Birmingham's Urban Forest

What might 2051 look like ?

Economic valuation for baseline and growth scenarios for Birmingham's Urban Forest

Birmingham City Council

National Trust

Treeconomics

Contents

Executive Summary

Birmingham city is slowly losing tree canopy cover (TCC). A ‘business as usual’ approach will do nothing to stem this, with continued reduction from today’s 17.3% to a projected level of 16.5% by 2051.

This relatively modest-sounding change would mean the loss of tens of thousand of trees - some 65,000 if they were all the size of the current average across the city. A reduction in the treescape on this scale for Birmingham is a reduction in amenity of £1.2 billion; it is the potential release of up to 19,000 tonnes of carbon valued at £19 million; it is a reduction of £1 million in annual ecosystem services for the people of Birmingham.

These city-wide figures hide the disproportionate impact of the changes. The model tested indicates a substantial de-greening of the urban areas - a loss of a fifth of the current levels of tree canopy cover, with a concentration of TCC within existing woodlands and green open spaces. The green gets greener and the grey gets greyer.

Altering this picture means pro-active intervention, with timing the vital aspect. Intervention to arrest the decline by 2031 indicates that the topline TCC figure of 17.3 % will recover by 2051. Leaving such an intervention another decade to 2041 means the loss of an additional 110 ha of TCC, a 10-fold greater loss in carbon stored and a 5-fold greater loss in annual ecosystem services.

Increasing all wards to a TCC of 25% will mean a trebling of the canopy in 4 wards and a doubling in another 17. Such a change would not only mean a more equal sharing of the tree canopy cover, it would mean better access to an additional £13 billion in amenity and £10 million in annual ecosystem services. To deliver this entirely through new planting is estimated to require £17 million annually at current costs, over the period to 2051. It is noted that this burden is shared between all landowners; the proportion falling upon the public purse for highways and street trees is estimated to be around 30% or £5 million. To deliver this in combination with a programme of active maintenance of the existing trees to maturity can dramatically reduce the overall figure. Just 0.37% annual growth in the extent of the existing tree canopy - a tenth of what has been achieved elsewhere, reduces the total cost by £2 million in today’s money.

The mix of tree species within Birmingham is already heavily biased towards larger stature trees, with some 70% of public trees and 78% of all trees falling into this category. A planting mix that does not match this profile can still deliver canopy growth, but at up to three times the cost.

Early intervention, with a balanced approach between new planting and maintenance of existing trees for growth looks to be the most cost effective route to Birmingham’s TCC growth ambitions.

Introduction

This study provides a high level guide to the scale of the costs and benefits of different options for tree establishment and canopy growth to achieve the Birmingham Urban Forest Master Plan.

Four scenarios

To bring this to life, the future of Birmingham's treescape is imagined under four different scenarios. These illustrate the types of options often discussed for city-wide interventions. They are deliberately high-level in their conception so as to provide clarity to those using this work. The four scenarios are:

1. Business as usual (change nothing)
2. Arresting the decline
3. Lifting all wards to 25% canopy cover
4. Maximising canopy through change of tree species mix

Valuing benefits

This particular study builds on the recently completed document: 'Valuing Birmingham's Urban Forest'[1]. This extensive work provides a reliable basis for the valuation of ecosystem services from trees and species mix, as well as asset and amenity valuations. See Table 1 (p. 6) for an extract of the headline figures.

Determining costs

To determine costs for planting, establishment and ongoing maintenance for trees across the entire city, a mix of published costs and a small number of interviews with individuals responsible for commissioning such work were used. In this way, planting costs per tree were established. These were scaled up to arrive at broad valuations for the costs associated with establishing tree canopy on a per hectare basis over the period to 2051.

Canopy cover as core metric

To understand the benefits related to each scenario, whether gained or lost, the potential extent of tree cover is used as the underlying metric. In essence, one hectare of tree cover is assumed to convey the same benefits and values as every other hectare of tree cover. This is not the case is reality, with depth of canopy and population density both heavily impacting local variation. However, it allows a broad perspective. Figure 1 (p. 6) shows the starting point for Birmingham city within the wards of the city and their canopy cover.

Indexed change vs % change

TCC can be expressed as area (e.g. ha) or % of an area (e.g. 23% of Birmingham). Absolute changes in TCC will be expressed in hectares or as % points (e.g. a change from 23% to 25% will be written as a 2% point change). Relative changes will be expressed as an index vs the starting point. (e.g. a change from 23% to 25% will be written as an index change of 107).

[1] Vaughan-Joncey et al, 2024

Wards as unit of analysis

The study area for this work is Birmingham's municipal boundary. The base unit for analysis is the ward, as it matches the decision-making framework of the city council. Recognising the clear differences that can exist within a single ward, the work employs land use types to give a more granular level of analysis.

Forecasting limitations

The best data available within the study area to establish a robust trend line for changes in TCC are two sets of canopy cover figures based on Bluesky National Tree Map (NTM) for June 2016 and June 2022.

Land use based model

To examine these scenarios, a base model was created by subdividing the study area into nine different land use types:

- Roads
- Rail
- Trees & shrubs
- Buildings
- Other man-made
- Private gardens
- Agriculture
- Water
- Other (mostly natural)

These were subsequently aggregated into five land use groups as shown in table 2 (p. 7).

Linear infrastructure

There are three significant elements to the linear infrastructure within Birmingham: Road, Rail and Canals. The first two have been treated as separate entities as easily identifiable within the data. The latter is less so, being not always distinguishable from larger bodies of water. Thus, these are not treated as a distinct entity, although this could be done for future, more detailed analysis.

Implementation options

To explore and cost the implementation of tree canopy cover expansion under each model, two ages of tree at planting were used:

- Single trees that have undergone formative pruning within a nursery environment to create the very recognisable 'tree shape' of a single stem with side branches. Such trees are typically 7 to 10 years old when planted out.
- 'Whips' are very young trees, often without any side branching and not subjected to formative pruning. Such trees are typically 1 to 2 years old when planted out.

Based on these two different tree options, six planting options are considered:

- Single trees in hard landscapes (standard pit)
- Single trees in hard landscapes (rooting cells)
- Single trees in soft landscapes (public/large private)
- Single trees in soft landscapes (private)
- Whips in soft landscapes (woodland) per ha
- whips in soft landscapes (rail) per ha

Finally, an additional option for tree canopy growth is used:

- Natural growth of existing non-woodland canopy per ha.

Birmingham City Today

The starting point for this analysis is the city as it is today, with an existing canopy cover of 17.3% (Bluesky NTM 2022). It can be broken down into 69 wards, as shown in Figure 1, which range in value from around 5% to over 40%. It follows that the ecosystem services related to trees, shown in Table 1, are distributed unevenly across the city.

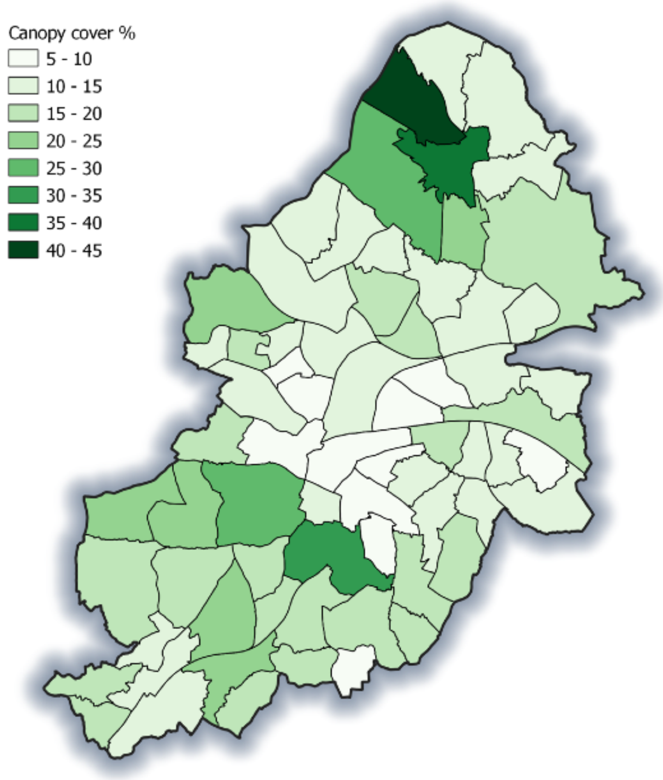


Figure 1. Canopy cover in Birmingham at individual ward level based on Bluesky National Tree Map data (2022)

Taken as a whole, the city has a substantial green asset valued at £858 million, generating £19.7 million of annual benefits based on the very limited subset of carbon sequestration, pollution removal and avoided runoff. Furthermore, those trees have an amenity valuation of £25 billion.

Birmingham's structure and composition headline figures		
Number of trees (estimate)	1,129,000	
Tree density (trees/hectare)	42	
Tree canopy cover	15% (4,017 ha)	
Shrub cover	11.8%	
Most common tree species	Silver birch (11.1%), sycamore (9%) & holly (8.3%)	
Replacement cost (CTLA)	£858 million	
Amenity valuation (CAVAT)	£25.3 billion	
Proportion of trees in good or excellent condition	72.9%	
Birmingham's ecosystem services headline figures		
Total carbon storage	419,000 tonnes	£407 million
Annual carbon sequestration	12,800 tonnes	£12,500,000
Annual pollution removal	80.4 tonnes	£6,420,000
Annual avoided runoff	481,000 m³	£776,000
Total annual benefits	£19,696,000	

Table 1. Headline Figures from the 'Valuing Birmingham's Urban Forest' study of 2024 using i-Tree Eco

Land use model

The key aggregation that underpins this model is combining 'Buildings', 'Other manmade' and 'Garden' together as 'Urban excl. roads' on the basis that the latter is often lost to provide space for the first two[2]. See Table 2 for all groupings by land use type and Figure 2 that illustrates how that looks for Birmingham today.

Land use types	Land use types
Roads	Roads
Rail (+5m buffer)	Rail (+5m buffer)
Trees & shrubs	Woodland & open green space
Buildings ❙ Other man-made ❙ Gardens	Urban excl. roads
Agriculture ❙ Water ❙ Other	Other natural

Table 2. Land use types aggregated into groups for modelling

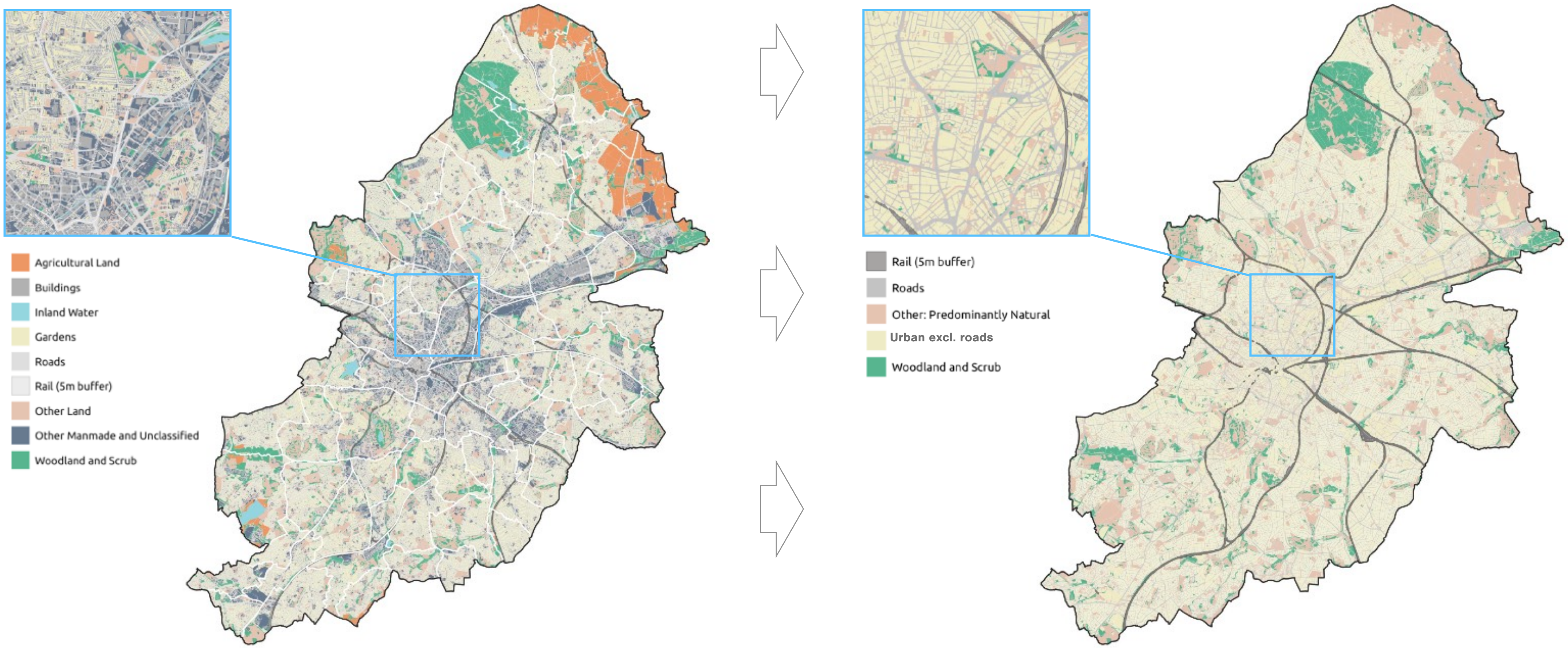


Figure 2. Map of Birmingham by land use type (left) and aggregated into land use type groups (right). Data source: Ordnance Survey. Analysis: Treeconomics

[2] Smith, 2010

Translating tree canopy cover growth

Whilst translating additional canopy cover into a number of extra trees is a simple way of understanding the challenge, it is not a straightforward solution, not least because trees are living organisms which take a long time to reach maturity and vary greatly in size. However, it can be a useful starting point if one accepts a single point in time and that trees take a long time to grow.

Many variables at play

Trees' size at maturity, assuming they get there, is dependent upon many factors, ranging from those related to the tree itself: species and provenance, to those that are dependent upon its immediate physical context: rooting space, soil type and quality, surface type, proximity to buildings and vehicles, impacts from animals and humans. The situation is further complicated by the impact of nursery practices, approaches to planting, aftercare and maintenance. Finally, there are the challenges of climate change itself as well as new pests and diseases it is likely to enable. In short, there are many variables that play a role in determining how large a tree could become.

Working with tree time

As an example, it can take 25 years for a tree to reach a semi-mature size of $36m^2$. Assuming the first ten of these were spent in the nursery and the tree was then planted out as a heavy standard, that gives a 15 year window to achieve the goal size. This would nominally entail a last planting date of 2036 for several hundred thousand trees. In reality the age diversity of the population needs to be managed over time to prevent a decline in canopy over the longer term.

Canopy growth options

For the purposes of this study, three high level options have been considered. These are:

1. Woodland planting. There are different protocols for planting spaces and thinning regimes, but essentially a large plot is planted with a large number of very young trees, known as whips, with a proportion removed periodically (thinning) to allow room for growth by the others. Such planting can be costed on a per hectare basis or per tree, with canopy closure achievable within a few years.
2. Single tree planting. This uses 'standard' trees which undergo formative pruning at the nursery and during establishment to create the classic 'street tree' form. The long preparatory lead time with a specialist nursery means that such trees are costed individually. Often used for planting in public spaces, planting them out can generate vastly different costs depending upon the substrate, underground infrastructure and other factors such as possible road closures and conflicts with utilities.
3. Maintaining existing trees to maturity. This is the most effective and the lowest cost of all the options on a per tree or per hectare basis. Essentially, it is about letting trees fulfil their growth potential and minimising intervention to enabling growth or managing risk. In the case of the latter, a balanced, rather than risk avoidance approach is required.

Maintaining existing trees to maturity vs new planting

Allocating resources to the protection and maintenance of existing trees is a valid option for driving TCC growth. It has been shown to have a positive impact on TCC figures, even where interventions have required the removal (i.e. loss) of large numbers of trees to facilitate the better growth of others. The 2022 study: Torbay's Urban Forest: Assessing Urban Forest Effects and Values, showed that in the 12 years since the previous study (both were large scale i-Tree Eco sample studies), the TCC had increased from 11.8% to 18.2%, despite the 'loss' of around 1/3 of the trees in same period.

This expansion over 12 years represents an annual growth index of 103.7 against the previous year. Taking a conservative approach, and using a figure one tenth of this (growth index of 100.37) would generate an additional 2% TCC (520 ha) across Birmingham by 2051.

To maintain trees effectively is estimated within this study at some £4,150 per hectare of TCC (see p. 11 - Costs). This figure represents the per hectare to establish new canopy with new planting, without the actual planting and early years costs. The extent to which this is a reflection of actual costs is highly dependent upon a large array of factors.

Maintaining existing trees to maturity is therefore considered as one of the options within this study. The extent to which it is employed, in both area and time, can make a vast difference to the costs of delivering on many of the options ultimately open to Birmingham City Council.

Valuing Benefits

To be able to assign values to different scenarios, this study takes a value transfer approach using valuation figures from other sources - e.g. Valuing Birmingham's Urban Forest[3] — converting them to per hectare and per 'average' tree values. See Table 3 for details.

These have then been used to assign values on the total amount of TCC gained or lost under each scenario in a simple and comparable manner.

The power of this approach lies in treating ecosystem service benefits as interchangeable, irrespective of the trees themselves, their species, condition or proximity to people. Thus all TCC is considered equal, which allows evaluations between options at the level of the canopy.

However, it is recognised that the same fact is its greatest weakness. Whilst the approach can be considered reasonable at the level of the entire city, its applicability rapidly declines with increasing granularity. The smaller the unit of measurement, the greater the uncertainty in the accuracy of the figures. Therefore these amounts and values should not be applied to small areas or individual trees.

Birmingham's structure and composition headline figures		Per nominal tree*	Per hectare**
Number of trees (estimate)	1,129,000		
Tree canopy cover	15% (4,017 ha)	36m²	
Replacement cost (CTLA)	£858 million	£760	£187,952
Amenity valuation (CAVAT)	£25.3 billion	£22,409	£5,542,169
Birmingham's ecosystem services headline figures			
Total carbon storage	£407 million	£360	£87,621
Annual carbon sequestration	£12,500,000	£11	£2,738
Annual pollution removal	£6,420,000	£6	£1,406
Annual avoided runoff	£776,000	£1	£170
Total annual benefits	£19,696,000	£17	£4,315

Table 3. Per tree and Per hectare estimates based on outputs from 'Valuing Birmingham's Urban Forest' report
*a nominal average tree 25 years in age with a 36m² canopy. Figures should not be applied to individual trees
**Per hectare numbers based on Bluesky National Tree Map canopy cover figure of 4565 ha, which results in a more conservative estimate

[3] Vaughan Johncecy, 2024

Costs

As with benefits, the ability to evaluate different options is well-served by taking a per-hectare approach to costing. Any such approach must recognise that the costs associated with different planting regimes and contexts cover a broad range.

Planting / establishment costs have been derived by reference to published literature and applying the Bank of England inflation rate from the date of publication.

To ensure a linkage to the trees and provide an ability to vary them in line with the size/age of the trees within the canopy, annual maintenance costs are expressed as a multiple of the £858 million asset value as determined as the replacement cost within the 'Valuing Birmingham's Urban Forest' report. In this way, values have been arrived at that can be applied on a per hectare basis. See Fgure 4. In each case, they have been sense checked against industry data where available. See Appendix I. Methodology for details.

	Planting & 3 years' establishment	Annual maintenance costs (yrs 4+)	Maintenance to reach 15 years planted out	Multiple of asset valuation (CTLA)	Total costs per tree*	Total cost per hectare of tree canopy*
Single trees in hard landscapes (standard pit)	£1,500	£15	£113	2.0%	£1,628	£454,073
Single trees in hard landscapes (rooting cells)	£8,000	£15	£113	2.0%	£8,128	£2,267,573
Single trees soft landscapes (public/large private)	£750	£15	£113	2.0%	£878	£244,823
Single trees soft landscapes (small private)	£100	£10	£75	1.3%	£185	£51,615
Whips in soft landscapes (woodland) per ha	£10,000	£500	£6,000	0.3%	n/a	£16,000
Whips in soft landscapes (railway) per ha	£9,900	£3,300	£39,600	1.8%	n/a	£49,500
Growth of existing woodland canopy per ha	£0	£500	£8,325	0.3%	n/a	£8,325
Growth of existing non-woodland canopy per ha	£0	£4,150	£62,250	2.0%	n/a	£62,250

Table 4. Broad estimated costs by type of planting and management to generate/maintain a hectare of tree canopy 15 years after planting out
*single trees assumed to reach average tree canopy of 36m^{2}; whips in soft landscape planting assumed to generate continuous canopy cover

Costs by land use

To align costs to the different land use types that this study is modelled with, there is a different mix of planting options applied for each one which remains the same under all scenarios. See Table 5.

Costs for maintaining trees to maturity

Expansion of the canopy of existing trees can be a significant contributor to growth. Those trees need to be maintained irrespective of any aggregate canopy growth achieved. The costs used in this report for the management of existing trees to maturity are simply those to establish canopy through planting trees, less the actual planting costs.

This simple approach is sufficient to enable comparisons, but does not reflect the vast array of factors involved. Both the tree and its context play a large role in determining maintenance costs.

For example: greater proximity to humans generally drives up the cost of maintenance; the greater the mismatch in size between trees and the available space above and below ground tends to drive up conflicts with other uses (buildings, utilities, transport) and thus costs.

	Roads	Rail	Woods & OGS	Urban Excl. roads	Other
Single trees in hard landcapes (standard pit)	45%	n/a	n/a	25%	n/a
Single trees in hard landscapes (rooting cells)	5%	n/a	n/a	5%	n/a
Single trees in soft landscapes (public/large private)	50%	n/a	n/a	10%	n/a
Single trees in soft landscapes (small private)	n/a	n/a	n/a	60%	n/a
Whips in soft (woodland)	n/a	n/a	100%	n/a	100%
Whips in soft (railway)	n/a	100%	n/a	n/a	n/a
Consequent cost per hectare	£440,123	£49,500	£16,000	£282,348	£16,000
Cost relative to amenity value per hectare	8%	1%	0.3%	5%	0%

Table 5. Showing the costings per hectare used in these models and as a proportion of their amenity valuation (CAVAT).

Scenario 1: Business as usual

Under a 'Business as usual' scenario, it is assumed that the current direction of travel continues with respect to tree canopy cover gains and losses. This high level approach allows myriad different factors to be taken into account, without specifically addressing them in detail. For example, the impact of development, whether at a large scale or simply at residential level within permitted development regulations is considered to continue on its current trajectory. The establishment or removal of trees, irrespective of the reasons behind it, can thus be accommodated in principle.

Overall Impact

Under 'Scenario 1: Business as usual', there is an anticipated loss of 233 hectares, or almost 0.8% points of canopy cover. Whilst this appears a relatively modest change over the period to 2051, it has a large impact. It translates into a loss of £1 million annually in ecosystem service benefits, £19 million of carbon stored, £40 million worth of tree assets based on their nominal replacement cost (CTLA) and £1.2 billion in amenity (CAVAT).

A breakdown of the canopy by land use for Scenario 1 shows a more important factor at play - the green parts get greener and the grey parts get greyer (Figure 3). The exception is the linear networks of the railways, which see a notable increase in cover which, whilst limited in overall effect, could be an important factor within individual wards. However, line side management practices, which can mean periodic tree removals, prioritise train movement and would indicate that this canopy gain cannot not be guaranteed.

		2022	2051	+/-
Canopy	ha	4,645	4,412	-233
	%	17.3%	16.5%	-0.8%
Estimated no. of trees	000s	1,297	1,232	-65
Carbon stored	tonnes	419,000	399,000	-20,000
	£m	407	388	-19
Annual ESS benefits	£m	19.7	18.7	-1.0
Replacement cost	£m	858	818.3	-39.7
CAVAT	£bn	25.3	24.1	-1.2

Table 6. Headline figures for Scenario 1 - Business as Usual

Loss of 65,000 trees with an amenity value of £1.2 billion

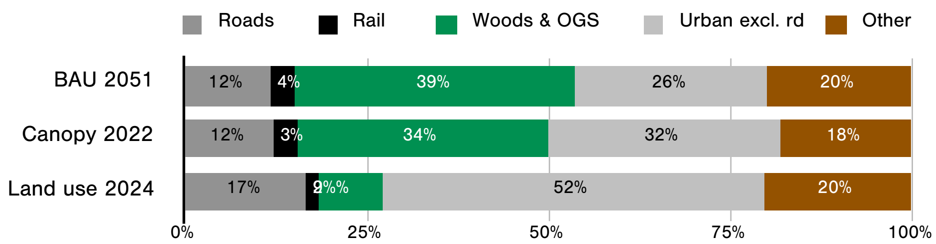


Figure 3. Sources of canopy cover by land use for Scenario 1: Business as usual (BAU) vs current position (2022).
Actual land use is shown to provide context

Forecasting Scenario 1

Forecasting the future is a difficult task, with many uncertainties. Doing so at the scale of a city over approximately three decades requires simplifying the task. This also facilitates easier understanding by a wide audience to make the work more applicable and accessible. This study has been designed with some simple assumptions.

Data limitations

Any such work is also limited by the data available. In this case, canopy cover data exists for just two points in time: June 2016 and June 2022[4]. It should also be recognised that any comparison of canopy data over time requires accepting this as a pure like-for-like comparison, ignoring seasonal, weather and technology variables.

Key assumptions

The key assumptions used for the 'Business as usual' scenario and upon which the other scenarios are built (explored in more detail in the methodology section) are as follows:

1. Straight line forecasts applied to small areas can be aggregated to provide an overall picture.
2. The highest and lowest TCC levels within existing data provide meaningful thresholds to temper any extremes that emerge in using a straight line approach.

[4] Bluesky National Tree Map

Using Scenario 1

Scenario 1 is best understood as the base case, against which the other scenarios can be benchmarked. It is, by definition, an attempt to capture the impact of all the policies of the city council on TCC in combination with the practices of all other landowners.

A good example is the use of the historical highs and lows as thresholds. No single ward has no trees, and the wards with the lowest TCC are growing, potentially because there has been a response to the situation on the ground which has resulted in an increase in TCC. Capturing those responses to model them in detail is challenging, but their effects can be seen at a larger scale.

The same logic is applied to areas with high TCC. No woodland area exceeds 85% TCC, possibly because this is the point where interventions are more geared towards maintaining a few open spaces within it.

Key findings

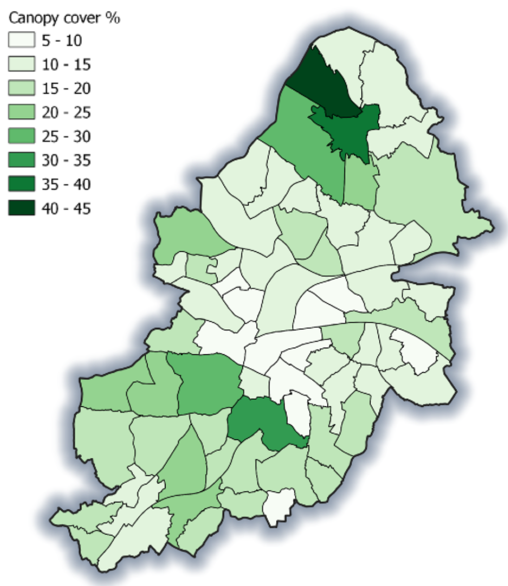


Figure 4. Canopy Cover 2022

Canopy cover by ward

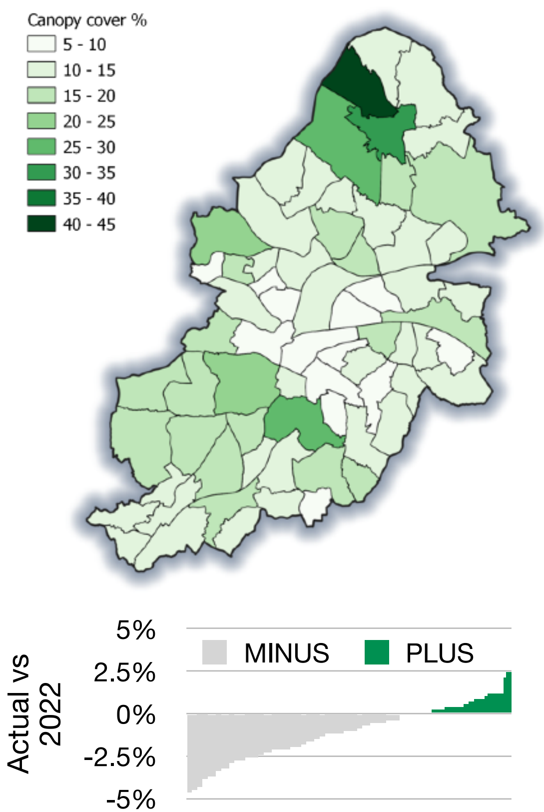


Figure 5. Scenario 1: Business as usual
Map shows canopy cover by ward in 2051
Chart shows change in canopy cover level

Change in canopy cover relative to starting point

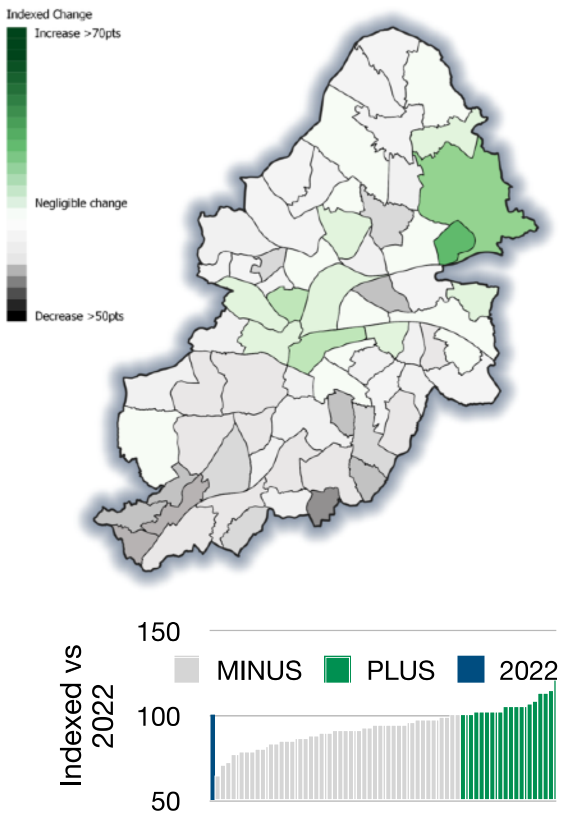


Figure 6. Scenario 1: Business as usual
Map shows change in canopy cover at ward level indexed against 2022

Impact on TCC is not evenly distributed

'Business as usual' shows greatest increases in two north-eastern wards and the city centre wards with the greatest decreases in the southern wards, particularly the most south-easterly.

An examination of impact at ward level vs 2022 (Figure 4) shows a spread of canopy cover changes from a loss of 2.5 percentage points (e.g. from 10% to 12.5%) to a gain of 4.6 percentage points (Figure 5). This appears to be a relatively narrow band with similar levels of change across the city.

However, this can be a misleading interpretation as the starting point is highly relevant when it comes to understanding the impact on the ground. Treating 2022 as index 100, the indexed changes at ward level range from 65 to 121 for 2051 - showing a far greater impact in some locations, as illustrated in Figure 6.

Significant changes in TCC by land use

The different changes at ward level hide as much change within land use types as is experienced across wards. In this scenario, there is a loss of TCC within the urban areas of 2.3% vs the 2022 level of 10.6% - which represents over a fifth of the total TCC. See Figure 7. At the same time, TCC over woods and open green spaces increases from 68.1% to 72.6%.

This results in the woods and green spaces taking on a greater importance in the provision of TCC vs the urban areas (Figure 3).

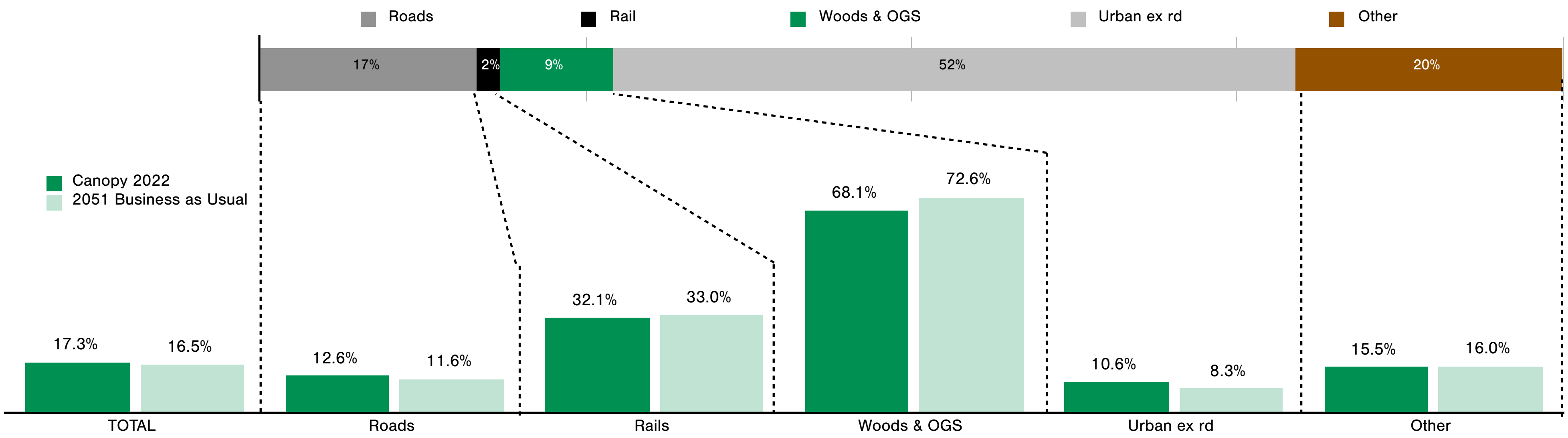


Figure 7. Canopy cover shares over different land use type groups for business as usual compared to 2022 (lower, column chart) The division of land area by land use is shown across the top (upper, bar chart)

Scenario 2: Arrest the decline

Arresting the decline means halting the loss of TCC seen in Scenario 1. To keep the model simple, it is assumed that the decline can be stopped at a moment in time - the arrest point. Any part of the model that was losing TCC, retains it through to 2051. Any part of the model that was gaining TCC, continues to do so through to 2051.

In reality, interventions do not work in this way at the city scale, given both size of task and the vast number of different landowners involved. Interventions can be expected to be spread over time and geography in a very unstructured way.

This huge simplification allows a comparison in the timing of interventions. It is a means to judge the impact of a time delay on what is a fixed time window to 2051.

Two options are considered:

- A faster one: Scenario 2a - decline arrested by 2031

and

- A slower one: Scenario 2b - decline arrested by 2041

		2022	2051	+/-
Canopy	ha	4,645	4632	-13
	%	17.3%	17.3%	0%
Number of trees	000s	1,297	1,294	-4
Carbon stored	tonnes	419,000	418,000	-1,000
	£m	407	406	-1.0
Annual ESS benefits	£m	19.7	19.6	-0.1
Replacement cost	£m	858	855.6	-2.4
CAVAT	£ bn	25.3	25.2	-0.1

Table 7. Headline figures for Scenario 2a - decline arrested by 2031

Intervention by 2031 has a highly significant impact vs the same intervention by 2041

		2022	2051	+/-
Canopy	ha	4,645	4522	-123
	%	17.3%	16.9%	-0.4%
Number of trees	000s	1,297	1,263	-34
Carbon stored	tonnes	419,000	408,000	-11,000
	£m	407	396	-11
Annual ESS benefits	£m	19.7	19.2	-0.5
Replacement cost	£m	858	835.3	-22.7
CAVAT	£ bn	25.3	24.6	-0.7

Table 8. Headline figures for Scenario 2b - decline arrested by 2041

Key findings

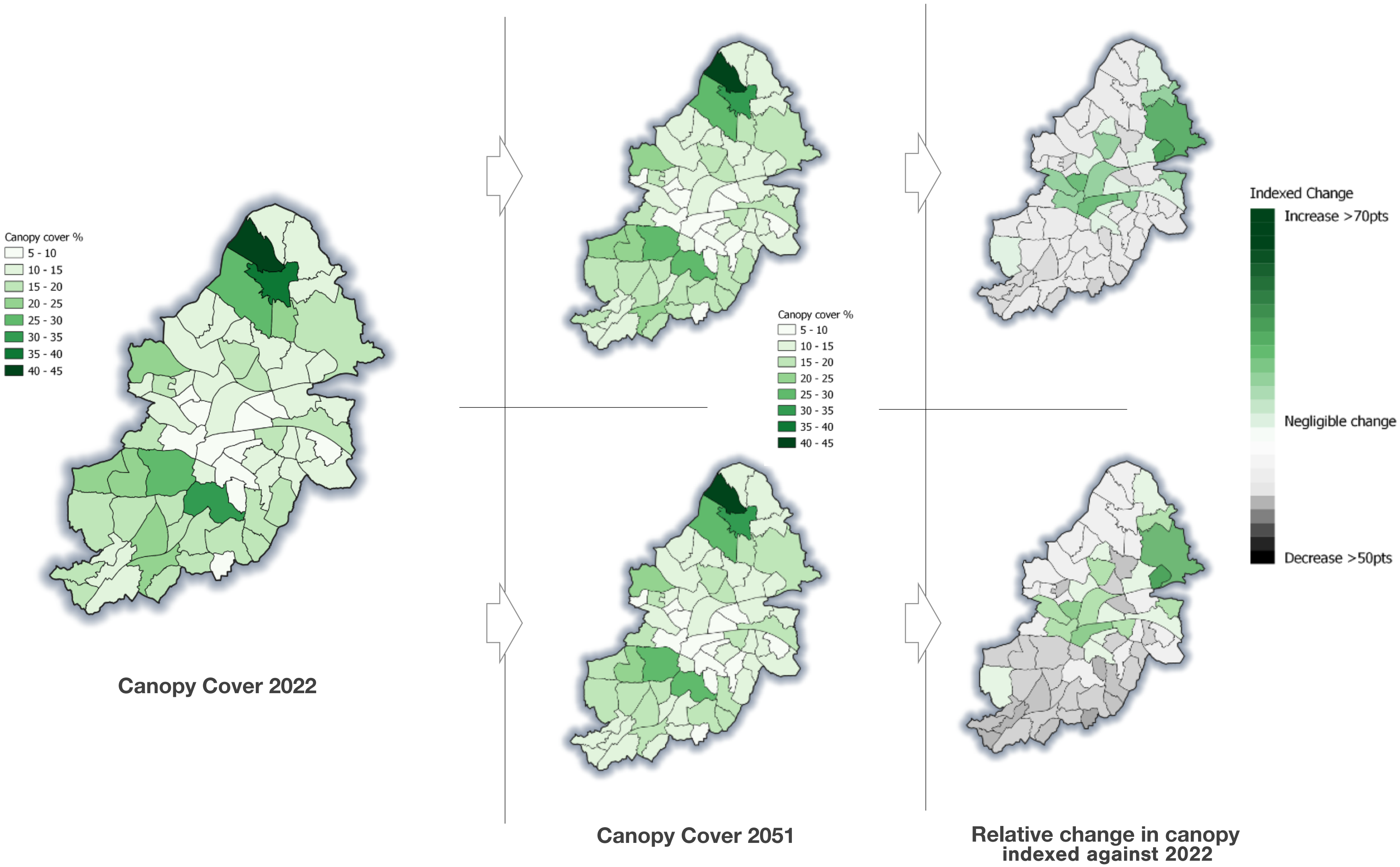


Figure 10. Maps showing canopy cover in 2022 and then in 2051 under the two 'arrest decline' scenarios and those wards experiencing the most change relative to their starting point.

Early intervention allows losses to be compensated
The timing of this scenario makes all the difference. Under the early intervention, areas in growth have time to compensate almost fully for TCC reductions in the early years, with overall recovery to 17.3% by 2051 (Table 7 p.17).

Late intervention still has an impact vs business as usual
Arresting the decline by 2041 will almost halve the net TCC loss seen under business as usual. (Table 8 p.17)

Early intervention does not stop the shift of TCC away from urban
Under both scenarios, the fundamental pattern of green getting greener and grey getting greyer continues to play out. Despite representing only 9% of the land, the share of the total TCC that trees in woodlands and open green space rises from 34% to 36% (early intervention) or 38% (later intervention) (Figure 9). In both cases, there is an even greater reduction in the share of TCC sitting over the urban areas (Figure 9)

Earlier intervention dramatically changes outcomes
Early intervention is shown to lead to lower declines in TCC across the majority of wards (Figure 10 p.18). It also delivers greater growth in TCC in those wards where growth was already occurring.

Comparing Tables 7 and 8 (p.17), it can be seen that early intervention results in greater levels of amenity (+£600 million), asset value (+ £20 million), carbon stored (£10 million) than the later intervention.

In terms of trees, early intervention is estimated to lead to the retention of some 30,000 trees and their 110 ha of TCC, that would otherwise be lost. (Tables 7 & 8 p.17)

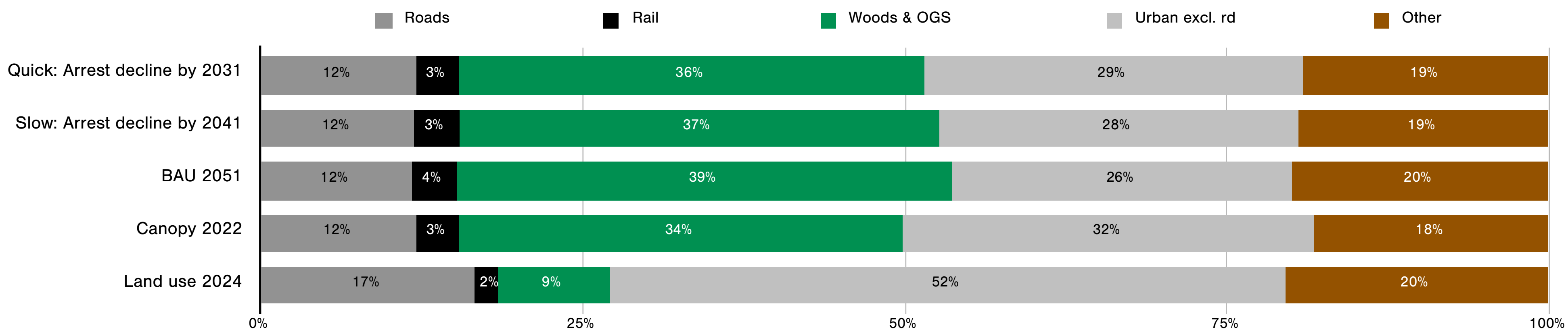


Figure 9. Sources of canopy cover by land use for different scenarios. Actual land use is shown to provide context.

Scenario 3: All wards to 25%

Under 'Scenario 3: All wards to 25%', it is assumed that the ‘easiest to plant’ land use types are planted first, i.e. 'Woods & Open green space', followed by 'Other' (natural) and land adjacent to 'Rail'.

Once these have reached an upper threshold, the more difficult to plant areas are used (roadsides and urban areas). It is assumed that planting continues until the desired 25% is reached, with both land use types contributing equally.

Whilst this approach minimises the anticipated planting within the most difficult to plant areas, it still generates some very high numbers within those hard landscaped areas. Beyond this simple prioritisation, this model ignores any practical (e.g. pavements too narrow) political (e.g. other funding priorities) or societal barriers (residents preferring car access over trees) that may exist when it comes to implementation. The trees would constitute an appreciating asset of £1.3bn with an amenity valuation approaching £39bn. In ecosystem services terms, annual benefits increase by £10m by 2051 and carbon stored by £213m.

		2022	2051	+/-
Canopy	ha	4,645	7078	2433
	%	17.3%	26.4%	9.1%
Number of trees	000s	1,297	1,977	680
Carbon stored	tonnes	419,000	638,000	219,000
	£m	407	620	213
Annual ESS benefits	£m	19.7	30.0	10.3
Replacement cost	£m	858	1,307	449
CAVAT	£bn	25.3	38.6	13.3

Table 9. Headline figures for Scenario 3: All wards to 25

25% canopy in all wards equates to 680,000 new trees maturing to each provide a canopy of 36m^2*.

*average tree size across Birmingham today

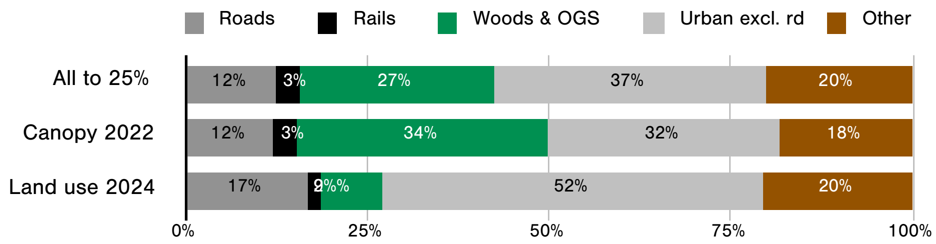


Figure 11. Sources of canopy cover by land use for Scenario 1: Business as Usual (BAU) vs current position (2022).
Actual land use is shown to provide context

Key Findings

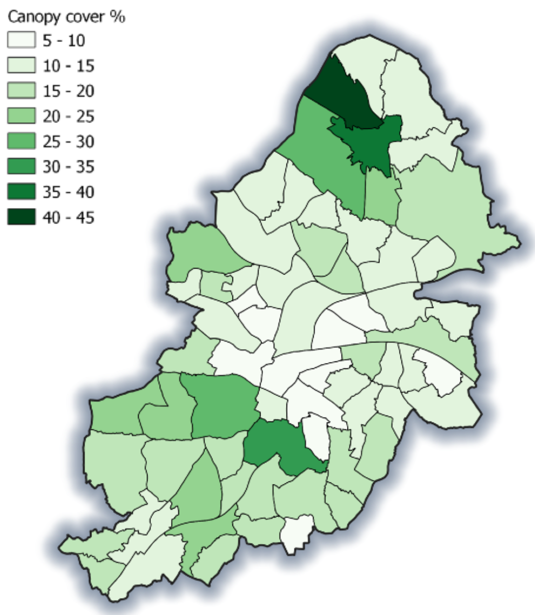
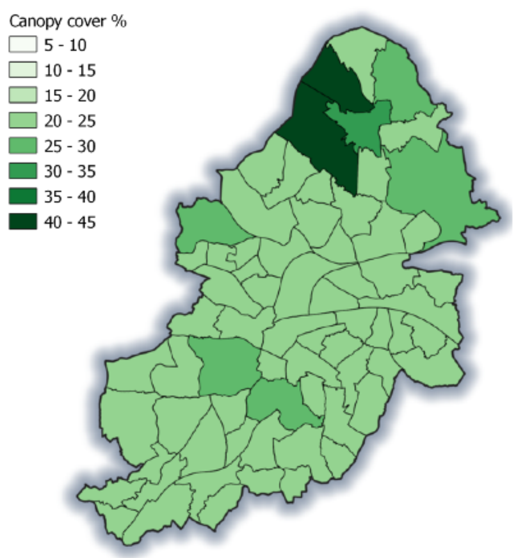


Figure 12. Canopy Cover by ward in 2022



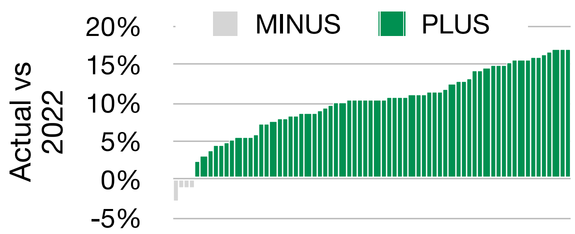
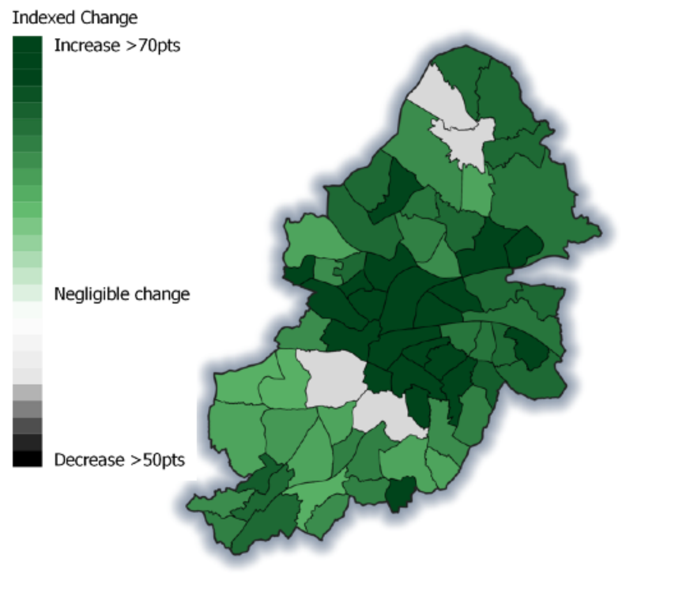


Figure 13. % change in TCC at ward level
Note scale change vs other scenarios



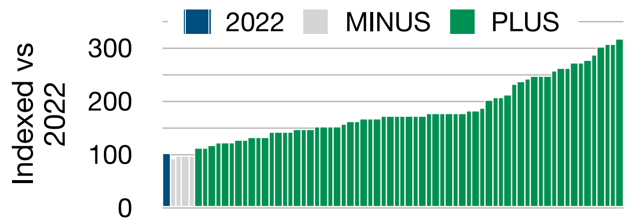


Figure 14. Index change to show relative change in TCC at ward level. Index 100 = 2022
Note scale change vs other scenarios

680,000 trees

Were it to be implemented, the ‘All wards to 25%’ approach could be understood in terms of an additional 680,000 trees with an average canopy of 36m^2, which is the average crown size for the current tree population across the city as a whole.[5] Birmingham would reach 26% TCC in total, storing around 638,000 tonnes of carbon, delivering £30m (Table 9).

As will be seen in Scenario 4 - ‘Maximise canopy through mix change’, the mature stature of trees selected in the mix will have a significant effect on the numbers required.

Average ward TCC growth of 10% points

Across the city, the range of growth levels required to reach 25% TCC runs from 2.5% pts to 17% pts, with an average of 10.5% pts.

Only 4 wards see any regression in TCC and this is of an order lower in scale, running from 1% pt to 2.5% pts.

25% requires a trebling of TCC in many wards

In some wards, the current levels of TCC are so low that a trebling of existing levels will be required to reach the target (Figure 14). This need is concentrated within the central regions of the city, where the relative impact will be greatest (Figure 14).

Urban areas to become the dominant TCC location

A city-wide move to 25% TCC will have the effect of making urban areas the most important source of tree canopy cover (Figure 11). This is in spite of the model prioritising all other land use types first.

It is the case that all land use types will require significant interventions, whether from planting or through a change to maintenance regimes.

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[5] Valuing Birmingham’s Urban Forest 2024

Costed options to deliver 25% in all wards

The goal of 25% canopy across all wards translates as sightly in excess of an additional 2,400 hectares. The area of TCC required to deliver 25% in all wards is shown in Table 10. This is also broken down by land use type.

Two options have been worked through below.

- Option a: Growth derived entirely from new planting, which would require an annual investment of circa £33m across the city to effect a change in value of some £13 bn in amenity valuation (see Table 11, p.24).
- Option b: Growth derived partly from maintenance of existing trees through to maturity which, delivers the same benefit for the lower level of £28m annually (see Table 12, p.24).

Assuming that there are enough younger trees that can achieve large stature, maintaining existing trees through to maturity can generate significant levels of additional canopy. That is the logic that underpins all new planting too - once in the ground, trees will develop to produce a canopy. If it is true of newly planted trees, it is self-evidently true of trees that are already in the ground. This remains true until they reach maturity which is species-dependent and can range from 40 to 200 years.

In the case of option a: new planting, the overall impact is a 12-fold return in terms of value vs cost when considering amenity benefits.

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Roads	£440,123	£63,000
Rail	£49,500	£49,500
Woods & OGS	£16,000	£8,325
Urban excl. roads	£282,348	£63,000
Other	£16,000	£8,325

Table 10. showing estimated costs related to an additional hectare of canopy cover. See Table 5 for detailed build-up
These are average figures within a model and cannot be applied to an individual location

In the case of options b: maintaining existing trees to maturity alongside new planting, the impact is a 14-fold return.

The TCC derived from single tree planting, rather than woodland planting, under scenario 3a is 1,449 ha and under scenario 3b is 1,232 ha - the difference being attributed to explicitly maintaining existing trees through to maturity.

	Roads	Rail	Woodland & OGS	Urban excl. road	Other	TOTAL
2022 TCC /ha	562	152	1,597	1,485	848	4,645
2051 All wards at 25% TCC /ha	878	228	1,894	2,638	1,441	7,079
TCC added through new planting /ha	316	75	297	1,153	593	2,434
Total cost (2024 values) / £m	139	3.7	4.8	326	9	483
Annual cost to 2051 (2024 values) /£m	4.8	0.1	0.2	11.2	0.3	16.6
Additional amenity & ecosystem services valuation /£m	1,779	422	1,672	6,491	3,338	13,703
Added value as a multiple of additional costs	8.1	97.9	384.0	9.0	384.0	5.6

Table 11 Option 3a. Estimated costs to move to 25% canopy across all wards using new planting only and associated additional values

	Roads	Rail	Woodland & OGS	Urban excl. road	Other	TOTAL
2022 TCC /ha	562	152	1,597	1,485	848	4,645
2051 All wards at 25% TCC /ha	878	228	1,894	2,638	1,441	7,079
TCC added through maintaining existing /ha	65	18	185	172	98	537
TCC added through new planting /ha	251	57	112	981	495	1896
Cost for new TCC from maintaining existing	4.1	0.9	1.5	11	0.8	18
Cost for new planting	110	2.8	1.8	277	8	400
Total cost (2024 values)	115	3.7	3.3	288	9	418
Annual cost to 2051 (2024 values) /£m	4.0	0.1	0.1	9.9	0.3	14.4
Additional amenity & ecosystem services valuation /£m	1,779	422	1,672	6,491	3,338	13,703
Added value as a multiple of additional costs	16	114	502	22.6	382	33

Table 12 Option 3b. Estimated costs to move to 25% canopy across all wards and associated additional values, taking into account growth of existing trees @ 0.37%* per annum

This value represents just 10% of the annual rate achieved within a UK authority

Scenario 4 - Maximise canopy through mix change

The mix of species is a large determinant factor in the ultimate extent, depth, richness and resilience of the resulting tree canopy. Longer lived, larger stature trees, such as oak, lime and plane, generate greater ecosystem services from a single tree than their smaller counterparts.

Planting and early year costs are largely the same, irrespective of species. Thus, significant savings per hectare of TCC can be achieved over the longer term by selecting species that mature with larger crowns. By the time a tree is 25 years old - the age a heavy standard could be expected to be once planted out for 15 years - the differences can be dramatic.

In theory, the greater canopy available from larger species can be utilised in one of two ways:

Option 1: Greater canopy can be obtained with the same number of trees.
Option 2: The same canopy requires fewer trees and thus lower cost.

Birmingham's trees tend to be of larger stature species for both public trees and non-public trees, see Table 13. The full lists for both tree populations can be found in Appendix III.

The impact of tree stature on the number of trees required to be planted to achieve a hectare of canopy is high.

Scale at maturity	Nominal canopy at 25 years (m^2)	Proportion of publicly managed trees[a]	Proportion of all trees[b]
Massive	64	28%	26%
Large	50	42%	52%
Medium	36	15%	9%
Small	12	5%	3%

Table 13. Birmingham's trees by scale at maturity (based on top 80% of species by population numbers) Trees were coded using the TDAG published species data.
Sources: a: Birmingham City Council Tree Inventory
b: Valuing Birmingham's Urban Forest study (i-Tree Eco study)

	Assumed canopy at 25 years (m^2)	Nominal trees per hectare of canopy
Massive	64	156
Large	50	200
Medium	36	278
Small	12	833

Table 14. Canopy sizes and conversion into trees per hectare of canopy, assuming trees are planted as heavy standards and have room to grow.

Key findings

Existing trees species mix favours canopy growth

The existing tree population within Birmingham is made up of almost 80% larger stature trees (Table 13). The average tree size in Birmingham is 36m², well below that of a mature large stature tree. Thus, there appears to be a lot of opportunity for additional TCC from maintaining the current population to full maturity.

Planting mix drives TCC expansion costs

The cost per hectare to create new TCC is highly dependent upon the mature stature of the tree species within that mix. The us of small stature vs medium stature trees will increase those costs by a factor of 3 (Figure 15). The sums involved are significant - an additional £1.5 million over 15 years. Greater savings are achievable by biasing wherever possible towards larger stature trees (Figure 15). In many situations smaller and medium sized trees are the appropriate solution for the location. Where the location allows, then larger stature can be priortised.

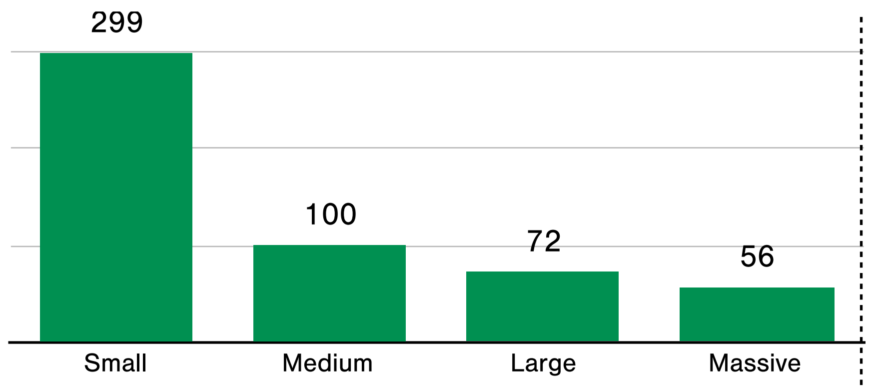

Figure 15. Cost to plant a hectare of trees indexed against the 'average tree' used within the model

	Total costs per tree	Total cost per hectare of tree canopy under different 'tree size' options				
		Average tree 36m²	Small 12m²	Medium 36m²	Large 50m²	Massive 64m²
Single trees in hard landscapes (standard pit)	£2,828	£788,873	£2,356,250	£785,417	£565,500	£441,797
Single trees in hard landscapes (rooting cells)	£8,128	£2,267,573	£6,772,917	£2,257,639	£1,625,500	£1,269,922
Single trees in soft landscapes	£1,628	£454,073	£1,356,250	£452,083	£1,625,500	£254,297

Table 15. Total cost per hectare assuming all trees were of a single size for different planting options

Conclusions

Business as usual leads to poor distribution of tree canopy cover
The overall impact of continuing on the current direction of travel is likely to be a hollowing out of the urban areas with respect to trees - a continued loss of tree canopy cover. At the city scale, it is anticipated that this would be mitigated to a large degree by canopy expansion within green spaces, thereby obscuring the dramatic impacts within individual neighbourhoods.

Arresting decline is highly dependent upon speed of intervention
Speed of intervention by 2031 vs 2041 is likely to mean dramatically different outcomes in both total canopy and its distribution. The faster timeline looks likely to allow the topline TCC figure to recover to current levels by 2051 with much reduced losses in urban areas. Under the slower timetable, any losses incurred are not recoverable without additional large-scale interventions within the remaining decade to 2051.

Benefits outweigh costs by a factor of ten in urban areas
The amenity benefit to those that live in close proximity to the trees planted is vastly in excess of the estimated costs required to do so. The additional canopy brings an increase in CAVAT value of £13 billion (2024 values) by 2051, against an estimated cost of just over £400m - at today's costs - spread over the next 25 years.

Greater natural growth reduces tree establishment costs
Just 0.1% growth in the 4,645 ha of existing TCC is equivalent to establishing and maintaining almost 1,300 'average' trees (based on average tree in Birmingham today with 36m^2 canopy - achievable in 15 years for a 'heavy standard' street tree). Annual natural growth rates many times this have been achieved within the UK. It is a highly cost-effective mechanism for expanding TCC.

Birmingham's species mix today provides good growth potential The existing species mix across Birmingham, whether all trees or public trees only, is strongly weighted towards larger growing types. Such trees have the greatest ability to add on additional capacity annually over a long period of time. To maintain this mix, new planting must reflect a similar balance in mature size.

Changing existing species mix unlikely to impact TCC positively As the existing mix is heavily dominated by larger growing species, it is likely that any significant change to that mix will include a greater proportion, by number, of smaller growing species. In a simple comparison, this will either lead to lower TCC under a tree-replacement regime or more trees altogether under a TCC expansion approach.

Appendix I. Methodology

The change in TCC over time was determined using Bluesky National Tree Map (NTM) data for the years 2016 and 2022. In both cases, the data collection flights took place in early June - a time of year where the majority of species have full leaf cover. Furthermore, the similarity in flight dates gives good confidence in a 'like-for-like' comparison as seasonal variations are minimised. The two points in time have been used to create a 'straight line' forecast from 2022 forwards to 2051.

Model approach

1. A straight line forecast was used for modelling

The study area was divided into 345 separate units baed on wards and land use types. The core assumption is that a straight line forecast will give a reasonable picture of the future for the whole area when applied at the level of ward/land use units.

2. Prior maximums and minimums used as TCC threshold points

Any system of straight line forecasting will produce nonsensical results given enough time - TCC levels above 100% or below 0%. To mitigate for this, cutoff points were factored in. i.e. if a forecast for a particular ward/land use unit reached a threshold level, the forecasting was not projected beyond that point. The thresholds were established using the existing data as a benchmark. For example, the lowest and highest canopy cover figures recorded for railways within a single ward were 11% and 83% respectively. These thus acted as the lower and upper limits for the 2051 forecast. See Table 16 for details of all threshold points.

	Road	Rail	Woods / Green space	Urban (ex roads)	Other (natural)
Upper threshold	33%	83%	86%	30%	35%
Lower threshold	5%	11%	38%	3%	5%

Table 16. Upper and lower thresholds for 2051 forecast, based on canopy cover calculated at land use / ward unit level.

NB. 2016 figures were respectively both lower and higher for the lower and upper thresholds than those for 2022.

3. The 'average tree' was used for modelling

The average tree in Birmingham has a canopy of $36m^2$.[6] For the purposes on this study, single tree planting is deemed to be sufficient to generate a crown $36m^2$ by 2051. Assuming it was 10 years old when planted, it would be 25 when expected to have a canopy of $36m^2$. This is easily achieved by many large stature trees, some medium sized trees and no small trees.

[6] Valuing Birmingham's Trees

4. A single planting mix is assumed in the modelling

Whilst the tree mix is undoubtedly a factor in reality, it is assumed for the purpose of modelling that the planting mix is one that would result in an average tree canopy of 36m^2 within 15 years.

5. The model assumes all trees are planted from 2024 to 2036

In practice, to achieve a crown of 36m^2 by 2051, a tree would likely need to be a heavy standard for a medium to large growing species, with 15 years' growth. The last time this is possible is 2036. Usefully, this is also about the midpoint in the timeline of Birmingham's Urban Forest Master Plan. Trees planted earlier will likely have larger canopies by 2051; trees planted later, smaller ones. This approach provides a simplified, pragmatic means to understand tree number requirements, whilst being plausible in time terms and canopy impact.

6. Land use changes are assumed to occur within groups of land use types

The land use aggregations employed in the modelling represent how the different landuse types interact with each other with respect to the treescape, within the limitations of the data available. For example, within large cities, new developments use land previously occupied by existing buildings, other grey infrastructure and private gardens taken together. i.e. the tree loss from a particular type of land use change - gardens lost to development - occurs within this one grouping.

Appendix II - Tree planting and maintenance costs

	Detail	Amount	References	Source
Single trees in hard landscapes (rooting cells)	Source Tree	£100		Industry sources
	Installation costs (2024 values)	£6,260	Street Tree Cost Benefit Analysis Report (2018)	GreenBlue Urban
	Inspection + watering costs yrs 1 to 3	£709	Urban Tree Challenge Fund Manual (2024)	DeFRA
	Calculated total	£6,969		
	Model value	£8,000		
Single trees in hard landscapes (standard pit)	Tree and installation costs	£424	Urban Tree Challenge Fund Manual	DeFRA
	Inspection + watering costs yrs 1 to 3	£709	Urban Tree Challenge Fund Manual	DeFRA
	Calculated Total	£1,133		
	Model Value	£1,500		
Single trees in soft landscapes (public/large private)	Tree and Installation costs	£338	Urban Tree Challenge Fund Manual	DeFRA
	Inspection + watering costs yrs 1 to 3	£709	Urban Tree Challenge Fund Manual	DeFRA
	Calculated Total	£1,046		
	Model Value	£500		
Single trees in soft landscapes (small private)	Tree and installation costs	£60	Project estimates	DeFRA
	Inspection + watering costs yrs 1 to 3	£15	Project estimates	DeFRA
	Calculated total	£75		
	Model value	£75		

	Detail	Amount	References	Source
Whips in soft landscapes (woodland) per ha	Estimated costs to establish woodland with public access	£10,000	Estimated current costs per hectare	Industry sources
Whips in soft landscapes (railway) per ha	Estimated costs to establish dense trackside planting over 3 years	£9,900	Division of vegetation management costs (2018) by estimated level of TCC in ha. Assumes no other vegetation type. Annual costs = £42m / (TCC of 32% (this study) x 50,000 hectares) adjusted for inflation. Assume planting costs equal to annual maintenance	FOI request to Network Rail
Single trees maintenance costs	Ongoing maintenance on a per tree basis	£15	Estimate derived from total contract values and tree population numbers for public sector tree management contracts	Local authority sources
Growth of existing woodland canopy per ha	Ongoing maintenance on a per hectare basis	£500	Estimated current costs per hectare	Forestry sector sources
Growth of existing non-woodland canopy per ha	Ongoing maintenance on a per hectare basis	£4,200	Scaled up from per tree costs using ‘average tree’ canopy of 36sqm (10,000/36) x15 = £4,166. Rounded up to £4,200	

Appendix III. Tree species mix across Birmingham

Massive	**23%**
Quercus robur	6%
Fagus sylvatica	3%
Tilia x europaea	2%
Platanus x acerifolia	2%
Chamaecyparis lawsonianna	2%
Aesculus hippocastanum	2%
Populus sp.	1%
Quercus sp.	1%
Pinus sylvestris	1%
Populus nigra italica	1%
Tilia cordata	1%
Pinus nigra nigra	1%
Large	**41%**
Acer pseudoplatanus	8%
Fraxinus excelsior	7%
Acer platanoides	5%
Betula pendula	5%
Tilia sp.	4%
Acer sp.	2%
Betula sp.	1%
Prunus avium	1%
Ilex aquifolium	1%
Alnus glutinosa	1%
X Cupressocyparis leylandii	1%
Salix sp.	1%
Carpinus betulus	1%
Salix fragilis	1%
Taxus baccata	1%
Robinia pseudoacacia	1%
Medium	**12%**
Prunus sp.	5%
Acer campestre	2%
Sorbus sp.	1%
Sorbus aucuparia	1%
Sorbus aria	1%
Salix caprea	1%
Sorbus intermedia	1%
Small	**5%**
Crataegus monogyna	2%
Malus sp.	1%
Crataegus sp.	1%
Grand Total	**80%**

Table 17. Showing Birmingham's top 80% of public tree population by size at maturity using TDAG species selection tool to allocate sizes.
Source: BCC (tree inventory)

Massive	**23%**
Quercus robur	8%
Tilia x europaea	5%
Fagus sylvatica	3%
Chamaecyparis lawsoniana	2%
Thuja plicata	1%
Pinus	1%
Tilia cordata	1%
Pinus sylvestris	1%
Platanus x acerifolia	1%
Large	**46%**
Betula pendula	11%
Acer pseudoplatanus	9%
Ilex aquifolium	8%
Fraxinus excelsior	7%
Prunus avium	4%
x Cuprocyparis leylandii	3%
Acer platanoides	2%
Alnus cordata	1%
Medium	**8%**
Acer campestre	3%
Sorbus aucuparia	3%
Salix caprea	1%
Sorbus aria	1%
Small	**3%**
Crataegus monogyna	3%
Grand Total	80%

Table 18. Showing Birmingham's top 80% of total tree population by size at maturity using TDAG species selection tool to allocate sizes.
Source: Valuing Birmingham's Urban Forest

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