the

UK, the canopy cover target is only 20 %, yet, as part of the 3–30–300 rule 30 % is cited as the minimum aspiration and findings suggest that even where the 30 % target is met there is still demand for more trees (Koeser et al., 2024). The definition of 'neighbourhood' is not provided by Konijnendijk and as such varies between studies. Owen et al. (2024) defined a building's neighbourhood as the area in a 300 m buffer, while Croeser et al. (2024) used census-based areas but highlighted that the definition of neighbourhood can affect results.

The 300 m distance chosen for access to greenspace is based on guidance from the World Health Organisation (World Health Organisation, 2017). The minimum size of greenspace, 1 hectare, is recommended as larger greenspaces allow more space for recreation, vegetation, and biodiversity (Konijnendijk, 2023). People may be willing to travel much further to access greenspaces; in Sheffield (UK), self-selecting users of a GPS app were found to visit greenspaces over 1.4 km from home, based on a median trip to a greenspace being 190 m and a median distance from home before a trip to a greenspace started of 1286 m (Mears et al., 2021). In this work, 50 % of trips were to local and large parks, underlining the importance of a minimum size of greenspace included in the 3–30–300 assessment. A survey of residents of Luxembourg City (Luxembourg), Brussels (Belgium) and Rouen (France) found that residents were willing to travel between 1.4 km and 1.9 km to access greenspaces (Schindler et al., 2022) although city structure appeared to affect distance travelled along with occupation, being retired, motorised vehicle ownership and satisfaction with local greenspace provision, highlighting the need to consider factors other than distance when evaluating greenspace accessibility and equity. Other key aspects that need to be considered include the maintenance, safety and amenities of the greenspace (Mears et al., 2019), as well as whether it is accessible by various modes of transport, opening hours, entrance fees and fences/walls which may limit how people can enter (Endalew Terefe and Hou, 2024). The 3–30–300 rule can highlight reduced access to greenspace, however, when making improvements these aspects should also be taken into account.

A 3–30–300 analysis relies upon several datasets, including those for buildings, tree cover and greenspace cover at a minimum. Therefore, each assessment is limited by the data that is available. Some countries, such as the UK, have access to fine scale data, covering individual trees, greenspaces and buildings as well as road and street networks. This enables a more detailed analysis of access to trees and greenspaces such as estimating the time needed to walk from a house to the nearest greenspace or identifying the different species of trees along a street. However, this is not the case in every country, with cities in Africa, mainland Asia and the Middle East identified as lacking appropriate open datasets (Croeser et al., 2024). To assess success at the 3–30–300 rule in such cities would require a simpler approach, using buffers instead of walking routes to greenspaces or the use of land cover maps from remote sensing datasets to identify areas of trees or greenspace (Owen et al., 2024).

Croeser et al. (2024) who examined cities in the US, Europe, Australia, South America and Asia, Owen et al. (2024) who examined European cities, and Iqbal et al. (2025) who studied Surakarta (Indonesia), found that meeting all thresholds of the 3–30–300 rule is uncommon, emphasising the need for more investment in urban trees and greenspaces globally. In England, Sales et al. (2023) demonstrated that the average tree canopy cover across electoral wards is 16.7 ± 0.6 %, showing that the country is far from meeting the 30 % target in most areas and Friends of the Earth (2020), identified that 1 in 5 people in England do not have access to the benefits of quality local greenspace, demonstrating inequality in greenspace provision.

Some councils in the UK, such as Aberdeenshire Council in Scotland, are already using the principle to guide improvements in urban greening (Bluesky International Ltd., 2025a). Furthermore, in July 2025, the Nature Towns and Cities programme was launched in the UK which aims to connect more people with nature closer to their homes and improve natural environments in 100 towns and cities (Harmar, 2025), showing that improving access to trees and greenspaces, particularly in urban areas, is a top priority for policymakers. Although it may not be possible to have 100 % success at the 3–30–300 rule without considerable land use changes (Owen et al., 2024), a baseline of how English cities currently perform at the 3–30–300 rule would be a useful tool that could be used to prioritise and guide existing greening efforts.

In this study, we measure the 3–30–300 rule in the local authority areas of seven English cities, examining how overall canopy extent and where the canopy is situated impact success on a neighbourhood scale. We apply both simple and more detailed approaches, comparing the results of buffer methods to network and window line-of-sight methods as well as comparing how different buffer and line-of-sight distances impact results for the 3-tree component.

2. Data and methods

2.1. Study sites and data

Bluesky's National Tree Map™ (NTM) data (Bluesky International Ltd., 2025b) was used for both tree locations and canopy cover calculations. This dataset provides location, height, and crown area for all trees over 3 m in height in Great Britain and the Republic of Ireland. For locations across the UK, NTM data are collected in any month from spring to autumn; in the spring trees generally have fewer, smaller leaves than in the summer months when the canopy reaches its maximum. Springtime data collection therefore results in a potential underestimation of canopy cover, and in trees being missed entirely due to their smaller size. To maximise the accuracy of our results and to allow comparison between locations, we used only NTM data collected between June and September. Fig. 1 illustrates the study locations selected for this work. Cities were chosen according to the availability of NTM data collected in the summer months, covering at least some of the city region. A detailed review of the available data allowed us to identify these cities. The NTM data for these locations was collected between 2017 and 2021; months and years for each location are presented in Table S1. NTM data was accessed through the EDINA Digimap service for Manchester, Plymouth, and Stoke-on-Trent (Bluesky International Ltd., 2023). For Leeds, Bradford, Wakefield, and York data was purchased from Bluesky directly.

Within the city regions selected we have used Lower Layer Super Output Areas (LSOAs) (Office for National Statistics, 2024) to represent neighbourhoods. These are areas with an approximate population of between 1000 and 3000 people. LSOAs were selected where summer NTM data was available covering the LSOA and a 100 m buffer around it. Additionally, only LSOAs classed as urban in the 2021 Rural Urban Classification (Office for National Statistics, 2025) have been assessed. These constraints resulted in 1425 LSOAs located in Leeds, Bradford, Manchester, Plymouth, Stoke-on-Trent, Wakefield, and York, shown in Fig. 1, with local authority boundaries taken from the OS District Borough Unitary Region shapefile (Ordnance Survey, 2024a).

The performance of individual buildings within each LSOA was calculated. Building footprints were obtained from the OS MasterMap building height attribute layer (Ordnance Survey, 2024b). The recommendation is to apply the 3–30–300 rule to homes, workplaces, and schools (Konijnendijk, 2023), however, we have used all buildings in the dataset as building function is not provided. While the OS MasterMap Site layer (Ordnance Survey, 2025a) provides the function of important locations such as schools, hospitals, and infrastructure sites (all of which should be analysed with the 3–30–300 rule), it does not provide the function of every building so cannot be used to determine which buildings should be excluded. For each study region the number of buildings analysed, and the proportion of the study site covered by buildings is presented in the Supplementary Material, Table S2.

Publicly accessible greenspace polygons and access points were obtained from the OS Open Greenspace dataset which provides locations and extents of spaces which are likely to be accessible to the public for

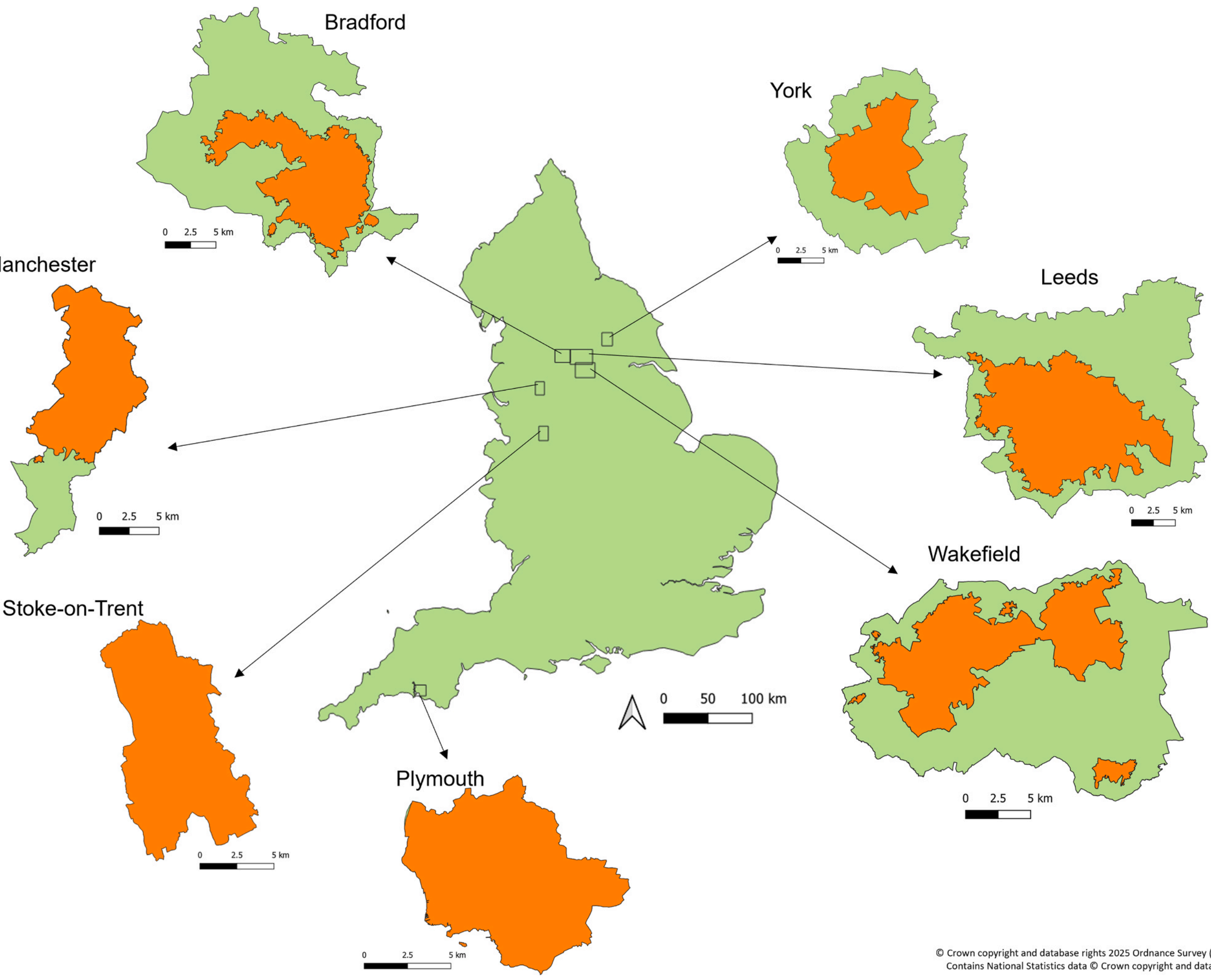


Fig. 1. The case study areas across England. Within each location the green area shows the full extent of the unitary authority area each city belongs to. The orange region shows the Lower Layer Super Output Areas (LSOAs) which are assessed in this study. LSOAs have been excluded where full coverage of summer canopy data was not available and where they are classed as rural. England boundary data from Runfola et al. (2020).

exercise and recreation in Great Britain (Ordnance Survey, 2024c).

2.2. Simple method

To calculate the 3–30–300 rule, two different approaches were taken, a *simple* method and a *detailed* method. In both methods calculations are made for individual buildings within an LSOA and then aggregated. In this description the boundary of the study area refers to the boundary of the subset of LSOAs in a city region, shown in orange in Fig. 1.

In the simple method, buffers are used around trees and greenspaces to assess both the 3-tree and 300 m rules. Fig. 2 demonstrates the simple 3–30–300 method. Each test is described in more detail below.

2.3. 30 % canopy cover

In the 30 % test, tree points are assigned a neighbourhood (LSOA). The crown area for each tree point within the neighbourhood counts towards the canopy cover for that neighbourhood. Buildings are also assigned a neighbourhood. Where buildings overlap a neighbourhood boundary, the building is assigned the neighbourhood in which it has the largest overlap. We then assign a neighbourhood canopy cover to each building.

2.4. 3 trees visible from buildings

For the 3-tree test, the buildings layer output from the 30 % test is taken as an input. Tree points are obtained for the study area boundary buffered by 100 m, the greatest buffer width analysed in this work. Tree points with crown areas less than 25 m^2 are removed (Konijnendijk, 2023). A buffer (30, 50 and 100 m buffers are analysed) is then applied to each established tree point and the number of overlaps of these buffers with each building is counted and recorded in the buildings layer.

2.5. 300 m to accessible greenspace

For the 300 m test, the buildings layer output from the 3-tree test is taken as an input. The full greenspace dataset for Great Britain is reduced to the boundary of the study area buffered by 500 m. Greenspaces less than 1 ha are removed, as advised by Konijnendijk (2023), along with greenspaces in the categories ’allotments or community growing spaces’, ’other sports facility’, ’tennis court’, ’bowling green’ and ’golf course’. These are removed as they are generally not accessible to the public and in many cases are not actually greenspaces e.g. sports facilities. This leaves the categories ‘cemetery’, ‘religious grounds’, ‘play space’, ‘playing field’ and ‘public park or garden’.

A 300 m buffer is applied to all greenspaces and if the buffer overlaps

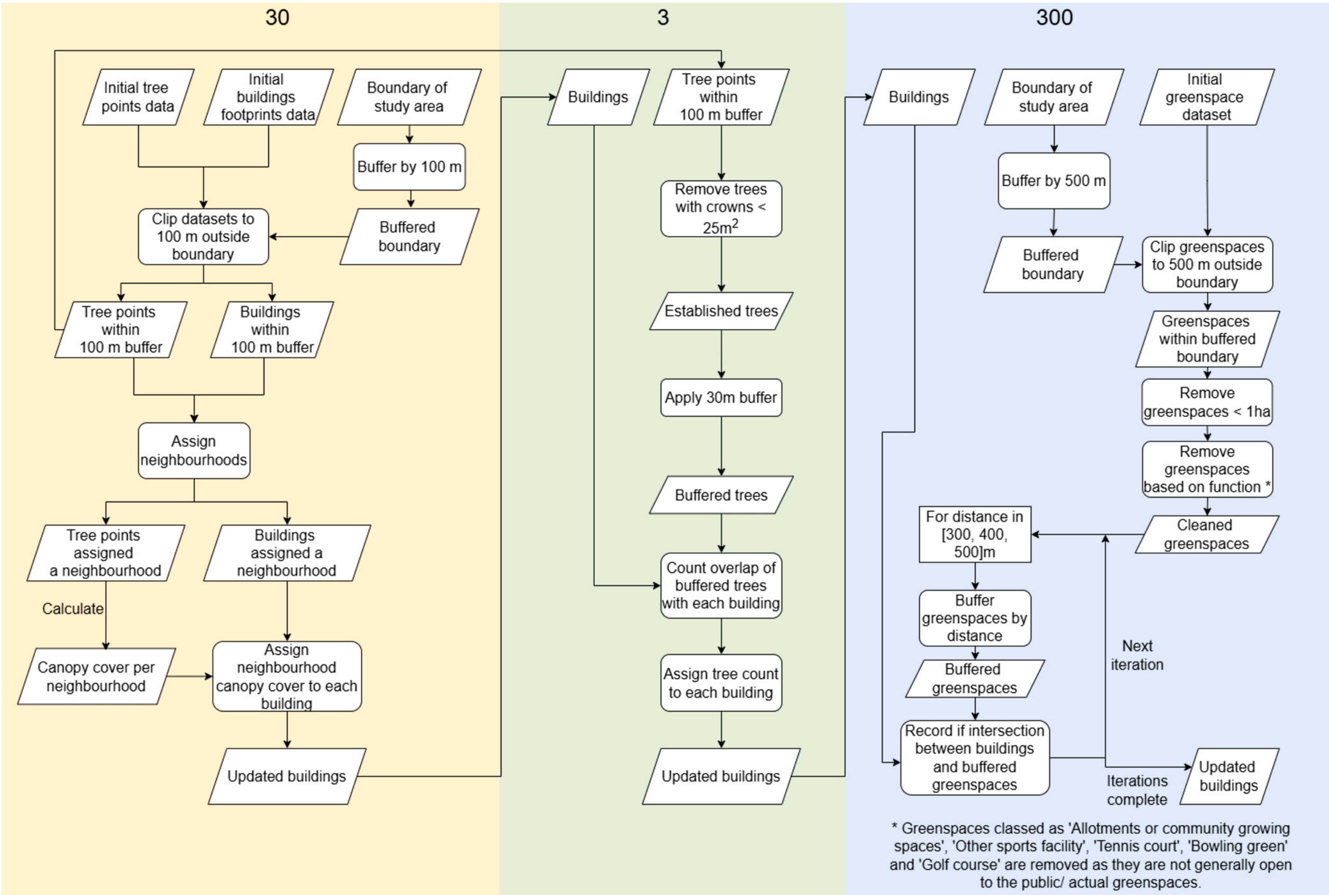


Fig. 2. Flow chart of the steps taken to calculate the 3–30–300 rule using the simple method defined in the text. Here, the study area refers to the boundary created by the subset of LSOAs studied in each city region.

with a building, this is recorded as a success for that building in the 300 m test. This is repeated for 400 m and 500 m buffers to allow the calculation of a graded score, described in more detail below.

2.6. *Detailed method*

2.6.1. *30 % canopy cover*

The approach for the 30 % test remains the same as in the simple method.

2.6.2. *3 trees visible from buildings*

For the 3-tree rule, rather than using a buffer around each tree, we generate lines-of-sight from simulated ‘windows’ on each building to tree points. Windows are simulated as points at 5 m intervals around the outsides of each building, following Croeser et al. (2024). The 20 nearest trees are identified for each window point, using the ‘BallTree’ algorithm implemented in the Python package scikit-learn (Pedregosa et al., 2011), and lines created between the trees and the window. As in the simple method, different distances between buildings and trees are investigated; any lines with distances greater than the distance under investigation i.e., 30, 50, or 100 m are removed. We also remove lines-of-sight where the angle between the line-of-sight and the building wall is less than 25°, to exclude unrealistic viewing angles from windows. Topography has not been considered, and it is assumed that the same number of trees can be viewed from different building levels. A small negative buffer of −0.01 is applied to buildings to prevent false intersections between building edges and lines-of-sight. Finally, any lines that intersect building polygons are removed, however other blocking features are not considered. Each tree only counts towards the building total once even if it can be seen from multiple windows. Tree counts for each building are the total number of unique trees seen from all windows; for a building to pass the test this must be greater than or equal to three trees. A comparison of the simple and detailed method for the 3-tree rule is shown in Fig. 3.

2.6.3. *300 m to accessible greenspace*

For the 300 m rule, rather than using greenspace buffers, walking routes are calculated from buildings (identified by their centroid) to greenspace access points. To do this the Python package OSMnx (Boeing, 2025), which takes features from OpenStreetMap, is used to generate a walking route network. As greenspace access points and building centroids don’t always fall onto a walking route, we identify the nodes on the network that are nearest to the building centroids and access points, and the walking distance is calculated between these nodes. This results in some nodes being slightly removed from the building or access point (Fig. 4). For each building, we record whether there is a greenspace access point within a 300 m, 400 m and 500 m walk. Greenspace access points are filtered using the same criteria as the simple method, and motor vehicle only access points are removed. A comparison of the simple and detailed method for the 300 m rule is shown in Fig. 5.

2.7. *Grading*

In both methods a grading has been calculated, providing each building with a score from 0 to 9 (Table 1). This follows a similar approach by Croeser et al. (2024), who use a 0 to 10 grading, weighted towards canopy cover, which can score from 0 to 4. We give equal weighting by setting a 3-point maximum for each test, following Iqbal

Fig. 3. Comparison of the simple and detailed methods for the 3-tree test. The detailed method (left) demonstrates lines-of-sight from 'windows' to trees, with the maximum length of lines-of-sight set at 30 m. The simple method (right) demonstrates a 30 m buffer around one tree, to show its overlap with the surrounding buildings. Tree data: Copyright © Bluesky International Ltd 2023. ALL RIGHTS RESERVED. ALL DATA IS PROVIDED "AS IS" AND Bluesky International Ltd EXCLUDES ALL LIABILITY HOWEVER ARISING IN RELATION TO THEM (EXCEPT FOR LIABILITY THAT BY LAW WE CANNOT EXCLUDE).

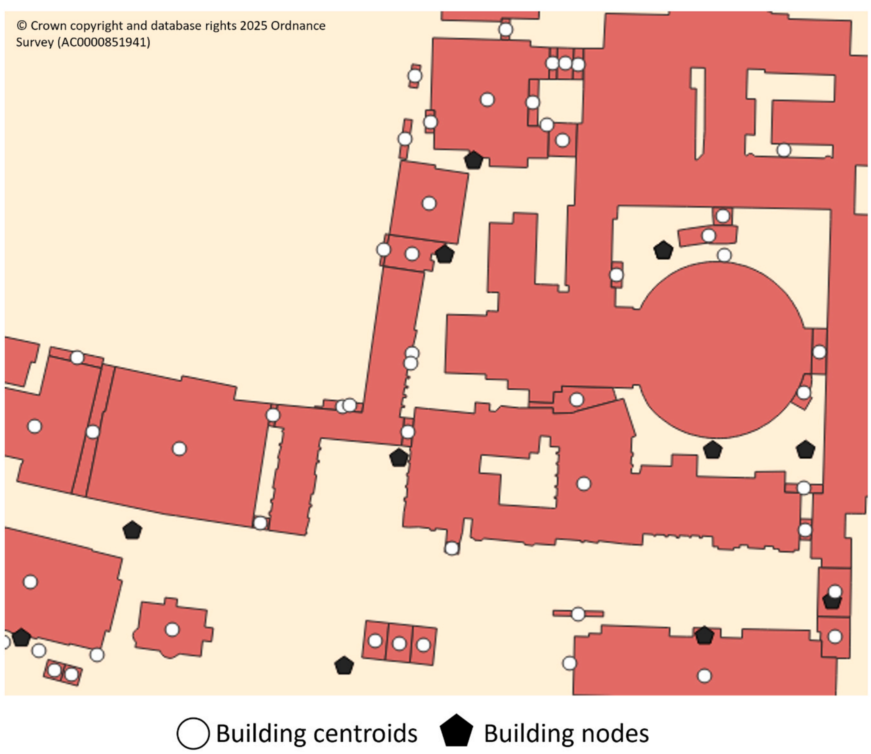


Fig. 4. An example of building centroids (white, circles) and the building nodes used to calculate walking distances for some buildings on the University of Leeds campus (black, pentagons).

et al. (2025). This grading gives a level of detail about a location's success not provided by a simple pass or fail. For further analysis, individual building results have been aggregated over LSOA areas.

2.8. *Land use*

We determine the land use type of each tree using multiple datasets and analyse the impact of land use at an LSOA scale. Trees are categorised in the following order: private garden, woodland, public greenspace, private greenspace, road/street, and other greenspace. For

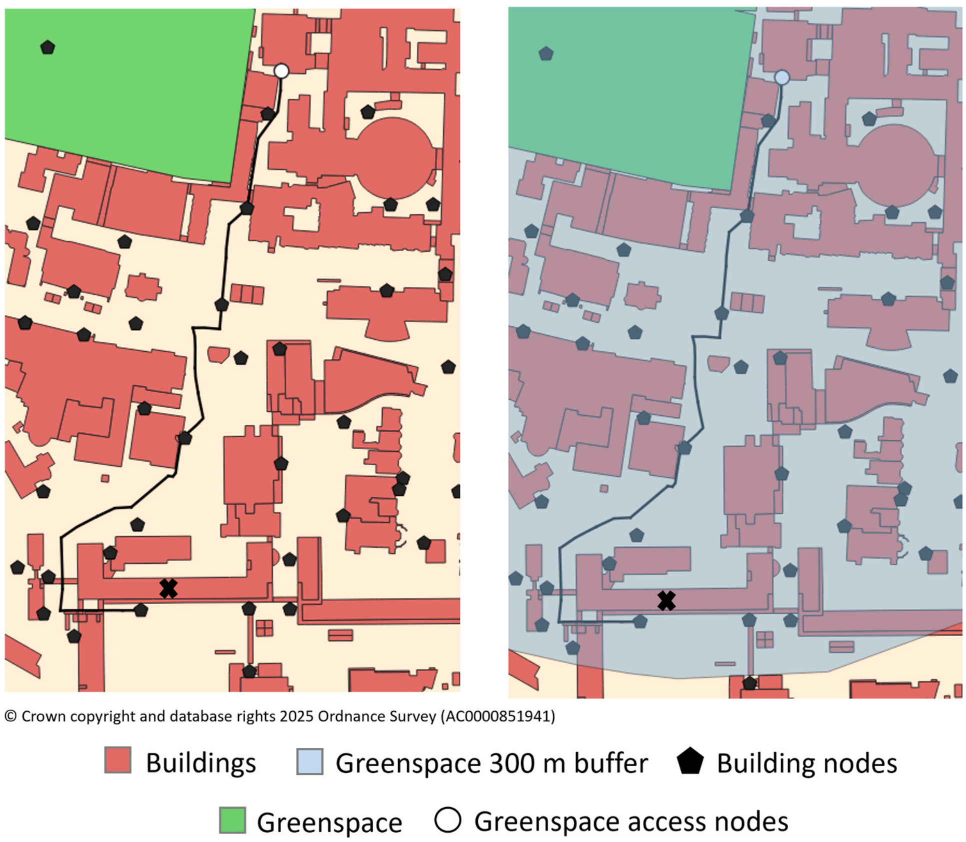


Fig. 5. Comparison of the simple and detailed methods for the 300 m test. The cross marks the building under analysis. The detailed method (left) demonstrates a walking route, in black, between the building node and a greenspace access node. The route measures 459 m, so the building fails in this case. The simple method (right) shows a 300 m buffer around the greenspace to which the access node belongs, as well as the example walking route. Buildings within the buffer are said to be within 300 m of greenspace, so the building passes.

Table 1
The score given to each building based on performance at each of the 3–30-300 thresholds. The maximum score possible is 9.

Score	Threshold		
	3 (number of trees)	30 (canopy cover, %)	300 (distance to greenspace, m)
0	0	< 10	> 500
1	1	≥ 10	≤ 500
2	2	≥ 20	≤ 400
3	≥ 3	≥ 30	≤ 300

private garden and the three greenspace categories we use the OS MasterMap greenspace layer (Ordnance Survey, 2024d). The greenspace layer covers urban areas greater than 6 km^2 for England, excluding several LSOAs that were included in the earlier calculations, leaving 1117 out of 1425 LSOAs for the land use analysis. For woodlands we combine the National Forest Inventory (NFI) dataset of England 2023 (Forestry Commission, 2024) and the Trees Outside Woodlands dataset (TOW) (Forest Research, 2025), taking only the 'NFI OHC' and 'small woodland' categories from TOW. Therefore, the smallest size of woodland included is 0.1 ha. Finally, for roads and streets we use the OS MasterMap highways networks – roads dataset (Ordnance Survey, 2023). As these are represented by lines, a 10 m buffer is added to capture trees on the sides of streets and roads. As trees in other categories such as private gardens are categorised first, an overlap with the street buffer does not recategorize them. In the final step of the analysis the application of a further buffer of 15 m around roads and streets captures trees which are not part of any other category. Following this method, 2 % of trees are left uncategorised. We also calculate the area of each land use in each LSOA (applying a buffer of 5 m to the roads dataset) and the average density of trees in each land use type in each LSOA.

To investigate how the land use of trees influences success at the 3–30–300 rule we use generalised linear mixed models (GLMMs) (Stroup et al., 2024) to model the overall grading, the proportion of buildings meeting the 3-tree rule and canopy cover per LSOA (hereafter referred to as the response variables). We use an ordered beta regression model (Kubinec, 2023) implemented in the R package 'glmmTMB' (Brooks et al., 2017). The model and justification for its use are described further in the Supplementary Material, section 4. The land use variables investigated are the density of trees in each land use type as well as the proportion of the LSOA that is woodland. Extreme outliers are removed from each land use variable using a 99th percentile filter and the values in each variable are standardised by subtracting the mean and dividing by the standard deviation of the variable. Analysis of Variance (ANOVA) tests between the land use variables and the location of the LSOAs (York, Leeds, Manchester, Bradford, Wakefield, Plymouth, Stoke-on-Trent) revealed statistically significant differences between location groups and therefore the location is included as random effect in the models, to account for this variation. The ANOVA process and an example of the results are presented in the Supplementary Material.

Initially, models including the density of trees in all land use categories in an LSOA (private garden, woodland, public greenspace, private greenspace, road/street, and other greenspace) as well as the proportion of LSOA that is woodland were tested for each response variable. For the grading and the proportion of buildings meeting the 3-tree rule we found that 'private greenspace density' and 'public greenspace density' had no relationship with the response variable as indicated by a model coefficient near zero and p values that showed no significance. Subsequently, these were removed from the analysis leaving the final variable choice as the density of trees in private gardens, woodlands, roads/streets and other greenspace alongside the proportion of LSOA that is woodland for the grading and proportion of buildings meeting the 3-tree rule models. All land use variables were included in the canopy cover model. The best model in each case was identified by the lowest Akaike Information Criterion (AIC) score. To verify the use of location as a random effect, models were also tested with and without location as a random effect. The models including this random effect had a lower AIC score each time.

3. Results

3.1. 3–30-300 results

3–30–300 results per city region are presented in Fig. 6 (and Table S3 in the Supplementary Material) and the spatial variation of grading in Leeds and Manchester is shown in Fig. 7 (with other cities shown in Figs. S1 – S5). In these results the detailed method has been used with a 50 m cut-off distance for lines-of-sight in the 3-tree test.

3.2. Methodological choices

The simple method produces median gradings across all LSOAs of 5.4, 6.0, and 6.1 for the 30 m, 50 m, and 100 m radius buffers around trees in the 3-tree test. The detailed method produces median gradings of 4.0, 4.5, and 4.7 for the 30 m, 50 m, and 100 m cut-off distances for lines-of-sight in the 3-tree test. Across all 3-tree cut-off distances, the grading of an individual LSOA ranges from 0.3 to 9.0 for the simple method and 0.1 to 8.6 for the detailed method. The distribution of the results across the gradings for each of these scenarios is shown in Fig. S9. Averaging across the 30 m, 50 m and 100 m cut-off distances for each city region, we found that the proportion of buildings meeting the 3-tree rule was 81.7 % using the simple method and 59.3 % using the detailed method. For the 300 m rule, the average proportion of buildings passing was 58.2 % for the simple method and 29.4 % for the detailed method. For the remaining results, the 50 m detailed method has been used. Justification for this choice and verification of the detailed method

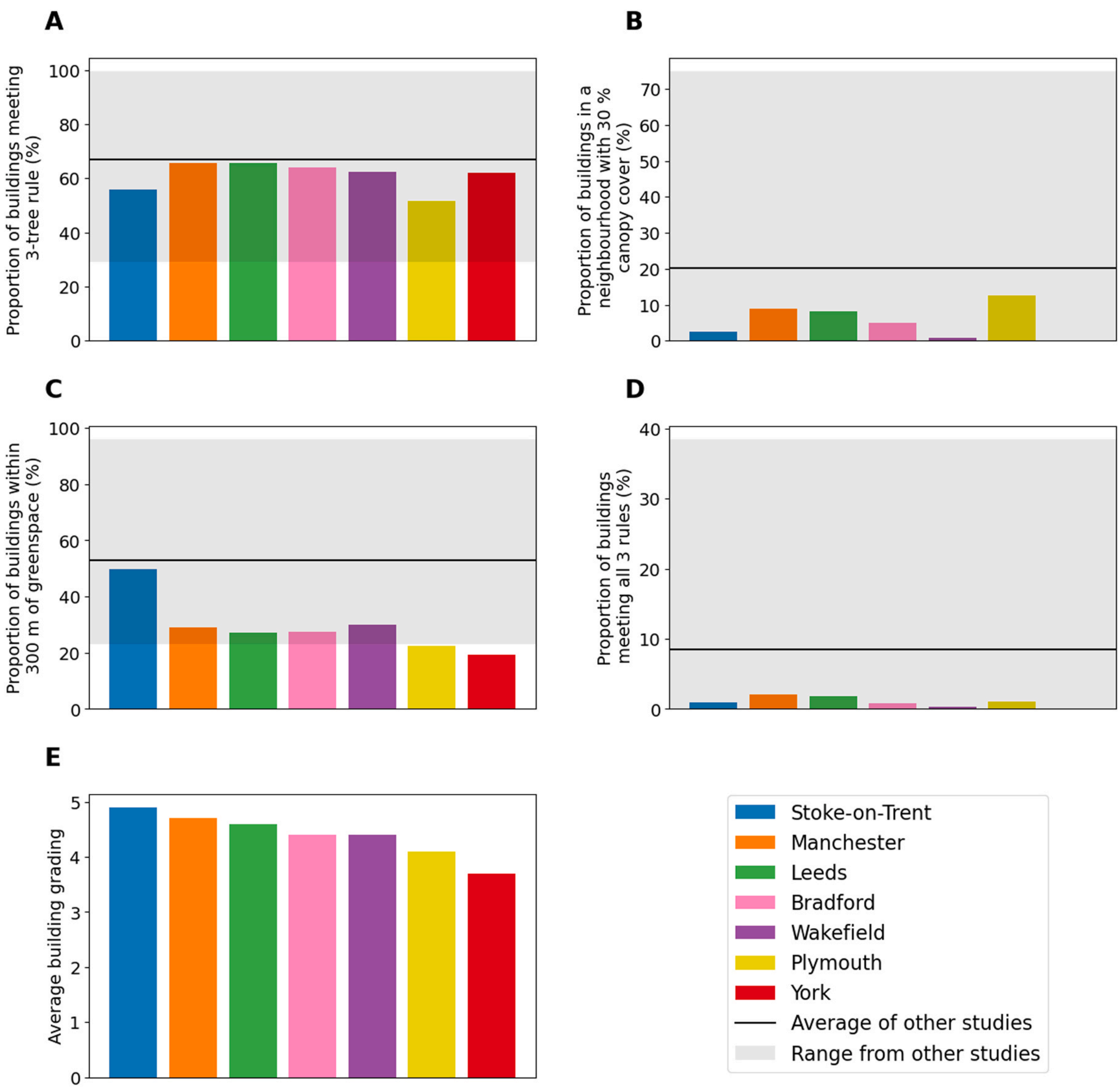
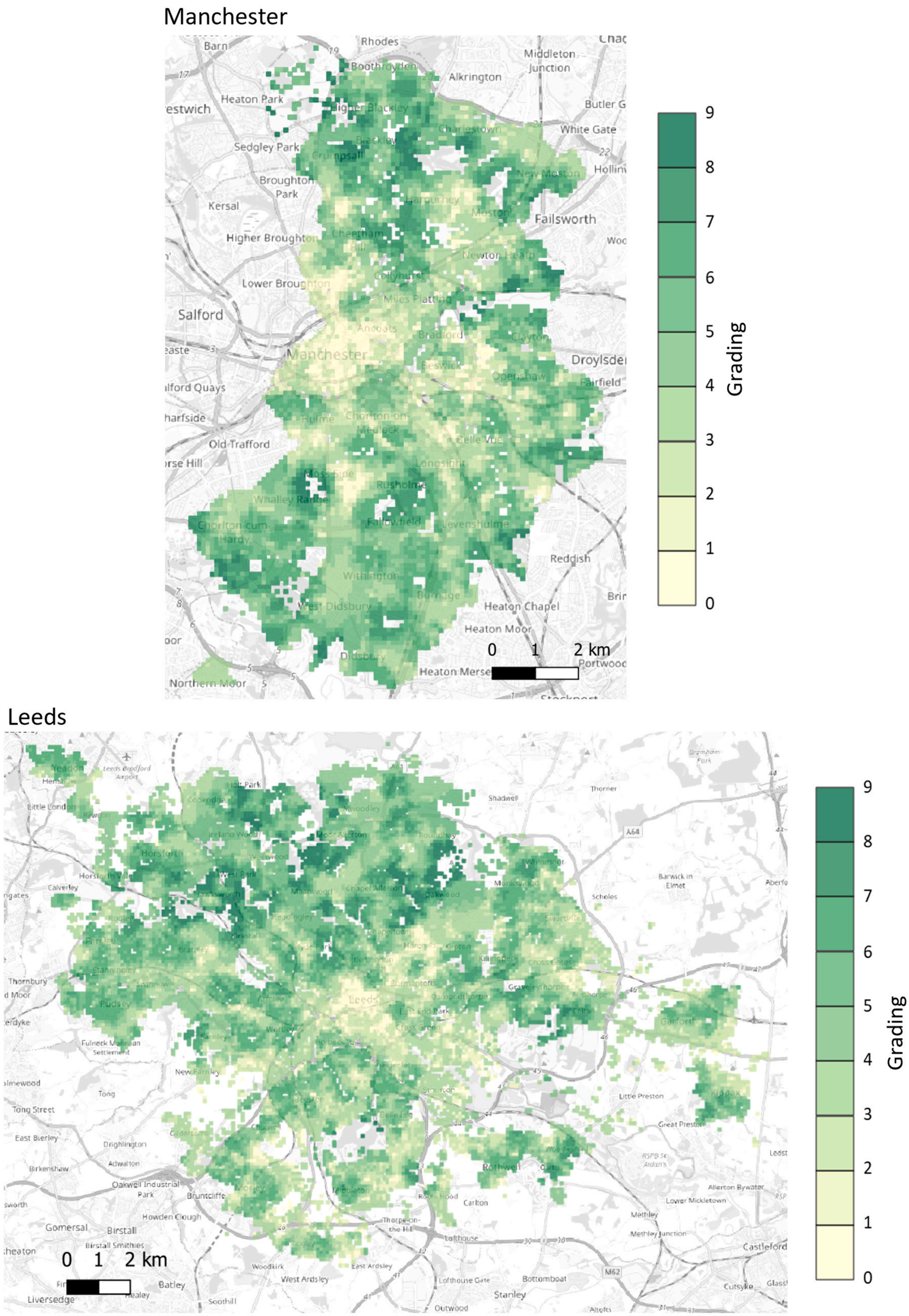


Fig. 6. The results for each component of the 3–30–300 rule (A-C), performance in all three components (D), and average grading for buildings (E) in each city. The detailed method and a 50 m cut off distance for the 3-tree rule were used. Panels A-D also show the mean (black line) and range (grey shading) of results from 3-30-300 studies in global cities: Paris (France), Aarhus (Denmark), Velika Gorica (Croatia) by Owen et al. (2024); Amsterdam (The Netherlands), Buenos Aires (Argentina), Seattle (USA), Denver (USA), New York (USA), Singapore (Singapore), Melbourne (Australia) and Sydney (Australia) by Croeser et al. (2024); Surakata (Indonesia) by Iqbal et al. (2025), discussed further in 4.1.



©MapTiler (https://www.maptiler.com/copyright/)
Map data from OpenStreetMap & contributors (under ODbL: openstreetmap.org/copyright)

Fig. 7. 3–30–300 gradings across the study areas of Manchester and Leeds, using the 50 m detailed method. Each grid cell is 1 ha, and the grading is the average across buildings within each cell. Where there were no buildings within a 1 ha grid cell, the cell is transparent. Similar figures for Stoke-on-Trent, Bradford, Wakefield, Plymouth and York can be found in the Supplementary Material: Figs. S1-S5.

against other methods is discussed in the Supplementary Material, section 3.

3.3. Impact of land use

The best models for explaining variability in grading, canopy cover and proportion of buildings meeting the 3-tree rule per LSOA are presented. The variables used and their estimated coefficients are shown for each model in Table 2.

The R package performance (Lüdecke et al., 2021) was used to generate the pseudo R^2 presented in Table 2. This is a conditional R^2, so includes the random effect of the location. The standard deviation of location as a random effect on the scale of the response variables was found to be 1.7 points, 12.3 %, and 9.6 % for grading, canopy cover and proportion of buildings meeting the 3-tree rule respectively.

The performance package was also used to visually check model assumptions (normality of residuals, normality of random effects, linear relationship, homogeneity of variance, and multicollinearity). These figures are provided in the Supplementary Material (Figs. S11– S13). The grading and 3-tree models are shown to perform well at these tests. From the homogeneity of variance and normality of residuals plots in the canopy cover model analysis (Fig. S12), we see some variability in the canopy cover model which indicates it is not representing the data as well as the other models. Extra care must therefore be taken when interpreting the results of the canopy cover model as it is not as reliable as the other models. As such, canopy cover was plotted against each land use variable and an R^2 calculated to examine how canopy cover responds to each variable independently (Fig. 8).

4. Discussion

4.1. 3–30-300 results

Fig. 6 summarises the results for the urban LSOAs assessed in English cities. Average building grading shows that Stoke-on-Trent performs the best, with an average building grading of 4.9 and York the worst with 3.7. However, this is not consistent across all components of the rule. Stoke-on-Trent has the highest success for the 300 m rule, with 49.9 % of buildings passing, however it is amongst the lowest performing cities for the 3-tree and 30 % rule, indicating that the 300 m rule success is the main driver of the higher building grading for Stoke-on-Trent. York performs least well of all seven cities for the 30 % and 300 m rules, with 0 % of buildings in a neighbourhood with 30 % canopy cover being of note. Although York is not the worst for the 3-tree rule, the 30 % and 300 m components result in reduced building gradings compared to the other cities. Looking at the proportion of buildings meeting all three rules highlights Manchester as the top performer, with 2.1 % of buildings meeting all three rules. Manchester is the best performer at the 3-tree rule (jointly with Leeds) and consistently performs near the top across all three rules, which results in the second highest building grading after Stoke-on-Trent. This tells us that a focus on all three components is necessary to generate the best performance at the 3–30–300 rule. However, 2.1 % of buildings is still extremely low; despite many of these cities working towards canopy cover targets, these statistics highlight consistently low access levels to trees and greenspace across the English cities in this study.

Further analysis of the proportion of buildings across all city regions which meet each component of the 3–30–300 rule is shown in Fig. 9. 25.1 % of buildings do not meet any of the rules, and only 1.2 % of all buildings studied meet all three components. Fig. 9 allows us to identify that achievement of the 30 % rule is impeding overall success most strongly out of the three components of the 3–30–300 rule, with only 6.2 % of buildings meeting this rule, compared to 29.4 % for the 300 m rule and 61.8 % for the 3-tree rule. Additionally, all combinations which include achievement of the 30 % rule report success for small proportions of buildings, all below 4 %, while the remaining combination of meeting the 3-tree rule and 300 m rule is achieved by 16.2 % of buildings.

Studies by Croeser et al. (2024), Owen et al. (2024) and Iqbal et al. (2025) cover various cities around the world. Within these studies, the mean proportion of buildings in each city meeting each rule (and the range across studies) is 3-trees: 66.8 % (29–99.6 %), 30 % canopy: 20.3 % (0–75 %), and 300 m to greenspace: 52.9 % (23–96 %), and the mean proportion of buildings meeting all 3 components (excluding Owen et al. who don't report success at all 3 components) is: 8.4 % (0–38.5 %). In each case we have taken the highest performing 300 m scenario from Iqbal et al. In these studies, results are calculated for individual buildings meeting each requirement (with the exception of the 30 % component by Owen et al. which was calculated per neighbourhood so has been excluded here) and reported for each study area as a whole. Other studies have implemented the 3–30–300 rule but report the results on a neighbourhood/ward level (Battisti et al., 2023; 2024) or the study was done on sample of the residents in an area (Koeser et al., 2024; Nieuwenhuijsen et al., 2022).

Fig. 6 compares the results for English cities in this work to the mean and ranges of results from Croeser et al. (2024), Owen et al. (2024) and Iqbal et al. (2025). The variation in methodologies between this study and the work of Croeser et al., Owen et al., and Iqbal et al., and how this may affect overall results, is discussed in the Supplementary Material, Section 6. None of the methodologies are exactly the same, often because of data and resource availability, therefore precise comparisons between these studies should be made with care. However, there is value in understanding where the performance of these English cities sits in the global context and the comparison also gives the opportunity to highlight the implications of methodological differences. Fig. 6 shows that the results of the 3-tree rule in each English city are all lower than the mean from other studies of 66.8 %, by up to 15.2 %. However, this is a deviation of one fifth of the mean at most, indicating these English cities generally perform as well as other locations at the 3-tree rule. For the 30 % rule, the English cities range from 0 % to 12.7 % of buildings

Table 2
Coefficient estimates for land use variables used in GLMM modelling for grading, canopy cover and proportion of buildings meeting the 3-tree rule per LSOA. The standard error and p value have also been provided.

	Grading			Canopy Cover			Proportion of buildings meeting the 3-tree rule		
	Coefficient estimate	Std. Error	p	Coefficient estimate	Std. Error	p	Coefficient estimate	Std. Error	p
Proportion of land that is woodland	0.35	0.02	< 0.001	0.40	0.01	< 0.001	0.13	0.02	< 0.001
Woodland density	0.07	0.02	< 0.001	0.10	0.01	< 0.001	0.06	0.02	< 0.01
Private garden density	0.23	0.02	< 0.001	0.21	0.01	< 0.001	0.52	0.03	< 0.001
Private greenspace density	-	-	-	0.03	0.01	< 0.001	-	-	-
Other greenspace density	0.05	0.02	< 0.05	0.03	0.01	< 0.01	-0.07	0.02	< 0.01
Public greenspace density	-	-	-	0.04	0.01	< 0.001	-	-	-
Road/street density	0.05	0.02	< 0.01	0.11	0.01	< 0.001	0.18	0.02	< 0.001
Pseudo R^2	0.81			0.86			0.88		

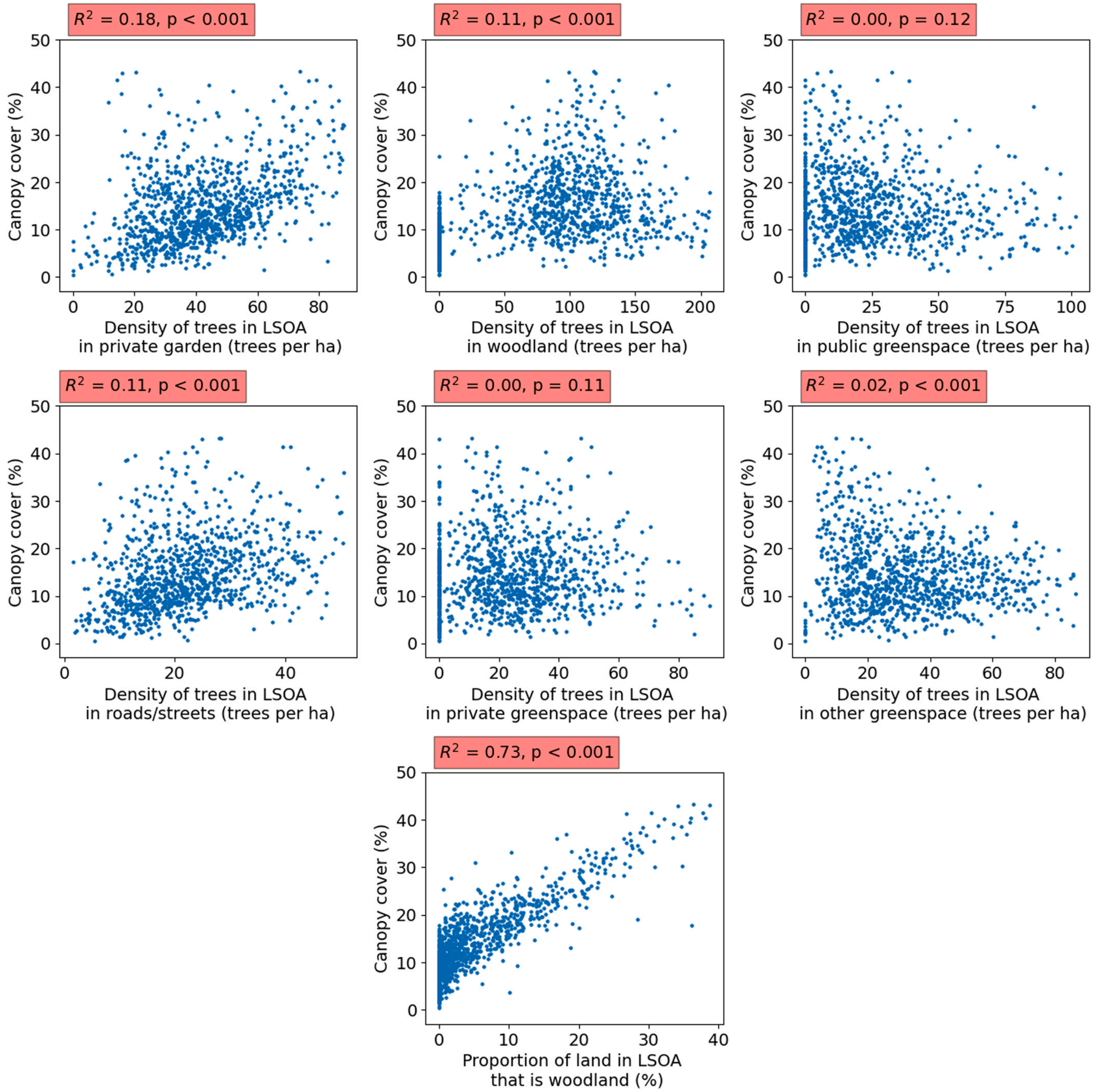


Fig. 8. The variation of canopy cover with the density of trees in each land use variable per Lower Layer Super Output Area (LSOA) as well as the proportion of land in the LSOA that is woodland. The R^2 value for each relationship is also shown.

passing compared to the mean of 20.3 % for the global studies, illustrating that these English cities perform worse for canopy cover. Finally, the mean of 52.9 % for the 300 m rule from other studies is higher than all cities in this study. Stoke-on-Trent is the only region which comes close to this at 49.9 % of buildings, with the other English cities all below 30 %. Notably Plymouth and York perform worst out of the English cities for the 300 m rule and are below the range of the results in the global studies. These comparisons indicate poor performance in English cities compared to other cities studied.

Fig. 7 and Figs. S1-S5 highlight how performance in the 3–30–300 rule varies in each location. In these figures, there are notable regions of the heatmap which are pale yellow (therefore scoring in the lowest grading range of 0 to 1). Grading around these regions tends to improve with increasing distance from them. Visual analysis shows that these poorly performing regions are often the urban centres. These lower scoring areas are missing out on many of the benefits identified from meeting the rule such as improved mental health, space for recreation, lower biodiversity and cooling effects. Poor performance is perhaps expected in these areas as they are generally more built-up with high demand for land and reduced space for trees and greenspaces. Robinson et al. (2022) compared greenspace, trees and greenness in urban centres across Great Britain, also making using of the OS Open Greenspace dataset, and found geographic disparities between urban centres. They found that lower overall greenness was associated with higher deprivation, highlighting that these already deprived areas are further excluded from the many benefits of trees and greenspaces. However,

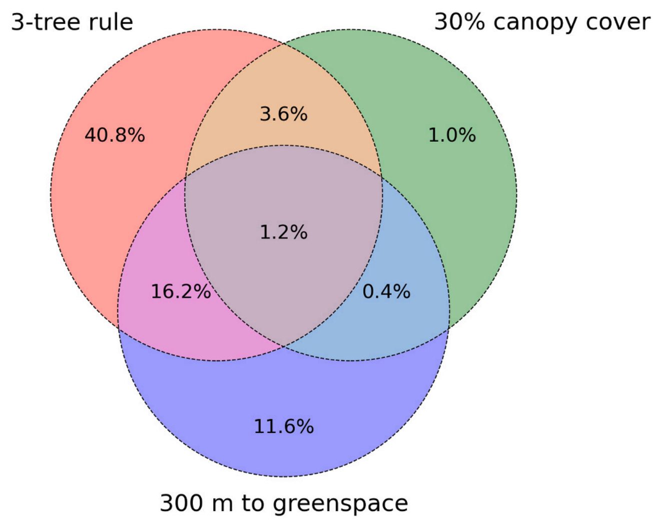


Fig. 9. A Venn diagram showing the proportion of buildings in all cities studied meeting each component of the 3–30–300 rule as well as different combinations of the components. 25.1 % of buildings are not represented in this diagram as they did not meet any of the rules.

even the highest scoring urban centre, Exeter, only recorded 11.67 % tree cover and 0.05 % greenspace coverage which still indicates overall low availability of trees and greenspace. Fig. 7 and Figs. S1-S5 indicate priority areas for improved tree cover and greenspace access and emphasize that there is still considerable work to be done in the most built-up areas to improve tree and greenspace access.

4.2. Methodological choices

The comparison between results for the simple and detailed methods show that a larger cut-off distance or buffer radius for the 3-tree test leads to higher gradings and that the simple method produces higher gradings for the same area than the detailed method (Fig. S9). This difference in results highlights the importance of knowing how 3–30–300 results for any location are determined, particularly if tracking changes over time; the overall grading is sensitive to the methodology used to measure it, which also indicates that the grading and all components of the rule have an associated uncertainty. However, the overall pattern of areas performing poorly or those performing well should remain the same. In this study, the median grading of LSOAs across different methods ranged from 4.0 to 6.1. With a difference of 2.1 grading points, almost a quarter of the maximum score possible, this could be the difference between a neighbourhood receiving an intervention or not. This is particularly important to highlight, as it is the quicker and more straightforward *simple* method that results in these higher gradings, which may be the more popular choice for a 3–30–300 analysis where there are limited resources. This also underlines the importance of choosing the correct method for the desired outputs of a study, discussed in further detail in the Supplementary Material, section 3.

The data requirements for the simple and detailed methods also differ. The detailed method requires fine scale data: building footprints, individual trees, a walking route network and greenspace access points at a minimum. Some of these could be replaced, for example, Iqbal et al. (2025) used the line-of-sight method with trees represented by proxy points within tree canopy boundaries, based on average tree spacing. A similar change could be made for greenspace access points; proxy points could be created at regular intervals around greenspaces, but greenspace polygons would be required for this. The main goal of the detailed method is to provide a realistic analysis, so the more detailed the data the better. However, the simple method is more flexible. For example, if there are building footprints available but only land cover statistics rather than specific greenspace polygons then a 300 m buffer could be applied around each building and the likelihood of the buffer overlapping with a greenspace could be calculated. With this approach, there is no need for a specific start and end point so the method can be altered more easily when data is limited. Since the simple method may be more likely to be used when data is scarce it is important to note that 3–30–300 scores may be biased towards the higher end of the scale and may overestimate performance, and this should be considered when interpreting the results. Additionally, comparisons between locations should be undertaken with care.

The 3–30–300 method offers a straightforward framework and provides spatial information for a city. In comparison to the Gini index for measuring tree and green space equality, 3–30–300 gives us more information about how access varies across a city and allows identification of priority areas for improvements. However, as with the Gini method and other approaches to measuring access to trees and greenspace, there is still freedom within the framework to make different choices in the methodology, and there is often variation due to data availability. The results in this study show that the methodology alters the results substantially and that there is still the issue of a lack of consistency between studies. Moreover, the 3–30–300 framework does not consider factors such as air pollution or income of a neighbourhood, so is a tool for measuring equality rather than equity such as with the tree equity score. This means the framework may not be identifying which areas are the highest priority which is highlighted when these other factors are combined with a lack of trees and greenspaces. Overall, the 3–30–300 rule is a beneficial addition to the existing tools in this area and is highly informative. With consistent methodology across cities to create meaningful comparisons, a 3–30–300 analysis can motivate real change in urban areas around the world.

4.3. Impact of land use

The coefficient estimates in Table 2 indicate the relative strength of the effect of each land use variable on the response variable (grading, canopy cover, proportion of buildings meeting the 3-tree rule). The p values indicate the significance of the relationship between the land use variables and the response variable. All the relationships within the models are shown to have statistical significance. This analysis is based on the existing distribution of trees in the LSOAs studied which is not necessarily the optimum arrangement for success at the 3–30–300 rule. Therefore, each model explains how the current distribution of trees across LSOAs can influence how successful a neighbourhood is at the 3–30–300 rule, but it cannot be used to predict changes in performance.

For the 3-tree model, the coefficients indicate that the density of trees in private gardens is the most important factor followed by the density of trees in roads/streets and the proportion of land in the LSOA that is woodland, with coefficients of 0.52, 0.18 and 0.13 respectively. The pseudo R^2 of this model is 0.88, indicating a good fit. In this model the coefficient for the density of trees in other greenspace is negative, but the increased density of trees anywhere is unlikely to reduce the proportion of trees meeting the 3-tree rule. As the coefficient is small and not as statistically significant as the other variables, it cannot be interpreted as an important factor for the proportion of buildings meeting the 3-tree rule. This negative coefficient may result from LSOAs where trees are within areas classed as ‘other greenspace’ rather than private gardens or roads/streets and so these neighbourhoods perform worse than others at the 3-tree rule. Future work could investigate how land classed as ‘other greenspace’ is used within English neighbourhoods and whether it could be utilised to improve 3–30–300 scores.

In the canopy cover model, the proportion of land in the LSOA that is woodland has the biggest impact with a coefficient of 0.40. Density of trees in private gardens follows with 0.21 and density of trees in woodlands and roads/streets come out as similarly important with coefficients of 0.10 and 0.11. In Fig. 8 the relationship between increasing woodland and increasing canopy cover in an LSOA corresponds to an R^2

of 0.73. From Fig. 8 it is clear that woodland area explains more of the variability in canopy cover than any other factor, confirming the results of the GLMM. Croeser et al. (2024) compared links between different components of the 3–30–300 rule, finding most notably that high achievement of the 3-tree test did not increase the likelihood of achieving the 30 % canopy cover threshold. In the UK neighbourhood context, this may be partially explained by our findings that canopy cover is mainly driven by woodland area, while 3-tree success is influenced more by the density of trees in private gardens.

The results of the overall grading model indicate that the two most important variables are the proportion of land that is woodland with a coefficient of 0.35 and the density of trees in private gardens with a coefficient of 0.23. Both have the highest significance level, with a p value less than 0.001 and the pseudo R^2 of 0.81 indicates a well-fitting model. As the density of trees in private gardens has the biggest impact for the 3-tree model and proportion of land that is woodland is most important for canopy cover it follows that these variables have the biggest impact on the overall grading of an LSOA.

These findings suggest that adding more areas of woodland alongside encouraging more planting of trees in private gardens, and enforcing greater restrictions on their removal, is the best way to maintain and improve success at the 3-tree and 30 % components and therefore improve overall grading. However, evidence suggests that private gardens are being lost in recent years, with many converted for other uses such as parking spaces (Frost and Murtagh, 2023). This creates a challenge for improvements in the 3-tree component and indicates a need for the importance of private gardens to be highlighted in urban areas. Additionally, other factors such as the species and suitability of a tree to its location and therefore its canopy size and likelihood of survival will play a role in a tree's contribution to a 3–30–300 score, and this should be considered before new trees are planted.

4.4. Limitations and future work

While we have used the OS MasterMap building height attribute layer to identify buildings, there are other datasets available which could provide additional information about buildings. For example, both the Verisk UKBuildings dataset (Verisk Analytics, 2025) and the OS National Geographic Database (Ordnance Survey, 2025b) provide building footprints and additional information on building use. Using one of these datasets would allow only the buildings classed as 'homes, schools or workplaces' to be considered as part of the 3–30–300 evaluation.

Additionally, the 'lines-of-sight' method for the detailed 3-tree rule could be swapped for a different method to be more representative of the eye-level greenness actually experienced by people on the ground. Although we have removed lines-of-sight that intersect buildings, we have not considered other blocking features nor the topography of the area. In the supplementary material (section 3) we have compared the lines-of-sight method to a viewshed analysis, which determines what is visible from an observer point (which could be on the ground, or on a floor of a building, for example). This offers an improvement on lines-of-sight but is done manually for each observer point and still includes some level of approximation. Other assessments could use window view analysis (Browning et al., 2024), which could be captured through questionnaires, or street view images (Lumnitz et al., 2021; Seiferling et al., 2017) to locate trees which could be combined with GPS data to map trees in people's activity space.

There are many areas that could be explored with future work. One area could further explore how changes in the methodology of a 3–30–300 analysis could impact results. In this study we investigate a simple and detailed method, and different distances for the 3-tree rule but it would also be worthwhile to consider how decisions such as the minimum size of greenspace or a minimum crown area of 25 m^2 for the 3-tree rule would affect the final results. Croeser et al. (2024) examined how parametric changes influenced 3–30–300 results in New York, finding, for example that the inclusion of parks of all sizes, rather than those larger than their chosen minimum size of 0.5 ha, resulted in 21 % more buildings meeting the 300 m rule. Given the considerable impact on the results, it would be beneficial to understand how these changes would alter results in an English context, and this would also help improve comparability to other studies.

An additional assessment exploring the relationship of 3–30–300 success to deprivation could be explored, building on the work of Robinson et al. (2022); Friends of the Earth (2023) and Sales et al., (2023) who all identified that lower greenness levels, be that canopy cover, greenspace or greenness, were all associated with higher levels of deprivation. Together with the 3–30–300 results, an evaluation of the deprivation in the cities analysed could prioritise areas in need of improvement even further.

Finally, in terms of the land use, we have already identified that optimising 3–30–300 scores, and how different land use types might play into that, could form future work. However, an additional investigation could centre around private gardens. This study identifies that private garden trees are an important factor for success in the 3-tree component of the 3–30–300 rule as well as in the 30 % component to a lesser extent. Although private garden trees are, by definition, on private land, they are often visually accessible by those in neighbouring buildings and therefore contribute to the 3-tree rule for multiple buildings. However, this does raise the question of whether public resources should be invested in tree planting on private land and private gardens. In particular, whether this would reduce resources available for public land and therefore exacerbate the inequalities that already exist in urban areas, where there is often lower canopy cover (Robinson et al., 2022; Sales et al., 2023), reduced quality greenspace provision (Friends of the Earth, 2020) and fewer private gardens (McIntyre and Gayle, 2022) in poorer areas. As private gardens also provide greenspace access for some, and have been shown to be more beneficial than public greenspace to mental health for some demographics in Great Britain (Collins et al., 2023), future work could investigate how the inclusion of private gardens as greenspace impacts 3–30–300 scores and investigate, for example, whether the priority areas change, or if the difference between higher and lower scoring buildings is further extended.

5. Conclusions

In this study we aimed to measure achievement of the 3–30–300 rule in the local authority areas of seven English cities and identify priority areas for existing urban greening efforts. We found that across these local authority areas inner-city regions tended to show the worst performance and a maximum of 2.1 % of buildings in any city met all three components of the rule, with the 30 % rule identified as the main obstacle to success. The average grading in these cities was 4.4, ranging from 3.7 in York to 4.9 in Stoke-on-Trent. Comparison to other 3–30–300 studies in cities across the globe showed that the English cities in this study perform similarly at the 3-tree component, but worse at the 30 % and 300 m components. The small number of cities studied limits the applicability of these findings to English cities in general; a nationwide study would provide a comprehensive analysis of England's performance at the 3–30–300 rule but relies on the availability of appropriate tree inventories with a similar level of detail across cities, to allow for comparison of results.

We examined how methodological choices impact the results of the 3-tree and 300 m components, finding that simple buffer methods produced higher scores compared to network analyses of walking distances and simulated lines-of-sight. Buffer methods provide a simple method to examine the variation in 3–30–300 success across a region and may be more appropriate where fine scale data is not available, but where specific building information is required, the detailed method may be more appropriate. Similarly, using a larger buffer or cut-off distance for the 3-tree rule produced higher gradings, and therefore the choice of distance used in a study should be appropriate for the desired outputs.

The density of trees on different land uses as well as the amount of woodland in LSOAs within the city regions was calculated and generalised linear mixed models were created to determine the importance of these variables to the overall grading, canopy cover and proportion of buildings meeting the 3-tree rule in an LSOA. These models showed that the density of trees in private gardens was the most important variable for the proportion of buildings meeting the 3-tree rule and the proportion of land in the LSOA that is woodland was most important for canopy cover. It therefore follows that these variables were the most important factors for overall grading with coefficients of 0.35 for woodland cover and 0.23 for density of trees in private gardens.

Overall, we have shown that English cities require more trees and greenspace to match the performance of other cities across the globe and to meet all the requirements of the 3–30–300 rule, and that this is particularly true in the inner-city areas. Our findings suggest that increasing the density of trees in private gardens and increasing woodland cover are the most efficient ways to see improvements in the 3-tree and 30 % components of the rule in UK neighbourhoods. Given that the proportion of buildings across all city regions meeting the 30 % rule is lowest out of all three components of the rule, priority should be given to increasing woodland, to increase canopy cover. Further work is required to identify the optimal placement of trees to maximise performance at the 3–30–300 rule and to predict changes based on potential tree planting scenarios, as well as to investigate how investment on private land may impact existing socio-economic inequalities.

CRediT authorship contribution statement

Christopher Fleet: Writing – review & editing, Supervision, Resources. **Eleanor S. Smith:** Writing – review & editing, Writing – original draft, Visualization, Software, Methodology, Formal analysis, Data curation, Conceptualization. **Stuart King:** Writing – review & editing, Supervision, Resources, Methodology. **Arjan S. Gosal:** Writing – review & editing, Supervision. **Ian Willey:** Software, Resources. **Hannah Walker:** Writing – review & editing, Supervision, Resources, Methodology, Conceptualization. **Catherine E. Scott:** Writing – review & editing, Supervision, Resources, Methodology, Conceptualization.

Data statement

The data generated in this study is not available due to licencing agreements.

Funding

This research has been supported by the Natural Environment Research Council (NERC) through a SENSE CDT studentship (grant no. NE/T00939X/1). CS was supported by NERC grant no. NE/S015396/1.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgment

We would like to thank the White Rose Forest for providing access to NTM datasets for West and North Yorkshire and acknowledge the use of Bluesky NTM data accessed through EDINA Digimap. We acknowledge the copyright and intellectual property rights for all Ordnance Survey data used: © Crown copyright and database rights 2025 Ordnance Survey (AC0000851941). This work contains National Statistics data (© Crown copyright and database right 2025), National Forest Inventory data and the National Trees Outside Woodland dataset (© Forestry Commission copyright and/or database right 2025. All rights reserved) all of which are licensed under the Open Government Licence v3.0.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ufug.2025.129221.

References

American Forests, 2024. Tree Equity Score Methodology. URL ⟨https://www.treeequityscore.org/methodology/⟩ (Accessed 4.25.24).

Astell-Burt, T., Feng, X., 2020. Does sleep grow on trees? A longitudinal study to investigate potential prevention of insufficient sleep with different types of urban green space. SSM Popul. Health 10, 100497. https://doi.org/10.1016/j.ssmph.2019.100497.

Astell-Burt, T., Feng, X., 2019. Association of urban green space with mental health and general health among adults in Australia. JAMA Netw. Open 2, e198209. https://doi.org/10.1001/jamanetworkopen.2019.8209.

Battisti, L., Aimar, F., Giacco, G., Devecchi, M., 2023. Urban green development and resilient cities: a first insight into urban forest planning in Italy. Sustainability 15, 12085. https://doi.org/10.3390/su151512085.

Battisti, L., Giacco, G., Moraca, M., Pettenati, G., Dansero, E., Larcher, F., 2024. Spatializing Urban forests as nature-based solutions: a methodological proposal. Cities 144, 104629. https://doi.org/10.1016/j.cities.2023.104629.

Bluesky International Ltd, 2025a. Scottish Council Leading the Way with Cross-Function Application of Green Space Analysis. URL ⟨https://bluesky-world.com/2025/05/01/scottish-council-leading-the-way-with-cross-function-application-of-green-space-analysis/⟩ (accessed 10.8.25).

Bluesky International Ltd, 2025b. National Tree Map™. URL ⟨https://bluesky-world.com/ntm/⟩ (accessed 8.19.25).

Boeing, G., 2025. Modeling and analyzing urban networks and amenities with OSMnx. Geogr. Anal., gean.70009 https://doi.org/10.1111/gean.70009.

Brooks, M., E., Kristensen, K., Benthem, K., J., van, Magnusson, A., Berg, C., W., Nielsen, A., Skaug, H., J., Mächler, M., Bolker, B., M., 2017. glmmTMB balances speed and flexibility among packages for zero-inflated generalized linear mixed modeling. R. J. 9, 378. https://doi.org/10.32614/RJ-2017-066.

Brown, D.K., Barton, J.L., Gladwell, V.F., 2013. Viewing nature scenes positively affects recovery of autonomic function following acute-mental stress. Environ. Sci. Technol. 47, 5562–5569. https://doi.org/10.1021/es305019p.

Browning, M.H.E.M., Locke, D.H., Konijnendijk, C., Labib, S.M., Rigolon, A., Yeager, R., Bardhan, M., Berland, A., Dadvand, P., Helbich, M., Li, F., Li, H., James, P., Klompmaker, J., Reuben, A., Roman, L.A., Tsai, W.-L., Patwary, M., O'Neil-Dunne, J., Ossola, A., Wang, R., Yang, B., Yi, L., Zhang, J., Nieuwenhuijsen, M., 2024. Measuring the 3-30-300 rule to help cities meet nature access thresholds. Sci. Total Environ. 907, 167739. https://doi.org/10.1016/j.scitotenv.2023.167739.

Bluesky International Ltd. 2023. National Tree Map [GeoPackage geospatial data], Scale 1:1250. [Online]. EDINA Digimap Ordnance Survey Service.

City of York Council, 2024. York Green Streets Project. URL ⟨https://www.york.gov.uk/YorkGreenStreets⟩ (accessed 4.26.24).

Coley, R.L., Sullivan, W.C., Kuo, F.E., 1997. Where does community grow?: the social context created by nature in Urban Public Housing. Environ. Behav. 29, 468–494. https://doi.org/10.1177/001391659702900402.

Collins, R.M., Smith, D., Ogutu, B.O., Brown, K.A., Eigenbrod, F., Spake, R., 2023. The relative effects of access to public greenspace and private gardens on mental health. Landsc. Urban Plan. 240, 104902. https://doi.org/10.1016/j.landurbplan.2023.104902.

Croeser, T., Sharma, R., Weisser, W.W., Bekessy, S.A., 2024. Acute canopy deficits in global cities exposed by the 3-30-300 benchmark for urban nature. Nat. Commun. 15, 9333. https://doi.org/10.1038/s41467-024-53402-2.

Davies, H., Doick, K., Handley, P., O'Brien, L., Wilson, J., 2017. Delivery of ecosystem services by urban forests. Forestry Comission.

Endalew Terefe, A., Hou, Y., 2024. Determinants influencing the accessibility and use of urban green spaces: a review of empirical evidence. City Environ. Interact. 24, 100159. https://doi.org/10.1016/j.cacint.2024.100159.

Forest Research, 2025. National Trees Outside Woodland Map. URL ⟨https://data-forestry.opendata.arcgis.com/documents/01667a77c65f4fd9aaf6a45279373a25/explore⟩ (accessed 4.7.25).

Forestry Commission, 2024. National Forest Inventory England 2023.

Friends of the Earth, 2023. Mapping English tree cover: results, ranking and methodology. URL ⟨https://policy.friendsoftheearth.uk/insight/mapping-english-tree-cover-results-ranking-and-methodology⟩ (accessed 10.6.25).

Friends of the Earth, 2020. England's green space gap. URL ⟨https://policy.friendsoftheearth.uk/sites/default/files/documents/2020-10/Green_space_gap_full_report_1.pdf⟩ (accessed 10.7.25).

Frost, R., Murtagh, N., 2023. Encouraging planting in urban front gardens: a focus group study. Perspect. Public Health 143, 80–88. https://doi.org/10.1177/17579139231163738.

Gini, C., 1912. Variabilità e Mutuabilità: Contributo allo Studio delle Distribuzioni e delle Relazioni Statistiche. Tipografia di Paolo Cuppini, Bologna.

Grove, J.M., O'Neil-Dunne, J., Pelletier, K., Nowak, D., Walton, J., 2006. A Report on New York City's Present and Possible Urban Tree Canopy.

Han, B., Cohen, D., McKenzie, T.L., 2013. Quantifying the contribution of neighborhood parks to physical activity. Prev. Med. 57, 483–487. https://doi.org/10.1016/j.ypmed.2013.06.021.
Harmar, O., 2025. Natural England Blog. Nature Towns and Cities Programme: Transforming Urban Landscapes for People and Planet. URL ⟨https://naturalengland.blog.gov.uk/2025/07/18/nature-towns-and-cities-programme-transforming-urban-landscapes-for-people-and-planet/⟩ (accessed 10.8.25).
Iqbal, L.M., Njaim, G.A., Vos, D., Permana, C.T.H., 2025. Parks please! implementing the 3-30-300 green space rule in developing countries-The Case of Surakarta, Indonesia. Urban For. Urban Green., 128797 https://doi.org/10.1016/j.ufug.2025.128797.
i-Tree, n.d. i-Tree Canopy.
Jenerette, G.D., Harlan, S.L., Stefanov, W.L., Martin, C.A., 2011. Ecosystem services and urban heat riskscape moderation: water, green spaces, and social inequality in Phoenix, USA. Ecol. Appl. 21, 2637–2651. https://doi.org/10.1890/10-1493.1.
Kluck, J., Klok, L., Solcerová, A., Kleerekoper, L., Wildschut, L., Jacobs, C., Loeve, R., 2020. The hittebestendige stad: Een koele kijk op de inrichting van de buitenruimte (The heat resistant city: A cool outlook on the design of outdoor spaces).
Koeser, A.K., Hauer, R.J., Andreu, M.G., Northrop, R., Clarke, M., Diaz, J., Hilbert, D.R., Konijnendijk, C.C., Landry, S.M., Thompson, G.L., Zarger, R., 2024. Using the 3-30-300 Rule to Assess Urban Forest Access and Preferences in Florida (United States). isa jauf.2024.007. https://doi.org/10.48044/jauf.2024.007.
Konijnendijk, C.C., 2023. Evidence-based guidelines for greener, healthier, more resilient neighbourhoods: introducing the 3–30–300 rule. J. For. Res. 34, 821–830. https://doi.org/10.1007/s11676-022-01523-z.
Kubinec, R., 2023. Ordered Beta Regression: a parsimonious, well-fitting model for continuous data with lower and upper bounds. Polit. Anal. 31, 519–536. https://doi.org/10.1017/pan.2022.20.
Labib, S.M., Huck, J.J., Lindley, S., 2021. Modelling and mapping eye-level greenness visibility exposure using multi-source data at high spatial resolutions. Sci. Total Environ. 755, 143050. https://doi.org/10.1016/j.scitotenv.2020.143050.
Leeds City Council, 2020. White Rose Forest Strategy Leeds.
Lüdecke, D., Ben-Shachar, M., Patil, I., Waggoner, P., Makowski, D., 2021. performance: an r package for assessment, comparison and testing of statistical models. JOSS 6, 3139. https://doi.org/10.21105/joss.03139.
Lumnitz, S., Devisscher, T., Mayaud, J.R., Radic, V., Coops, N.C., Griess, V.C., 2021. Mapping trees along urban street networks with deep learning and street-level imagery. ISPRS J. Photogramm. Remote Sens. 175, 144–157. https://doi.org/10.1016/j.isprsjprs.2021.01.016.
Manchester City Council, 2023. Manchester Tree and Woodland Action Plan 2023-33.
Marselle, M.R., Bowler, D.E., Watzema, J., Eichenberg, D., Kirsten, T., Bonn, A., 2020. Urban street tree biodiversity and antidepressant prescriptions. Sci. Rep. 10, 22445. https://doi.org/10.1038/s41598-020-79924-5.
Martin, A.J.F., Conway, T.M., 2025. Using the Gini Index to quantify urban green inequality: A systematic review and recommended reporting standards. Landsc. Urban Plan. 254, 105231. https://doi.org/10.1016/j.landurbplan.2024.105231.
McIntyre, N., Gayle, D., 2022. Poorest areas of England have less than third of garden space enjoyed by richest. Guardian.
Mears, M., Brindley, P., 2019. Measuring Urban greenspace distribution equity: the importance of appropriate methodological approaches. IJGI 8, 286. https://doi.org/10.3390/ijgi8060286.
Mears, M., Brindley, P., Barrows, P., Richardson, M., Maheswaran, R., 2021. Mapping urban greenspace use from mobile phone GPS data. PLoS ONE 16, e0248622. https://doi.org/10.1371/journal.pone.0248622.
Mears, M., Brindley, P., Maheswaran, R., Jorgensen, A., 2019. Understanding the socioeconomic equity of publicly accessible greenspace distribution: The example of Sheffield, UK. Geoforum 103, 126–137. https://doi.org/10.1016/j.geoforum.2019.04.016.
Nieuwenhuijsen, M.J., Dadvand, P., Márquez, S., Bartoll, X., Barboza, E.P., Cirach, M., Borrell, C., Zijlema, W.L., 2022. The evaluation of the 3-30-300 green space rule and mental health. Environ. Res. 215, 114387. https://doi.org/10.1016/j.envres.2022.114387.
Nyelele, C., Kroll, C.N., 2020. The equity of urban forest ecosystem services and benefits in the Bronx, NY. Urban For. Urban Green. 53, 126723. https://doi.org/10.1016/j.ufug.2020.126723.
O'Brien, L., Morris, J., Stewart, A., 2014. Engaging with Peri-Urban Woodlands in England: the contribution to people's health and well-being and implications for future management. IJERPH 11, 6171–6192. https://doi.org/10.3390/ijerph110606171.
Office for National Statistics, 2025. Rural Urban Classification (2021) of LSOAs in EW.
Office for National Statistics, 2024. Lower layer Super Output Areas (December 2021) Boundaries EW BFE (V10).
Ordnance Survey, 2025a. OS MasterMap Sites Layer. URL ⟨https://www.ordnancesurvey.co.uk/products/os-mastermap-sites-layer⟩ (accessed 6.12.25).
Ordnance Survey, 2025b. OS NGD Documentation. URL ⟨https://docs.os.uk/osngd⟩ (accessed 10.7.25).
Ordnance Survey, 2024a. Boundary-LineTM [SHAPE geospatial data], Scale 1:10000. EDINA Digimap Ordnance Survey Service.
Ordnance Survey, 2024b. OS MasterMap Building Height Attribute [FileGeoDatabase geospatial data], Scale 1:2500. EDINA Digimap Ordnance Survey Service.
Ordnance Survey, 2024c. OS Open Greenspace [SHAPE geospatial data], Scale 1:25000. EDINA Digimap Ordnance Survey Service.
Ordnance Survey, 2024d. OS MasterMap Greenspace [SHAPE geospatial data], Scale 1:2500. EDINA Digimap Ordnance Survey Service.
Ordnance Survey, 2023. OS MasterMap Highways Network [GeoPackage geospatial data], Scale 1:2500. EDINA Digimap Ordnance Survey Service.
Owen, D., Fitch, A., Fletcher, D., Knopp, J., Levin, G., Farley, K., Banzhaf, E., Zandersen, M., Grandin, G., Jones, L., 2024. Opportunities and constraints of implementing the 3-30-300 rule for urban greening. Urban For. Urban Green., 128393 https://doi.org/10.1016/j.ufug.2024.128393.
Pedregosa, F., Varoquaux, G., Gramfort, A., Michel, V., Thirion, B., Grisel, O., Blondel, M., Prettenhofer, P., Weiss, R., Dubourg, V., Vanderplas, J., Passos, A., Cournapeau, D., Brucher, M., Perrot, M., Duchesnay, É., 2011. Scikit-learn: machine learning in python. J. Mach. Learn. Res. 12, 2825–2830.
Robinson, J.M., Mavoa, S., Robinson, K., Brindley, P., 2022. Urban centre green metrics in Great Britain: a geospatial and socioecological study. PLoS ONE 17, e0276962. https://doi.org/10.1371/journal.pone.0276962.
Runfola, D., Anderson, A., Baier, H., Crittenden, M., Dowker, E., Fuhrig, S., Goodman, S., Grimsley, G., Layko, R., Melville, G., Mulder, M., Oberman, R., Panganiban, J., Peck, A., Seitz, L., Shea, S., Slevin, H., Youngerman, R., Hobbs, L., 2020. geoBoundaries: a global database of political administrative boundaries. PLoS ONE 15, e0231866. https://doi.org/10.1371/journal.pone.0231866.
Sales, K., Walker, H., Sparrow, K., Handley, P., Vaz Monteiro, M., Hand, K.L., Buckland, A., Chambers-Ostler, A., Doick, K.J., 2023. The canopy cover Webmap of the United Kingdom's towns and cities. Arboric. J. 45, 258–289. https://doi.org/10.1080/03071375.2023.2233864.
Schindler, M., Le Texier, M., Caruso, G., 2022. How far do people travel to use urban green space? A comparison of three European cities. Appl. Geogr. 141, 102673. https://doi.org/10.1016/j.apgeog.2022.102673.
Seiferling, I., Naik, N., Ratti, C., Proulx, R., 2017. Green streets − Quantifying and mapping urban trees with street-level imagery and computer vision. Landsc. Urban Plan. 165, 93–101. https://doi.org/10.1016/j.landurbplan.2017.05.010.
Speak, A., Montagnani, L., Wellstein, C., Zerbe, S., 2020. The influence of tree traits on urban ground surface shade cooling. Landsc. Urban Plan. 197, 103748. https://doi.org/10.1016/j.landurbplan.2020.103748.
Stenfors, C.U.D., Rådmark, L., Stengård, J., Klein, Y., Osika, W., Magnusson Hanson, L.L., 2024. More green, less depressed: residential greenspace is associated with lower antidepressant redemptions in a nationwide population-based study. Landsc. Urban Plan. 249, 105109. https://doi.org/10.1016/j.landurbplan.2024.105109.
Stroup, W.W., Ptukhina, M., Garai, J., 2024. Generalized Linear Mixed Models. Modern Concepts, Methods and Applications. CRC Press.
Tree Equity Score UK, 2024. Tree Equity Score UK. URL ⟨https://uk.treeequityscore.org/⟩ (accessed 10.2.24).
UFWACN, 2018. England's Urban Forests: Using Tree Canopy Cover Data to Secure the Benefits of the Urban Forest.
Verisk Analytics, 2025. Verisk products: UKBuildings. URL ⟨https://www.verisk.com/en-gb/products/ukbuildings/⟩ (accessed 10.7.25).
Vesuviano, G., Fitch, A., Owen, D., Fletcher, D., Jones, L., 2024. How well does the 3-30-300 rule mitigate urban flooding? Urban For. Urban Green., 128661 https://doi.org/10.1016/j.ufug.2024.128661.
Wei, H., 2024. Roots of urban equality: are low-income neighborhoods paying more for street trees? Landsc. Urban Plan. 247, 105045. https://doi.org/10.1016/j.landurbplan.2024.105045.
World Health Organisation, 2017. Urban green spaces: a brief for action. World Health Organization, Regional Office for Europe, Bonn.