



Canopy Cover Assessment & Recommendations for Wycombe District

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Executive summary

This study estimates tree canopy cover in Wycombe District using the Bluesky National Tree Map dataset (Appendix 1). Estimates of canopy cover for each ward, as well as the district total were calculated. The results provide a snapshot of the current tree canopy cover (Figure 28) and a baseline for comparison with future surveys.

The study also compared other 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, house prices, social deprivation and life expectancy) to observe if there was any correlation with tree canopy cover.

The canopy cover of Wycombe District is estimated at 25 percent and the canopy cover of the main urban areas within the district is as follows.

Urban Area	% Canopy Coverage
Princes Risborough	13.7%
Stokenchurch	16.8%
Walter's Ash/Naphill	21.0%
Speen	26.6%
Green End	17.3%
Bledlow Ridge	18.7%
Loosley Row	16.0%
Longwick	10.8%
Lane End	12.4%
Marlow	18.4%
Medmenham	25.9%
High Wycombe Urban Area(Bourne End/Flackwell Heath, Great Kingshill, Hazlemere/Tylers Green and High Wycombe)	19.4%
Hazlemere/Tylers Green	24.9%
High Wycombe	18.2%
Bourne End/Flackwell Heath	19.5%
Great Kingshill	17.6%
Hughenden Valley	18.3%

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1 Introduction

1.1 Background

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

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

Canopy cover assessments help to observe change over time at a relatively low cost in comparison to ground 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.

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

Canopy cover, which is often also referred to as tree canopy cover, urban tree cover and urban canopy cover, can be defined as the area of leaves, branches, and stems of trees covering the ground when viewed from above. Canopy cover is a two dimensional metric, indicating the spread of canopy cover across an area. It is not to be confused with leaf area index (LAI), which is a measure of the number of layers of leaves per unit area of ground (although canopy cover studies can be used to estimate LAI).

1.2 Objectives

This report aims to provide a snapshot of Wycombe District’s canopy cover, to enable its protection and enhancement in the future. The “what gets measured gets managed” adage indeed applies to the urban forest. By providing a baseline for Wycombe District’s canopy cover, this report paves the way for evidence-based planting and protection strategies by enabling the setting of measurable targets.

Furthermore, the study wanted to find out if there were correlations between tree canopy cover and human health and wellbeing by comparing with geographically explicit available data from the ONS and other sources.

The data presented here will hopefully inform tree policies and strategies, so that the residents and visitors of Wycombe District can continue to enjoy the benefits of urban trees and so the district can build resilience to climate change. A key area where this information is particularly relevant is in planning and development; this document has been written with a particular emphasis on informing local planning policy.

1.3 Policy drivers

1.3.1 National policy drivers

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 as leafier environments improve consumer spending¹. Additionally, businesses are prepared to pay greater ground rents², also associated with higher paid earners who are also more productive (Kaplan, 1993; Wolf, 1998), house prices increase³, and crime is reduced⁴ thereby (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

¹ Shoppers claim that they will spend 9% to 12% more for goods and services in central business districts having high quality tree canopy (Wolf, 2005).

² 7% higher rental rates are achievable for commercial offices having high quality treescapes (Laverne and Winson-Geideman, 2003).

³ The presence of larger trees in gardens and as street trees adds from 3% to 15% to home values (Wolf, 2007).

⁴ Public housing residents with nearby trees and natural landscapes reported 25% fewer acts of domestic aggression and violence (Kuo and Sullivan, 2001a). Public housing buildings with greater amounts of vegetation had 52% fewer total crimes, 48% fewer property crimes, and 56% fewer violent crimes than buildings with low amounts of vegetation (Kuo and Sullivan, 2001b).

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 crime⁵ therefore helping to 'create safe and accessible environments' (paragraph 69), which are also 'visually attractive' (paragraphs 58, 59).

Trees (Section 8) "Promote healthy environments". 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 communities⁶. 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 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 Section 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 over Wycombe District and within individual developments, is that it 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), LPAs have a statutory duty to consider the protection and planting of trees when granting planning permission for proposed development. The

⁵ A 10% increase in trees roughly equals a 12% decrease in crime (Troy, 2012).

⁶ See <http://depts.washington.edu/hhwb/> for international peer reviewed research on this topic.

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.

1.3.2 Other national drivers

The 'Government Forestry and Woodlands Policy Statement'⁷ 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.'

1.3.3 Local policy drivers

The NPPF has Sustainable development at its heart. Setting this national standard within local planning policy is supported by paragraph 152 of the NPPF.

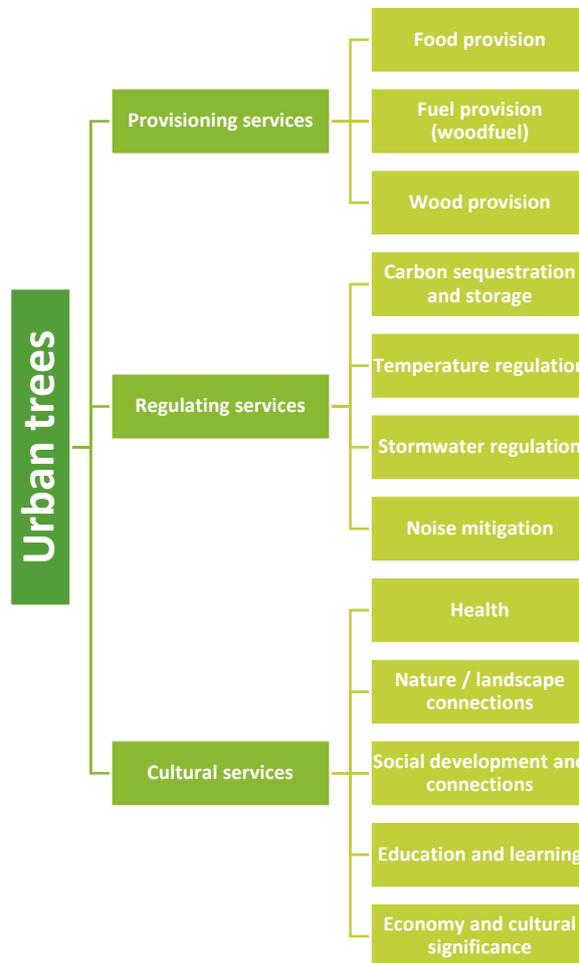
In the context of local planning policy, Wycombe District Council have historically had policies which aim to secure the protection of trees, wildlife and green infrastructure, ensure good quality landscaping, and design. The new production of a new Local Plan which is currently being written, has offered the opportunity to include policies which are more proactive in the requirement for more, bigger and better green infrastructure, including trees.

In line with the National Planning Policy Framework, Wycombe District Council is producing new planning policies which set the local context for making planning decisions and will influence the way in which the district develops economically, socially and environmentally. Trees provide a large number of benefits wherever they are found and as such they form a central role in the delivery of Green Infrastructure benefits. In new developments it is important to both retain existing trees which are of a suitable quality and also incorporate new trees which can grow successfully to provide the new urban forest. The aspiration to achieve a good level of tree canopy cover can only be ensured through planning policies which require a quantifiable level of canopy cover. This document is evidence which supports a canopy cover policy for new developments.

⁷ https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/221023/pb13871-forestry-policy-statement.pdf

2 Background to the role of trees in cities

Green infrastructure can deliver significant benefits to urban areas. Trees in particular can provide a wide range of benefits (or ecosystem services) such as storing carbon, reducing the urban heat island effect and improving air quality. Understanding the value of the Wycombe District's green infrastructure can inform decisions that will improve human health and environmental quality. The following summary of ecosystem services provided by urban trees is taken from Davies et al. (2016) which should be referred to for more detailed information on each service.



2.1 Provisioning services

2.1.1 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).

2.1.2 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.

2.1.3 Wood provision

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

2.2 Regulating services

2.2.1 Carbon sequestration and storage

Trees act as a sink for carbon dioxide (CO₂) by fixing carbon during photosynthesis and storing excess carbon as biomass. CO₂ sequestration refers to the annual rate of CO₂ 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.

2.2.2 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 evapotranspiration 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.

2.2.3 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 throughfall. Trees also improve infiltration into the soil by channelling water onto pervious surfaces around the trunk, and through the soil along root channels.

2.2.4 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.

2.2.5 Noise mitigation

Urban areas can be a source of unwanted sound, for example road noise. Trees can mitigate urban 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.

2.3 Cultural services

2.3.1 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.

2.3.2 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.

2.3.3 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).

2.3.4 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.

2.3.5 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 paintballing, 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.

3 Data analysis

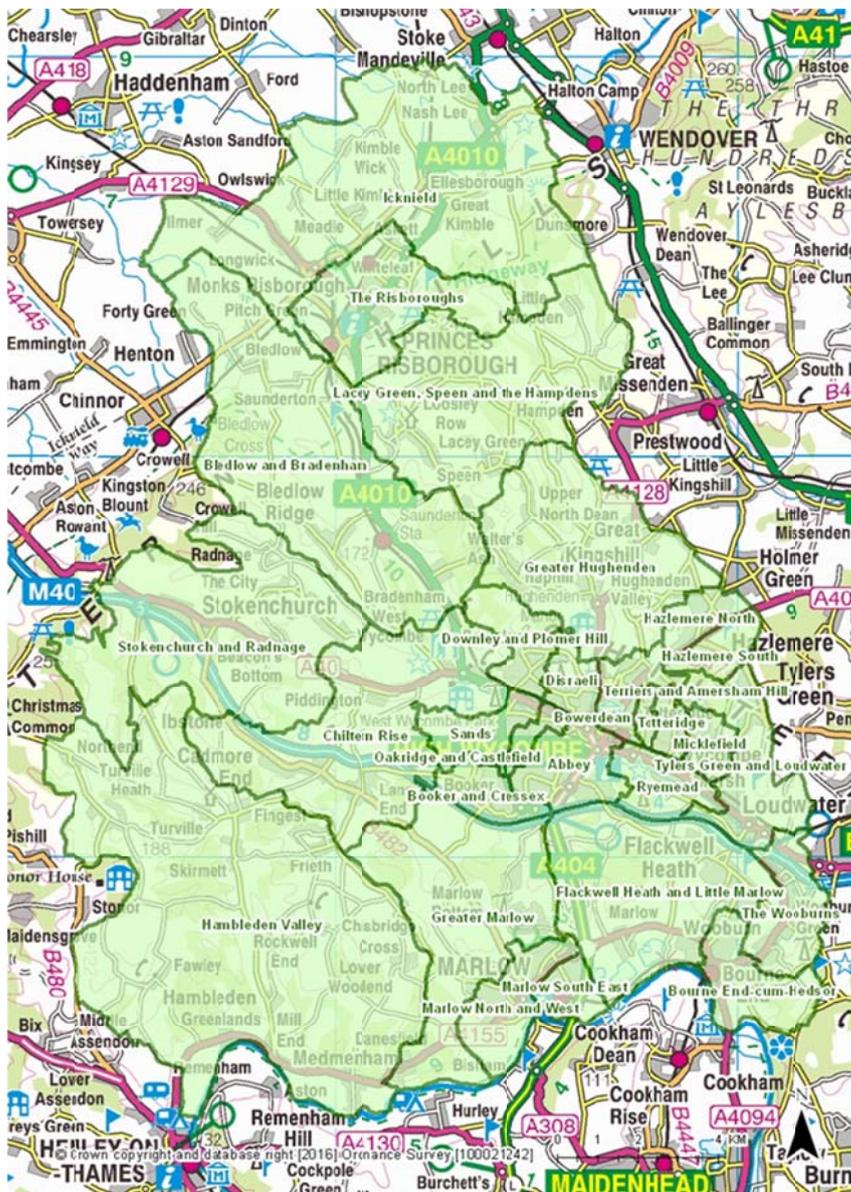
3.1 Methodology

Bluesky National Tree Map was used to interpret aerial images across Wycombe District. The overall picture was built up by analysing the 28 wards (see figure 1) that make up Wycombe District. Additional administrative boundaries were used in the study to match the level at which the statistics were published. The amount of canopy in each area was calculated on a pro rata basis, i.e. where an individual tree has canopy in two administrative boundaries that canopy is assigned to the boundary into which it falls. This analysis allowed direct comparison with the published statistics. Where statistics were aggregated, statistics were calculated by area on a pro rata basis. All analysis was completed using ArcGIS 10.2 for desktop.

Figure 1: Wycombe District wards

The point locations of each tree in the ProximiTREE dataset allowed each individual tree to be assigned a ward, a lower layer super output area (LSOA) and a middle layer super output area (MSOA), allowing for comparing canopy cover with other statistics.

More information about the Bluesky National Tree Map can be found in Appendix 1.



3.2 Datasets used in the analysis

Data was collected from a range of sources to use in the comparative analysis with canopy cover. Not all of these datasets contributed to the results that follow.

Use	Description	Source
Canopy cover	National Tree Map	Bluesky
Boundary	Ward boundary	OS Boundary Line Data
Boundary	Parish boundary	OS Boundary Line Data
Boundary	Postcode areas	OS Boundary Line Data
Boundary	Lower Super Output Areas (LSOA) boundary	Census 2011 - Lower Super Output Areas (LSOA)
Boundary	Middle Super Output Areas (MSOA) boundary	Census 2011 - Middle Super Output Areas (MSOA)
Boundary	Urban areas	Census 2001
Boundary	Wycombe's conservation areas	Wycombe District Council
Boundary	Wycombe's grass cutting areas	Wycombe District Council
Boundary	Land Owned by Red Kite	Wycombe District Council
Boundary	land owned by Wycombe District Council	Wycombe District Council
Boundary	Wycombe's openspaces areas	Wycombe District Council
Boundary	Wycombe's town centres	Wycombe District Council
Land Use	OS Master Map	Ordnance Survey
Statistics	Police Crime data	data.police.uk
Statistics	Index of Multiple Deprivation	Index of Multiple Deprivation
Statistics	Neighbourhood statistics in England: academic year 2013 to 2014	Office for National Statistics
Statistics	House Price Statistics for Small Areas (1995–2013)	Office for National Statistics
Statistics	Subnational Health Expectancies	Office for National Statistics
Statistics	NHS health statistics	Public Health England

3.3 Results

The average canopy cover across Wycombe District was estimated at 25%⁸. However, this value ranges from 9% in the Oakridge and Castlefield ward (to the west of the town centre) to 41% in the Downley and Plomer Hill ward, a largely residential ward to the north-east of High Wycombe (figure 2). Some of the areas studied have a high percentage of their tree cover located with openspace and woodland, it was uncertain how this might affect the findings and so in some instances analysis has been repeated with the openspace and woodland removed.

Figure 2: Canopy cover by ward

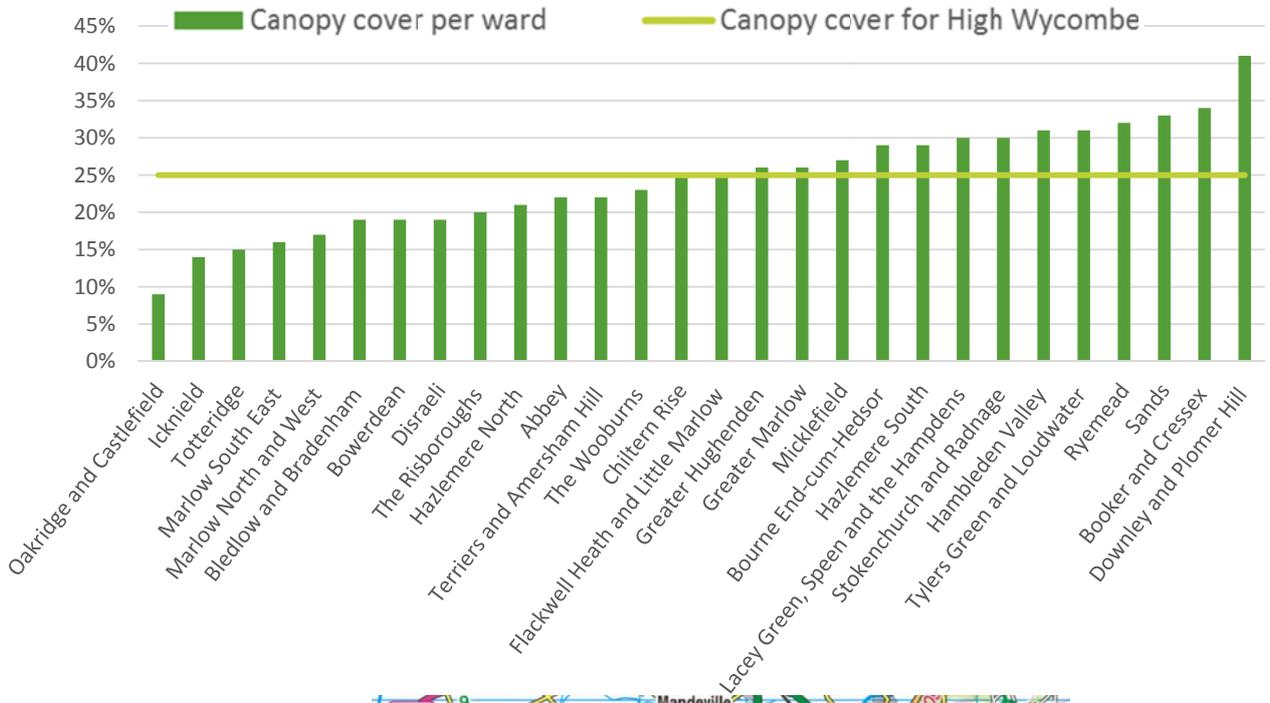
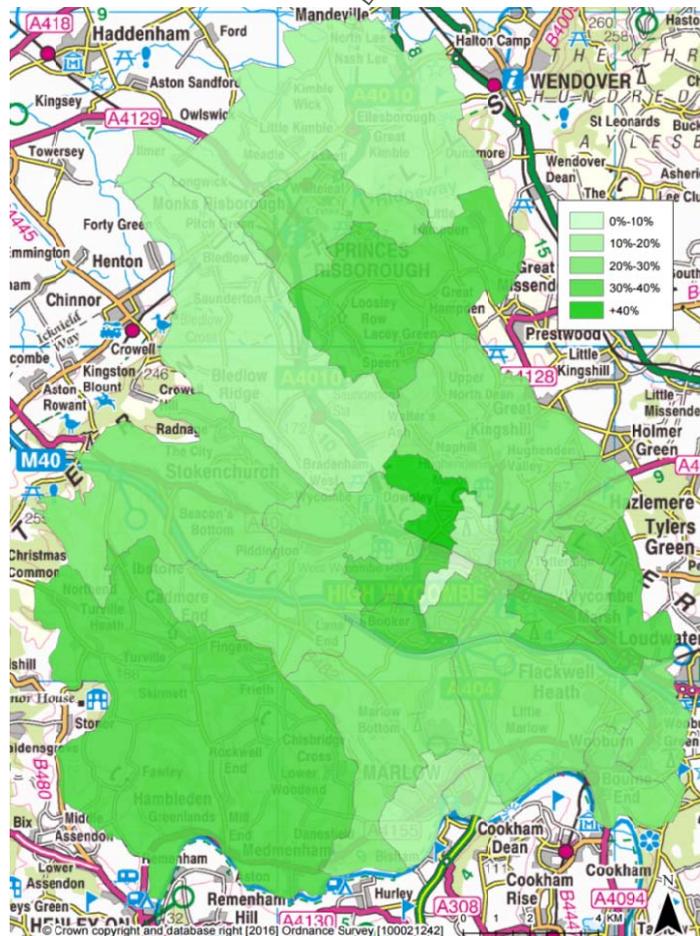


Figure 3: Map of canopy cover by ward



⁸ For comparisons with other UK cities, see Appendix 2

4 Interpretation of the results: correlations observed in Wycombe District

This section compares canopy cover with various quality of life indicators for Wycombe District. These are shown for the smallest geographical level that the data is produced at, in this case Middle layer Super Output Areas (MSOA) and Lower layer Super Output Areas (LSOA). Output Areas are built from clusters of adjacent unit postcodes. They were designed to have similar population sizes and to be as socially homogenous as possible based on tenure of household and dwelling type.

For the first chart of each indicator, we have grouped the Output Areas that possess less than 25% canopy cover and those that possess a canopy cover equal or greater than 25%. What the charts show are not necessarily causations or even clear correlations, however it seems that areas with higher tree canopy generally perform well on other indicators (e.g. are less “deprived”).

For some indicators, we have chosen to also display the data as a box-whisker plot. A box-whisker plot is a standard method to describe a dataset's distribution. The data's median is represented by the box's central line, with the bottom and top of the box showing the first and third quartile respectively. The lines, or whiskers, extending from the box represent maximum and minimum values; any outliers are shown as hollow circles. The mean value is displayed as a black diamond. The first box-whisker plot represents the whole dataset; “open spaces Removed” is where the open space has been removed before calculating tree canopy.

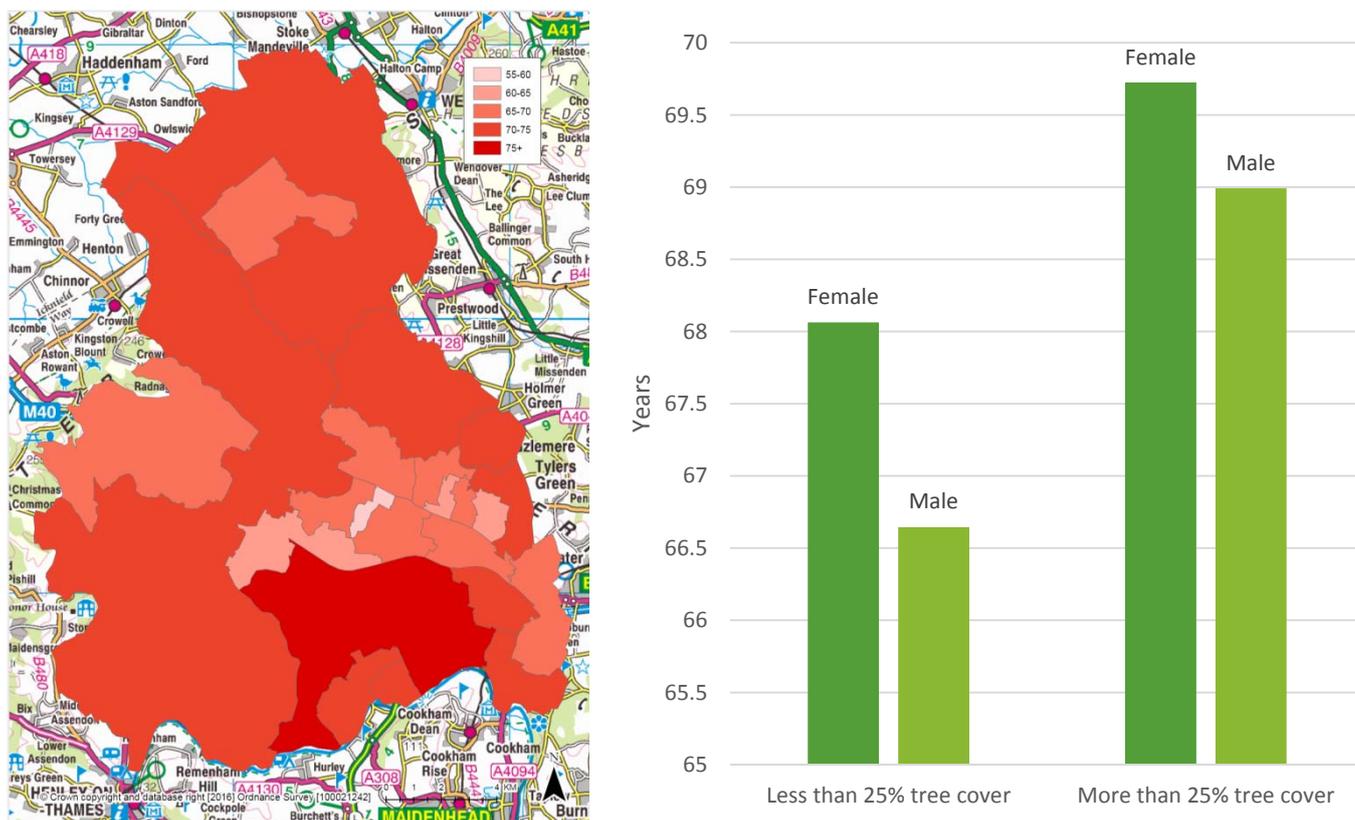
4.1.1 At MSOA scale

4.1.1.1 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.

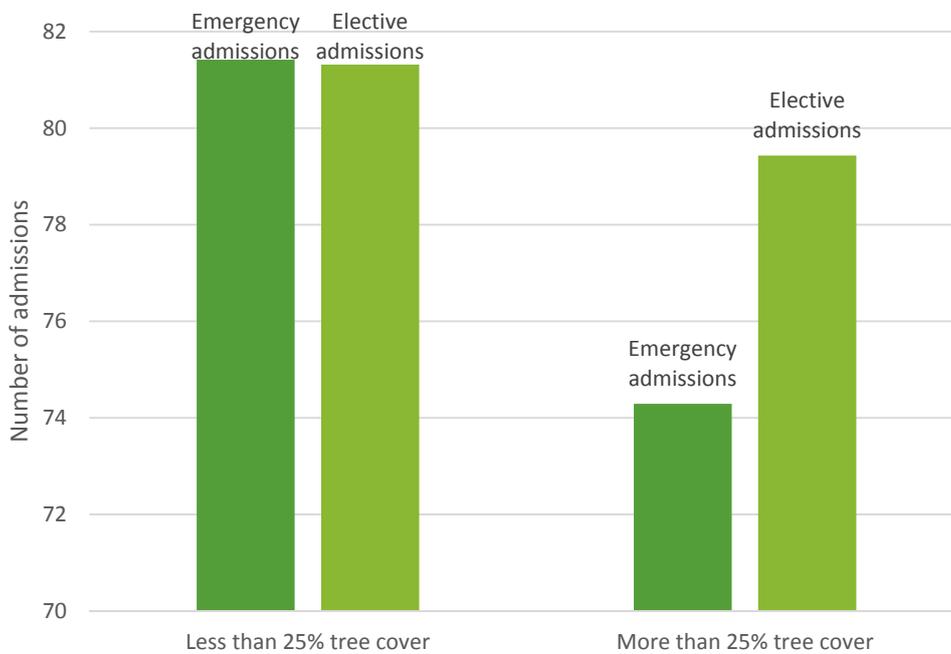
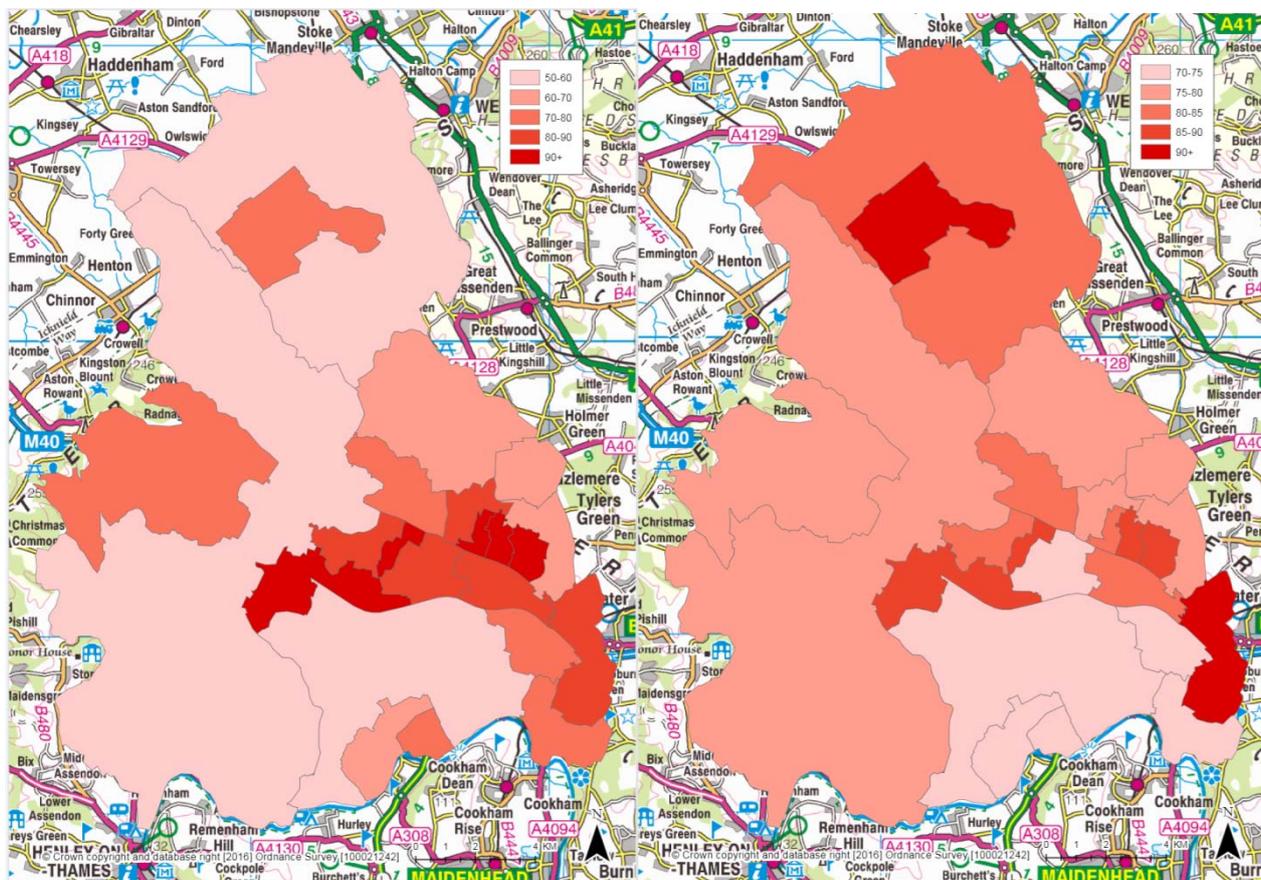
Figure 4: Average healthy life expectancy



4.1.1.2 Hospital admissions

In the same way that increased canopy cover correlates with higher life expectancy, more “treed” areas of Wycombe District have significantly fewer hospital admissions.

Figure 5: Emergency and elective hospital admissions



4.1.1.3 Educational achievement

The following charts show: the number of pupils achieving five A* to C grades in their GCSEs (including English and Mathematics) and the number of pupils achieving the expected level in each of the new 17 early learning goals.

Figure 6: GCSE achievement

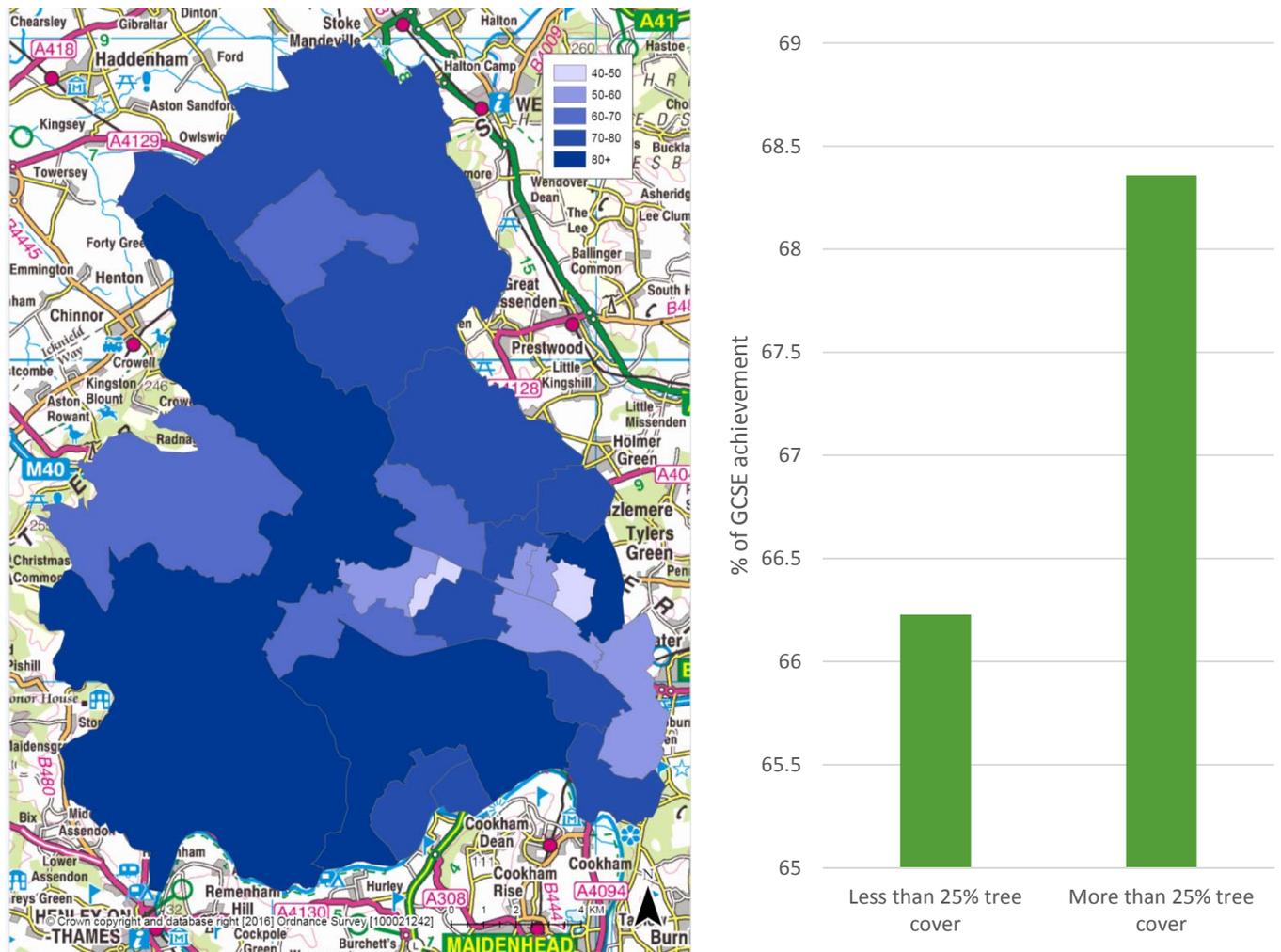


Figure 7: GCSE achievement distribution

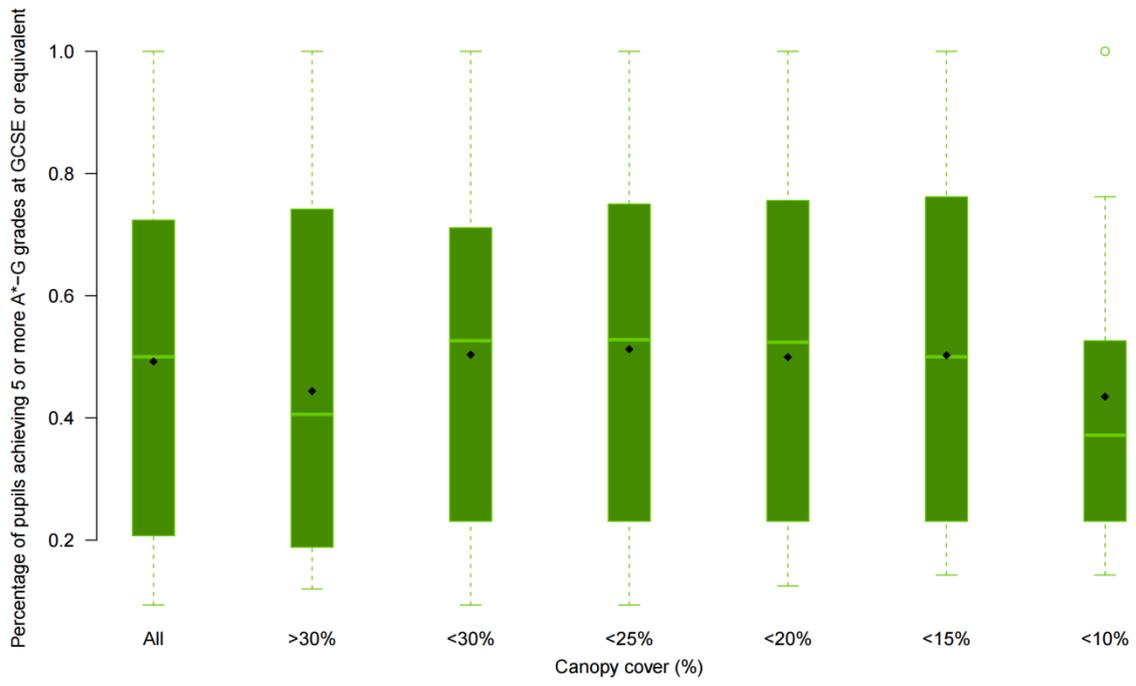


Figure 8: GCSE achievement distribution – open spaces removed

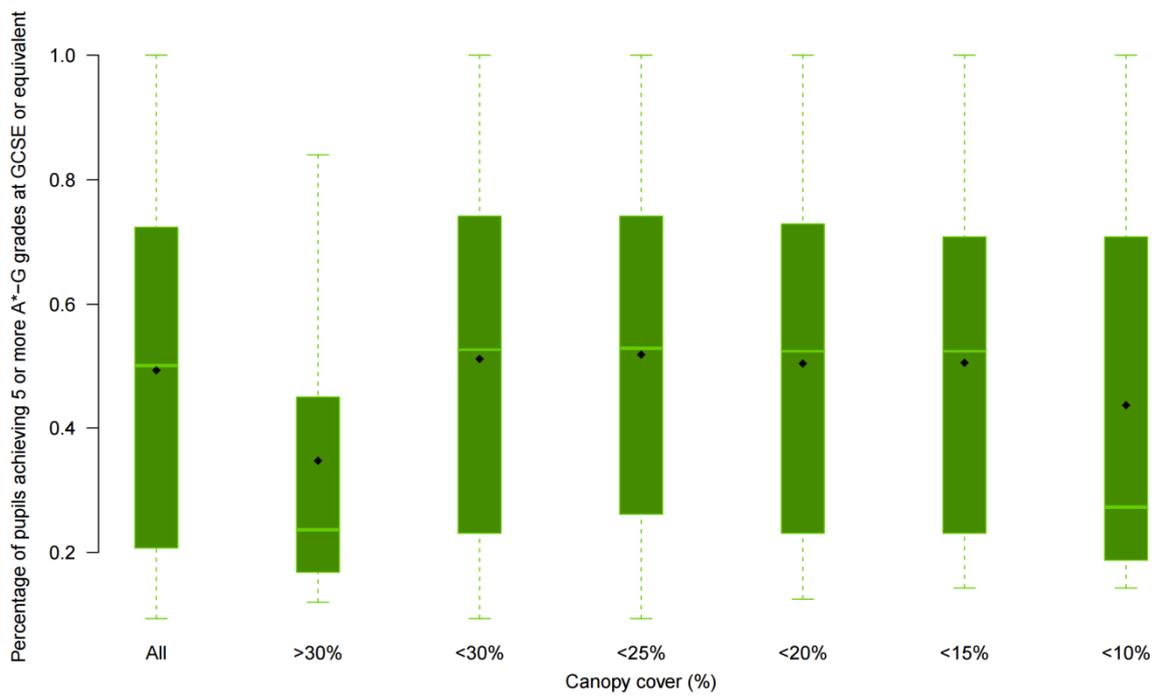


Figure 9: 17 early learning goals achievement distribution

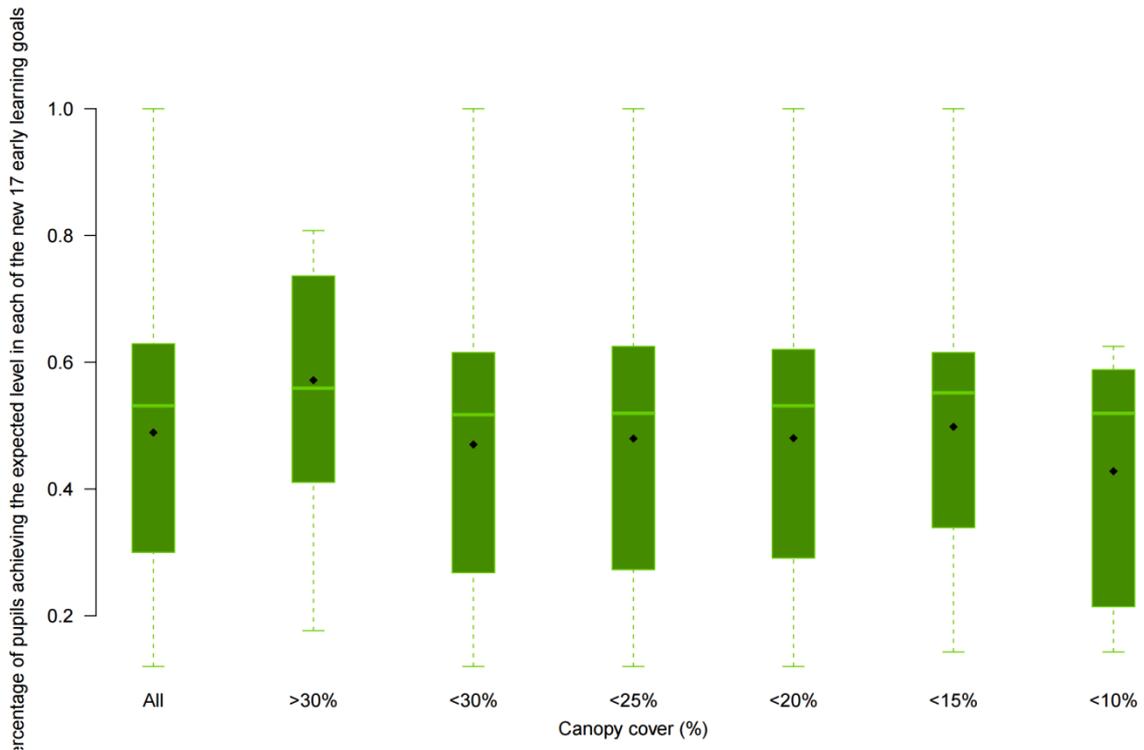
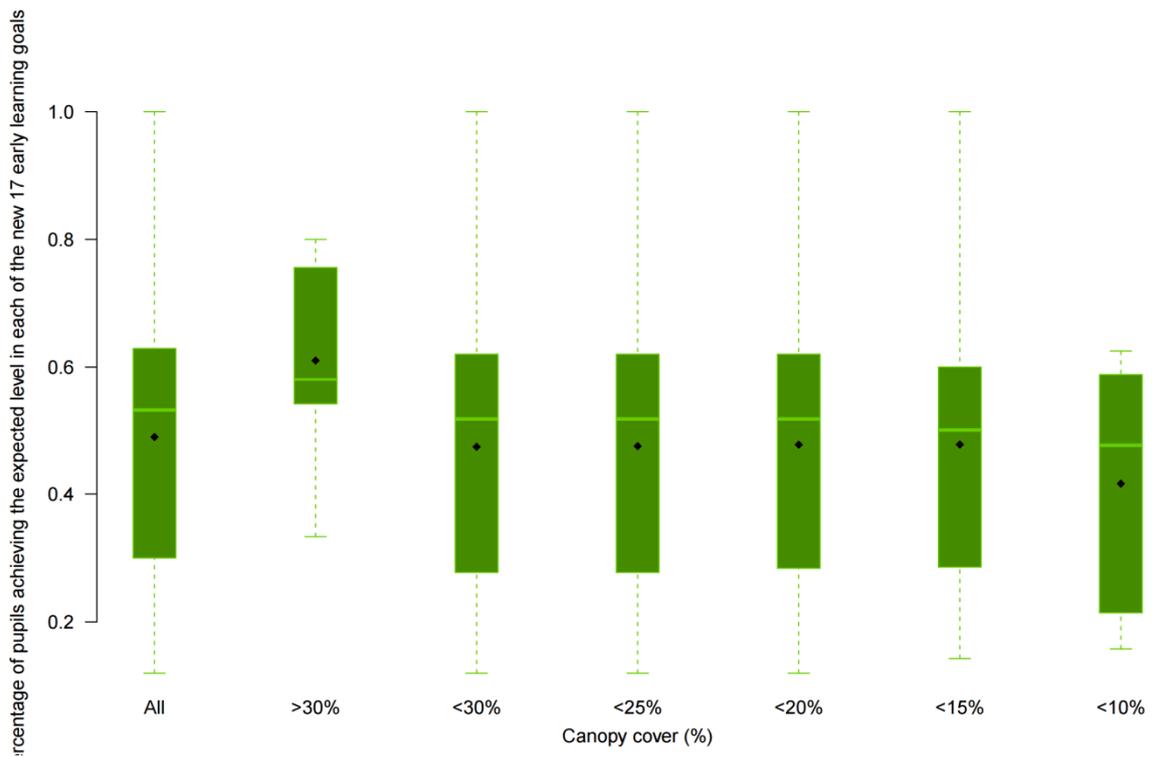


Figure 10: 17 early learning goals achievement distribution – without open spaces



4.1.1.4 Sale prices

These statistics report the median price paid for residential dwellings and are calculated using Land Registry data on property transactions. Houses on the leafier streets of Wycombe District sell for higher prices, as shown in the chart below.

Figure 11: Sale prices

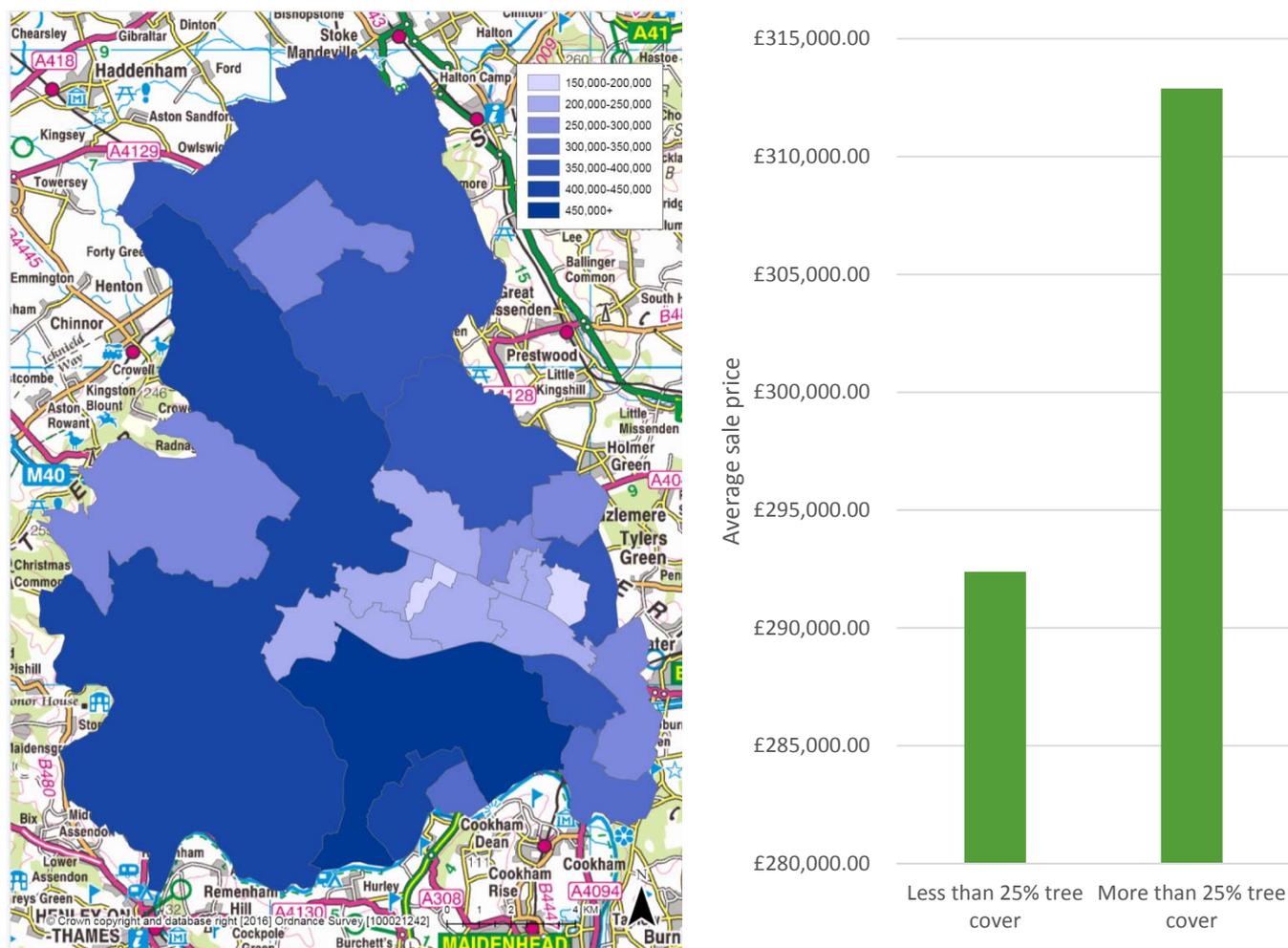


Figure 12: Sale prices distribution

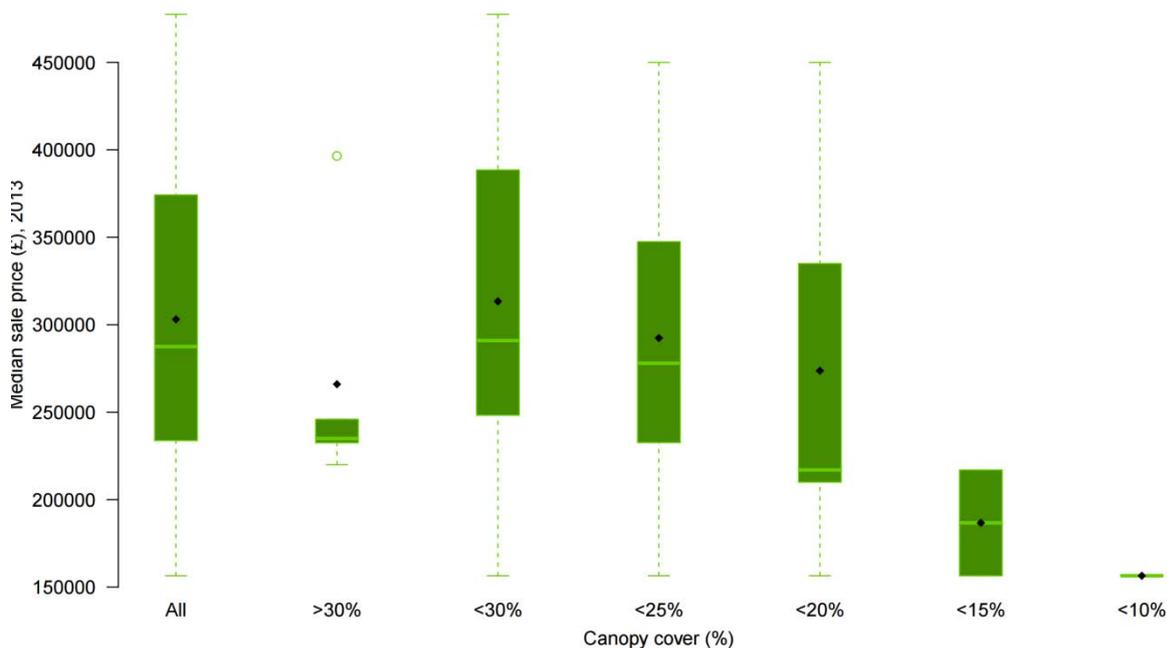
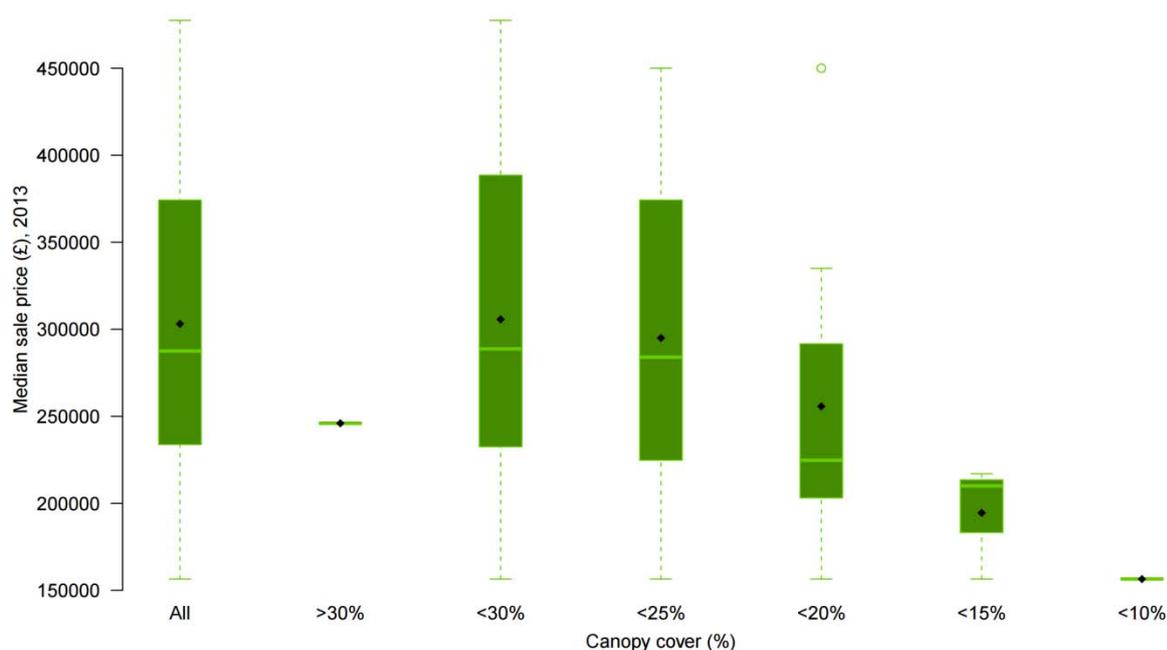


Figure 13: Sales prices distribution – without open space



4.1.2 At LSOA scale

Data concerning deprivation is collected at this scale and displayed in the charts below, again contrasting the Output Areas with less than 25% canopy cover and those with a canopy cover equal or greater than 25%.

In the case of the Income and Employment deprivation domains and the supplementary children and older people indices, the scores are meaningful and relate to a proportion of the relevant population experiencing that type of deprivation. So, for example, if a Lower layer Super Output Area has a score of 0.38 in the Income Deprivation Domain, this means that 38 per cent of the population is income deprived in that area. The scores for the Index of Multiple Deprivation and the other remaining domains are less easy to interpret, as they do not relate straightforwardly to the proportion of the population experiencing deprivation.

4.1.2.1 Index of Multiple Deprivation

The Index of Multiple Deprivation (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.

Figure 14: Index of Multiple Deprivation score

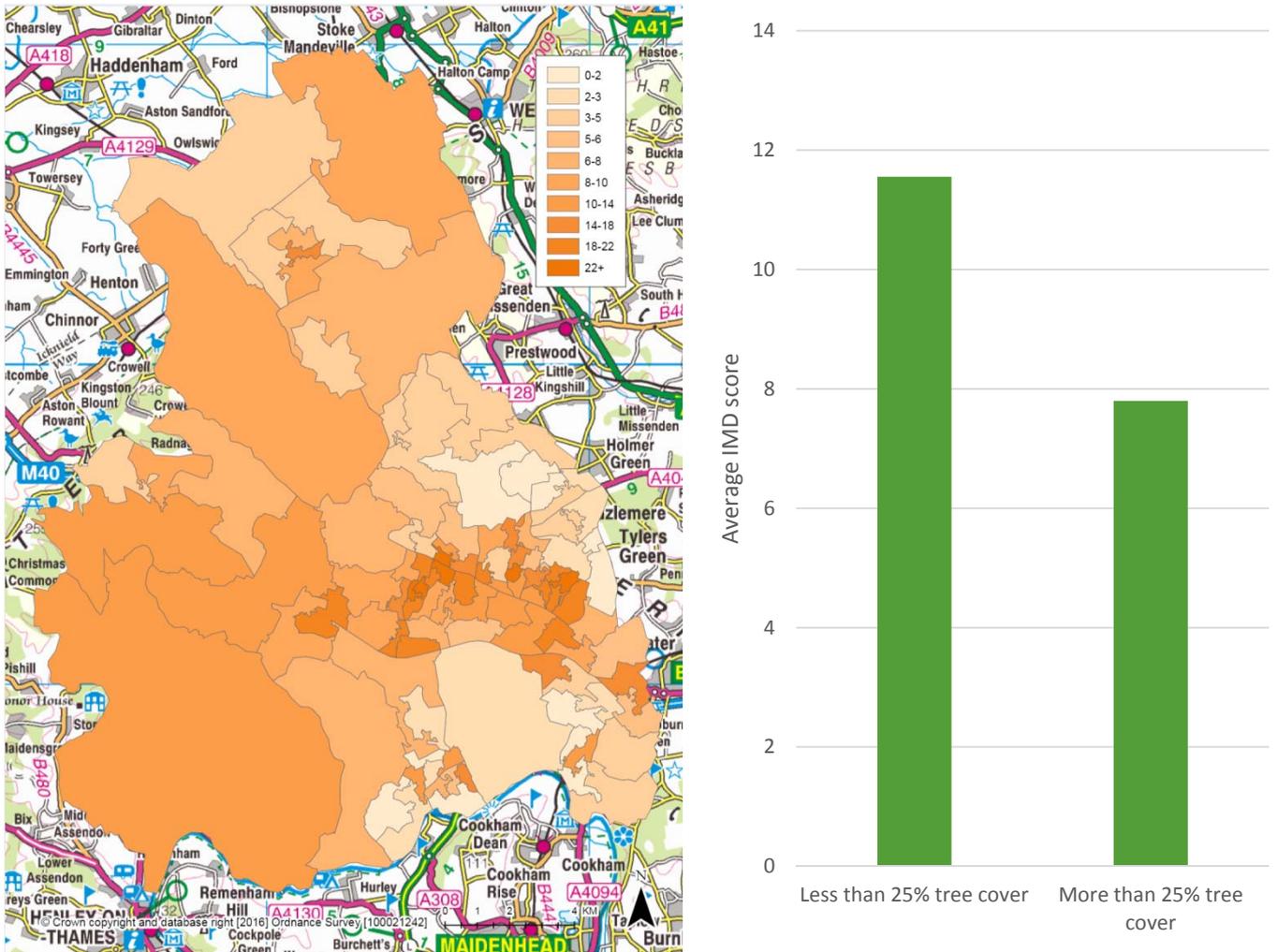


Figure 15: Index of Multiple Deprivation score distribution

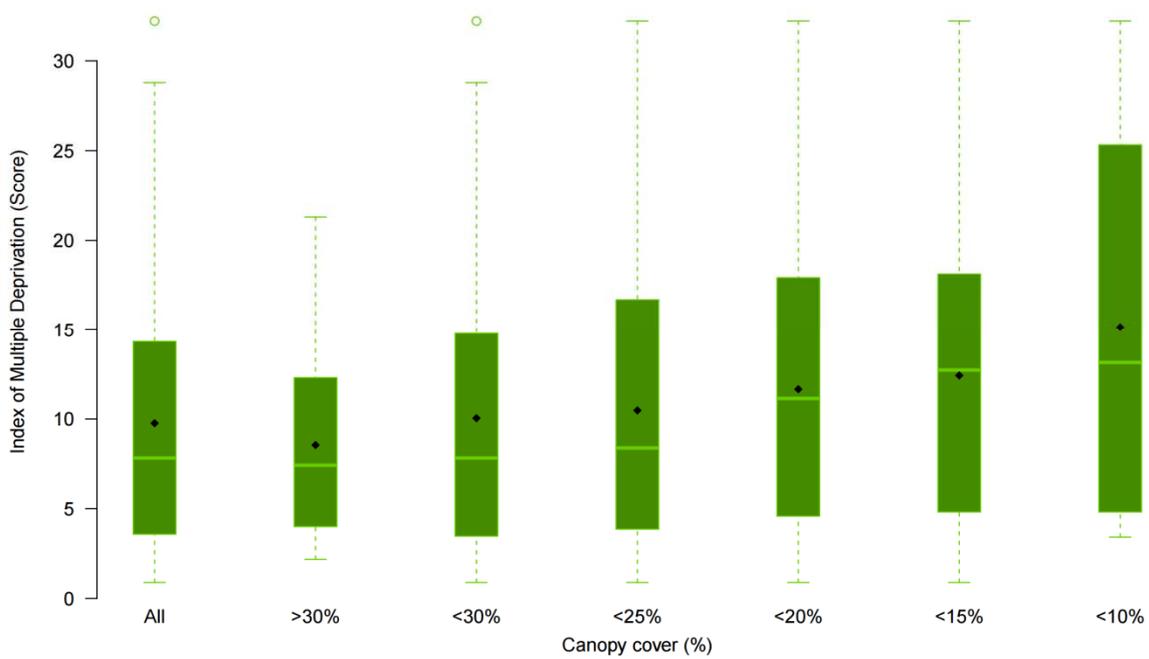
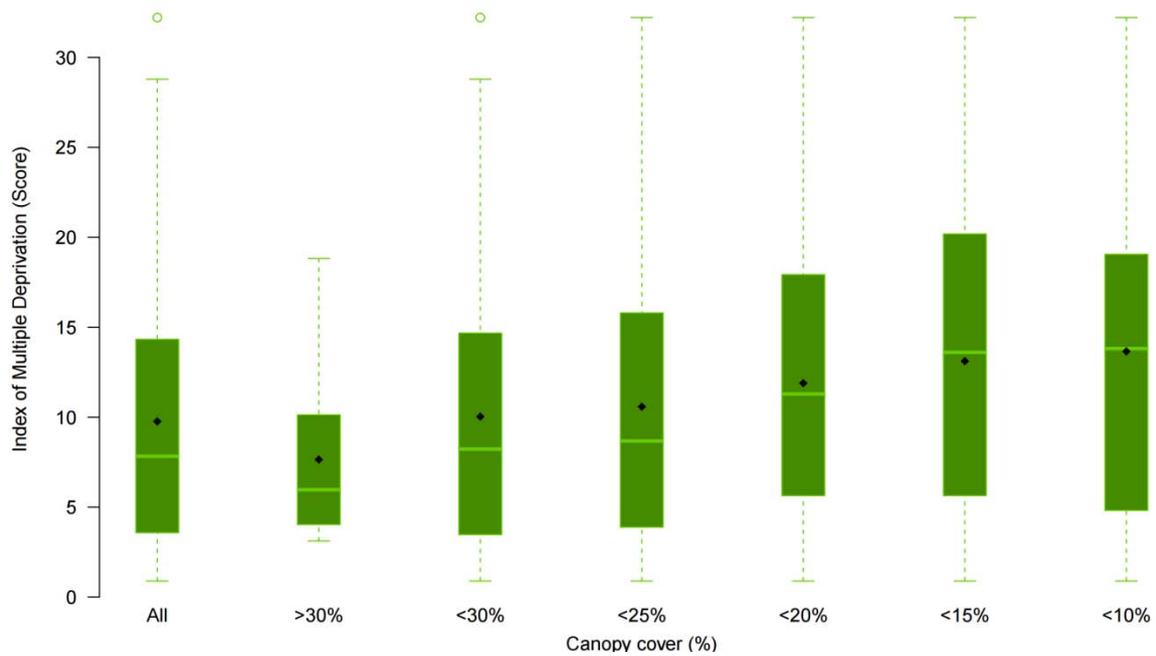


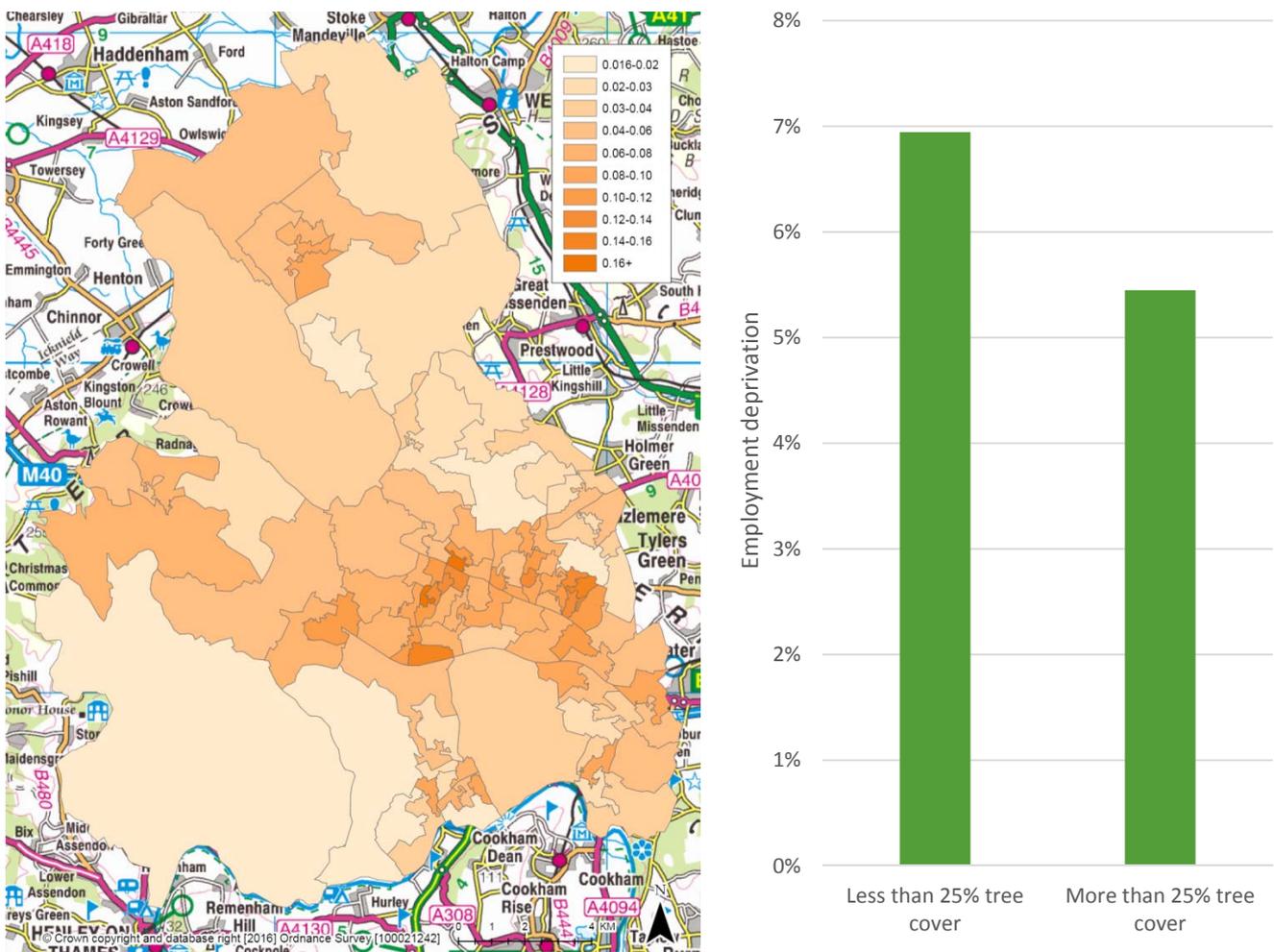
Figure 16: Index of Multiple Deprivation score distribution—with open spaces removed



4.1.2.2 Employment deprivation

The Employment Deprivation domain measures the proportion of the working-age population in an area involuntarily excluded from the labour market. This includes people who would like to work but are unable to do so due to unemployment, sickness or disability, or caring responsibilities.

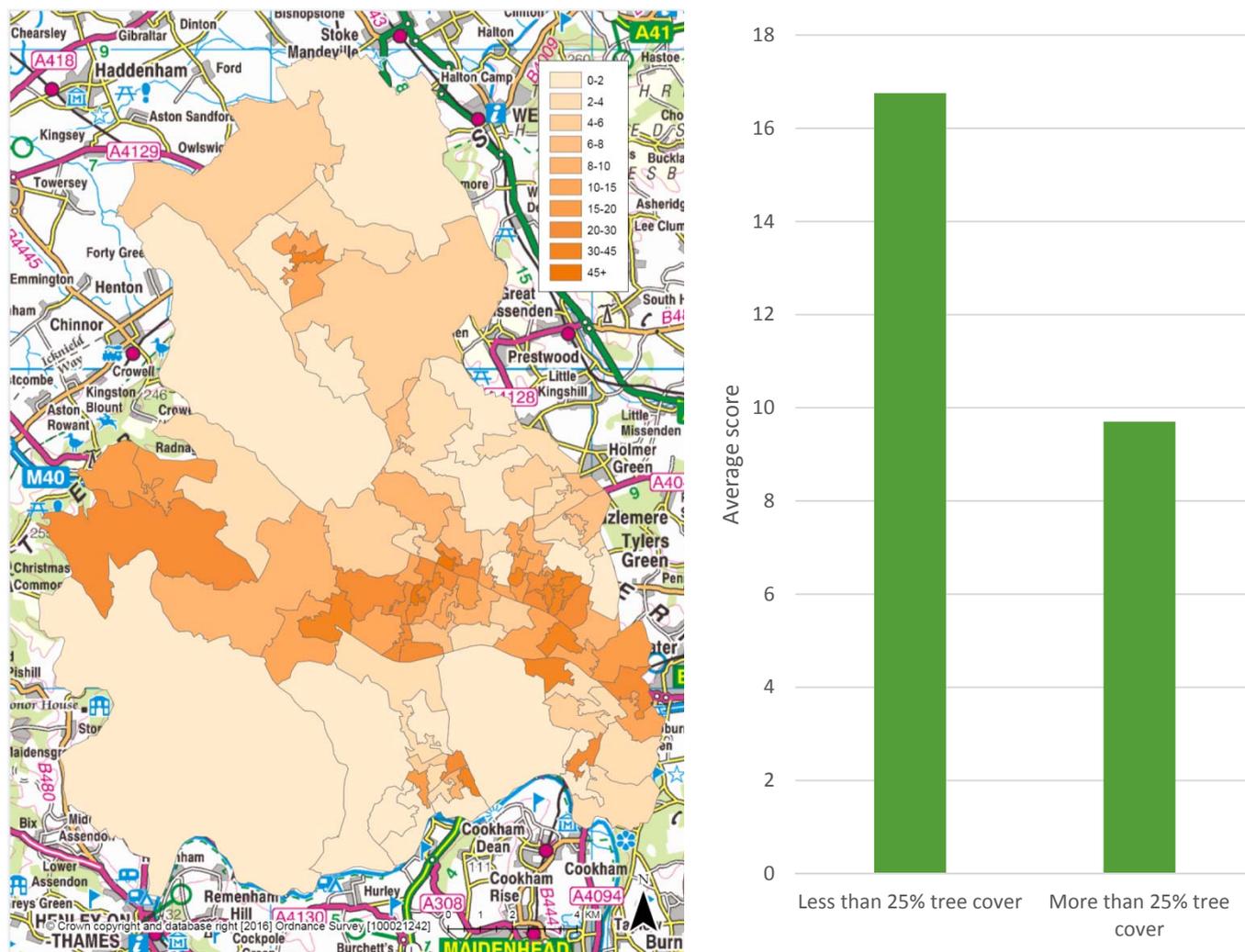
Figure 17: Employment deprivation



4.1.2.3 Education, Skills and Training Deprivation

The Education, Skills and Training Deprivation domain measures the lack of attainment and skills in the local population. The indicator is calculated by taking into account two sub-domains: one relating to children and young people and one relating to adult skills.

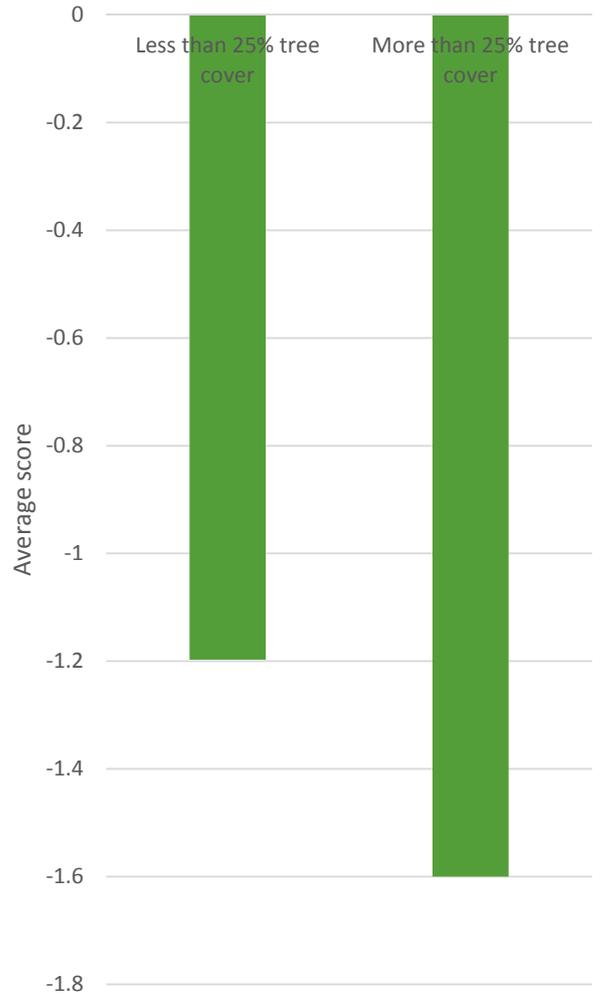
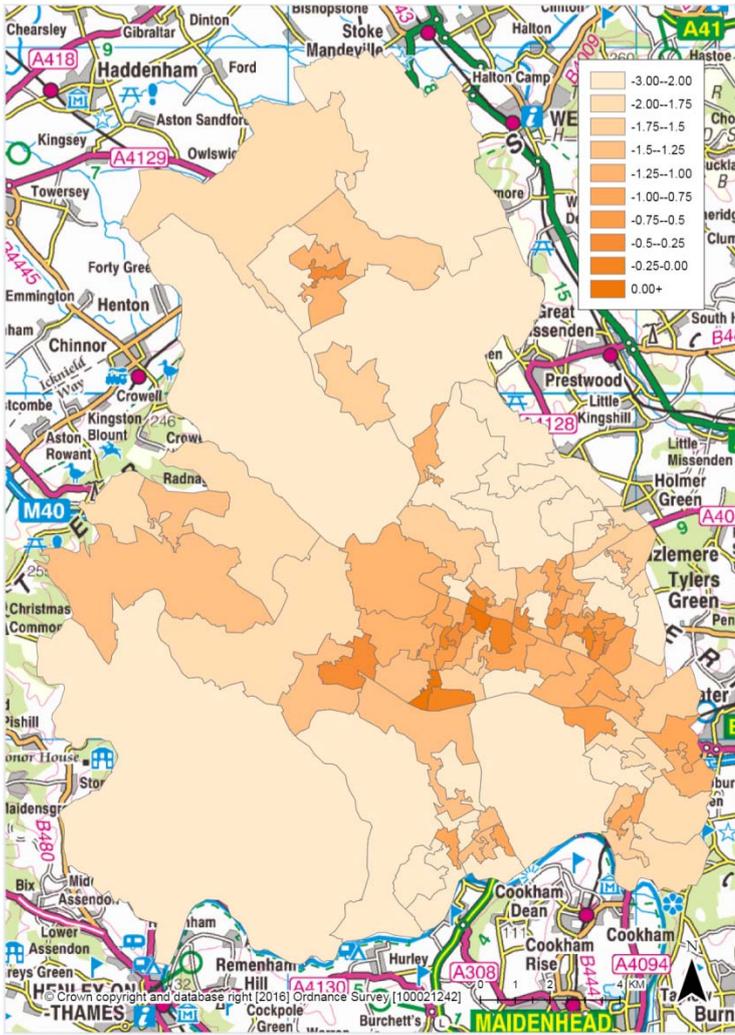
Figure 18: Education, Skills and Training Deprivation



4.1.2.4 Health Deprivation and Disability

The Health Deprivation and Disability domain measures the risk of premature death and the impairment of quality of life through poor physical or mental health. The indicator measures morbidity, disability and premature mortality. The bars being negative show that Wycombe District is performing relatively well as far as health indicators are concerned.

Figure 19: Health Deprivation and Disability



4.1.2.5 Crime

The Crime domain measures the risk of personal and material victimisation at local level. Similarly to the previous indicator, Wycombe District in general performs well, especially the areas with higher canopy cover.

Figure 20: Crime

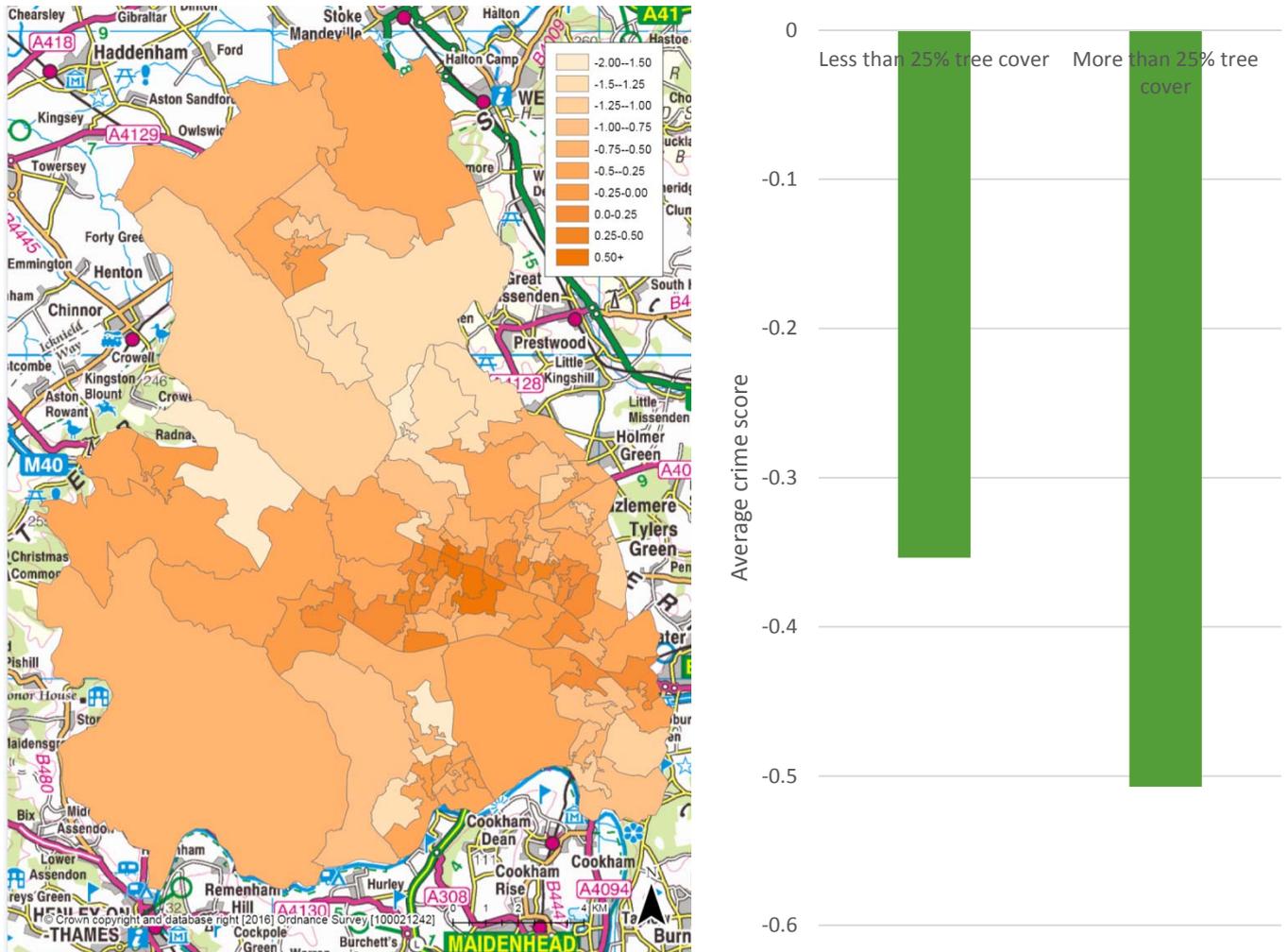


Figure 21: Crime distribution

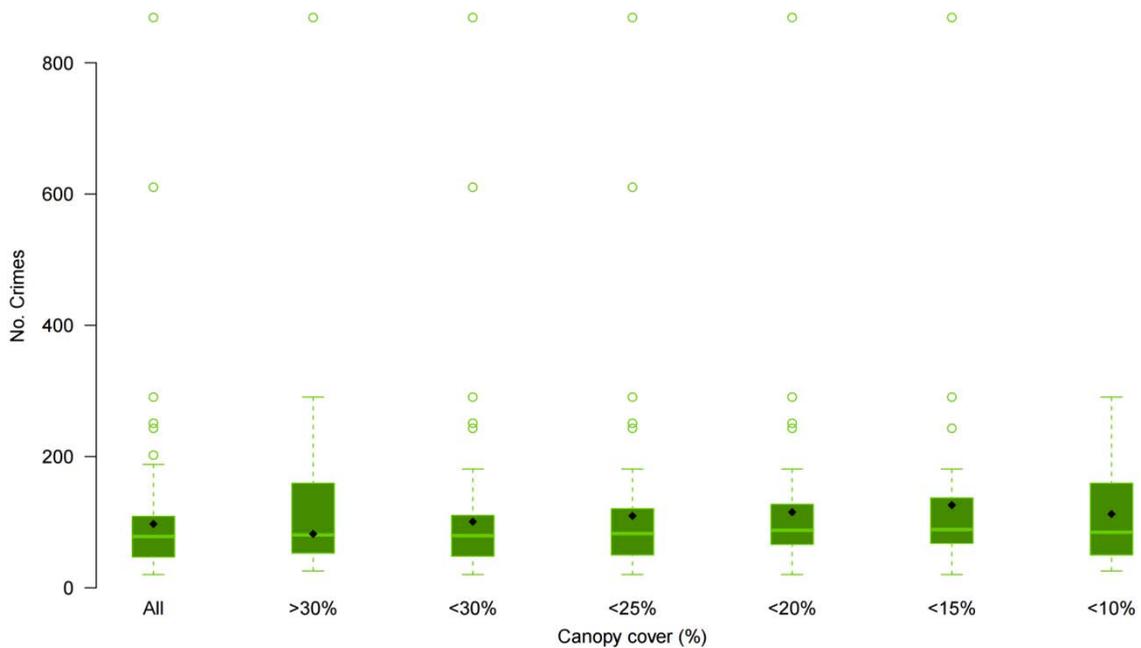
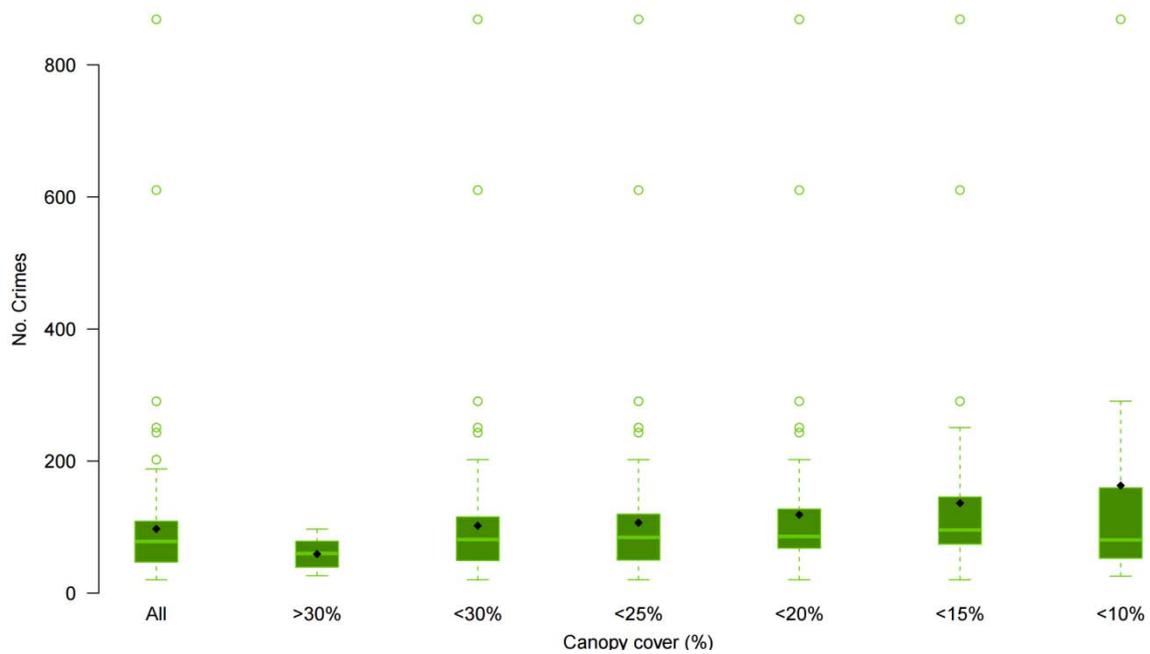


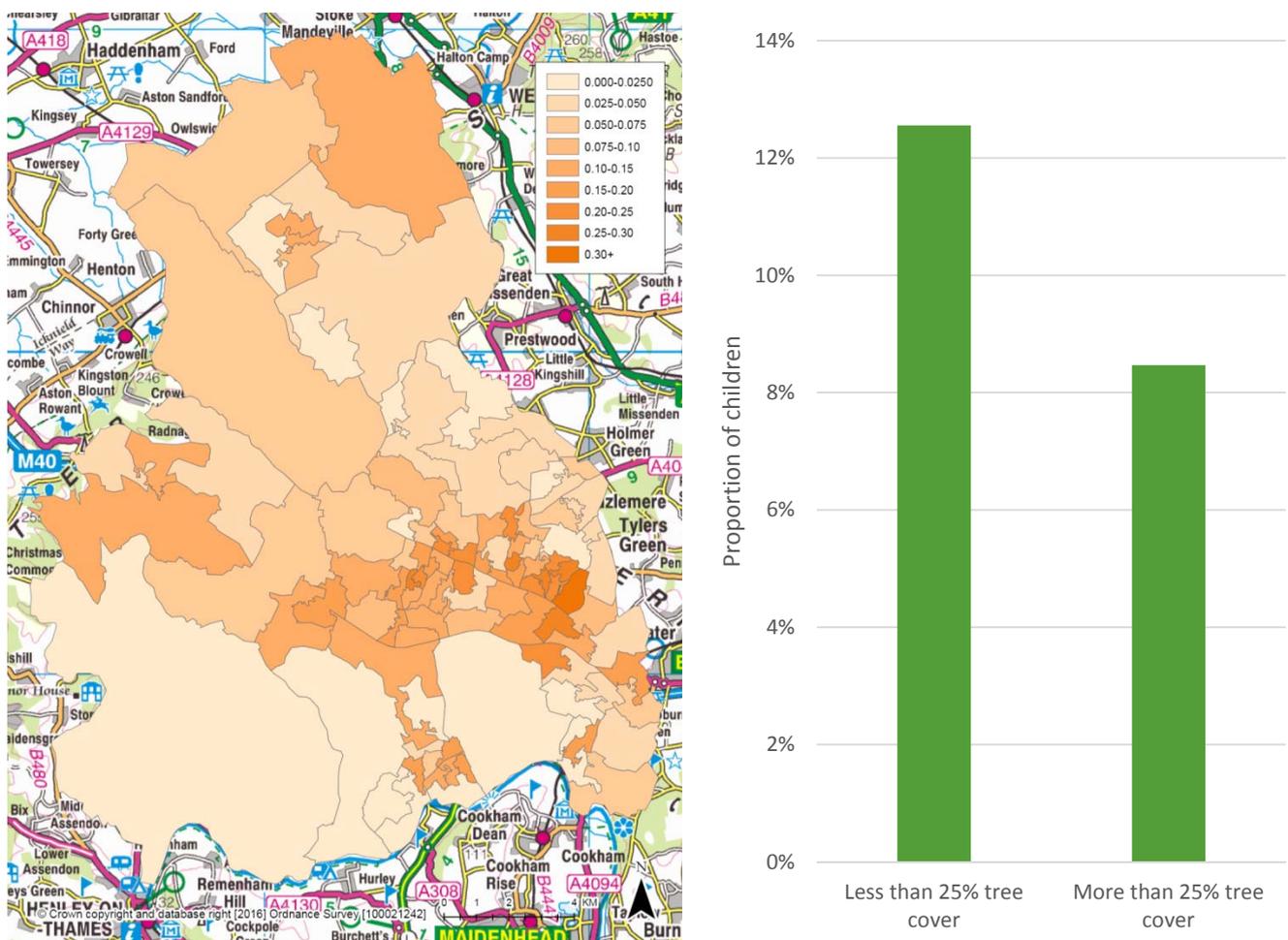
Figure 22: Crime distribution – with open spaces removed



4.1.2.6 Income Deprivation Affecting Children

The Income Deprivation Affecting Children Index (IDACI) measures the proportion of all children aged 0 to 15 living in families experiencing deprivation related to low income. The definition of low income used includes both those people that are out-of-work, and those that are in work but who have low earnings (and who satisfy the respective means tests).

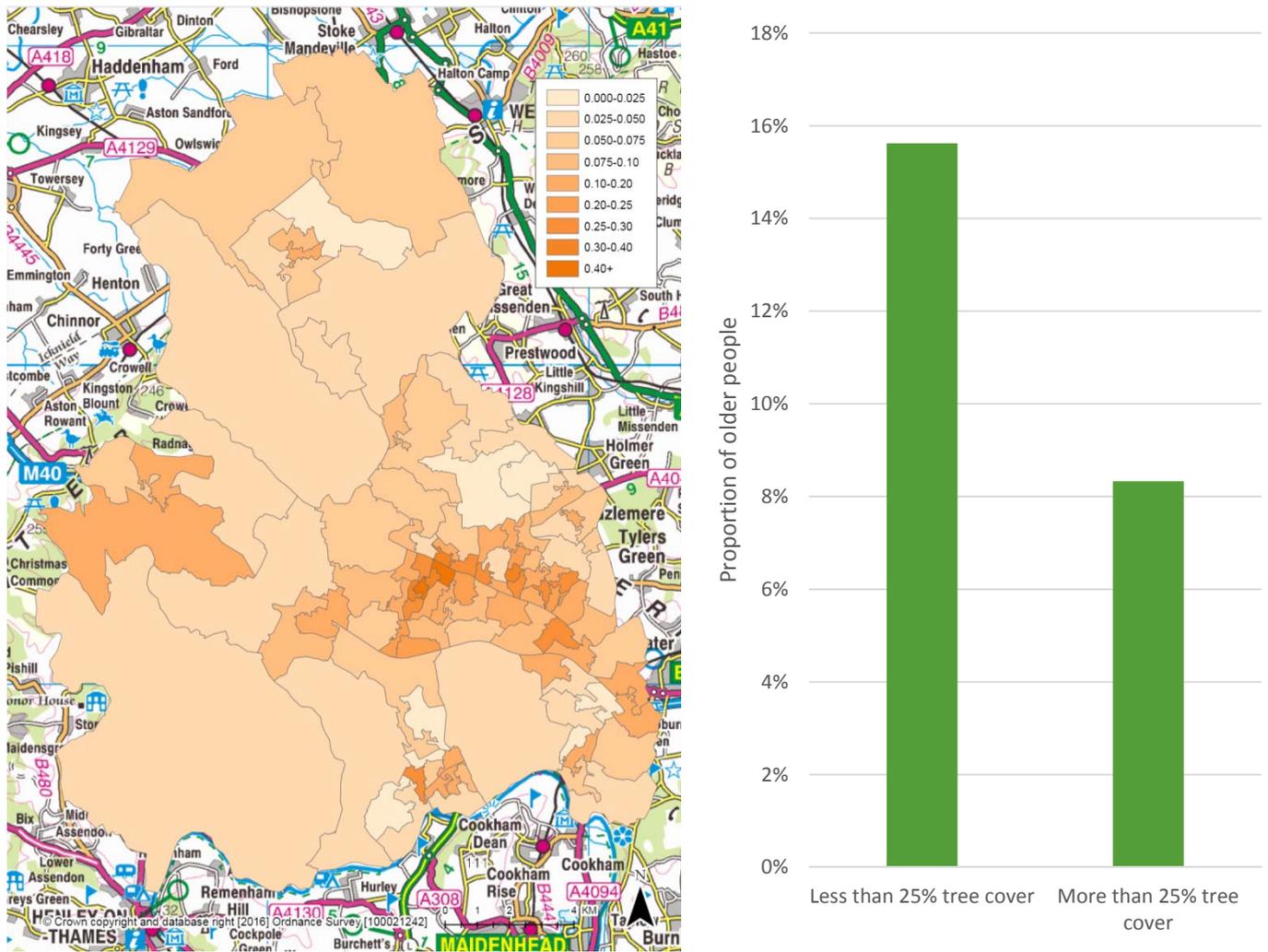
Figure 23: Income Deprivation Affecting Children



4.1.2.7 Income Deprivation Affecting Older People

Similarly, the Income Deprivation Affecting Older People Index (IDAOP) measures the proportion of all those aged 60 or over who experience income deprivation.

Figure 24: Income Deprivation Affecting Older People



5 Conclusions

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

Figure 25: Photo of High Wycombe treescape



The many benefits provided by trees justify the investment required to establish and maintain large trees in the urban environment. It equally points to the vulnerability arising when a high proportion of value resides in a few species and large old trees which are in the latter stages of their life. A more detailed study of Wycombe District's treescape with ground surveys would detail the benefits provided and the threats faced by each species of tree.

5.1 Conclusion for policy inception

5.1.1 Tree retention in development

Site developers may complain about tree protection, or planting costs, however there are significant benefits which are not recorded on the balance sheet. Understanding potential market values in different urban forest conditions is an important step in understanding the economics of urban forest protection and creation.

Generally, trees and forest cover in development growth areas add value. One study found that development costs were 5.5% greater for plots where trees were conserved (Hardie and Nickerson, 2004). Given increased plot and home valuations, builders have reported that they were able to recover the extra costs of preserving trees through a higher sales price for a house, and that homes on wooded lots sell sooner than homes on unwooded lots (Seila and Anderson, 1998). It is also clear that developers know that creating images with a sylvan character showing the

potential of new tree planting in a positive light helps them to sell houses. The vision these images portray should become a reality.

5.1.2 Parks and open space

Over 30 studies⁹ have shown that people are willing to pay more for a property located closer to an urban open space than for a house that does not offer this amenity, a finding known as the “proximate principle” (Crompton, 2001a). The studies evaluate the effects of parks and open spaces that usually contain trees and forests.

Price Increase	Condition
10%	Inner city home located within 1/4 mile of a park
10%	House 2 to 3 blocks from a heavily used, active recreation park
17%	Home near cleaned-up vacant lot
20%	Home adjacent to or fronting a passive park area
32%	Residential development adjacent to greenbelts

Studies find that homes adjacent to naturalistic parks and open spaces are typically valued at about 8% to 20% higher than comparable properties (Crompton, 2001b).

Values show a linear decline with distance from the edge of an open space, with a positive price effect declining to near zero at about 1/2 mile away (Hammer et al., 1974; Tyrväinen and Miettinen, 2000; More et al., 1988). Other factors affecting property values include usage rate (more park users = lower property values), user activity (athletic fields and games = lower property values up to 150 metres away), and care and upkeep (lower maintenance = lower property values). For instance, the values of properties close to heavily used or unkempt parks are typically lower than similar properties farther away.

5.1.3 Tree canopy cover and development viability

This report highlights much scientific research that support the assertion that trees provide a wide range of valuable ecosystem services. Wycombe District as a whole has 25% tree canopy cover, but many of the most deprived developments in the district the canopy cover is much lower and so too is the value of ecosystem services.

The level of ecosystem services increases as the percentage of canopy cover increases. However there is likely to be a limit to the level of canopy cover which would be desirable, achievable and viable within development. Many areas in the country have set a canopy cover target as a strategic objective for their areas. Typically these are in the range of 20-30% (Appendix 2).

For Wycombe District it has been considered that the appropriate target level of tree canopy cover for new developments should be 25%, for the following reasons:

1. The current level of tree canopy cover for Wycombe District is 25%,
2. 25% tree canopy cover is in line with what is proposed as a target in other parts of the country,
3. A good level of ecosystem services are likely to be delivered at 25% canopy cover,

⁹ https://depts.washington.edu/hhwb/Thm_Economics.html

It is clear that a canopy cover needs to not only be aspirational but also achievable. Therefore a study of building layouts, building density (in terms of dwellings per hectare and footprint per hectare) and achievable canopy cover per hectare has been carried out using the 3D design computer programme 'Sketchup Pro'.

The study used the following methodology:

1. 1 kilometre (km) squares were drawn over selected areas of Ordnance Survey Mastermap in the GIS computer programme MapInfo.
2. The 1 km squares were imported into Sketchup Pro and the footprint of dwelling was drawn over and then calculated in metres square.
3. The number of dwellings was counted.
4. Standardised images of large trees (19m height, 10 m crown diameter and approximately 80m² crown projection) were drawn on to the layouts in suitable locations, the canopy cover % for each plot was then calculated.

The Figures that follow show development layouts with building density of between 29 dwellings per hectare and 34 dwellings per hectares with canopy cover of between 25.6% and 35.2%. The development density and the style of development is dependent upon the site and its particular constraints, however the densities used in these examples give a fairly good indication of the typical level of density which might be expected in an average development within the district.

Figure 26
34 Dwellings per hectare
2385 m ² of footprint (23.9%)
32 trees = 25.6% canopy cover



Figure 27
34 Dwellings per hectare
2,434 m ² of footprint (24.4%)
32 trees = 25.6% canopy cover



Figure 28

34 Dwellings per hectare

1,966 m² of footprint (19.7%)

32 trees = 25.6% canopy cover



Figure 29

29 Dwellings per hectare

1,694 m² of footprint (16.9%)

44 trees = 35.2% canopy cover



In areas which have a lower density of development it tends to be the case that the amount of space in which trees can be planted is higher. This is at least partly due to the fact that a large proportion of development within the district is relatively low rise, and so there is usually quite a close correlation between the numbers of dwellings and the footprint they occupy. However, flatted development can achieve a higher density of development for the footprint it occupies and therefore enable a good level of canopy cover to be provided whilst also providing a higher density of dwellings.

It must therefore be recognised that there can be a variety of options for developing a site which can provide opportunities for planting enough trees to meet a canopy cover target without necessarily compromising the ability to build at a particular density.

5.2 Attainment

For 25% tree canopy cover to be achieved, it is necessary to understand the factors upon which it relies and how an assessment can be made into whether a proposal will meet the requirement. The factors are discussed briefly here but more detailed guidance will be forthcoming.

The primary factors to be considered are:

1. Retention of existing trees,
 - a. BS5837:2012 Trees in relation to design, demolition and construction – Recommendations,
 - b. Measurement of existing canopy,
2. Requirements from new tree planting,
 - a. Number size and shape of trees,
 - b. Soil requirements, quantity and quality,
3. Time to canopy cover target attainment,
4. Design of layout to accommodate future growth of trees without conflict,

5.2.1.1 Retention of existing trees,

For a canopy cover to be achieved in a new development it may in some instances be appropriate to meet or exceed the 25% target without planting any trees, this will only be possible if there is already a substantial tree canopy cover on the site which is being retained.

5.2.1.2 BS5837:2012 Trees in relation to design, demolition and construction – Recommendations,

The British Standard (BS5837) is the standard which developers and local authorities work to when considering how trees are treated on a development site. Once the existing trees have been surveyed it will be possible to work out which trees are most suitable for retention. The canopy spread of trees is measured at the four cardinal points and once they have been plotted on a plan it will be easy to measure their area retained trees.

5.2.1.3 Measurement of existing canopy,

The initial canopy cover measurement of retained trees can be derived from the tree survey however as the crowns of trees often grow across boundaries it is important to make it clear that for the purposes of measurement, only canopy which is to be retained within the boundary of the development site can be counted.

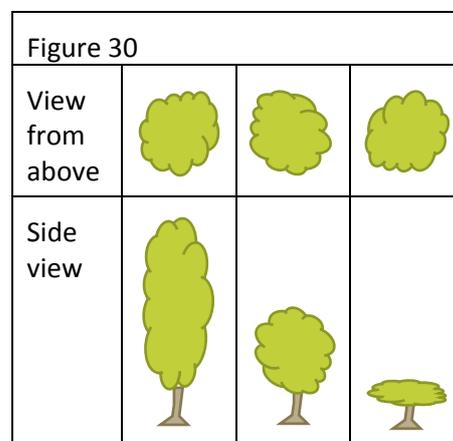
5.2.1.4 Requirements from new tree planting,

Once the current level of canopy cover on the site has been measured, it is necessary to work out how new tree planting can achieve the canopy cover target.

5.2.1.5 Number, size and shape of trees,

These factors are interdependent; it is possible for 10m² of tree canopy cover to be provided by 1 tree of 10m² or by 10 trees of 1m². It can be estimated what the canopy cover of any tree will be, by referring to the wide range of literature which gives not only predicted ultimate size but also size after just a few years.

The situation can become more complicated when the shape of the tree is taken into consideration. Figure 30 shows illustrations of the three trees all of which have the same canopy cover when viewed from above. However, the side view shows that due to their differing shapes: their leaf area, the volume of soil they would require and the ecosystem services they provide, would be quite different.



The simplest way to correct this problem is for a factor to be associated with different tree species and sub species which takes into account their shape and size and which can be applied to give a more accurate representation of the canopy cover value and the soil volume requirements for each tree to be planted.

5.2.1.6 Soil requirements, quantity and quality,

There is a direct relationship between how well a tree can grow above ground and the health and resources of the root system below. Trees need soil in which to grow and that soil needs to provide for the tree for many years if it is to reach its potential. Too often trees are planted in a small pit which is surrounded by compacted inhospitable soil; as a result many trees barely grow in size and die early. The volume and quality of soil, and the way it is provided will dictate the size to which a tree can grow. It is often considered that a tree needs approximately 0.6m³ of soil for each 1m² of canopy projection, this figure needs amending to in specific circumstances to reflect the shape of the tree. Therefore, the further guidance to be produced will include requirements for planting specifications and details of the soil volume expected for different species and subspecies.

5.2.1.7 Time to canopy cover target attainment,

Unless the canopy cover of a site is already at or very close to the target, it will not be possible to reach the target at the time of planting. It takes many years for trees to grow to their potential and so the canopy cover target is aimed at a future time. The further guidance on species and sub species assumes the canopy cover will be achieved when trees reach close to their mature size, different trees grow at different rates, live for different lengths of time and will reach maturity at different points in the future.

Therefore it is less important to consider when in the future the target will be reached, but instead to focus on ensuring the right combination of provisions has been put in place to enable trees to grow healthily until the target is reached.

5.2.1.8 Design of layout to accommodate future growth of trees without conflict,

The urban design of new developments has to take into account many competing constraints, it is imperative that Arboriculturists and Landscape Architects are coordinated with Urban Designers from an early stage and throughout the design process to ensure the target can be met in an appropriate manner. Trees are important in streets, gardens, open spaces and other areas, to ensure that their benefits are maximised throughout a development their distribution must be appropriately balanced, taking account of the effect they can offer in different locations.

6 Recommendations

The following recommendations would help Wycombe District to may its tree management decisions on the basis of the best available information and therefore ensure that resources are focussed to maximise the benefits trees can provide, where they are most needed.

6.1.1.1 *iTree Eco Survey*

Undertake an iTree Eco 'bottom-up' survey of trees within the Wycombe District administrative area in order to:

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

6.1.1.2 *Tree strategy or urban forest masterplan*

Prepare a comprehensive tree strategy/ urban forest masterplan for public and privately owned trees which will:

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

6.1.1.3 *Undertake a full Multi Criteria Decision Analysis (MCDA) to further tree planting decisions*

The canopy results presented within this report could also be used within Multi Criteria Decision Analysis (MCDA).

As a proof of concept the following is a simple MCDA looking at opportunities to expand trees and woodlands within the Wycombe area. In this example we look at three factors:

1. Building density (includes all artificial surfaces: roads, paths, houses, etc.),
2. The Index of Multiple Deprivation (IMD),
3. Canopy cover.

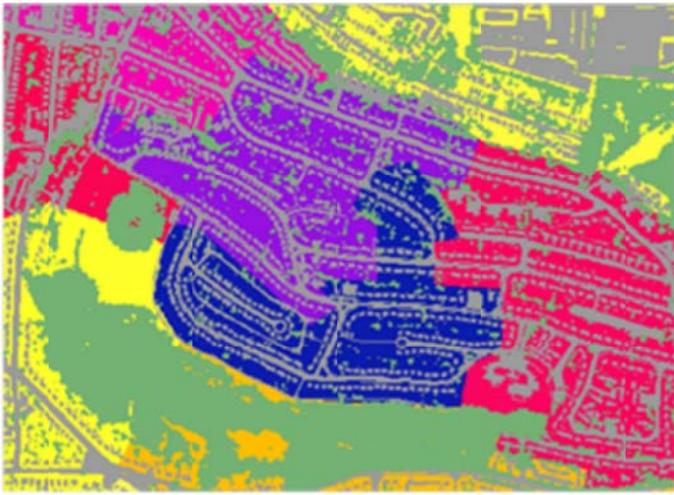
Each factor was mapped from its original value to a range between 1 and 0. All factors were equally weighted and combined to give an overall score, the higher the score the greater the opportunity to create woodlands and to plant trees. The map should identify areas where there is:

1. A high level of deprivation,
2. low canopy cover,
3. room to plant more trees.

In figure 31 a single LSOA has been identified which, according to the MCDA, is a prime candidate area for increased canopy cover. It has a high IMD value (32.215), a low tree cover of 5.7% and a low density of buildings (16%).

The simple example of MCDA is a proof of concept. However, a more complex analysis could be used to refine targeted tree planting even further. For example, land ownership (public/private) could be identified with low canopy cover and strategies could be tailored to target an increase in canopy cover in different geographic areas.

Figure 31: Example of a Multi Criteria Decision Analysis



Outputs



Inputs



7 Appendix 1: Bluesky National Tree Map¹⁰

The National Tree Map (NTM) by Bluesky International Ltd. is a commercial product which seeks to identify all trees and bushes in England and Wales over 3m in height. Classification of trees is achieved using stereo aerial photography (RGB/CIR), Digital elevation models (DTM/DSM) and hydrological models. The process produces three datasets: crown polygons, idealised crowns and height points (**Error! Reference source not found.**). The map operates a 5 year rolling update program (NTM, 2015).

Figure 32: Bluesky datasets



Aerial photography

Crown polygons

Idealised crowns

Height points

7.1 Coverage

England and Wales

7.2 Variables

The National Tree Map consists of three GIS datasets:

- Crown Polygons (Vector - Polygon) - Representing individual trees or closely grouped tree crowns
- Idealised Crowns (Vector - Polygon) – Crown polygons visualised as circles for ease of use. Area measurement remains true to original crown feature
- Height points (Vector - Point) - Detailing the centre point and height of each crown

The variables contained in each dataset are given in table 2:

¹⁰ Source: Handley and Doick (2015)

Table 2: National Tree Map variables

Field Name	Type	Description
NTM_ID	Text	Unique Id for each crown feature
Max	Numeric (decimal)	Maximum height value of the crown (m)
Mean	Numeric (decimal)	Average height value of the crown (m)
STD	Numeric (decimal)	Standard Deviation of all height measurements
Perimeter	Numeric (decimal)	Perimeter of the idealised crown (m)
Area	Numeric (decimal)	Area of the crown (m ²)

7.3 Accuracy

Bluesky claims that the product captures more than 90% of all canopy coverage and within 50m of buildings greater than 95% all canopy coverage (NTM, 2015).

8 Appendix 2: Comparison with other UK cities

McPherson et al. (1998) highlight how canopy cover is a useful metric for comparison across and between cities, regardless of size of total land cover. Wycombe District compares very favourably with other UK towns and cities (see table 3 below) that have completed canopy surveys, although urban tree cover in the UK is generally lower than that found in continental Europe and the US.

The following figures are from the Urban Tree Cover website¹¹; the footnotes refer to the surveys the data originate from. Where data is missing in this table, it is because the city has not set a canopy cover goal or has not measured the potential plantable space or the number of trees. These numbers provide snapshots of the urban forests at different times, but can be used to have an idea of how the cities compare.

Table 3: Tree cover of UK cities

City	Area (ha)	Population	Canopy cover	Canopy cover goal	Potential plantable space	Number of trees
Crawley	4,495	108,971	25.1%	/	/	/
Wycombe District	32,457	174,878	25%	/	/	/
Birmingham	598,900	1,092,330	23%	/	/	6,000,000
Sidmouth	4,300	12,570	23%	/	60%	405,000
Exeter	4,703	117,773	23%	/	/	/
London	157,200	8,400,000	21.9%	30%	29%	8,421,000
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%	/	/	/
Walsall	10,395	269,323	17.3%	/	/	/
Cambridge	11,560	123,900	17.1%	/	/	/
Edinburgh	26,400	487,500	17%	/	/	638,000
Wrexham	3,833	61,603	17%	/	28%	364,000
Eastbourne	4,416	99,412	15.9%	/	/	/
Manchester	63,030	514,417	15.5%	/	/	/
Glasgow	17,550	596,550	15%	/	32%	2,000,000
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%	818,000

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. 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. One of the best examples of this is the enthusiasm following the valuation of the urban forest benefits in Torbay.

¹¹<http://www.urbantreecover.org/>

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