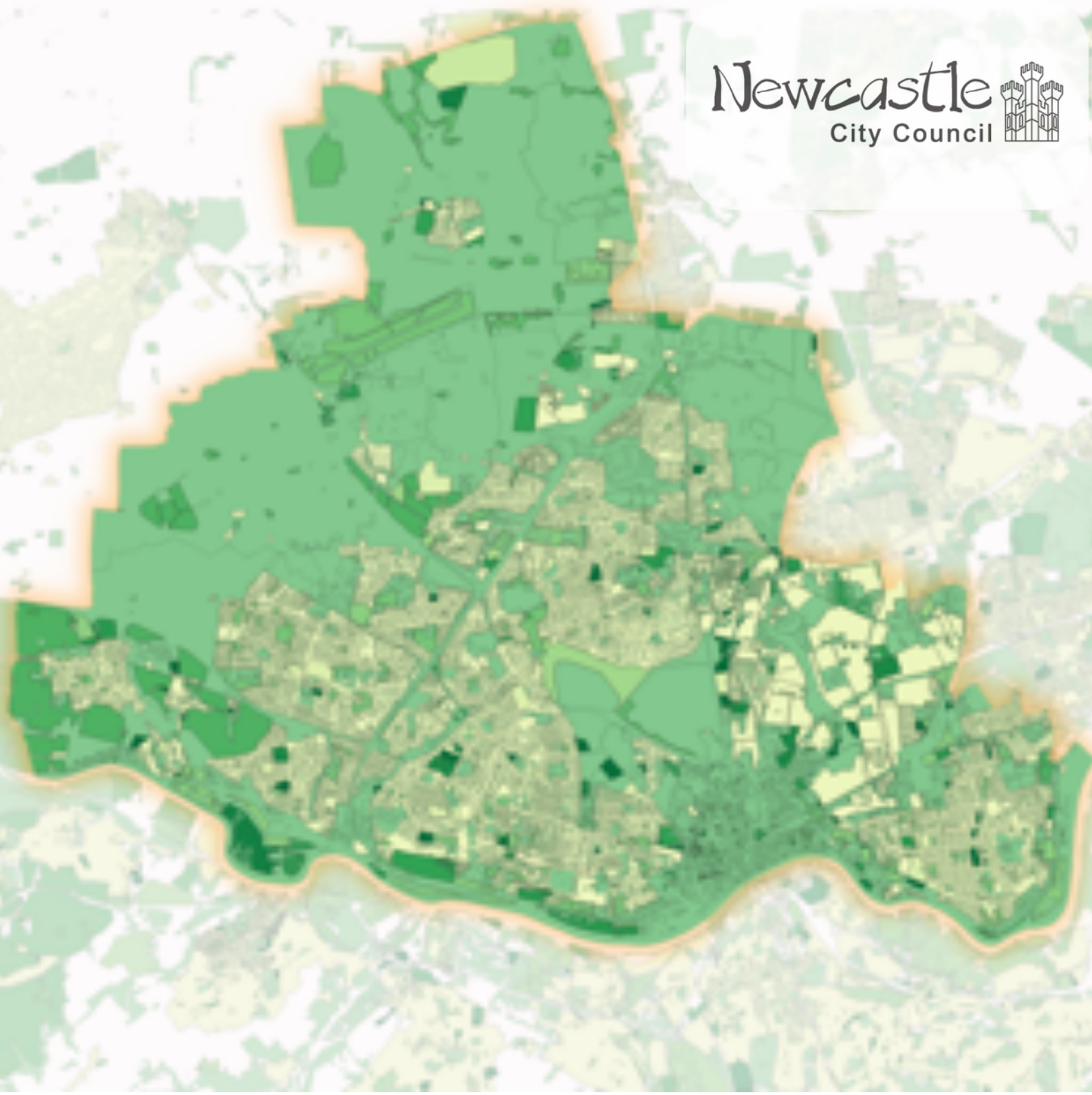


Newcastle City Council

Tree Canopy Cover Assessment

Treeco$_2$nomics

i-Tree

What is Tree Canopy Cover?

Tree Canopy Cover, which is often also referred to as canopy cover and urban canopy cover, can be defined as the area of leaves, branches, and stems of trees covering the ground when viewed from above.

Canopy Cover is a two-dimensional metric, indicating the spread of canopy cover across an area. Quantifying the spatial extent of the urban forest is one of the first steps in managing this important resource and answers the fundamental questions: 'What canopy cover have we got?' and 'Where is it?'

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

Understanding the extent of the tree canopy cover in the city of Newcastle, and its relationship with other indicators is the first step in 'measuring to manage' the urban forest. This appreciating asset (part of Newcastle's Natural Capital) can now be improved and maintained using this study and its data, with resources targeted to the areas that need it most.

The Authors

David Hansford - Treeconomics
Annabel Buckland - Treeconomics
Kenton Rogers - Treeconomics

This assessment was carried out by Treeconomics

Contents

Executive Summary

Trees are arguably the single most important component of Green Infrastructure (the mosaic of parks, street trees and all other 'green assets' found in urban areas), yet are often overlooked and undervalued. In particular, trees are important because they enhance and improve the urban environment by providing a wide range of benefits (or ecosystem services) at relatively little cost. For example, there is a growing body of research which demonstrates that trees improve our health and well being. Trees also provide a 'sense of place', moderate extremes of high temperature in urban areas, improve air quality and act as a carbon sink[1].

Estimates of canopy cover for each ward in the city of Newcastle Administrative Boundary were calculated (fig1 illustrates the area of study). The results provide a snapshot of the current tree canopy cover (table 1) and a baseline to allow for comparison with any future tree canopy surveys. The study also compared tree canopy cover with relevant statistics from the Office for National Statistics (ONS) and reviewed other available sources of geographical data on human health, wellbeing and societal factors (such as crime rates, social deprivation and life expectancy) to observe if there was any correlation with tree canopy cover.

Highlights of the report are:

- **The overall canopy cover of the city of Newcastle administrative area is estimated at 18.1%.**
- **In comparison with other studies (Urban Tree Cover, 2018), the canopy cover is above the average (17%) estimated in the 320 towns and cities surveyed in the UK. This gives Newcastle the ranking of #112 of 320.**
- **In all cases the correlation between Tree cover and Social Indicators demonstrated that areas with increased tree cover also score higher for community wellbeing.**
- **It is suggested that Newcastle could reasonably aspire to a canopy cover of 20% by 2050 subject to the production of a fully costed and resourced action plan**

Canopy cover by ward area figures and a selection of total canopy cover in UK cities is provided in Table 1 overleaf.

1 Further details are provided in later sections of this report

Canopy cover estimates across Newcastle range from just 10.2% in both Castle and Chapel Wards to 31.6% in the Parklands Ward of the city. Canopy cover in Newcastle is higher than the national and regional averages reported in Trees in Towns 2 (2008) at 8.2% and 4.0% respectively.

Ward	Tree Canopy Cover (%)
Arthurs Hill	16.50
Benwell and Scotswood	20.60
Blakelaw	12.50
Byker	14.10
Callerton and Throckley	15.90
Castle	10.20
Chapel	10.20
Dene and South Gosforth	29.00
Denton and Westerhope	14.90
Elswick	18.30
Fawdon and West Gosforth	18.20
Gosforth	24.10
Heaton	18.20
Kenton	18.80
Kingston Park South	15.50
Lemington	21.90
Manor Park	17.40
Monument	14.90
North Jesmond	25.60
Ouseburn	15.20
Parklands	31.60
South Jesmond	28.00
Walker	17.10
Walkergate	12.80
West Fenham	13.70
Wingrove	14.50
City of Newcastle Average	**18.10**

Table 1: Tree Canopy Cover by Ward (alphabetical) within the administrative area of the city of Newcastle

Figure 1: Ward map of Newcastle

City/District	% Tree cover	Source
Birmingham	23.00	i-Tree Canopy Survey 2012
Exeter	23.00	i-Tree Canopy Survey 2013
London	21.90	i-Tree Eco Project 2015
Oxford	21.40	i-Tree Canopy Survey 2015
Plymouth	18.50	i-Tree Canopy Survey 2017
Newcastle	18.10	i-Tree Canopy Survey 2018
Walsall	17.30	i-Tree Canopy Survey 2012
Edinburgh	17.00	i-Tree Survey 2012
Wrexham	17.00	i-Tree Survey 2014
Ealing	16.90	i-Tree Survey 2018
Eastbourne	15.90	i-Tree Canopy Survey 2011
Manchester	15.50	Red Rose Forest survey 2007
Glasgow	15.00	i-Tree Survey 2014
Bristol	14.00	Bristol Tree Survey 2009
Telford	12.50	i-Tree Canopy Survey 2012
Torbay	12.00	i-Tree Survey 2011

Table 2: A selection of urban areas across the UK and their estimated canopy cover

1. Introduction

1.1 Background

Measuring tree canopy provides the means to help city planners, urban foresters and communities consider trees and forests as distinct elements of green infrastructure, as a key component of community planning, sustainability and resilience.

> *'Green Infrastructure is a strategically planned and delivered network comprising the broadest range of high quality green spaces and other environmental features. It should be designed and managed as a multifunctional resource capable of delivering those ecological services and quality of life benefits required by the communities it serves and needed to underpin sustainability. Its design and management should also respect and enhance the character and distinctiveness of an area with regard to habitats and landscape types.*
>
> *Green Infrastructure also encompasses river systems and coastal environments (these are sometimes also referred to as Blue Infrastructure).*
>
> *Green Infrastructure includes established green spaces and new sites and should thread through and surround the built environment and connect the urban area to its wider rural hinterland. Consequently it needs to be delivered at all spatial scales from sub-regional to local neighbourhood levels, accommodating both accessible natural green spaces within local communities and often much larger sites in the urban fringe and wider countryside.'*
>
> *Natural England Green Infrastructure Guidance (2009).*

The importance of vegetation in urban areas has long been recognised (e.g. Oke, 1982, Huang et al., 1987, Nowak et al., 2010). Amongst other benefits, vegetation provides shading, evaporative cooling and rainwater interception (Gill et al., 2007). Tree canopy cover has a strong influence on a number of factors including energy demand, air quality and noise pollution, biodiversity, ameliorating high urban summer temperatures and human health and wellbeing.

Canopy cover assessments help to observe change over time at a relatively low cost in comparison to field surveys. Quantifying tree canopy cover has been identified by many authors (Britt and Johnston, 2008; Escobedo and Nowak, 2009; Schwab, 2009) to be one of the first steps in the management of the urban forest.

There is a growing body of international research and literature which supports the theory that overall, increasing tree cover in our towns and cities provides multiple benefits at little cost. For example, a study in Torbay found that for every £1 spent on an Oak tree, £4.96 was returned in benefits, taking into account all the costs on management and maintenance, whilst only being able to value just 2 of the associated benefits (pollution removal and carbon storage/sequestration - Sunderland et al., 2012). A similar study in New York found that for every $1 spent on its street trees $5 were returned in benefits (Wells, 2012).

Trees and urban tree cover are also implicitly linked to other key concepts that are emphasised and highlighted within The National Planning Policy Framework (NPPF). Sustainability, ecosystem services and green infrastructure are all dependent on the significant contribution that trees in the urban forest make. Of the 13 sections in the NPPF trees are able to contribute to meeting the objectives of 11 of them.

For example, increased tree cover can increase economic growth (Rolls and Sunderland, 2014) and prosperity as leafier environments improve consumer spending (Wolf, 2005). Additionally, businesses are prepared to pay greater ground rents associated with higher paid earners who are also more productive (Kaplan (1993), Wolf (1998), Laverne & Winson-Geideman (2003)), house prices increase and crime is reduced thereby “Building a strong, competitive economy”, (Section 1 NPPF, paragraph 18). This is also directly linked to “Ensuring the vitality of town centres” (Section 2).

A full summary of how trees benefit local communities within the context of the National Planning Policy Framework is provided in Appendix III. In addition to the above, these include:

- Supporting a prosperous rural economy
- Improving journey quality and encouraging use of alternative transport corridors
- Increasing property prices and reducing crime
- Improving the ‘liveability’ of urban areas, increasing happiness and reducing stress
- Providing habitat, increasing biodiversity and therefore recreational value

Note: Canopy cover is not to be confused with total leaf area, which seeks to estimate all of the layers within a tree canopy expressed as a volume. This is normally expressed in cubic metres (m^3) or using leaf area index (LAI).

1.2 Aims and Objectives

This is a factual, evidence-based document which seeks to underpin the aspirational, ongoing aim of providing a positive argument to support policy development in favour of developing a robust, inter-connected urban forest network.

The main objective of this report is to provide a snapshot of canopy cover in the city of Newcastle administrative area. It is important to be able to measure this vital component of Green Infrastructure to ensure that it will be embedded and enhanced as part of the growth agenda for the area.

The original brief was to:

- Use i-Tree Canopy to calculate the % canopy cover for each of the 26 administrative wards for the city of Newcastle
- Compare tree canopy cover with available ONS statistical data on Health, Crime and Deprivation.

A key area where this information is particularly relevant is in planning and development; this document has been written with an emphasis on informing local planning policy (see also Appendix III and IV). However, its purpose is not to create policy within the document itself, but to highlight the importance of the urban forest as a distinct and unique element of Green Infrastructure.

The data presented here can be used to inform tree policies and other environmental strategies, so that residents and visitors to Newcastle can continue to enjoy the benefits of urban trees long into the future. The information will also be useful in targeting future planting and management schemes. Tree planting, protection and maintenance as a means to increase canopy cover will be an important part of delivering equitable access to the benefits trees provide.

This study also explores any possible correlations between tree canopy cover and human health and wellbeing, by comparing canopy cover information with selected, geographically explicit data from the Office of National Statistics (ONS).

1.3 The Role of Trees in Cities

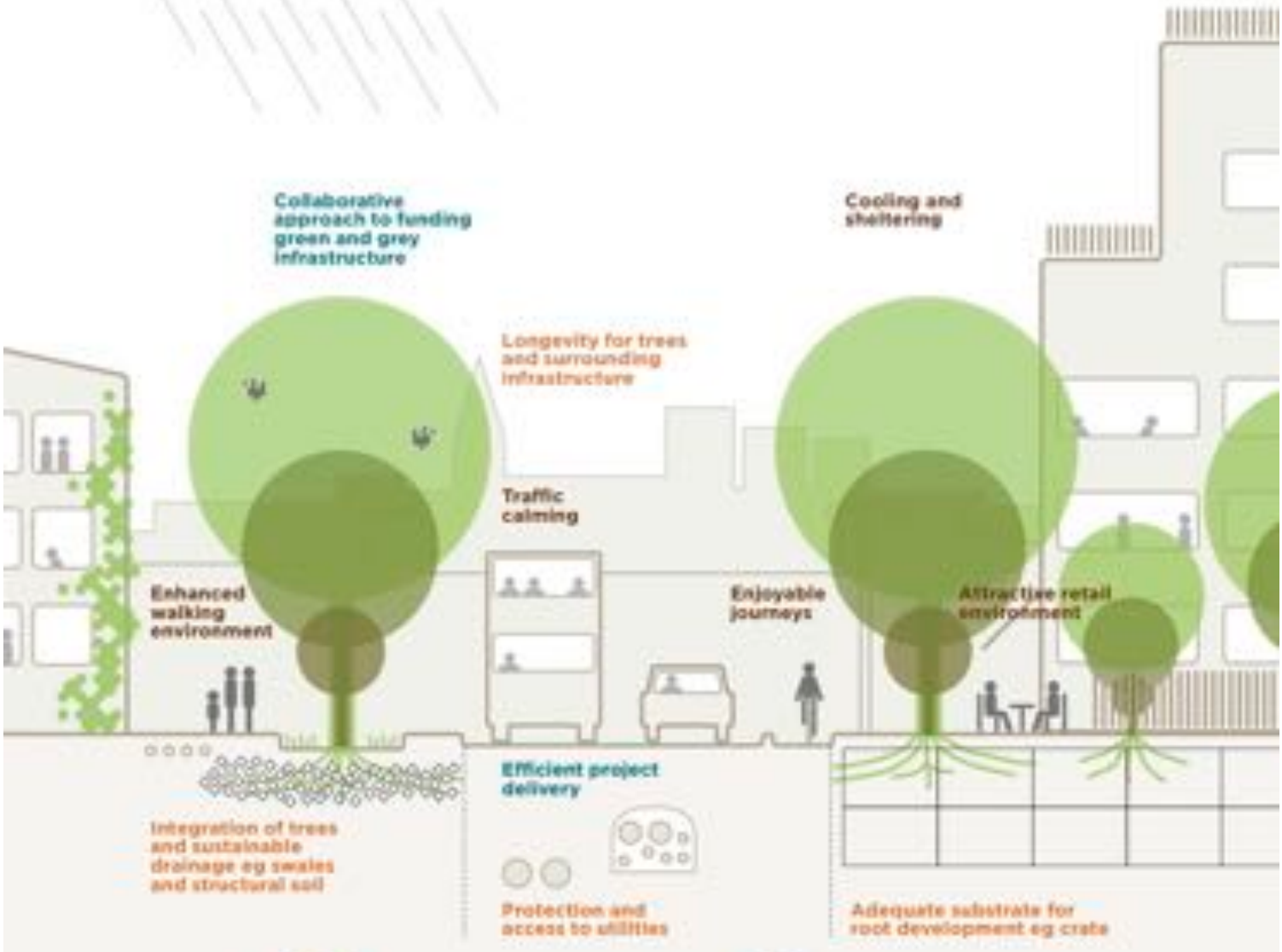
In 2014, around 54% of the worlds population were living in towns and cities. That figure is set to increase to 70% by 2050 (Ekelund, 2015). In addition, it is estimated that almost two-thirds of the urban environment which will exist in 2030 is yet to be built. This suggests that the rate of urban development is set to accelerate considerably.

If we are to produce happy, healthy communities, it is paramount that we create and maintain healthy and sustainable urban environments, designed to incorporate inter-connected elements of green infrastructure and urban forest to improve the liveability of the places in which people live. Figure 2, overleaf, produced by the Trees and Design Action Group (TDAG) gives an overview of the benefits and challenges of incorporating trees in urban design.

Understanding the value and extent of Canopy Cover in the city of Newcastle will inform decisions that will improve human health and environmental quality.

In a study of 283 UK towns and cities, Doick et al. (2017) recommends a minimum canopy cover target of 20% (with 15% for coastal locations), and currently many UK cities are exceeding that. For example, London is aiming for 30% canopy cover and both Torbay and Plymouth have set goals of 20% canopy cover, whilst Bristol has set a target to double its canopy cover by 2050 from 15 to 30%. This therefore gives an indication for the potential canopy cover goals for the areas surveyed in this report.

21st century opportunities and challenges



Collaborative Process

Weaving natural resources, especially trees, into the built environment requires a cross-disciplinary collaborative approach from project initiation through to design, implementation, maintenance and monitoring. This guide looks at when, how and with whom joined-up working needs to happen.

Designing with Trees

Achieving long-term benefits from trees requires a concerted strategy. This guide explores current evidence on the enabling factors for trees to bring value to the hard landscapes in which they grow.

Time in Years

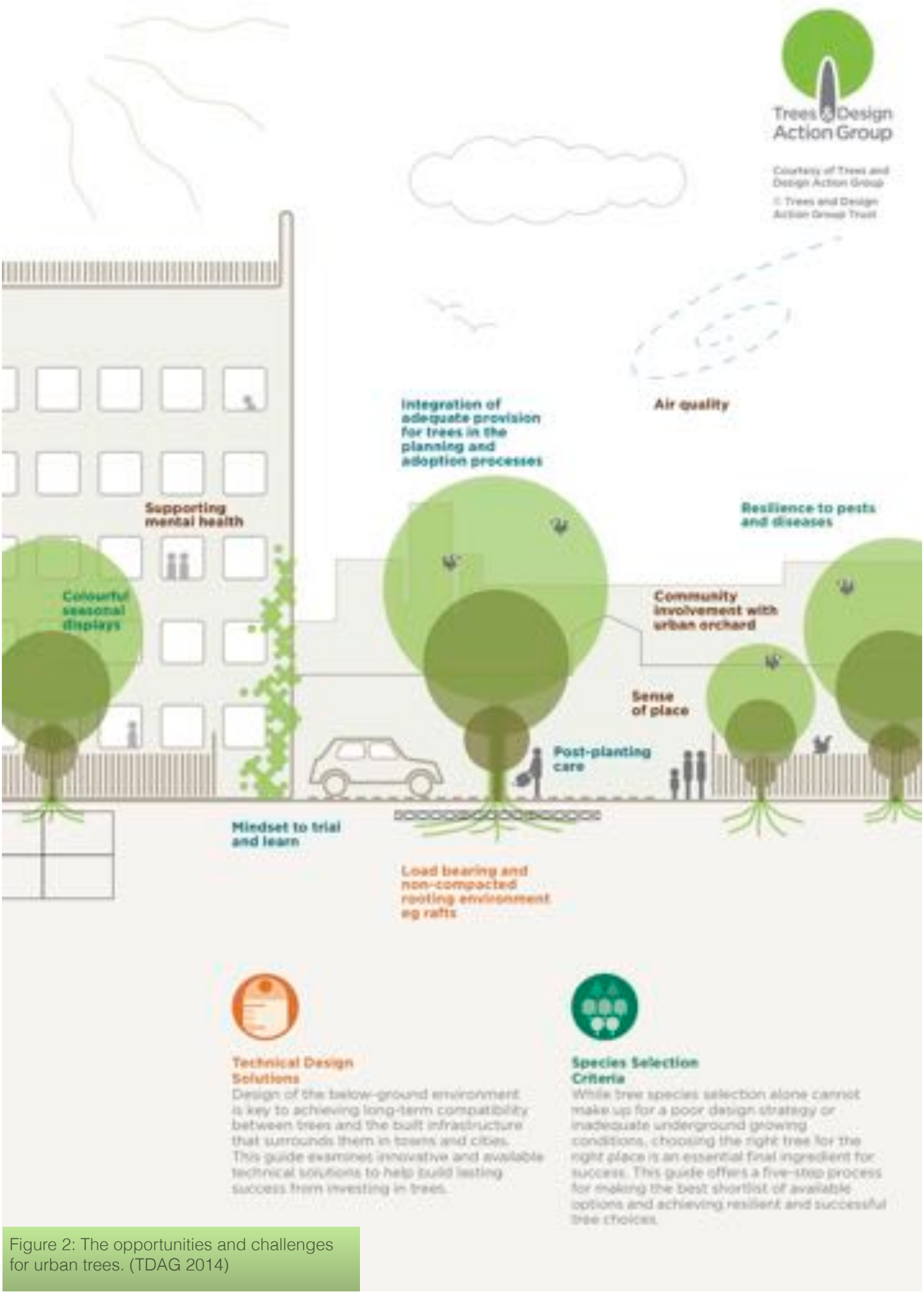


Figure 2: The opportunities and challenges for urban trees. (TDAG 2014)

2. Data analysis

2.1 Methodology

Project boundaries were supplied for the Newcastle administrative area by Newcastle City Council. Additional background data was obtained from open sources, referenced on the maps.

Tree canopy cover within the city of Newcastle has been assessed using the i-Tree Canopy tool. i-Tree Canopy is one of the suite of i-Tree tools for assessing urban forests and allows the user to estimate canopy cover and tree benefits for a given area with a random sampling process.

Health and socio-economic data has been obtained from the Office of National Statistics (ONS) and Public Health England (PHE) official published data.

These three datasets were combined utilising Geographical Information System (GIS) software to provide the maps used in this report.

The aerial images were separated into 3 classifications; Tree Canopy Cover, Potential Plantable Space, and Other.

Potential plantable space represents an area where planting space is available, but may not actually be possible due to other factors (such as refusal of permission by landowner or the current land use). Potential plantable space is a measure that would therefore benefit from on the ground assessment or further investigation in order to establish *'actual plantable space'.*

Notes:

- In some cases it is difficult to distinguish between an 'other' area of grass, for example a football pitch/playing field, and a 'potential plantable space'. In this case a judgement call, and context to the area in the aerial imagery, was used.
- Where the point falls in shadow and the land cover is indistinguishable the area is either defined as 'other', or whatever else it can be reasonably assumed to be.

3. Results

3.1 Average Canopy Cover

The average canopy cover across the city of Newcastle was calculated at 18.1%.

Canopy cover by ward is depicted in fig 4 (overleaf)

At the low end, canopy cover values range from 10.2% in both Castle and Chapel Wards and at the high end, 31.6% in the Parklands Ward of the city.

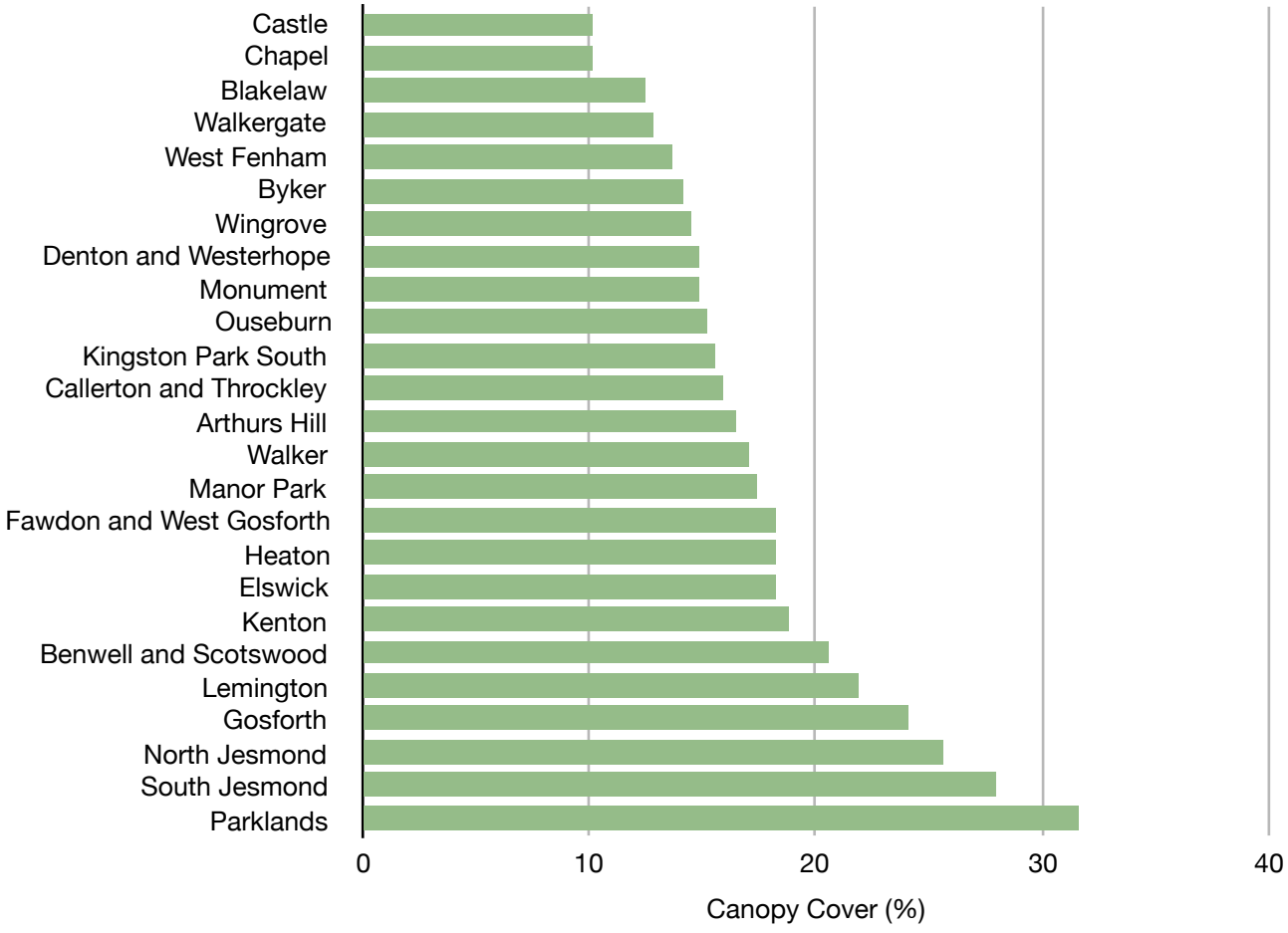


Figure 3: Canopy Cover ranked by % area per ward for Newcastle

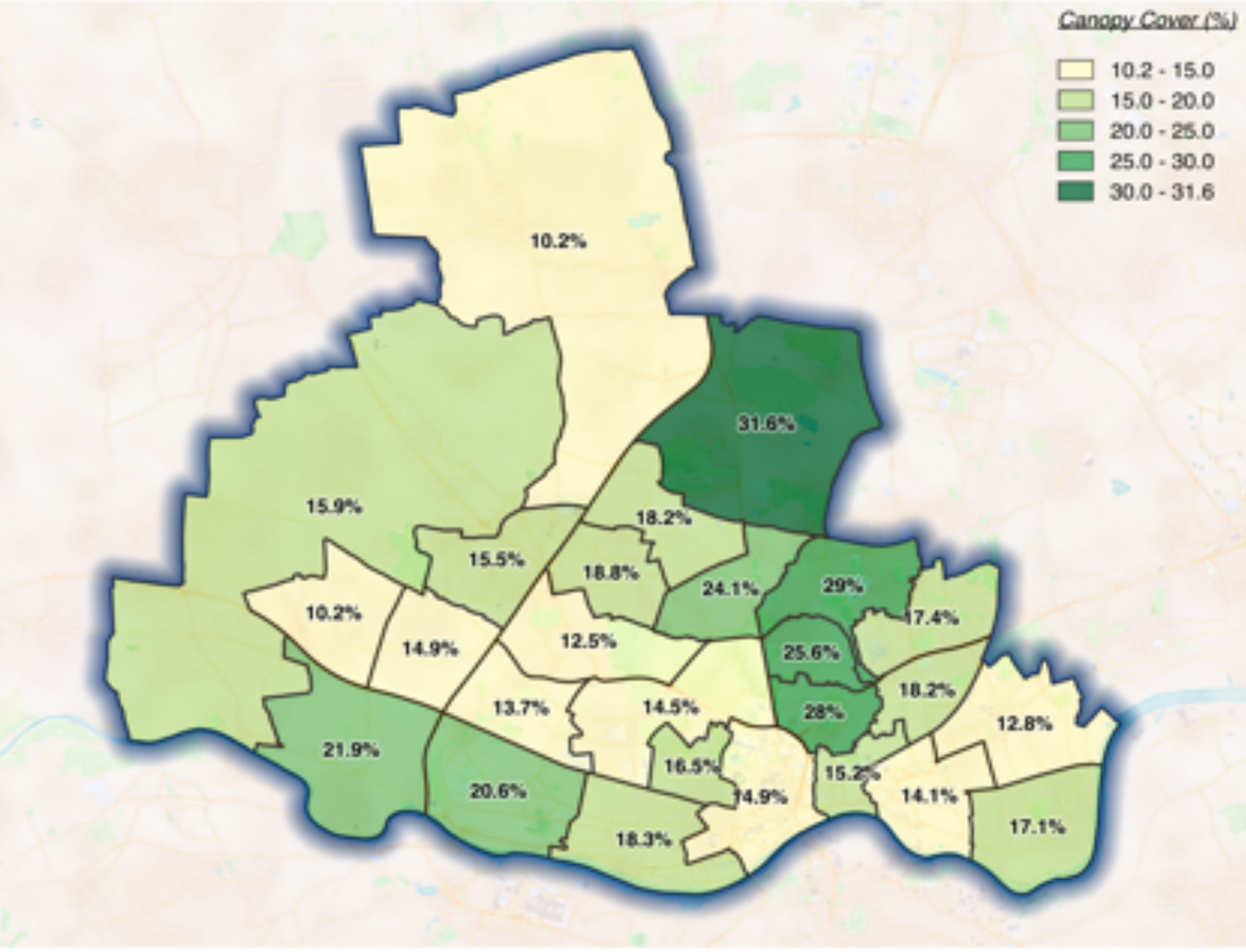


Figure 4: Map of Canopy Cover by ward

3.2 Potential Plantable Space

Table 3 (below) shows the results for potential plantable space, which ranges widely between wards. What is clear is that there is likely to be considerable opportunity to plant more trees across the city.

However, these results should be treated with caution, as the viability of planting opportunities requires a more thorough, ground-based assessment. Some wards, for example Callerton and Throckley and Castle, contain significant elements of agricultural land which may in theory be easy to plant, to make canopy cover gains, but this may not be viable for significant portions of the wards.

Further analysis would also be required to assess the need, at the ward and sub-ward level, to increase canopy cover locally to improve the access to and provision of

ecosystem services on a more refined basis. Furthermore species selection and subsequent management is important to maximise future canopy development and ecosystem service delivery.

Ward	Potential Plantable Space (%)
Arthurs Hill	27.1
Benwell and Scotswood	22.1
Blakelaw	44.0
Byker	13.7
Callerton and Throckley	66.7
Castle	75.6
Chapel	45.8
Dene and South Gosforth	16.7
Denton and Westerhope	23.0
Elswick	16.7
Fawdon and West Gosforth	15.0
Gosforth	18.0
Heaton	12.1
Kenton	21.6
Kingston Park South	30.3
Lemington	36.0
Manor Park	19.9
Monument	3.9
North Jesmond	5.3
Ouseburn	7.5
Parklands	29.1
South Jesmond	3.7
Walker	17.3
Walkergate	14.0
West Fenham	26.0
Wingrove	48.0
City of Newcastle Average	**25.3**

Table 3: Potential plantable space by Ward (alphabetical) within the administrative area of the city of Newcastle.

3.2 How does Newcastle compare to other cities?

Comparing canopy cover values between cities is an interesting exercise but should be made with caution as there are many attributes of a city which will affect urban forest structure and function. Furthermore, other studies have used a variety of different methods to assess canopy cover. Nonetheless, these figures can be informative in providing an approximate benchmark for Newcastle.

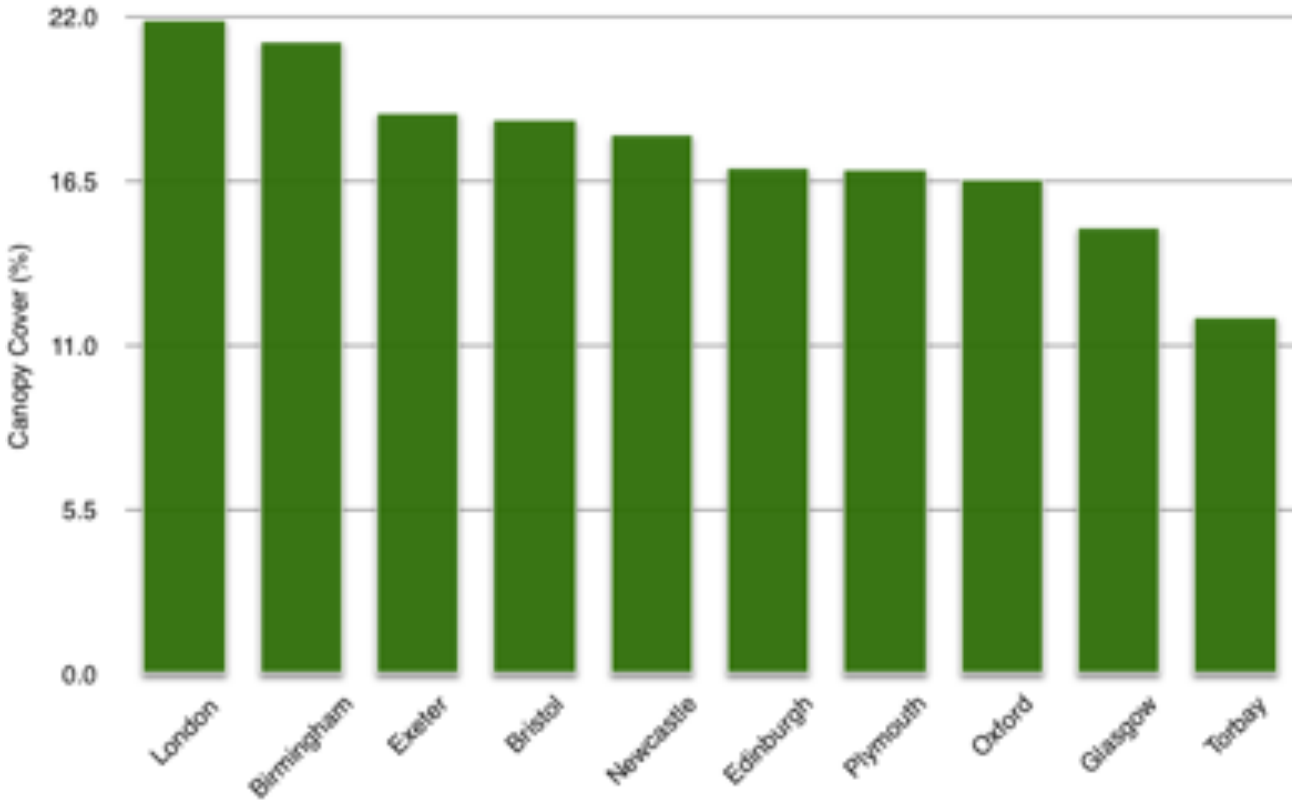


Figure 5: Canopy Cover estimates for selected UK cities

In comparison with other studies (Urban Tree Cover, 2018), the canopy cover is above the average (17%) estimated in the 320 towns and cities surveyed in the UK. This gives Newcastle the ranking of #112 of 320.

4. Canopy Cover and Quality of Life

This section compares canopy cover with various quality of life indicators for Newcastle. These are shown for the smallest or 'lowest' (most precise) geographical level that the data is produced at by the Office of National Statistics. These are referred to as the 'Middle layer Super Output Areas' (MSOA) and 'Lower layer Super Output Areas' (LSOA).

These 'Output Areas' (the areas shown on the map) are based on clusters of adjacent post-codes. They were designed so as to have similar population sizes and to be as socially homogenous as possible based on tenure of household and dwelling type. Therefore, the maps produced below will not align perfectly with the Ward Boundaries for the project.

For each indicator, we have grouped the Output Areas that possess less than 18.1% canopy cover (the average canopy cover across the Newcastle Policy Area) and those that possess a canopy cover equal or greater than 18.1%.

The information presented below should be treated with caution, and it must be borne in mind that these charts do not necessarily show causations or even clear correlations. However, it draws attention to the fact that areas with higher tree canopy generally perform well on other indicators (e.g. greater tree cover = less "deprived").

The insert on each map shows the corresponding canopy cover replicated from figure 4 (page 17).

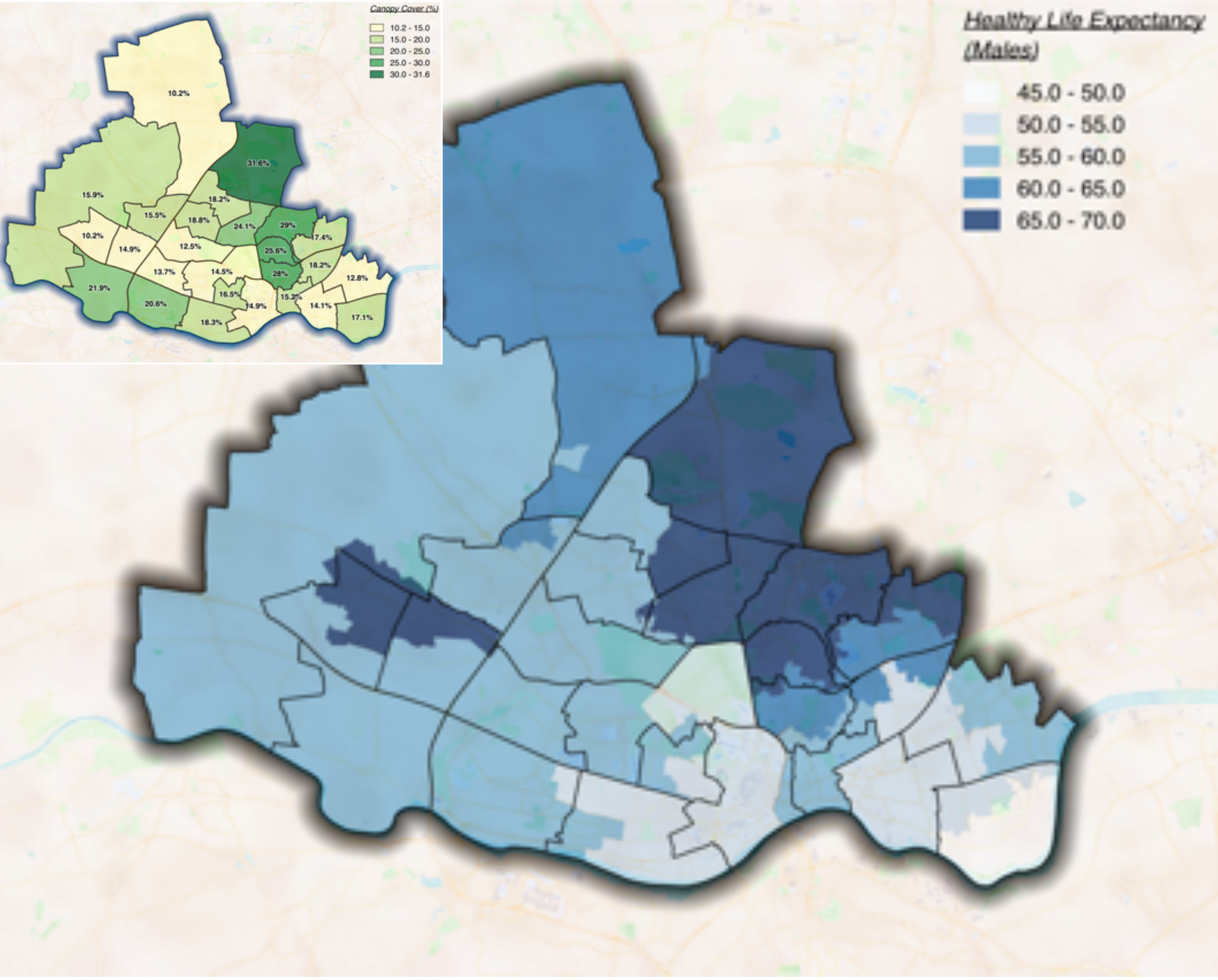


Figure 6: Healthy life expectancy for males by MSOA area. (Inset: Canopy Cover by ward).

4.1 Healthy Life Expectancy

As life expectancy continues to increase, it is important to measure what proportion of these additional years of life are being spent in favourable states of health, or in poor health and dependency. Healthy life expectancy (HLE) helps us to address this question by adding a dimension of quality of life to estimates of life expectancy.

HLE estimates the average number of years a person would live in 'Very good' or 'Good' health if he or she experienced the specified population's particular age-specific mortality and health status for that time period throughout the rest of his or her life. Although overall life expectancy continues to rise (Newcastle City Council, 2014), there are stark differences between areas within the city.

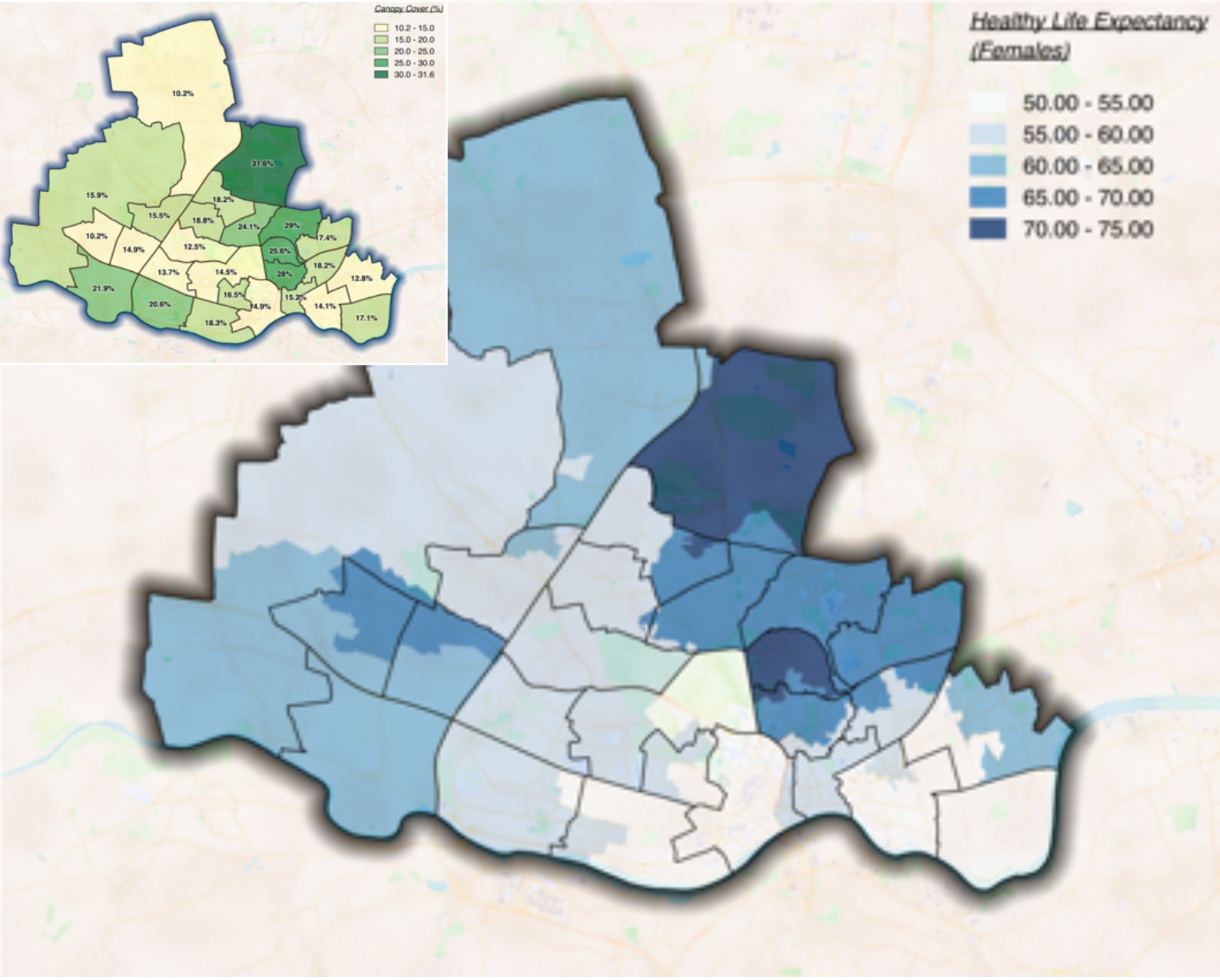


Figure 7: Healthy life expectancy for females by MSOA area. (Inset: Canopy Cover by ward).

The difference between average male life expectancy between South Gosforth and Byker is 12.6 years (Byker Ward having lower life expectancy). Newcastle is also well above the national average in terms of mortality rates for the under-75 years of age group, with mortality rates for cancer particularly high (PHE, 2016).

The results (see figure 8) show that in areas with higher tree canopy cover, HLE is also higher. However other socio-economic factors will also influence the result (for example higher paid families and individuals, leading healthier lifestyles in leafier environments). Yet, these results do serve to highlight that access to tree canopy cover is not always equitable and issues of environmental justice need to be considered when devising tree strategies or developing new areas for housing.

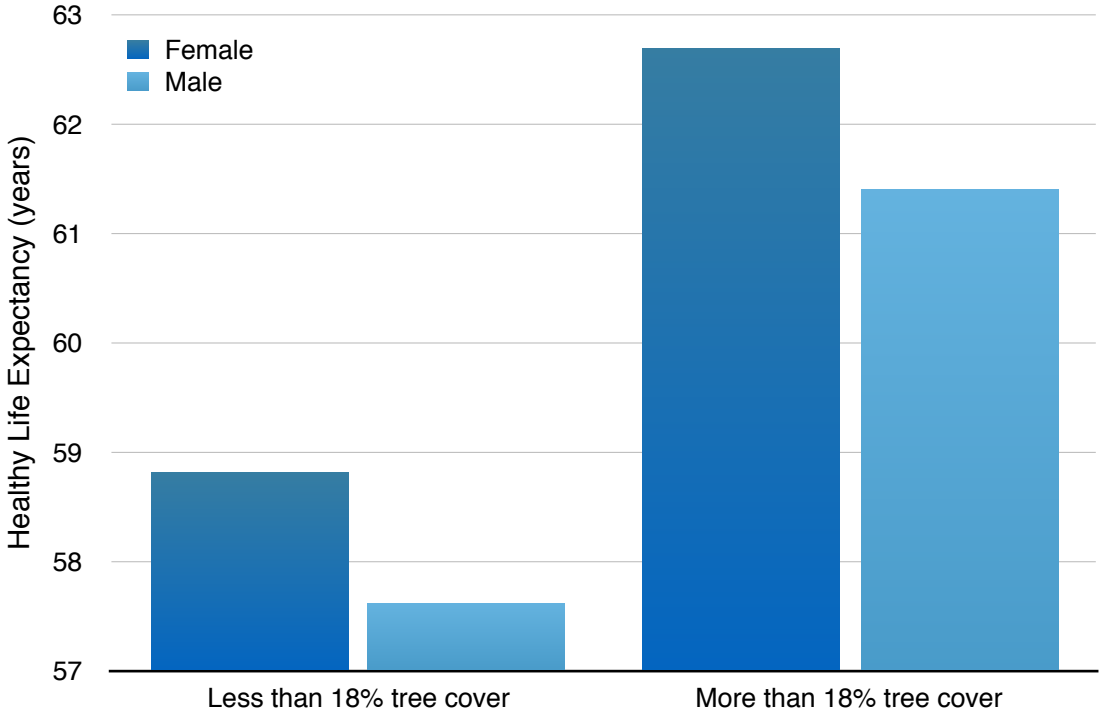


Figure 8: Healthy life expectancy and average canopy cover

4.2 Hospital Admissions

Trees help to promote healthy environments and there is a growing body of research which shows people are happier in leafier environments, with reduced levels of stress and blood pressure (Hartig, 2003).

Stress is one of the key contributing factors to mental health issues, which access to good quality green spaces can alleviate (White, 2013). Depressive disorders are now the foremost cause of disability in middle-high income countries and can be precursors to chronic health problems. In Newcastle 1 in 6 adults suffers from a common mental health problem, although hospital admissions for mental health issues are generally low compared to the national average, those for self harm and attempted suicide are slightly above above the national average (PHE, 2016).

Increased tree cover can help to promote good health (and therefore reduced numbers of hospital admissions) passively, by filtering air pollution and lowering peak summer temperatures, for example, and by promoting physical activity. Where green space is available it can be used for physical activity and may even help to reduce social health inequalities (Mitchell & Popham, 2008). This is important because in Europe 1 in every 15 deaths is associated with a lack of physical activity and Public Health England estimates that 30% - 34.9% of adults aged 16 and over in Newcastle are obese.

There is a positive correlation between canopy cover and higher life expectancy and a negative correlation between canopy cover and emergency hospital admissions.

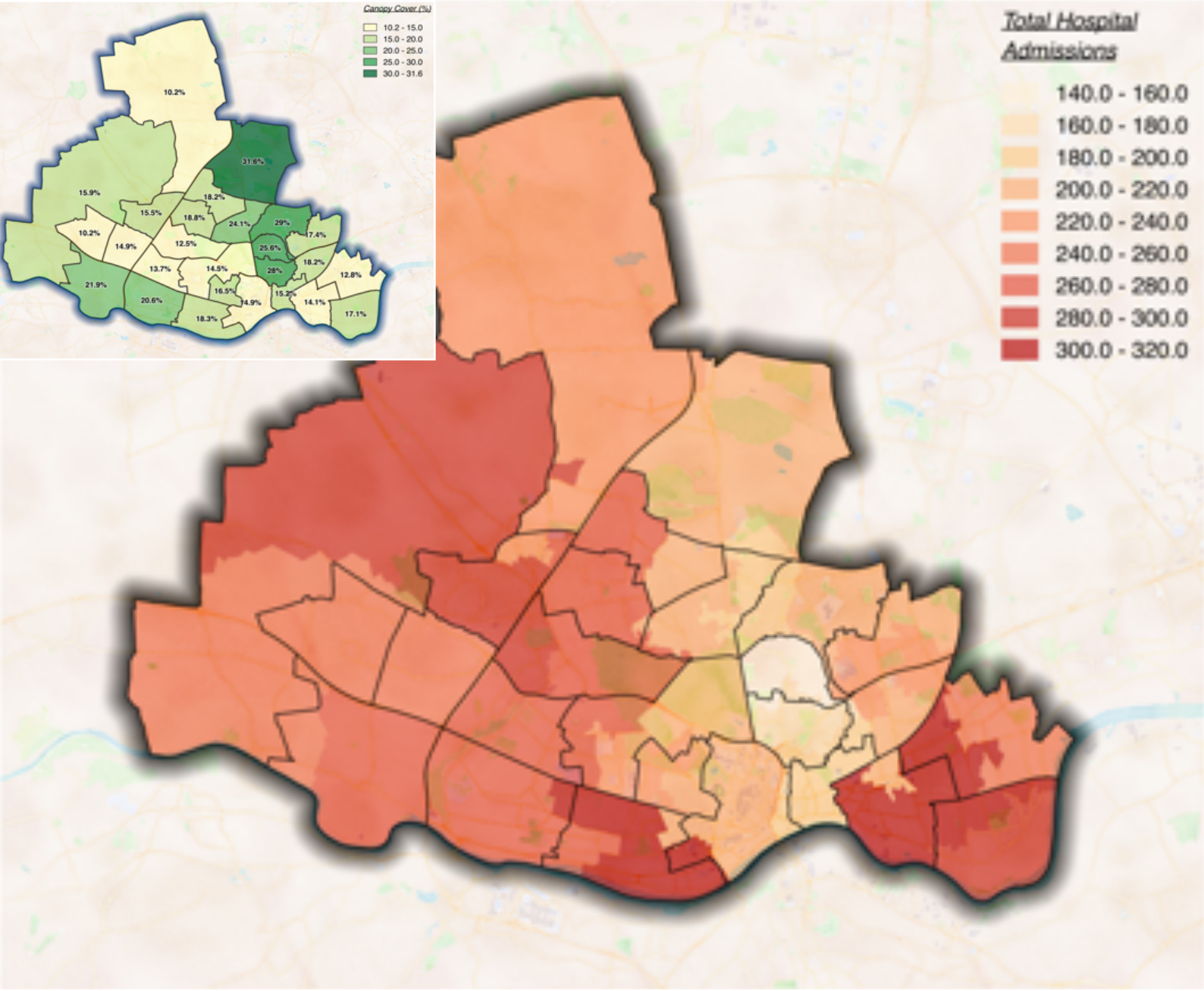


Figure 9: Total hospital admissions (emergency and elective) by MSOA area. Ward boundaries shown. (Inset: Canopy Cover by ward).

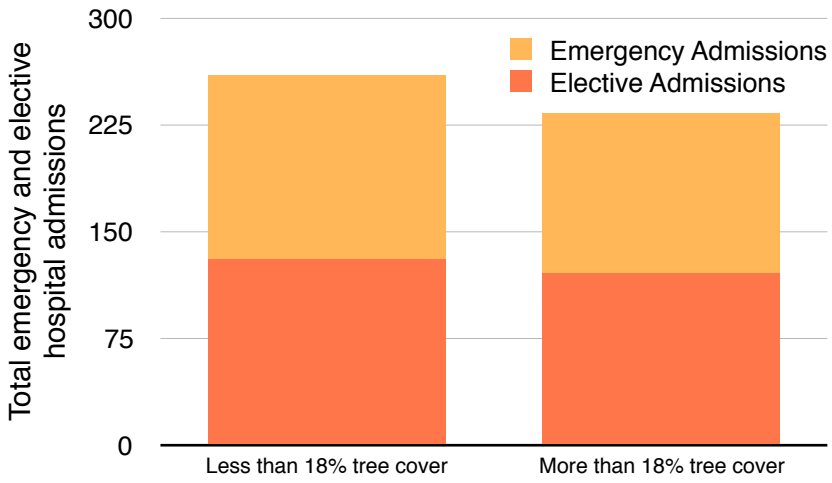


Figure 10: Hospital Admissions and average tree cover. Note that both emergency and elective admissions are included in Figure 9 above.

4.3 Index of Multiple Deprivation

Data concerning deprivation is collected at the Low Super Output Area (LSOA) scale and displayed in the following charts and figures, contrasting the Output Areas with less than 18.1% canopy cover and those with a canopy cover equal or greater than 18.1%.

The Index of Multiple Deprivation (IMD) scores relate to a proportion of the relevant population experiencing that type of deprivation.

The scores for IMD do not relate straightforwardly to the proportion of the population experiencing deprivation. For example, an area with an IMD score of 60 is not necessarily twice as deprived as an area with a score of 30. The scores are derived from the raw data, which is why the following maps don't have a common scale.

IMD combines information from seven domains to produce an overall relative measure of deprivation.

The domains are combined using the following weights:

- Income Deprivation (22.5%)
- Employment Deprivation (22.5%)
- Education, Skills and Training Deprivation (13.5%)
- Health Deprivation and Disability (13.5%)
- Crime (9.3%)
- Barriers to Housing and Services (9.3%)
- Living Environment Deprivation (9.3%)

The weights were derived from consideration of the academic literature on poverty and deprivation, as well as the levels of robustness of the indicators. Combining information from the seven domains produces an overall relative measure of deprivation, the Index of Multiple Deprivation.

The relationship between Canopy Cover and IMD is illustrated in figures 11 and 12, below.

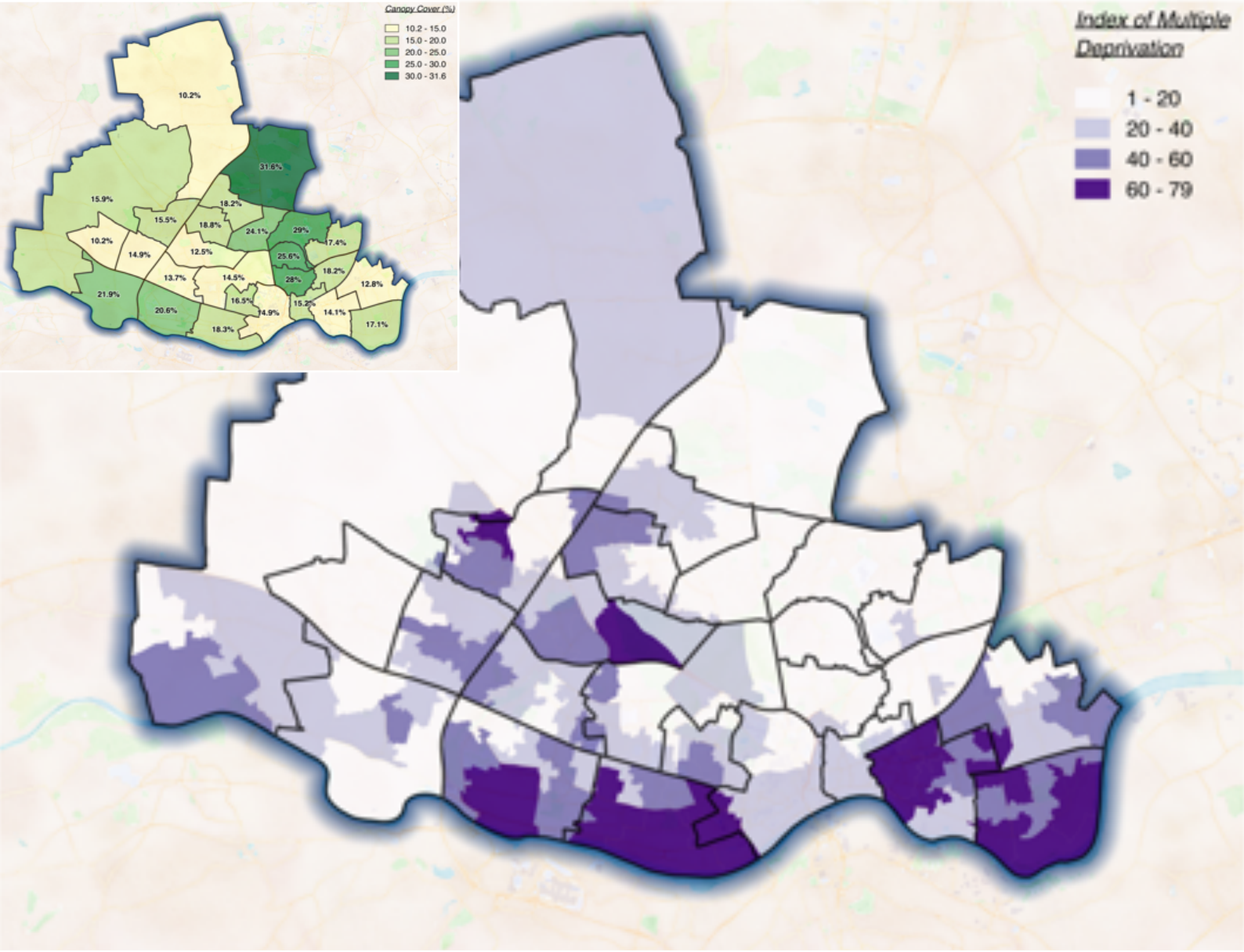


Figure 11: Index of Multiple Deprivation by LSOA area. Ward boundaries shown. (Inset: Canopy Cover by ward).

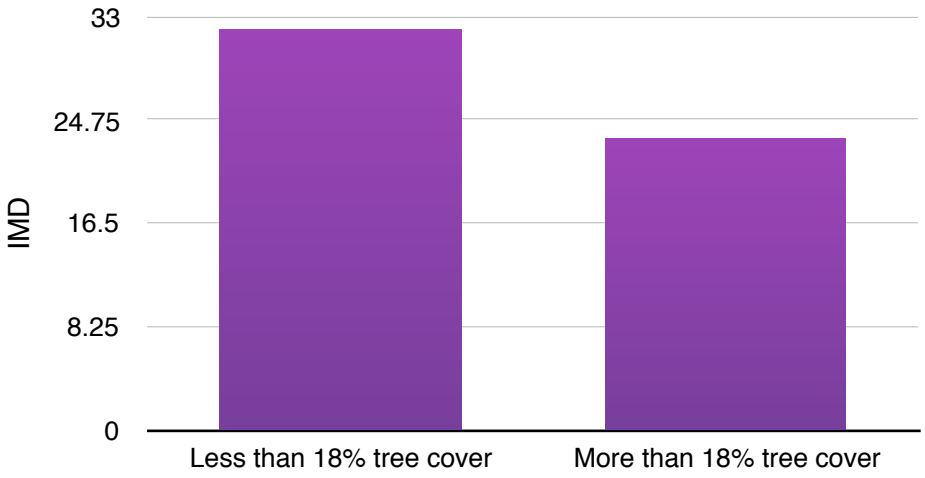


Figure 12: Index of Multiple Deprivation and average tree cover.

4.4 Crime

The crime domain measures the risk of personal and material victimisation at local level. Similar to previous indicators, tree cover in general shows a strong correlation with this indicator. Overall, the correlation is a negative one; *higher* canopy cover in Newcastle corresponds with *lower* crime rate (see figures 13 and 14, below). This conforms well with published data and previous canopy cover assessments.

The crime rate overall in Newcastle is higher than the national average when compared with similar areas (Police.UK, 2018). There is, however a wide variation between LSOA data output areas across a small spatial area.

Increasing tree cover would be one way to create safe and accessible environments, which are also visually attractive. Although poorly maintained areas can increase the perception of crime, studies in the US have demonstrated that a 10% increase in tree cover equalled a 12% reduction in crime (Troy, 2012). Furthermore, among minor crimes, there is less graffiti, vandalism, and littering in outdoor spaces with natural landscapes than in comparable spaces with little green open space (Brunson, 1999).

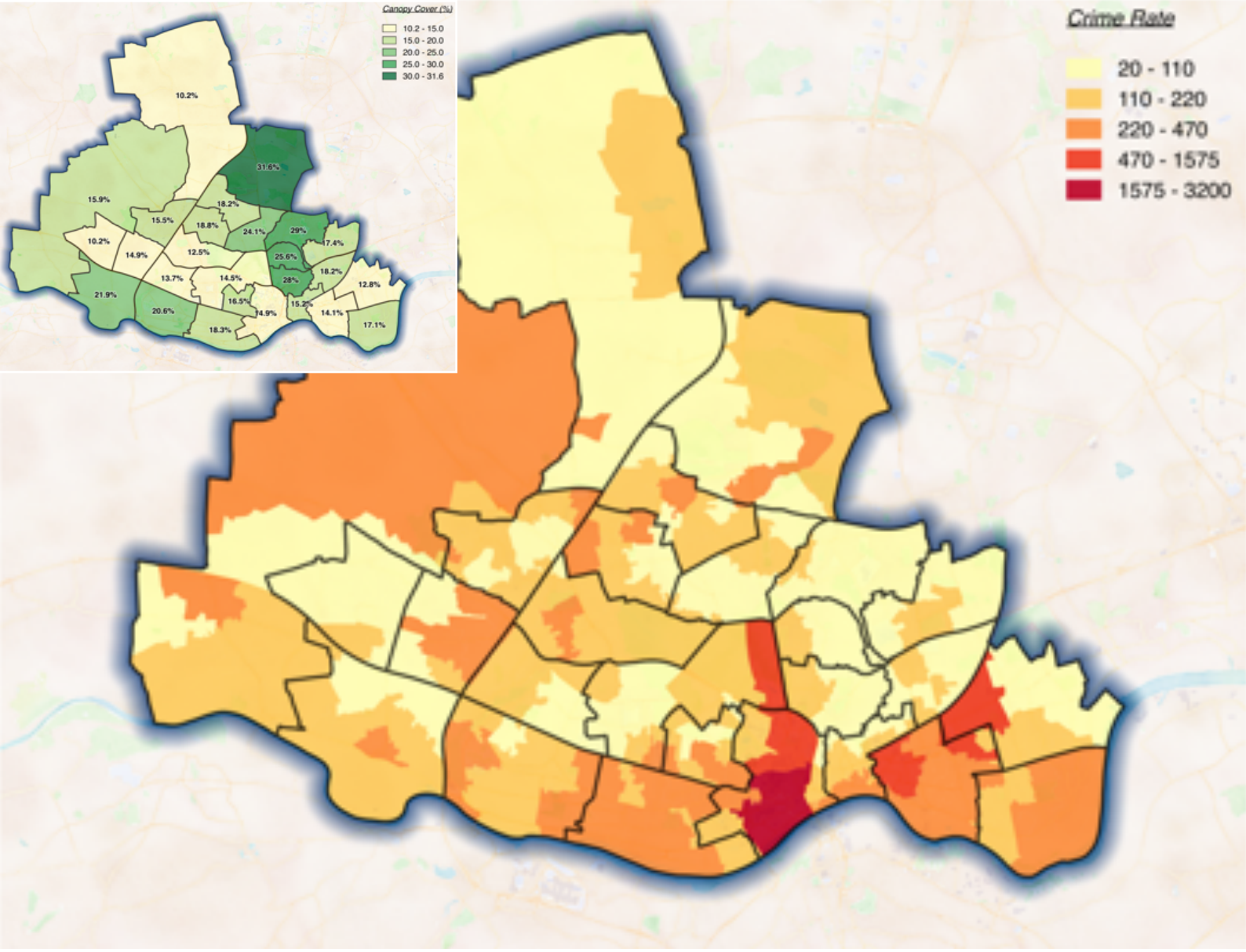


Figure 13: Crime Rate by LSOA area. Ward boundaries shown. (Inset: Canopy Cover by ward).

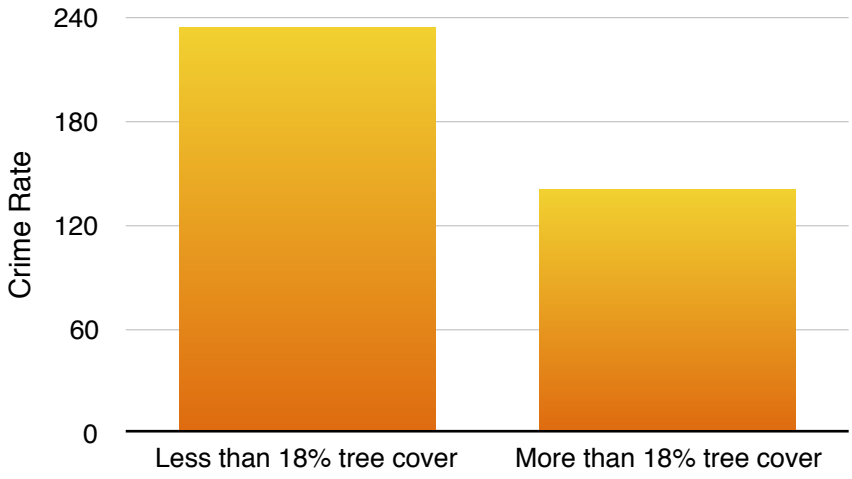


Figure 14: Crime Rate and average tree cover.

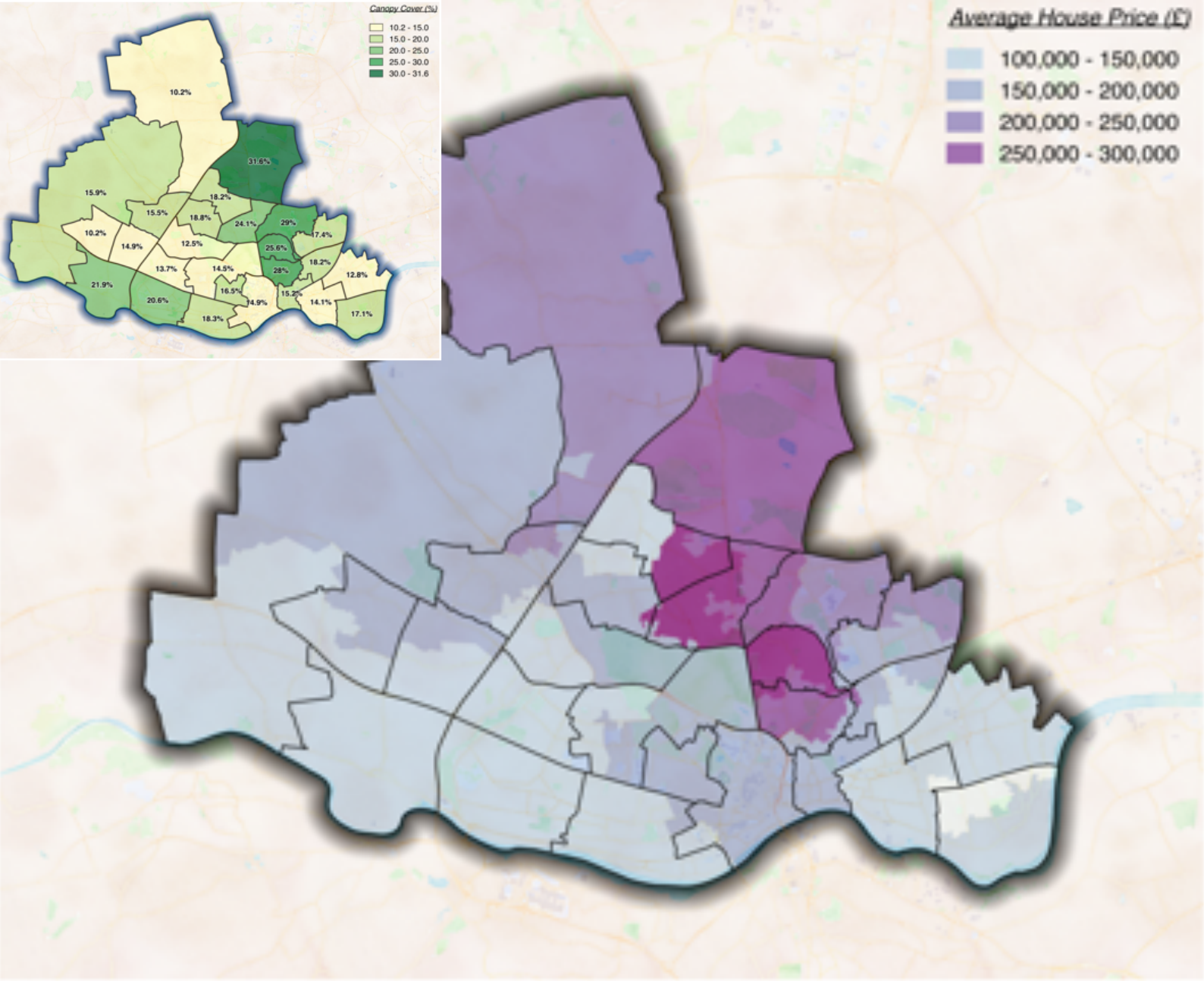


Figure 15: House Price data by MSOA area. Ward boundaries shown. (Inset: Canopy Cover by Ward).

4.5 House Prices

The house price domain reports the median price paid for residential dwellings and are calculated using Land Registry data on property transactions.

As the charts and the maps in figure 15 and 16 below, show, house prices in areas of higher canopy cover are significantly higher than those in areas of lower canopy cover.

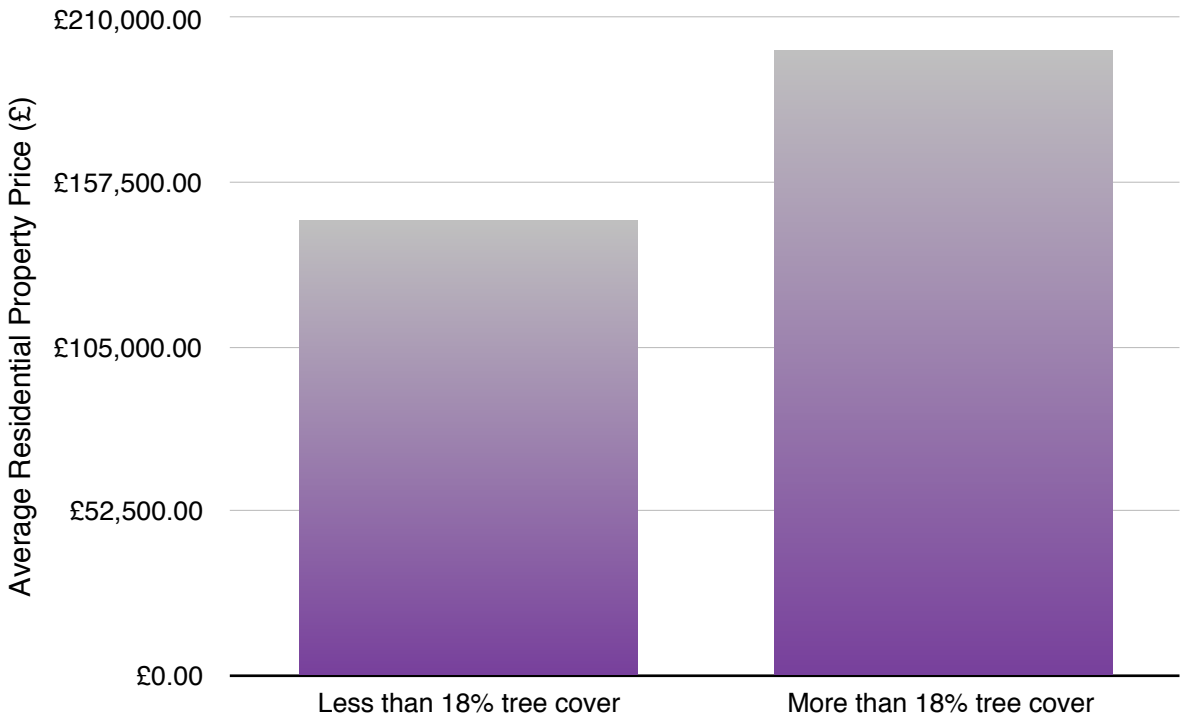


Figure 16: Average residential property price and canopy cover.

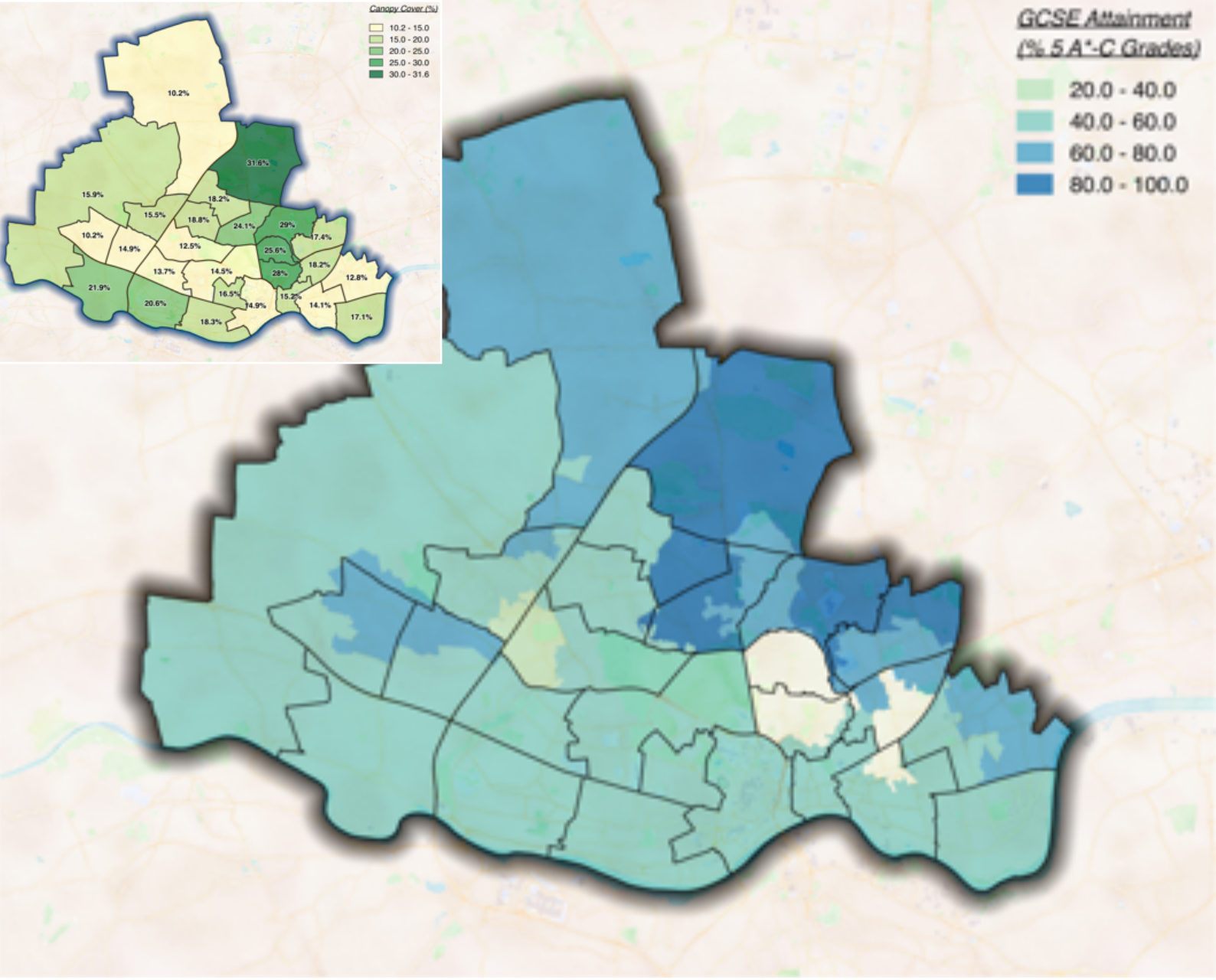


Figure 17: Educational achievement data by MSOA area. Ward boundaries shown. (Inset: Canopy Cover by Ward).

4.6 Educational Achievement

Educational Achievement is reported at the MSOA level by the ONS. The variable used in this report is the percentage of pupils achieving five A*-C at GCSE Level.

As the charts and the maps in figure 17 and 18 below show, educational achievement for pupils in areas of higher canopy cover is significantly greater than for those in areas of lower canopy cover.

Note: No data were available for three of the MSOA areas. These are shown in white on the map above.

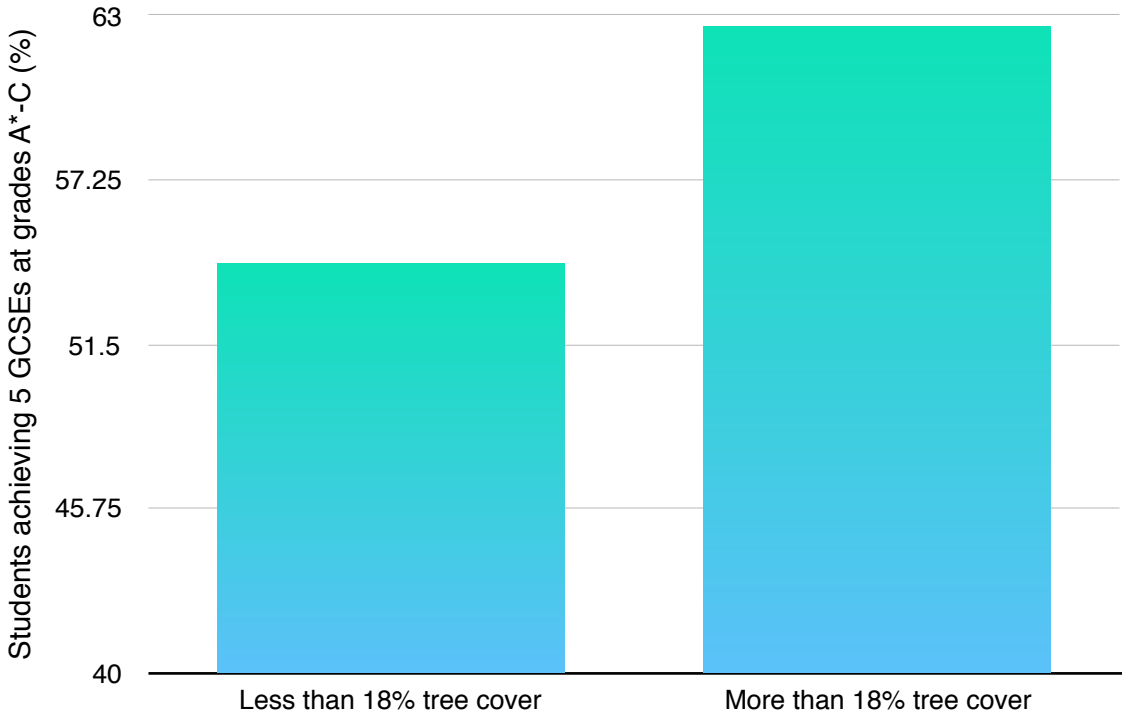


Figure 18: Number of students achieving 5 A-C GCSE grades and canopy cover.*

5. Conclusions

This preliminary study presents data on the canopy cover found in the city of Newcastle and within its smaller administrative boundaries. It also establishes a baseline which can be used to monitor future progress, or used in further research.

Primarily however, the data collected can inform where there are opportunities to increase tree cover by highlighting areas of low tree canopy cover and the available plantable space within them. Furthermore, planting could also be targeted to the areas which also are the most deprived.

This report highlights much scientific research that supports the assertion that trees provide a wide range of valuable ecosystem services. Newcastle as a whole has 18.1% tree canopy cover, but within many of the most deprived areas the canopy cover is much lower, and so too is the value of ecosystem services provided.

Increasing Tree Cover in Newcastle will provide multiple benefits to the community and should be part of the solution in creating resilient places for people to live and work.

6. Recommendations

The following recommendations have been formulated to assist Newcastle City Council to make tree management decisions on the basis of the best available information and to ensure that resources are focused to maximise the benefits trees can provide, and that they can be targeted to areas where they are most needed.

With Newcastle anticipated to grow to a population of approximately 318,000 by 2041 (ONS, 2016), planning how best to manage existing tree cover and new planting for the future is essential.

6.1 Set a Canopy Cover Target

Many towns and cities in both this country and internationally have set a canopy cover target as a strategic objective. Typically these are in the range of 20-30% (See Appendix II).

The level of ecosystem services increases as the percentage of canopy cover increases. However, it is clear that a canopy cover needs to not only be aspirational but also achievable, taking account of local geographies, land use and industrial heritage.

Decision-makers should seek to maintain rather than increase canopy cover in the wards with the highest canopy cover, whilst seeking to maximise tree planting in the most deprived areas that also lack tree canopy cover.

It is suggested that an appropriate Canopy Cover Target for Newcastle would be to achieve an average of 20% Canopy Cover by 2050.

This is a reasonable and achievable target given the timescale and available potential plantable space. However, a detailed plan to deliver this target is beyond the scope of this report.

6.2 Conduct an iTree Eco Survey

The last time there was any structured canopy survey of the trees across Newcastle was as part of the 2005 (released in 2008) Trees in Towns II study.

As there are no plans for a national Trees in Towns 3 survey at the moment an i-Tree Eco sample survey would:

1. Provide more detailed information on the structure and composition of the urban forest such as the species present, the size and age (structural diversity) and health of the trees;

2. Inform and facilitate planning of future planting and maintenance activities to ensure that current canopy levels can at least be sustained, if not improved where appropriate;

3. Quantify and estimate the £-value the benefits trees are delivering

This comprehensive understanding of the tree population within the study area will provide a basis for evidence-led, strategic planning and management of the urban forest and associated benefits, including best practices such as:

- **Strategic management of risks** – i-Tree Eco provides information on management concerns such as tree health, diversity, infrastructure conflicts and potential impact of pests such as Asian long-horned beetle, emerald ash borer, and *chalara* dieback of ash – enabling a thorough understanding of vulnerability. This can be balanced with the understanding of benefits and value i-Tree Eco also provides, thus facilitating robust decision-making.

- **Financial planning** – The value assessment i-Tree Eco provides enables adherence to asset management good practice for financial planning – allocating resource for investment based on needs and in commensurate amount to the asset value.

- **Benchmarking and monitoring** – The figures i-Tree provide are standardised, thus making it easy to carry year-on-year comparison and to benchmark with other tree populations / areas.

- **A compelling set of key facts for advocacy** – i-Tree provides the information needed to develop strong headlines and a common language on the relevance of trees, allowing to communicate more effectively and engage new audiences.

Example 1: The impact of the i-Tree findings on tree planting in London Victoria.
In London Victoria, the i-Tree Eco study highlighted the dependence of the community on the large, mature London Plane for delivery of benefits and a tree planting strategy was commissioned to seek to improve the age, size and species structure of the tree

population.

Example 2: The impact of the i-Tree findings on financial planning in Torbay.
Torbay's study revealed that the trees stored £5.1 million pounds worth of carbon and removed 50 tons of pollutants from the air every year, a service worth £1.4 million per annum. This information was crucial in making the case for trees and to secure investment for their ongoing management. In Torbay it led to an extra £25,000 to the tree planting and maintenance budget in both the year of study and in 2014.

Example 3: The impact of the i-Tree findings on public engagement in Wrexham.
In Wrexham, on the day following the release of the i-Tree Eco report and before the local authority had issued their press release, the local media got interested in the key findings and put in the limelight the value of the benefits the local trees brings to the area. Such level of interest by the local press on the positive impacts of trees had never happened before.

6.3 Produce a Plan for Trees

The Urban Forest of Newcastle is considered a unique attribute of the green infrastructure of the city with a variety of stakeholders which share an interest in its preservation and enhancement. To recognise its importance and uniqueness, the city would benefit from the preparation of a comprehensive tree strategy/urban forest masterplan for public and privately owned trees, which will:

1. Describe the nature and extent of the urban forest of Newcastle and provide a vision that is needed in the future, together with an action plan for delivery and monitoring;
2. Set individual canopy cover targets for key land uses and/or geographic areas as Key Performance Indicators which is integral to the delivery of the Local Plan;
3. Set ambitious targets for cooperative development of the Urban Forest with communities, local business, utility companies and so on;
4. Monitor canopy cover as a Key Performance Indicator for management of the urban forest;
5. Identify and prioritise action through planting and management to ensure that tree cover is maintained, sustained and improved where this is appropriate;
6. Describe the role of trees within the landscape setting of Newcastle;

7. Develop a set of principles, standards, policies and constraints relating to trees that can be used to guide the design, development, deployment and operation of services delivered by trees in the city of Newcastle.

The i-Tree Eco survey and the Plan for Trees will be essential tools to ensure trees are an integral part of the planning system as the city grows.

6.4 Use the mapping to support future planting decisions

The canopy results presented within this report could also be used in a Multi Criteria Decision Analysis (MCDA). Such an analysis would look at opportunities to increase canopy cover in the city of Newcastle. Factors such as building density (includes all artificial surfaces: roads, paths, houses, etc.), air pollution, flooding and tree canopy cover could be combined within a Geographical Information System. All these factors could then be equally weighted and combined to give an overall score. The higher the score the greater the opportunity to create woodlands and to plant trees.

At the most basic level the maps could identify areas where there is:

- a high level of deprivation;
- low canopy cover;
- room to plant more trees;

As part of this study Newcastle now has readily accessible and useable map files illustrating the tree canopy cover over the city. It is a straightforward and easily repeatable task to identify new planting areas at the ward level. This will help focus where to target resources for future tree planting.

6.5 Tree Canopy Cover and Development Viability

This report highlights much research which supports the assertion that trees provide a wide range of ecosystem services. Whilst the canopy cover for Newcastle as a whole is 18.1%, some of the more deprived areas possess much lower levels of canopy cover. Consequently, the value of ecosystem services provided by trees in these areas is much lower.

There is likely to be a limit to the level of canopy cover which would be achievable and desirable within new development. Many towns and cities in the UK have set a target for the level of canopy cover as a strategic objective. Typically these are in the range 20-30%.

A previous canopy cover study for Wycombe showed that dwelling densities of 29 - 34 / ha could be designed to accommodate projected canopy cover of 25.6 - 32%. This projection also allowed for the prevailing trend of predominantly low-rise, detached residential development. More attached housing and flatted development, for example, would allow for more communal space with increased canopy cover without sacrificing total dwelling footprint size.

Many factors will combine to influence the delivery of a desired level of future canopy cover in a development. These include:

1. Level of existing canopy cover (i.e. retention of existing trees)
    - Guidance and legislation (e.g. BS 5837: 2012 Trees in relation to design, demolition and construction - Recommendations; Town and Country Planning Act 1990 (as amended))
2. Requirements from new tree planting (i.e. mature tree canopy projection)
    - Number, size and crown shape of trees
    - Soil requirements (quality and quantity)
3. Estimated time to achieve canopy cover target
4. Design of layout to accommodate future growth
5. Success in establishing trees and achieving longevity in the landscape. (BS 8545)

Incorporating these factors into the urban forest masterplan/strategy would help to engage a variety of stakeholders, including across the departments of the planning authority. This is key to incorporating canopy cover targets into the design process of new development.

Appendix I. i-Tree Canopy Technical Notes

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

There are three steps to this analysis:

1. Import a file that delimits the boundary of your area of analysis (e.g., city boundary). Some standard boundary files for the US can be located on the US Census website. Data from these sites will require some minor processing in GIS software to select and export a specific boundary area polygon.
2. Name the cover classes you want to classify (e.g. tree, grass, building). Tree and Non-Tree are the default classes given, but can be easily changed.
3. Start classifying each point: points will be located randomly within your boundary file. For each point, the user selects from a dropdown list the class from step 2 that the point falls upon.

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

Credits

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

Limitations

The accuracy of the analysis depends upon the ability of the user to correctly classify each point into its correct class. Thus the classes that are chosen for analysis must be able to be interpreted from an aerial image. As the number of points increase, the

precision of the estimate will increase as the standard error of the estimate will decrease. If too few points are classified, the standard error will be too high to have any real certainty of the estimate. Information on calculating standard errors can be found below. Another limitation of this process is that the Google imagery may be difficult to interpret in all areas due to relatively poor image resolution (e.g., image pixel size), environmental factors, or poor image quality.

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

In photo-interpretation, randomly selected points are laid over aerial imagery and an interpreter classifies each point into a cover class (e.g., tree, building, water). From this classification of points, a statistical estimate of the amount or percent cover in each cover class can be calculated along with an estimate of uncertainty of the estimate (standard error (SE)). To illustrate how this is done, let us assume 1,000 points have been interpreted and classified within a city as either “tree” or “non-tree” as a means to ascertain the tree cover within that city, and 330 points were classified as “tree”.

To calculate the percent tree cover and SE, let:

N = total number of sampled plots (i.e. 1000)
n = total number of points classified as tree (i.e. 330), and
p = n/N (i.e. 330/1000 = 0.33)
q = 1 - p (i.e. 1 - 0.33 = 0.67)
SE = $\sqrt{(pq/N)}$ (i.e. $\sqrt{(0.33 \times 0.67/1000)} = 0.0149$)

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

Confidence Interval

In the case above, a 95% confidence interval can be calculated. “Under simple random sampling, a 95% confidence interval procedure has the interpretation that for 95% of the possible samples of size n, the interval covers the true value of the population mean” (Thompson 2002). The 95% confidence interval for the above example is between 30.1% and 35.9%. To calculate a 95% confidence interval (if N>=30) the SE x 1.96 (i.e.,

0.0149 x 1.96 = 0.029) is added to and subtracted from the estimate (i.e., 0.33) to obtain the confidence interval.

SE if n < 10

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

SE = (√n) / N

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

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Appendix II

Comparison with other UK towns and cities

Although a number of towns in the UK have identified the importance of green infrastructure, many councils fall short of attributing appropriate resources to increasing canopy cover and thus improving the quality of life of their residents and the urban fabric's resilience to climate change and deteriorating air quality. Where additional funding is provided for urban trees, inventories and datasets are more complete and up to date, and as a result, tree planting and management strategies are more comprehensive.

City	Area (ha)	Population	Canopy Cover (%)	Canopy Cover Goal	Potential Plantable Space
Crawley	4,495	108,971	25.1	-	-
Wycombe District	32,457	174,878	25	25	-
Birmingham	598,900	1,092,330	23	-	-
Sidmouth	4,300	12,570	23	-	60
Exeter	4,703	117,773	23	-	-
London	157,200	8,400,000	21.9	30	29
Worcester	3,328	98,768	21.9	-	-
Oxford	4,559	155,000	21.4	-	-
Dudley	9,795	312,925	20.5	-	-
Southampton	7,280	253,651	20.4	-	-
Plymouth	7,984	260,200	18.5	20	-
Newcastle	11,540	268,064	18.1	-	-
Walsall	10,395	269,323	17.3	-	-
Cambridge	11,560	123,900	17.1	-	-
Edinburgh	26,400	487,500	17	-	-
Wrexham	3,833	61,603	17	-	28
Eastbourne	4,416	99,412	15.9	-	-
Manchester	63,030	514,417	15.5	-	-
Glasgow	17,550	596,550	15	-	32
Portsmouth	4,028	205,400	14.7	-	-
Bristol	11,000	432,500	14	30	-
Telford	7,803	170,300	12.5	-	-
Torbay	6,375	134,000	12	20	8

Table A-1: Table comparing Urban Forest data and goals between towns and cities

Appendix III

Trees in the National Policy Planning Framework

The National Planning Policy Framework (NPPF) only mentions trees in the context of *'aged or veteran trees'* in paragraph 118. However, trees and urban tree cover are implicitly linked to other key concepts that are emphasised and highlighted within the framework.

Sustainability, ecosystem services and green infrastructure are all dependent on the significant contribution that trees in the urban forest make.

The ministerial foreword to the NPPF is particularly relevant:
"Sustainable means ensuring that better lives for ourselves doesn't mean worse lives for future generations."
"Our natural environment is essential to our wellbeing, and it can be better looked after than it has been."
"Our standards of design can be so much higher."
"Planning must be a creative exercise in finding ways to enhance and improve the places in which we live our lives."

Of the 13 sections in the NPPF trees are able to contribute to meeting the objectives of 11 of them.

Trees, and the benefits which they provide are crucial to securing economic, social and environmental sustainable development - NPPF Introduction (Paragraph 7). Trees also contribute to positive improvements in the quality of built and natural environment (Paragraph 9).

Increased tree cover can increase economic growth (Rolls and Sunderland, 2014) and prosperity (Wolf, 2005) as leafier environments improve consumer spending. Additionally, businesses are prepared to pay greater ground rents (Laverne &. Winson_Geideman, 2003), also associated with higher paid earners who are also more productive (Kaplan, 1993; Wolf, 1998), house prices increase, and crime is reduced thereby (Wolf (2007), Kuo & Sullivan 2001a, 2001b). This accords with NPPF (Section 1) *"Building a strong, competitive economy"* (paragraph 18).

This is also directly linked to (Section 2) *"Ensuring the vitality of town centres"*. Furthermore, trees also contribute to (Section 3) "Supporting a prosperous rural economy", through the provision of non woody forest products, wood fuel and timber. Trees also improve journey quality (Davies et al., 2014) (Section 4) "Promoting sustainable transport" and can encourage use of alternative transport corridors such as pavements and cycleways (Trees and Design Action Group, 2014). Additionally, trees near road networks absorb pollution and airborne particulates (Escobedo and Nowak, 2009), reduce noise (Van Renterghem, 2014; Van Renterghem et al., 2012) and lower traffic speeds (Mok et al., 2003) (paragraphs 34,35,37,38).

Trees improve property prices thereby contributing to (Section 6) *"Delivering a wide choice of high quality homes"* providing a positive contribution to good design (Section 7) *"Requiring good design"* by positively making places better for people (paragraphs 56, 57).Trees not only contribute to 'attractive' and 'comfortable' streetscapes (or tree-scapes) but also are an asset which appreciates, delivering even greater benefits as they grow, adding to the quality of the area in over and above the lifetime of the development (paragraphs 58, 63). They are essential to the 'incorporation of green and other public space' and the 'Integration of new development into the natural, built and historic environment' (paragraph 61). Increases in tree cover have even been shown to reduce crime[24] therefore helping to *'create safe and accessible environments'* (paragraph 69), which are also 'visually attractive' (paragraphs 58, 59).

Trees *"Promote healthy environments"* (Section 8). There is a growing body of research that shows people are happier in leafier environments: hospital recovery times (Ulrich, 1984) and stress (Korpela et al., 2008; Hauru et al., 2012) are reduced and birth weights are increased (Donovan et al., 2011), meaning fewer health issues later in life (paragraph 69). Conversely, when tree cover is reduced asthma rates and respiratory problems often increase. Trees thereby promote healthy communities. They also provide a cultural link to the wider environment (paragraph 70) and act as a focal point for shared space and can frame high quality open space (paragraph 73).

In *"Protecting Greenbelt"* (Section 9) trees are also key to enhancing biodiversity by providing habitat (paragraph 81) and places of recreation (paragraph 92). Trees are fundamental to strategies which aim to help *"Meet the challenge of climate change, and flooding"* (Section 10). Trees reduce stormwater runoff by attenuating precipitation in their

canopies (Thomas and Nisbet, 2007; Nisbet and Thomas, 2006) and also reduce peak summer temperatures. temperatures in both the urban and wider environment by several degrees (Doick and Hutchings, 2012), thereby 'minimising vulnerability and providing resilience to the impacts of climate change, and supporting the delivery of renewable and low carbon energy and associated infrastructure' (paragraph 93).

Additionally, *"local planning authorities should adopt proactive strategies to mitigate and adapt to climate change, taking full account of flood risk, coastal change and water supply and demand considerations (98). The plans should also take account of climate change over the longer term, including factors such as flood risk, coastal change, water supply and changes to biodiversity and landscape"* (99).

New development should be planned to avoid increased vulnerability to the range of impacts arising from climate change. When new development is brought forward in areas which are vulnerable, care should be taken to ensure that risks can be managed through suitable adaptation measures, including through the planning of green infrastructure (GI) - this means trees, often the single largest component of GI.

Perhaps most commonly understood are trees' ability to *"Conserve and enhance the natural environment"* (Section 11). Specifically, in Paragraph 114 of the NPPF it states that local planning authorities should *"set out a strategic approach in their Local Plans, planning positively for the creation, protection, enhancement and management of networks of biodiversity and green infrastructure"*. A key reason for using tree canopy cover as a tool to maintain and enhance tree cover across Newcastle and within individual developments, is that if offers a means by which improvements and *"opportunities to incorporate biodiversity in and around developments should be encouraged (118)"*; it can also be monitored and measured (Paragraph 113,114). This is because you simply cannot manage what you have not measured (117).
As well as providing economic benefit, previously planted trees provide a cultural link to the past (Section 12) *"Conserving and enhancing the historic environment"* and protecting and enhancing valued landscapes (Paragraphs 109, 126, 128).

The Government attaches great importance to the design of the built environment. Trees make a significant contribution to good design and good design is a key aspect of sustainable development, is indivisible from good planning, and should contribute positively to making places better for people.

Regardless of any other 'external drivers', under the current legislation (TCPA Act 1990), LPAs have a statutory duty to consider the protection and planting of trees when granting planning permission for proposed development. The potential effect of development on trees, whether statutorily protected (e.g. by a tree preservation order or by their inclusion within a conservation area) or not, is a material consideration that must be taken into account when considering planning applications. In order to exercise that duty adequately, LPAs need to have an understanding of the existing tree resource so that they can make an informed judgement about what might be needed/appropriate, in terms of tree impact, from developments.

Other national drivers

The 'Government Forestry and Woodlands Policy Statement' (Defra, 2013) is the latest government statement which covers trees. In the Ministerial Foreword, the Executive Summary, Section 7 *'Expanding Our Woodland Resource'* and recommendations 6 and 16, it makes it clear that *'We want to see more trees and woodlands in and around our towns and cities.'*

Appendix IV

Summary of Ecosystem Services Provided by Trees

Provisioning services

Food provision

Urban forests are regarded primarily as service providers rather than as sources of goods, however, trees and woodlands provide humans with food resources both directly (e.g. fruits, berries and nuts that are produced by the trees themselves) and indirectly (e.g. mushrooms and deer that reside in woodland habitats).

Fuel provision (woodfuel)

Woody biomass is the accumulated mass, above and below ground, of the roots, wood, bark, and leaves of living and dead trees and woody shrubs. Through the processes of harvesting and combustion, woody biomass can be used as a source of heat, electricity, biofuel and biochemicals.

Wood provision

Trees can provide timber for construction, veneers and flooring, as well as wood chip and pulp for boards and paper.

Habitat provision

Trees provide unique ecological niches for a variety of wildlife. This in turn adds to the biodiversity of the local environment and increases the enjoyment and attractiveness of an area for locals and visitors alike, thus increasing economic opportunities.

Regulating services

Carbon sequestration and storage

Trees act as a sink for carbon dioxide (CO_2) by fixing carbon during photosynthesis and storing excess carbon as biomass. CO_2 sequestration refers to the annual rate of CO_2 storage in above- and below-ground biomass. Increasing the number of trees can therefore slow the accumulation of atmospheric carbon, a contributor to climate change.

Temperature regulation

Trees are not only good reflectors of short-wave radiation, but their canopies also shade low albedo surfaces that would otherwise absorb such radiation, reducing surface temperatures and convective heat. Trees also reduce warming of the local environment through the process of evapo-transpiration where the evaporation of water from leaf surfaces, solar energy is converted into latent rather than sensible heat, thus ‘cooling’ the surrounding air and improving human thermal comfort.

Stormwater regulation

Urban trees and woodlands regulate stormwater by intercepting and storing rainfall on their leaves, which either subsequently evaporates, or reaches the groundwater more slowly through gradual release as through-fall. Trees also improve infiltration into the soil by channelling water onto pervious surfaces around the trunk, and through the soil along root channels.

Air purification

Trees remove air pollutants from the atmosphere mainly through dry deposition, a mechanism by which gaseous and particulate pollutants are captured and transported to plants that absorb them through their leaves, branches and stems.

Noise mitigation

Urban areas can be a source of unwanted sound, for example road noise. Trees can mitigate ur- ban noise through the scattering and absorption of (typically mid to high frequency) sound waves by the leaves, branches and trunks, thus obstructing the pathway between the noise and the receiver.

Cultural services

Health

By providing a setting where the activities can take place, the urban forest can support physical activities such as walking, running and cycling, and relaxing activities such as bird watching, reading or having a picnic; thus encouraging physical well-being, mental restoration, escape and freedom, and enjoyment and fun.

Nature / landscape connections

Benefits arise from visual aspects of an ecosystem, e.g. trees and woodland can obscure unsightly structures, as well as other senses such as the smell of honeysuckle or the sound of birdsong. People can gain a sense of place from their local or favourite

woodland, whilst physical interactions with trees such as fruit picking or conservation volunteering can add to feelings of connection with nature.

Social development and connections

Activities undertaken within woodlands and parks can strengthen existing social relationships, while organised activities within treed environments can create the opportunity for new relationships, including people's involvement with volunteer groups and community forests (known as social capital).

Education and learning

This category includes personal development for people of all ages, gained through informal learning, such as parents teaching their children tree names or where wood and paper comes from, and formal education via approaches such as Forest School (O'Brien, 2009). Learning can also take place through activities such as volunteering, apprenticeships, and play for children.

Economy and cultural significance

The urban forest can contribute to the economy by encouraging inward investment, boosting tourism, providing a setting for recreation industries such as climbing and paint-balling, and by enabling environmental cost savings (EFTEC, 2013). The urban forest can also contribute directly to the economy through the generation of new employment, such as arboricultural consultants and tree surgeons, and to a lesser extent, through the provision of food, fuel or wood products.

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