

Plymouth Policy Area

Tree Canopy Cover Assessment

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Treeconomics

Forest Research

The Steering Group

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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 basic questions; What 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.

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Executive Summary

Trees are arguably the single most important component of Green Infrastructure, 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. Trees improve health and well being, store carbon, reduce the urban heat island effect and improve air quality[1]. Understanding the extent of the Plymouth Policy Area (PPA) tree canopy cover and its relationship with other indicators is the first step in 'measuring to manage' this important resource. This appreciating asset (part of Plymouth's Natural Capital) can now be improved and maintained using this study and its data, with resources targeted to the areas that most need it.

This study estimates tree canopy cover within the Plymouth Policy Area using the Bluesky National Tree Map dataset (For details and specification of this dataset see Appendix I).

Estimates of canopy cover for each Ward in the Plymouth City Administrative Boundary, the Plymouth Urban Fringe and the total Plymouth Policy Area were calculated. The results provide a snapshot of the current tree canopy cover (Fig 1) and a baseline to allow for comparison with 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.

The overall canopy cover of the Plymouth Policy Area is estimated at **18.5%** and the canopy cover of these areas are provided in Table 1 overleaf. This falls to **16.9%** in the Plymouth City Administrative area and rises to **24.8%** in the Urban Fringe.

There was a wide range of canopy cover across Plymouth ranging from just 2.87% in Sutton and Mount Gould Ward to over 31% in the Moor View Ward. Canopy cover in Plymouth is above the national and regional averages reported in Trees in Towns 2 (2008) at 8.2% and 11.8% respectively.

It is suggested that an appropriate Canopy Cover Target for Plymouth would be to achieve an average of 20% Canopy Cover by 2034.

[1] Further deta s are a so prov ded n ater sect ons of th s report.

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

Ward	Tree Canopy Cover
Sutton and Mount Gould Ward	2.87%
Drake Ward	4.95%
Devonport Ward	5.28%
St. Peter and the Waterfront Ward	5.82%
Stoke Ward	9.75%
St. Budeaux Ward	10.63%
Peverell Ward	12.73%
Honicknowle Ward	13.88%
Plymstock Dunstone Ward	14.01%
Plympton Chaddlewood Ward	14.31%
Plymstock Radford Ward	15.43%
Plympton St. Mary Ward	15.87%
Compton Ward	18.29%
Efford and Lipson Ward	19.50%
Ham Ward	19.55%
Eggbuckland Ward	20.50%
Plympton Erle Ward	21.16%
Budshead Ward	25.30%
Southway Ward	25.40%
Moor View Ward	31.73%
Wembury & Brixton Ward	7.42%
Woolwell Ward	30.34%
Newton & Yealmpton Ward	31.79%
Bickleigh & Cornwood Ward	36.86%
Average Plymouth Administrative Area	16.90%
Average Urban Fringe	24.87%
Average Plymouth Policy Area	18.50%

Table 1 : Tree Canopy Cover

Note: The boundary used was from the “full urban fringe v2.shp” file supplied by Plymouth. The ward data is from the Ordnance Survey England Ward shapefile (resolution: 10k) and consists of Unitary Wards and District Wards. The boundary file does not exactly match the ward data file. In most cases this is a trivial amount (<1% and likely to be caused by slight mismatch in boundaries used between files, or the presence of significant bodies of water). However, Bickleigh & Cornwood Ward, Newton & Yealmpton Ward and Wembury & Brixton Ward all have reduced areas as these three wards are only partially represented within the Urban Fringe and the PPA. The following maps and tables are still representative as we are merely showing the canopy cover for the area described.

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[2]. For example, a study in Torbay found that for every pound 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[3]. A similar study in New York found that for every 1$ spent on its street trees $5 were returned in benefits[4].

Trees and urban tree cover are 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[5]. Additionally, businesses are prepared to pay greater ground rents[6], also associated with higher paid earners who are also more productive (Kaplan, 1993; Wolf, 1998), house prices increase[7], and crime is reduced[8] 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 (eg mushrooms, moss for floristry), wood fuel and timber.

A full summary of how trees benefit local communities within the context of the National Planning Policy Framework is provided in Appendix III.

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[2] Co ated nternat ona research on the econom c benefits of trees s ava ab e at: http://depts.wash ngton.edu/hhwb/.

[3] Sunder and et a 2012

[4] We s 2012

[5] Shoppers c a m that they w spend 9% to 12% more for goods and serv ces n centra bus ness d str cts hav ng h gh qua ty tree canopy (Wo f, 2005).

[6] 7% h gher renta rates are ach evab e for commerc a offices hav ng h gh qua ty treescapes (Laverne and W nson-Ge deman, 2003).

[7] The presence of arger trees n gardens and as street trees adds from 3% to 15% to home va ues (Wo f, 2007).

[8] Pub c hous ng res dents w th nearby trees and natura andscapes reported 25% fewer acts of domest c aggress on and v o ence (Kuo and Su van, 2001a). Pub c hous ng bu d ngs w th greater amounts of vegetat on had 52% fewer tota cr mes, 48% fewer property cr mes, and 56% fewer v o ent cr mes than bu d ngs w th ow amounts of vegetat on (Kuo and Su van, 2001b).

1. Introduction

1.1 Background

Measuring tree canopy 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). Tree canopy cover 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.

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 tree canopies over a given area. It is normally expressed in square meters (m^2) or hectares (ha^2).

Canopy cover **is not** to be confused with total leaf area, which represents all of the layered leaves within a tree canopy. This is normally expressed in cubic meters (m^3) or using leaf area index (LAI).



Fig 1 : Extent of Tree Canopy cover in Plymouth

"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 - Planning the Urban Forest

1.2 Objectives

This report aims to provide a snapshot of canopy cover in the Plymouth Policy Area, to enable its protection and enhancement in the future. It is important to be able to measure this important 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:

- Undertake a detailed Tree Canopy survey of the Plymouth Policy Area to neighbourhood level, comparing tree canopy cover with available ONS data on Health, Crime and Deprivation.
- Use the data to influence Section 106 funding – so that Plymouth can access funds not just in the area where there is a loss but in areas where there is a need.
- Calculate the cover percentage per ward and set a canopy cover target for 2034.
- Use existing data sets for Plymouth Policy Area to provide baseline information on tree species and composition.

This is a factual, evidence based document to provide evidence to support policy development. 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 (see also Appendix III and V). However, its purpose is not to create policy within the document itself.

By providing a baseline for the Plymouth Policy Area's canopy cover, this report will provide an evidence base to inform the development of planning policy and to embed targets and standards within Supplementary Planning Documents.

Furthermore, the study wanted to explore whether there were correlations between tree canopy cover and human health and wellbeing, by comparing tree cover aerial imagery with geographically explicit data from the Office of National Statistics (ONS) and other sources[9].

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

[9] L sted n Append x I

1.3 Background to the Role of Trees in Cities

In 2014, around 54% of the worlds population were living in towns and cities and that figure is set to increase to 70% by 2050[10].

Almost 2/3 of the urban environment that will exist by 2030 is yet to be built. If we want healthy, happy and productive communities it is paramount that we create and maintain healthy and sustainable urban environments.

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 and extent of Canopy Cover in the Plymouth Policy Area can inform decisions that will improve human health and environmental quality.

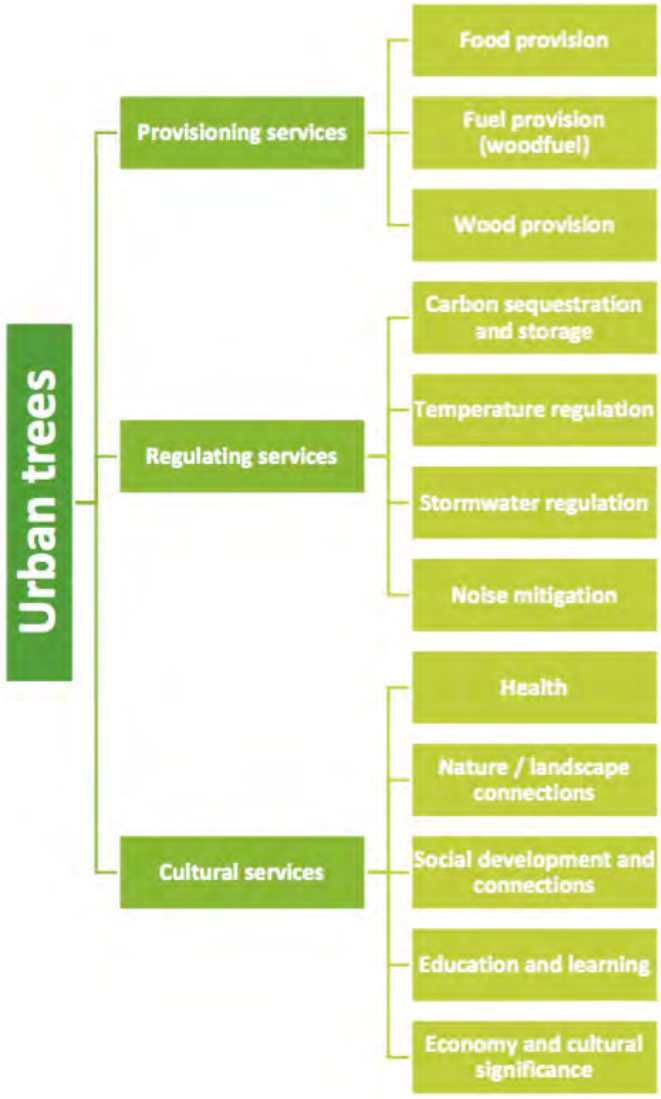


Fig 2: Ecosystem Services Provided by Trees

Davies et al. (2016) provides detail of each of the ecosystem services provided by urban trees (see fig 2) which is also summarised in Appendix IV. An illustrated example is also provided as fig 3 (overleaf).

[10] Eke und (2015)

The Benefits of Trees

Energy Saving

Trees located alongside buildings can act as a secondary insulating layer, regulating temperatures around buildings. If well placed, trees can help keep buildings cool in the summer and warmer in the winter.

Property Value

Tree-lined streets have been proven to increase house prices by as much as 15%. Most people chose to live in and/or around trees where possible.



Improving Air Quality

Trees filter fine particles from the air reducing pollution and improving health.

Storm Water Attenuation

Trees help to reduce localised flooding by intercepting rainfall and maintaining soil permeability.

Shade and Cooling

Trees cool the air by providing shade and through evapotranspiration from their leaves. Larger canopy species are particularly effective.

Aesthetic

Trees bring a sense of place and maturity to new developments, whilst larger species help to create a more human scale to old and existing townscapes.

Storing Carbon

As trees grow they accumulate carbon in their woody tissues, reducing the amount of this greenhouse gas in the atmosphere.

Urban Forest Food

Trees provide fruit and nuts for wildlife and humans. They also provide an important source of nectar for bees and other insects.

Biodiversity and Habitat

An increase in tree diversity will benefit a host of insects, birds and mammals in our towns and cities.



Landscape Screening

Not everything in cities is aesthetically pleasing and in some instances, trees and other vegetation can be of assistance in screening undesirable views.

Assists Recovery

Helps improve recovery times from illness, reduces stress plus improves mental health and well being.

Focal Point

Improves social cohesion. Reduces crime.

Fig 3: The Benefits of Trees (adapted from Rogers et al 2015)

2. Data analysis

2.1 Methodology

Project boundaries were supplied for the Plymouth Policy Area by Plymouth Council. The Plymouth City Administrative area and the additional wards (and partial wards) that make up the Urban Fringe and Plymouth Policy Area were obtained from Ordnance Survey (see fig 4 opposite).

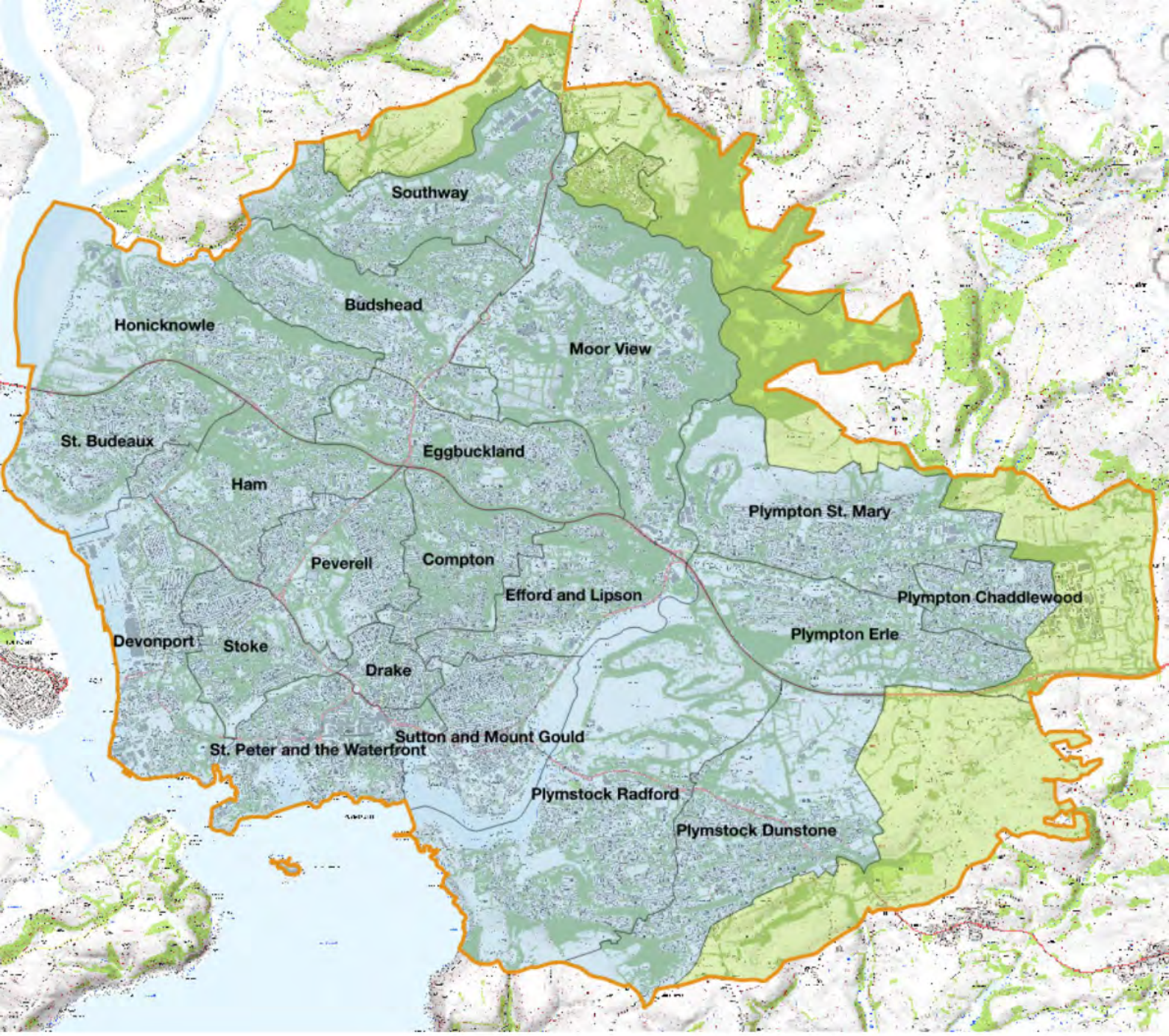
Tree Canopy mapping (The National Tree Map) was purchased from Bluesky for the desired project area.

Health and Socio economic data was obtained from a variety of official sources such as the Office of National Statistics (ONS), other sources are listed in Appendix I).

These three datasets were combined on a Geographical Information System to provide the maps used in this report.

Because the Plymouth Policy Area did not directly match the Ordnance Survey Boundaries, further areas were used in the study to match the level at which the ONS 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 the majority of the canopy falls. This 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 and QGIS 2.8.



Legend	
	Plymouth City Administrative Boundary (Wards)
	Urban Fringe
	Plymouth Policy Area - Study Area

Fig 4: Study Areas including Plymouth City Wards and Urban Fringe

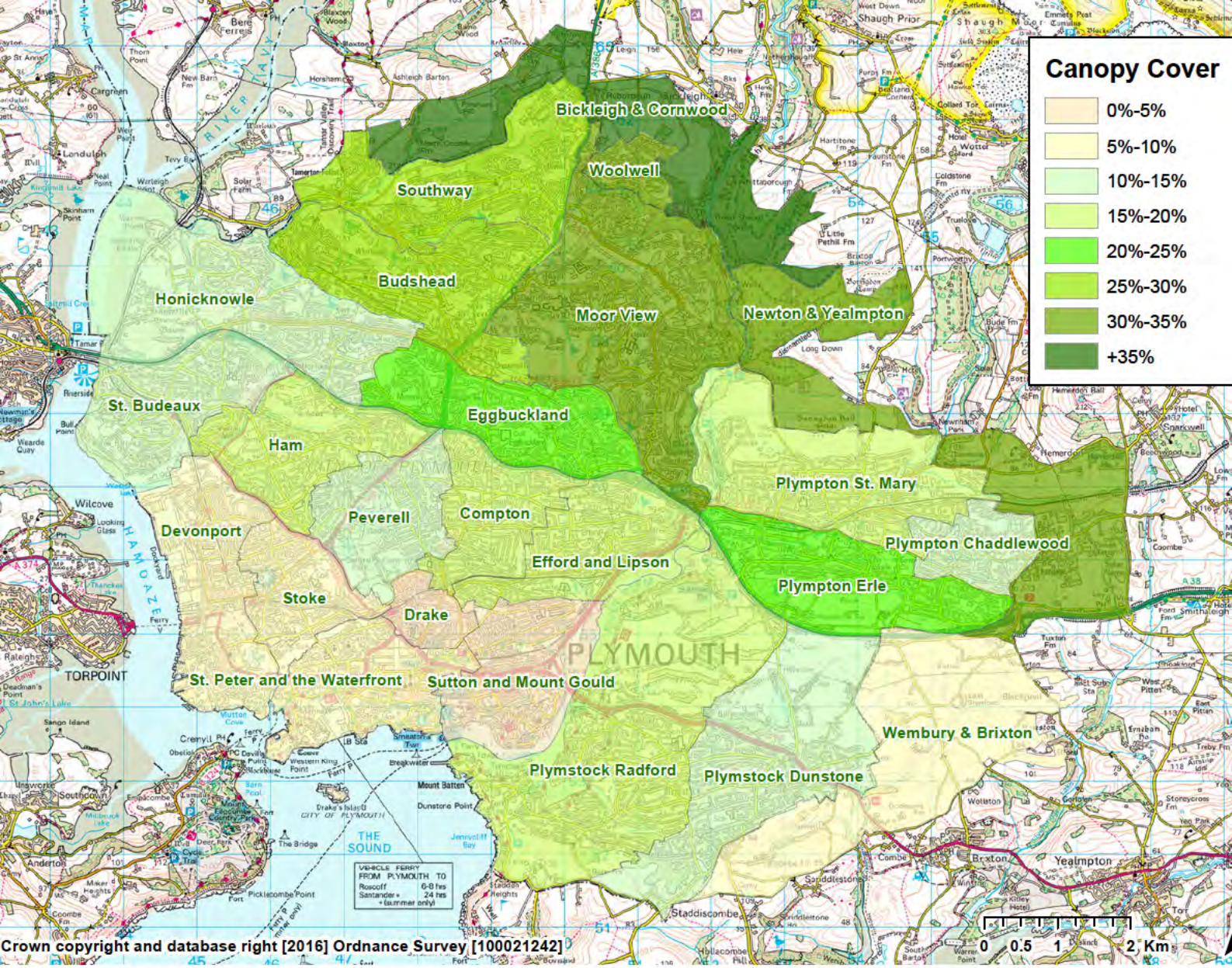


Fig 5: Canopy Cover

3. Results

3.1 Average Canopy Cover

The average canopy cover across the Plymouth Policy Area was calculated at 18.5%. Averages for the Urban Fringe and the Plymouth City Administrative Area were calculated at 24.9% and 16.9% respectively.

Canopy cover values range from just 2.9% in the Sutton and Mount Gould Ward to 31.7% in the Moor View Ward.

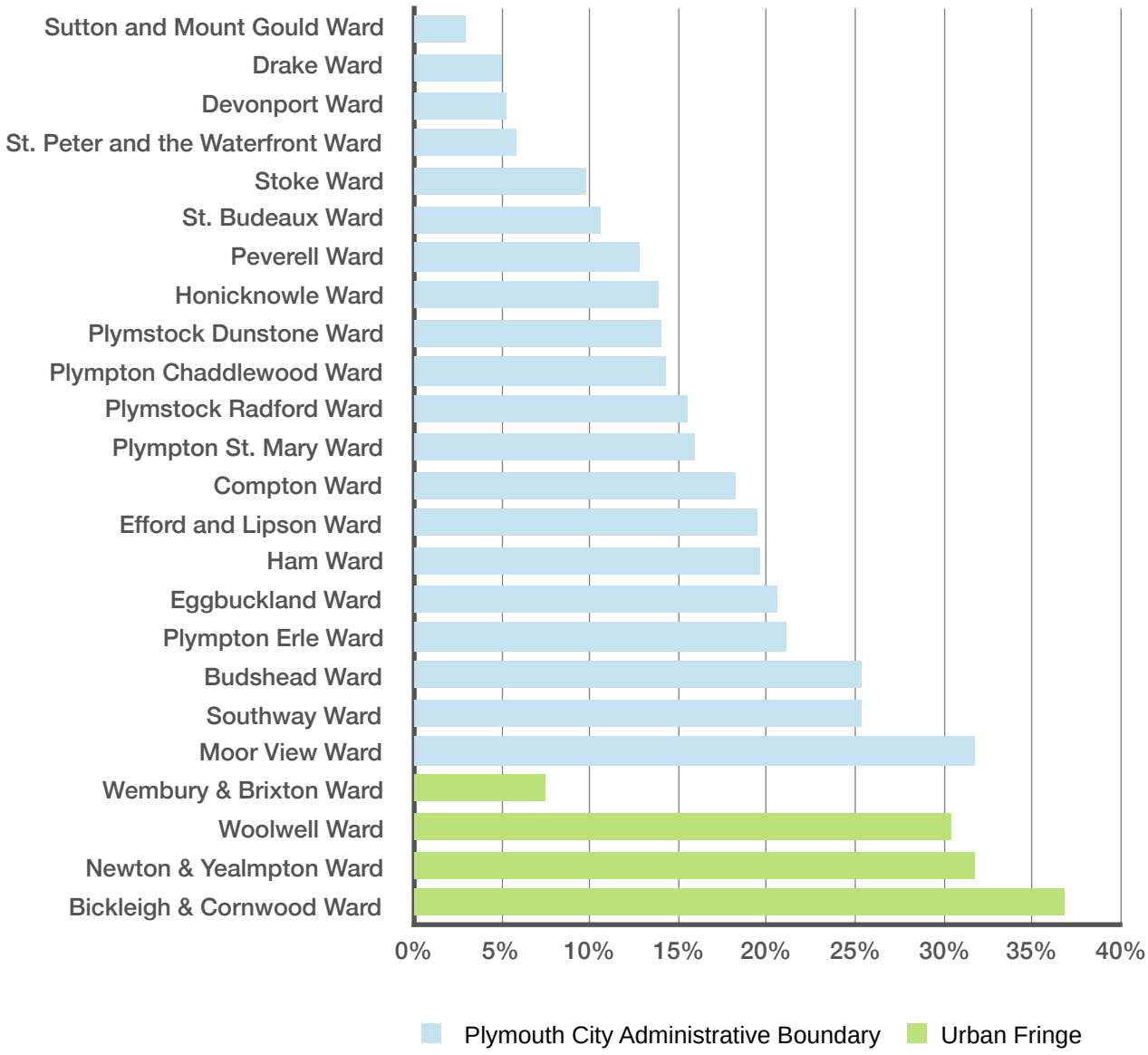


Figure 6: Tree Canopy Cover in Plymouth Administrative Area and Urban Fringe

3.2 How does Plymouth compare to other cities?

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

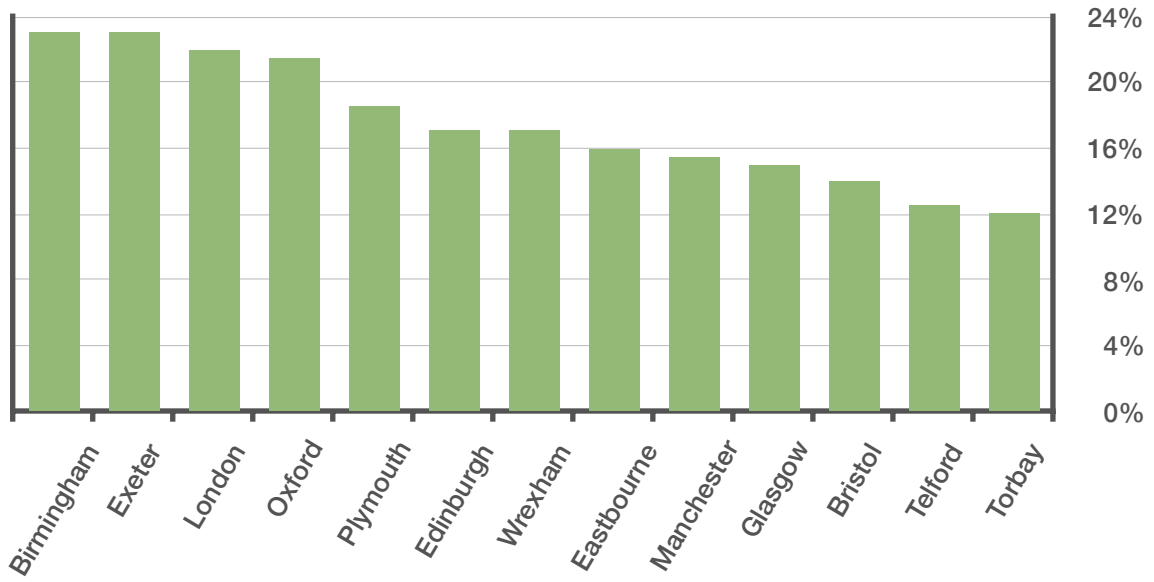


Figure 7: Percentage of Tree Canopy Cover for UK cities

4. Canopy Cover and Quality of Life

This section compares canopy cover with various quality of life indicators for Plymouth. These are shown for the smallest or 'lowest' (more 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 shapes 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% canopy cover (the average canopy cover across Plymouth Policy Area) and those that possess a canopy cover equal or greater than 18%.

What the following charts show are not necessarily 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 fig 5 (page 17).

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[11], Plymouth has one of the widest healthy life expectancy gaps in the UK. There is a life expectancy difference of nearly 20 years between the west and east of the City.

The results (see fig 8) show that in areas with higher tree canopy cover Healthy Life expectancy is increased, however other socioeconomic 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.

[11] L fe Expectancy n P ymouth 2016 - Pub c Hea th, P ymouth C ty Counc

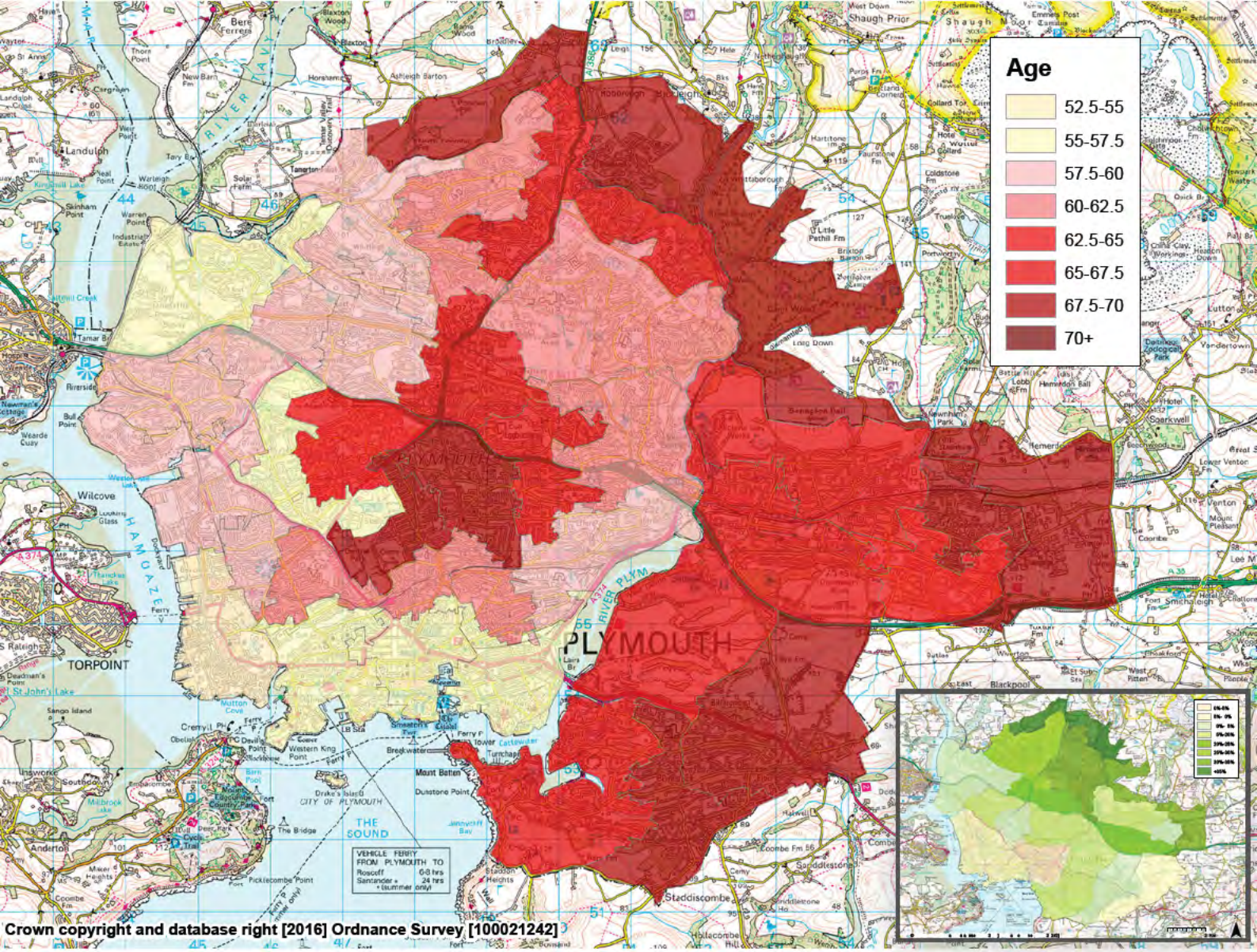
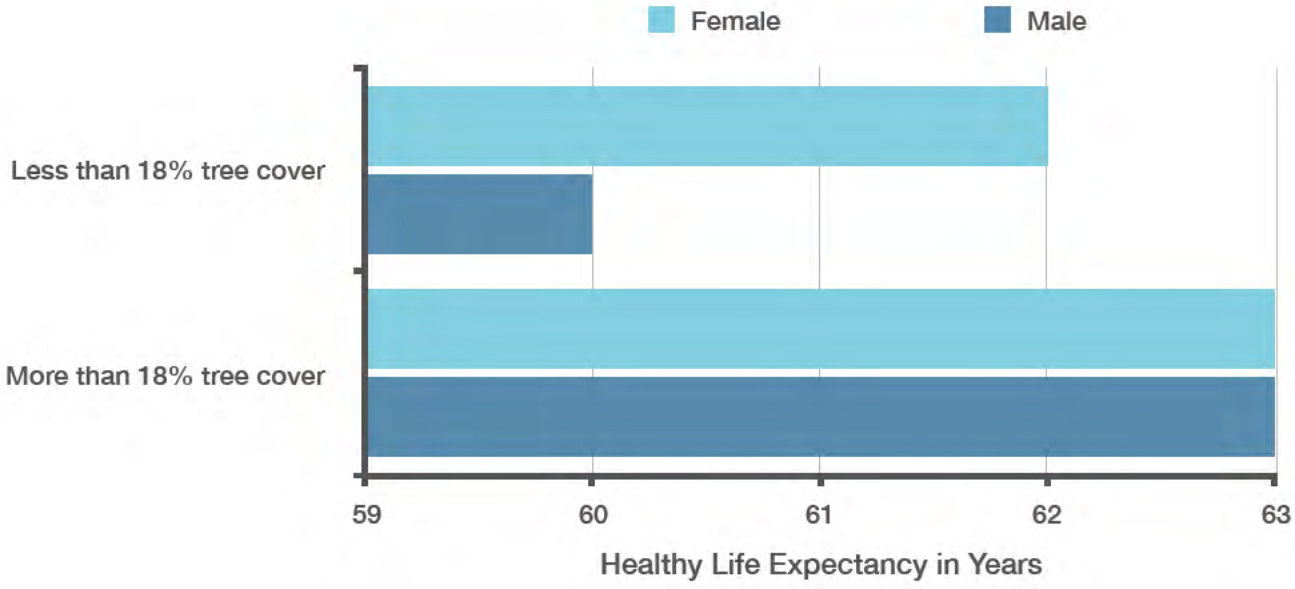


Figure 8 (above): Healthy Life Expectancy by MSOA

Figure 9 (below): Healthy Life Expectancy and Average Tree Cover



4.2 Hospital Admissions

In the same way that increased canopy cover correlates with higher life expectancy, more “treed” areas of Plymouth have significantly fewer emergency hospital admissions. However, elective admissions are significantly greater in areas where higher tree canopy cover is present (see fig 9 and 10 opposite).

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.[12]

Stress has been estimated to cost Plymouth £2.65 million a year[13] and is one of the key contributing factors to mental health issues, which access to good quality green-spaces can alleviate[14]. Depressive disorders are now the foremost cause of disability in middle high income countries and can be precursors to chronic health problems. In Plymouth levels of depression are above the national average, although hospital admissions for mental health issues are generally low compared to the national average, those for self harm and attempted suicide are above the national average[15].

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 will be used and may even help to reduce social health inequalities[16]. 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 approximately 60% of adults in Plymouth are overweight.

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[12] Hart g, 2003

[13] P ymouth Hera d Feb 16, 2016

[14] Wh te 2013

[15] Br t sh Med ca Assoc at on, May 2008. L veWe Commun ty Menta Hea th Profi e for P ymouth 2012

[16] M tche and Popham, 2008

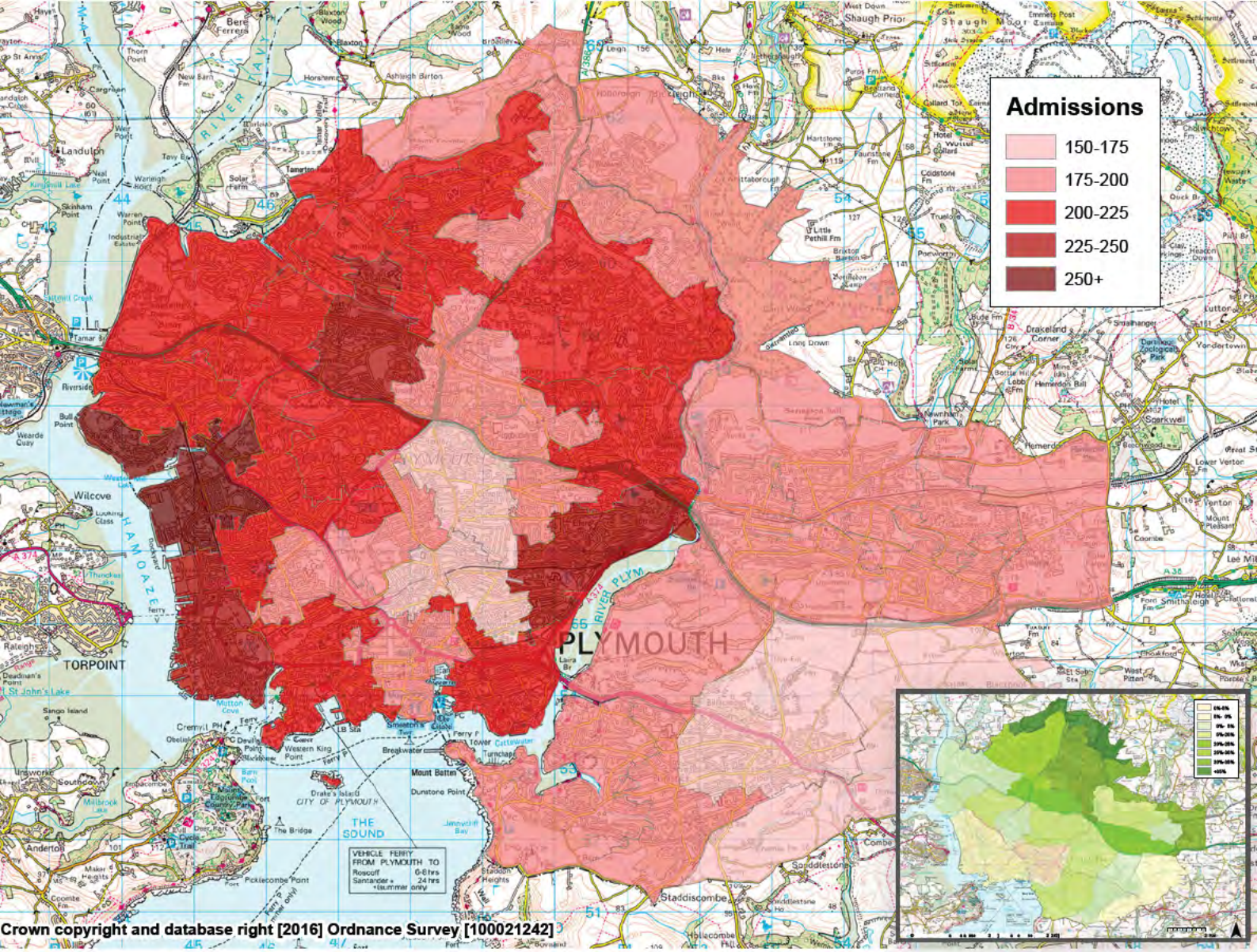
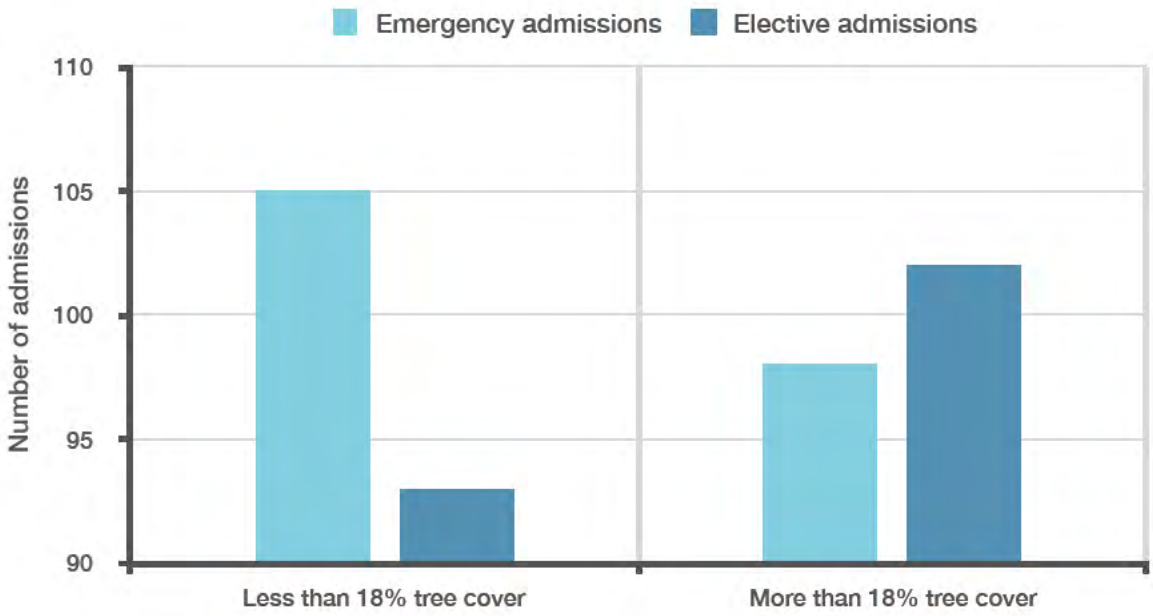


Figure 10 (above): Hospital Admissions by MSOA

Figure 11 (below): Hospital Admissions and Average Tree Cover



4.3 Index of Multiple Deprivation

Data concerning deprivation is collected at the Low Super Output Area (LSOA) scale and displayed in the charts below, contrasting the Output Areas with less than 18% canopy cover and those with a canopy cover equal or greater than 18%.

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

The scores for the Index of Multiple Deprivation do not relate straightforwardly to the proportion of the population experiencing deprivation. For example, an area with a score of 60 on the Index of Multiple Deprivation 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.

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.

The relationship between Canopy Cover and IMD is illustrated in fig 12 and 13 below.

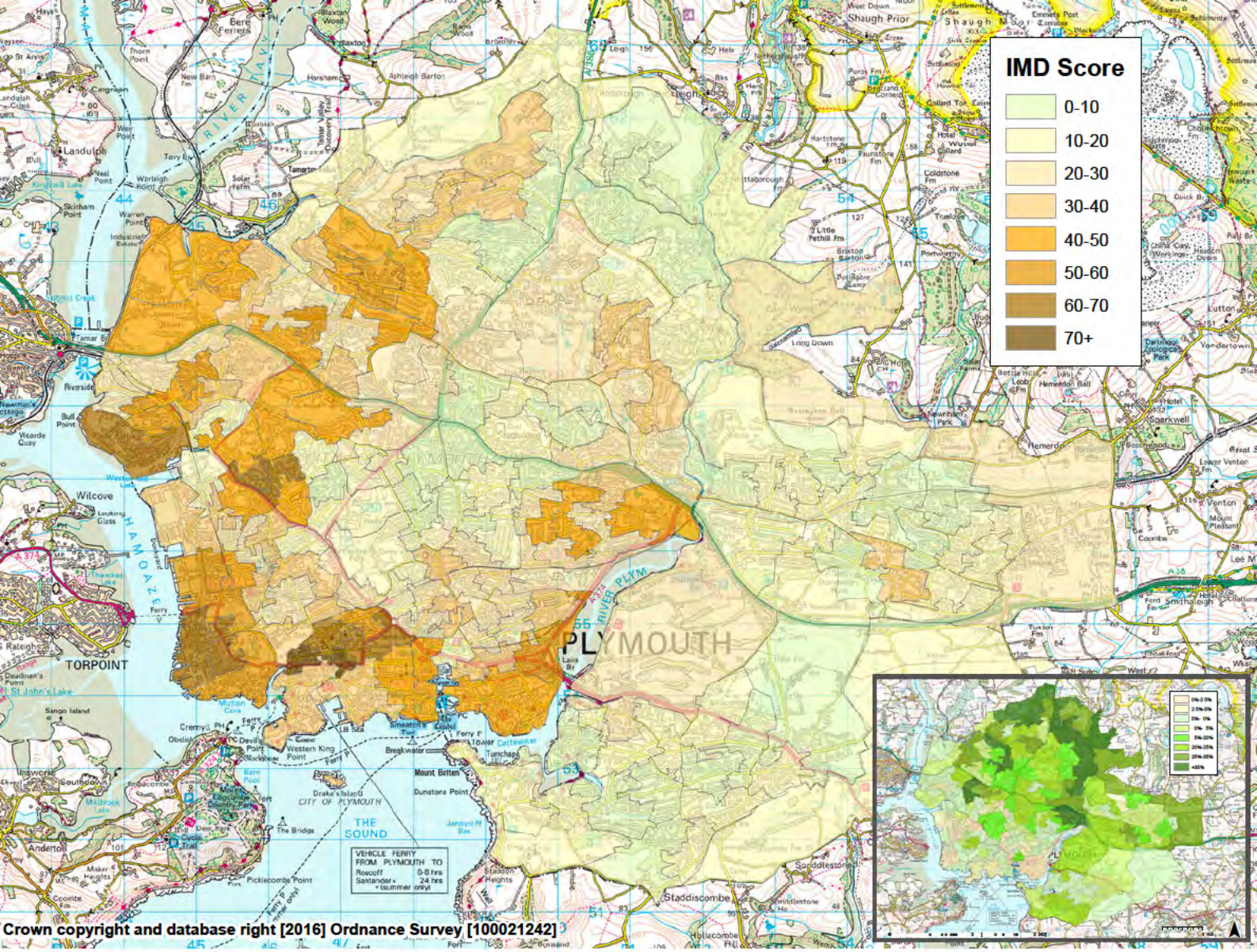
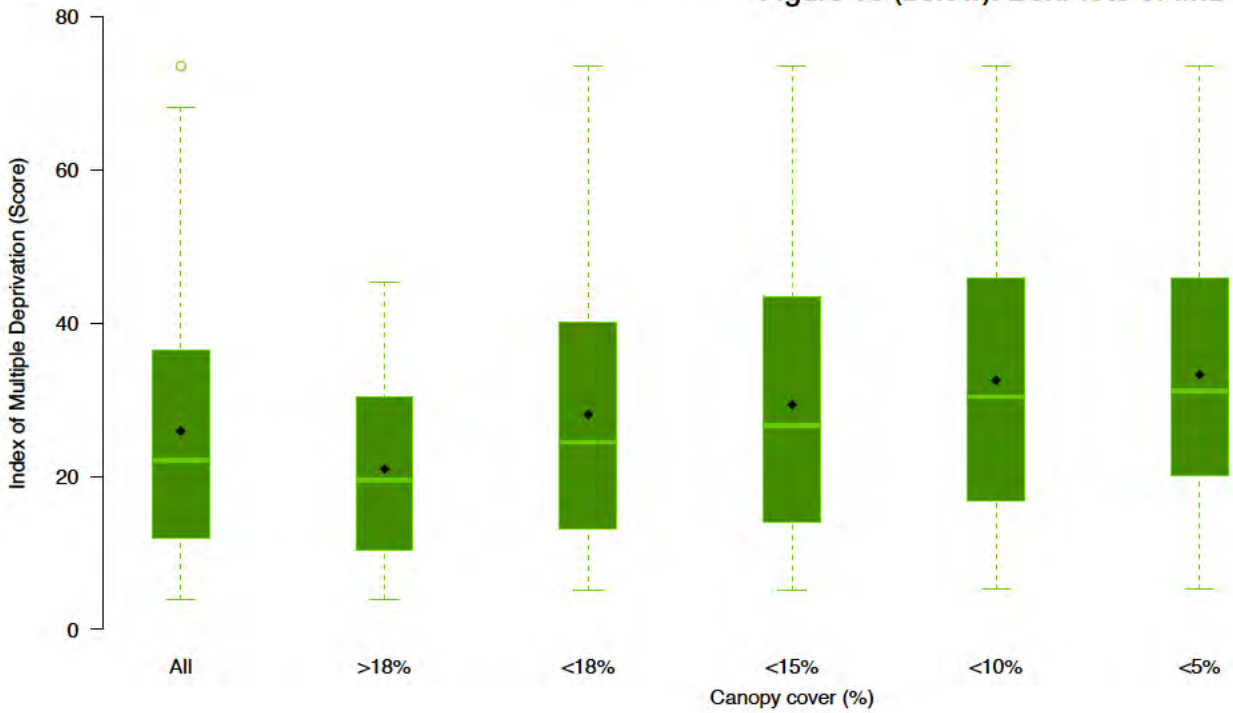


Figure 12 (above): Index of Multiple Depravation by LSOA

Figure 13 (below): BoxPlots of IMD at LSOA



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.

Plymouth has the highest crime rate in the Devon and Cornwall area with 68.93 crimes per 1000 residents, compared to an average of 46.53. However, across similar areas (within England) Crime in Plymouth is currently ranked below average[17].

Nonetheless, there is a wide variation between areas like Plympton and Chaddlewood (circa 100 crimes and 14% tree cover) and Sutton and Mount Gould (circa 500+ crimes and 3% tree cover). Generally, across the Plymouth Policy Area, areas with higher tree cover also have lower crime rates.

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[18]. Furthermore, among minor crimes, there is less graffiti, vandalism, and littering in outdoor spaces with natural landscapes than in comparable plant-less spaces[19].

[17] Po ce.UK

[18] Troy 2012

[19] Brunson 1999

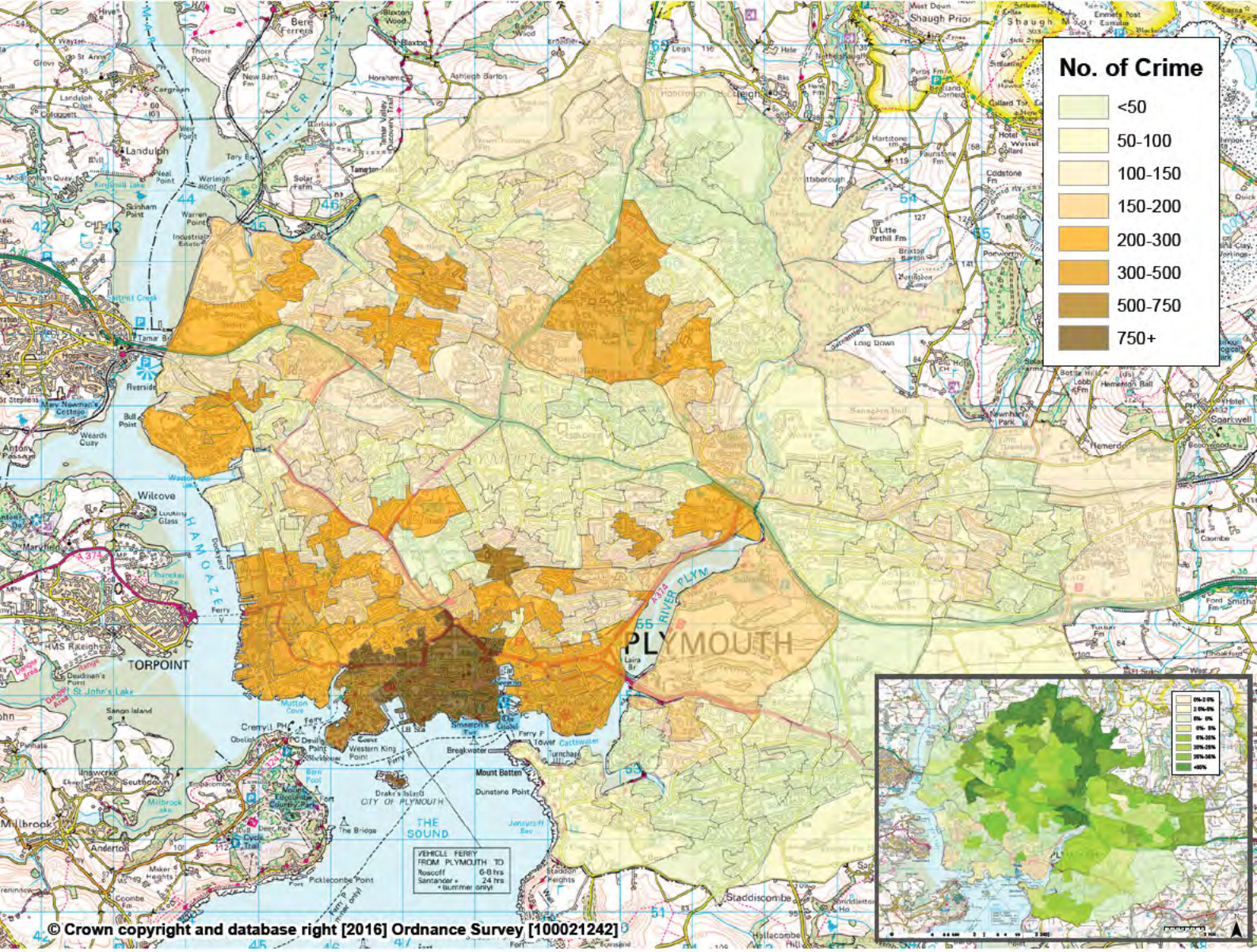
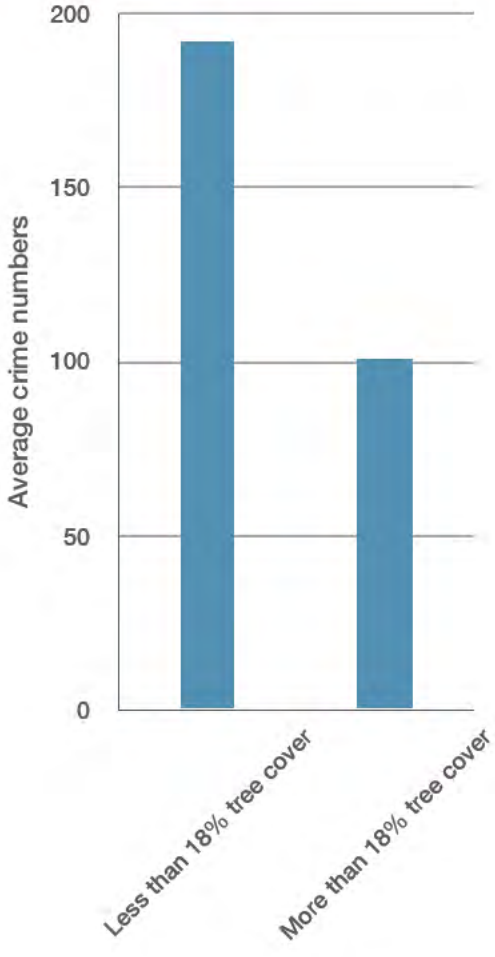


Figure 13 (above): Crime by LSOA

Figure 14 (below): Crime and average tree cover



5. Conclusions

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

For example; the canopy cover 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.

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. Plymouth as a whole has 18% 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 Plymouth 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 would help Plymouth Policy Area to make tree management decisions on the basis of the best available information and therefore 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 Plymouth City Councils' growth agenda aiming to increase population to over 300,000, 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.

In the most 'treed' wards the aim should be to maintain rather than increase 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 Plymouth Policy Area would be to achieve an average of 20% Canopy Cover by 2034.

6.2 Conduct an iTree Eco Survey

The last time there was any structured survey of the trees across Plymouth was as part of the 2005 (released in 2008) Trees in Towns 2 study. Tree composition data from the Trees in Towns II Survey, combined with other available datasets are presented in Appendix VI.

As there are no plans for a national Trees in Towns 3 survey 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 gypsy moth, emerald ash borer, and Ash Dieback – 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: The impact of the i-Tree findings on tree planting in London VictoriaIn 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: 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 has meant an extra £25,000 to the tree budget in both the year of the study and in 2014.

Example: The impact of the i-Tree findings on public engagement in Wrexham
In Wrexham, on the next day of the release of the i-Tree Eco report and before the local authority had had the time to issue the 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

Prepare 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 that exists within Plymouth and provide a vision for the urban forest 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;
3. Monitor canopy cover as a key performance indicator for management of the urban forest;
4. Identify and prioritise action through planting and management to ensure that tree cover is maintained, sustained and improved where this is appropriate;
5. Describe the role of trees within the landscape setting of Plymouth.
6. 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 Plymouth Administrative Area.

The iTree Eco survey and the Plan for Trees will be essential tools to ensure trees are 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 with other maps to quickly determine where it will be best to plant trees. 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 Plymouth now has readily accessible and useable map files illustrating the tree canopy cover over the entire Plymouth Policy Area. It is a straightforward and easily repeatable task to identify new planting areas at any scale. This will help focus where to target resources for future tree planting.

Appendix I
Mapping Datasources

The National Tree Map (NTM) by Bluesky International Ltd is a commercial product which seeks to identify all trees and shrubs 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. The map operates a 5 year rolling update program (NTM, 2015).



Aerial photography



Crown polygons



Idealised crowns



Height points

The National Tree Map consists of three GIS datasets:

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

The point locations of each tree in the NTM 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 from ONS.

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).

Datasets used in this report were collected from a range of sources to use in the comparative analysis with canopy cover. Not all of these datasets contributed to the results within the report.

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	Plymouth Urban fringe boundary	Plymouth City 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

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. 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%	
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%

For updated Tree Canopy Cover figures go to: www.urbantreecover.org

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 as leafier environments improve consumer spending[20]. Additionally, businesses are prepared to pay greater ground rents[21], also associated with higher paid earners who are also more productive (Kaplan, 1993; Wolf, 1998), house prices increase[22], and crime is reduced[23] thereby (Section 1) "Building a strong, competitive economy", (paragraph 18). This is also directly linked to (Sec-

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[20] Shoppers c a m that they w spend 9% to 12% more for goods and serv ces n centra bus ness d str cts hav ng h gh qua ty tree canopy (Wo f, 2005).

[21] 7% h gher renta rates are ach evab e for commerc a offices hav ng h gh qua ty treescapes (Laverne and W nson-Ge deman, 2003).

[22] The presence of arger trees n gardens and as street trees adds from 3% to 15% to home va ues (Wo f, 2007).

[23] Pub c hous ng res dents w th nearby trees and natura andscapes reported 25% fewer acts of domest c aggress on and v o ence (Kuo and Su van, 2001a). Pub c hous ng bu d ngs w th greater amounts of vegetat on had 52% fewer tota cr mes, 48% fewer property cr mes, and 56% fewer v o ent cr mes than bu d ngs w th ow amounts of vegetat on (Kuo and Su van, 2001b).

tion 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 (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 communities[25]. 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

[24] A 10% ncrease n trees rough y equa s a 12% decrease n cr me (Troy, 2012).

[25] [25] See http://depts.washington.edu/hhwb/ for international peer reviewed research on this topic.

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 across Plymouth 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), 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'[26] 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.'

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, Plymouth 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, Plymouth 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.

[26] https://www.gov.uk/government/up oads/system/up oads/attachment data/fi e/221023/pb13871-forestry-po cy-statement.pdf

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.

Regulating services

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.

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 la-

tent 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 throughfall. 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 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.

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 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.

Appendix V
Notes on attaining Canopy Cover Goals within new developments

For 20% 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 need to be produced.

The primary factors to be considered are:

1. Retention of existing trees
    a) BS5837:2012 Trees in relation to design, demolition and construction
    b) Measurement of existing canopy

2. Requirements and specification of 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.

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 20% 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.

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.

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.

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.

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.

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 should be produced to include requirements for planting specifications and details of the soil volume expected for different species and subspecies.

Time to canopy cover target attainment

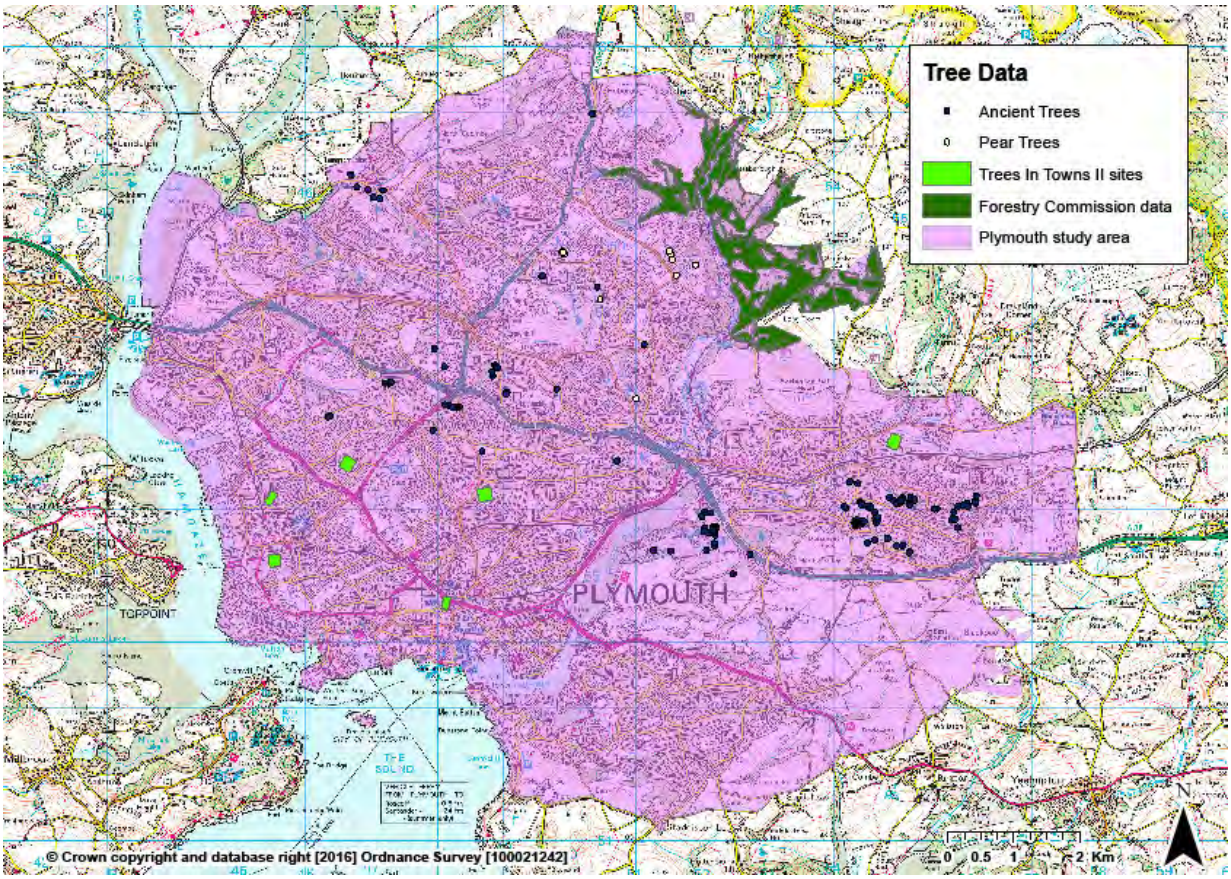
Unless the canopy cover of a site is already at or very close to the target, it will not be possible to reach the target at the time of planting. It takes many years for trees to grow to their potential and so the canopy cover target is aimed at a future time. The further guidance on species and sub 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.

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.

Appendix VI - Tree Composition in the Plymouth Policy Area



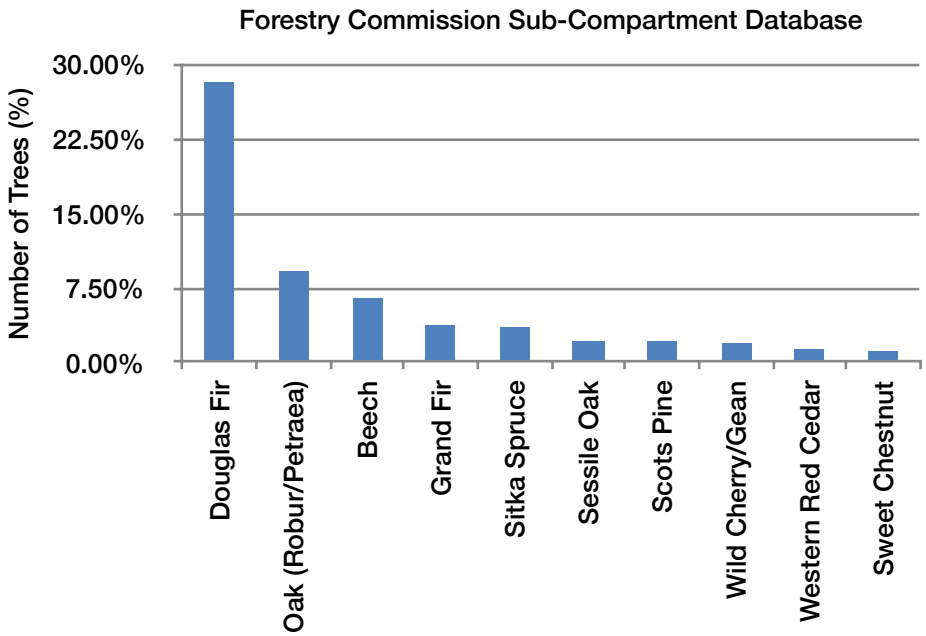
We investigated the use of existing databases to draw conclusions about the composition and characteristics of Plymouth's urban forest. In this study four inputs were used: Ancient Tree data, Pear Tree data, the Trees in Towns II database and Forestry Commission's Sub-Compartment database (see map above). The Treezilla platform was also checked but does not currently hold any information on trees in the Plymouth area (www.treezilla.org). No information was found on the Freedom of Information websites (www.whatdotheyknow.com).

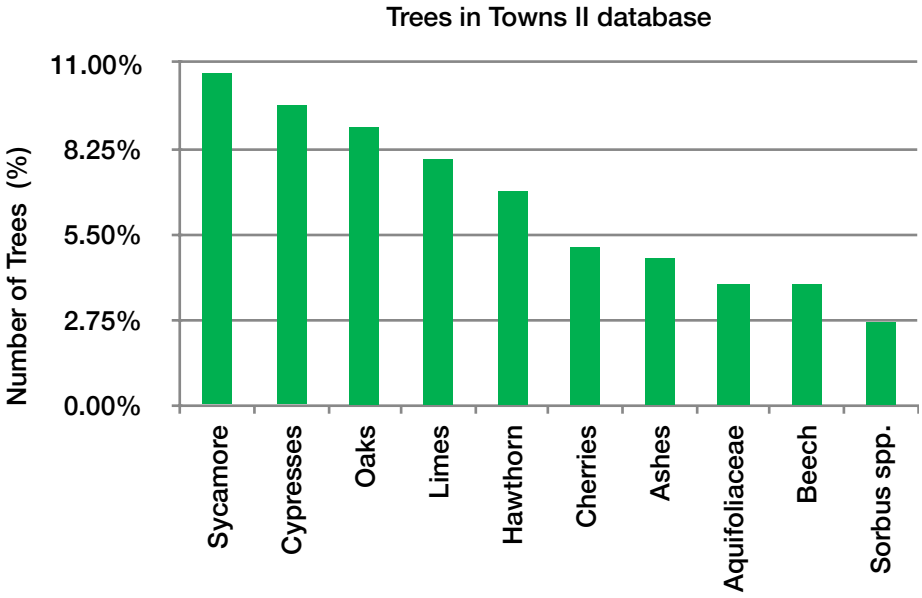
In each dataset different trees are most common. Oak and Beech are important species for all data sources. There appears to be a stronger correlation between the Trees and Towns II and the Ancient Trees datasets (see charts below). Species appearing in large numbers in both databases include Sycamore, Lime, Ash. The Sub-compartment Database, where most data is rurally based, is dominated by Douglas fir (28%), and contains 5 conifer species; this reflects its purpose as a production forest. A full list of species in each dataset is also included below.

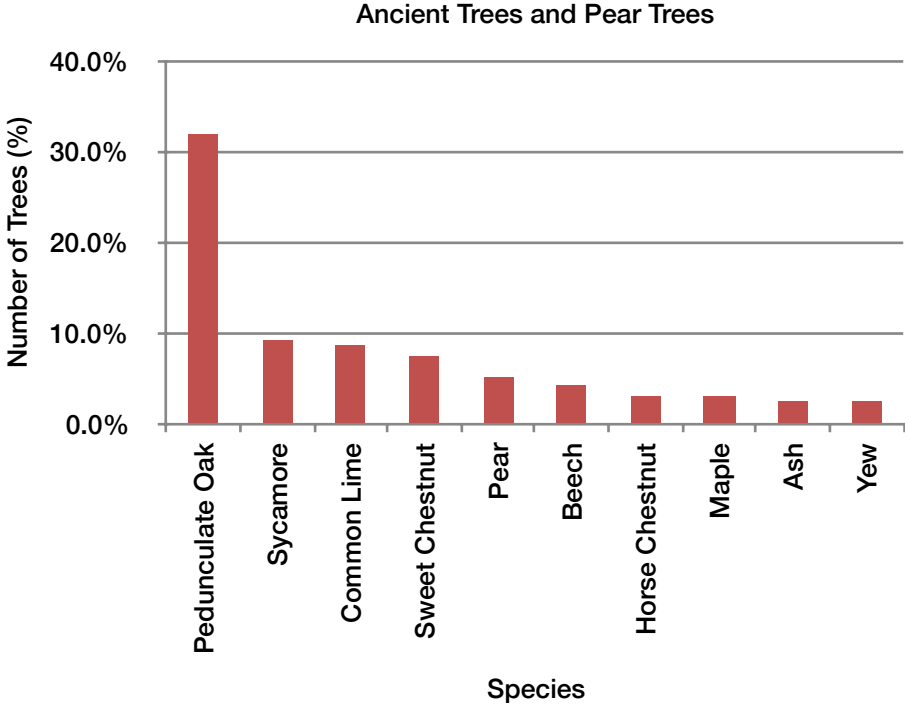
For most of the datasets it is not possible to quantify the area of Plymouth's urban forest they represent. This is because only a revelatory small proportion of the urban forest has been captured. The Forestry Commission's Sub-Compartment database represents approximately 13.49% of the total canopy cover with the study area.

As well as species information, each dataset contains additional information reflecting the purpose for which they were collected. For example, the Sub-Compartment database contains information on expected growth rates as the data will be used for timber production estimates, whereas the Ancient Tree data included estimated ages and flora found on the tree. Therefore, it is possible to extract more information than just species name, but the differing standards and collection methodologies may represent a problem when combining datasets. For this reason we do not attempt, in this study, to draw conclusions regarding the composition of Plymouth's Urban forest; instead we are describing the available datasets and their coverage.

In the future we recommend that a common standard should be used to record all tree records within Plymouth (See 7.2).


Forestry Commission Sub-Compartment Database
Number of Trees (%)
30.00%
22.50%
15.00%
7.50%
0.00%
Douglas Fir
Oak (Robur/Petraea)
Beech
Grand Fir
Sitka Spruce
Sessile Oak
Scots Pine
Wild Cherry/Gean
Western Red Cedar
Sweet Chestnut


Trees in Towns II database
Number of Trees (%)
11.00%
8.25%
5.50%
2.75%
0.00%
Sycamore
Cypresses
Oaks
Limes
Hawthorn
Cherries
Ashes
Aquifoliaceae
Beech
Sorbus spp.


Ancient Trees and Pear Trees
Number of Trees (%)
40.0%
30.0%
20.0%
10.0%
0.0%
Pedunculate Oak
Sycamore
Common Lime
Sweet Chestnut
Pear
Beech
Horse Chestnut
Maple
Ash
Yew
Species

Ancient Tree and Pear Data		Shade tolerance		Drought tolerance		Waterlogging tolerance	
Species	Count	Score	SE	Score	SE	Score	SE
Ash	4	2.66	0.13	2.5	0.25	2.7	0.3
Atlas Cedar	1	1.97	0.41	3.3	0.15	1.03	0.02
Beech	7	4.56	0.11	2.4	0.43	1.02	0.01
Black Walnut	1	1.93	0.25	2.38	0.38	1.83	0.27
Cedar of Lebanon	1	1.35	0	2.75	0	1.03	0
Coast Redwood	2	4.21	0.21	2	0	0.95	0.05
Common Lime	14	2.1	0.43	4.38	0.47	1.39	0.38
Cork Oak	1	2.51	0.3	3.75	0.23	1.64	0.27
Eastern Hemlock	1	4.83	0.14	1	0	1.25	0.25
Eucalyptus	1						
Hawthorn	3	3.97	0.12	2.66	0.16	1.65	0.06
Hazel	1	3.53	0.23	3.04	0	1.68	0.09
Holm Oak	1	3.02	0.19	4.72	0	1.04	0
Horse Chestnut	5	3.43	0.27	2.82	0.15	1.39	0.17
Japanese Red Cedar	1	3.17	0.44	2.75	0.25	2	1
Juniper	1	1.63	0.24	4.8	0.17	1.27	0.05
London Plane	2	2.93	0.16	2.88	0.25	2.36	0.15
Lucombe Oak	3	2.51	0.3	3.75	0.23	1.64	0.27
Maple	5	3.58	0.18	2.58	0.27	1.59	0.26
Monterey Pine	1	2.97	0.03	3	0	1	0
Pear	8	2.22	0.25	3.38	0.45	1.62	0.2
Pedunculate Oak	51	2.45	0.28	2.95	0.31	1.89	0.18
Persian Ironwood	1	2.3	0.14	2.46	0.08	2.1	0.32
Pin Oak	1	2.49	0.51	2.38	0.38	3.49	0.17
Red Oak	1	2.51	0.3	3.75	0.23	1.64	0.27
Sessile Oak	1	2.73	0.27	3.02	0.15	1.2	0.2
Silver Pendant Lime	1	3.34	0.34	2.81	0.12	1.52	0.25
Smooth-leaved Elm	3	4.18	0.16	2.75	0.15	1.83	0.16
Sweet Chestnut	12	3.15	0.23	3.46	0.18	1.32	0.28
Sycamore	15	3.73	0.21	2.75	0.16	1.1	0.08
Tulip Tree	1	2.07	0.27	2.6	0.3	1.3	0.12
Turkey Oak	2	2	0	5	0	1	0
Unkown	1						
Wild Cherry	1	3.33	0.33	2.66	0.22	1.19	0.17
Wych Elm	1	3.53	0.13	2.41	0.13	2.03	0.44

Yew	4	4.43	0.13	3.01	0.17	1.32	0.28

Trees in Towns II Data			Shade tolerance		Drought tolerance		Waterlogging tolerance	
Species	Count	Area (%)	Score	SE	Score	SE	Score	SE
Maples	15	2.6%	3.58	0.18	2.58	0.27	1.59	0.26
Sycamore	62	10.6%	3.73	0.21	2.75	0.16	1.1	0.08
Alders	2	0.3%	1.59	0.3	1.99	0.33	3.04	0.28
Birches	6	1.0%	1.77	0.22	1.83	0.26	2.08	0.23
Hornbeam	7	1.2%	3.97	0.12	2.66	0.16	1.65	0.06
Cedars	1	0.2%	1.97	0.41	3.3	0.15	1.03	0.02
Cypresses	56	9.6%	2.38	0.26	3.89	0.22	1.39	0.16
Pines	8	1.4%	1.8	0.25	3.71	0.3	1.48	0.19
Spruces	4	0.7%	4.12	0.28	2.25	0.21	1.49	0.15
Yews	10	1.7%	4.43	0.13	3.01	0.17	1.32	0.28
Beech	23	3.9%	4.56	0.11	2.4	0.43	1.02	0.01
Oaks	52	8.9%	2.51	0.3	3.75	0.23	1.64	0.27
Ashes	28	4.8%	2.73	0.33	2.59	0.27	2.86	0.19
Aquifoliaceae	23	3.9%	3.52	0.52	2.85	0.27	2.39	0.31
Fabaceae	9	1.5%	1.77	0.13	3.55	0.31	1.6	0.18
Hippocastanaceae	7	1.2%	3.52	0.32	2.39	0.11	1.79	0.16
Juglandaceae	1	0.2%	2.48	0.35	2.83	0.21	1.9	0.24
Lauraceae	9	1.5%	3.31	0.27	2.72	0.13	1.86	0.16
Magnoliaceae	7	1.2%	2.92	0.18	1.98	0.2	1.66	0.29
Moraceae	1	0.2%	1.83	0.4	3.4	0.2	1.42	0.23
Simaroubaceae	1	0.2%	2.44	0.44	2.96	0.12	1.52	0.27
Palms	14	2.4%	3.58	0.18	2.58	0.27	1.59	0.26
Planes	2	0.3%	2.93	0.16	2.88	0.25	2.36	0.15
Apple/crab apple	14	2.4%	2.08	0.35	2.97	0.28	1.25	0.06
Cherries	30	5.1%	2.28	0.26	2.83	0.25	1.3	0.13
Hawthorn	40	6.8%	1.97	0.27	3.44	0.17	1.35	0.17
Pears	6	1.0%	2.22	0.25	3.38	0.45	1.62	0.2
Plums	5	0.9%	2.28	0.26	2.83	0.25	1.3	0.13
Sorbus spp.	16	2.7%	2.43	0.19	3.16	0.24	1.22	0.27
Poplars	2	0.3%	1.51	0.17	2.18	0.24	2.53	0.26
Willows	4	0.7%	1.57	0.1	1.65	0.23	3.88	0.14
Poplars	2	0.3%	1.51	0.17	2.18	0.24	2.53	0.26
Willows	4	0.7%	1.57	0.1	1.65	0.23	3.88	0.14

Limes	46	7.9%	3.67	0.28	2.52	0.11	1.45	0.11
Unidentified tree	1	0.2%						
Berberidaceae (sh)	2	0.3%	2.11	0.25	3.58	0.06	1.51	0.27
Betulacaeae (sh)	24	4.1%	2.23	0.27	2.19	0.27	2.27	0.25
Buddlejaceae (sh)	5	0.9%	1.56	0.19	3.46	0.42	1.04	0
Caprifoliaceae (sh)	3	0.5%	2.84	0.14	2.63	0.13	2.25	0.19
Cornaceae (sh)	1	0.2%	3.39	0.22	2.49	0.3	1.63	0.15
Ericaceae (sh)	1	0.2%	2.34	0.21	2.39	0.27	2.46	0.29
Oleaceae (sh)	5	0.9%	2.63	0.31	2.62	0.29	2.62	0.21
Rosaceae (sh)	16	2.7%	2.1	0.23	3.34	0.25	1.4	0.17
Unidentified shrub	9	1.5%						
	584	100.0%						

Forestry Commission Data			Shade tolerance		Drought tolerance		Waterlogging tolerance	
Species	Area (ha)	Area (%)	Score	SE	Score	SE	Score	SE
Ash	1.62	0.5%	2.66	0.13	2.5	0.25	2.7	0.3
Aspen	1.99	0.6%	2.22	0.07	2.85	0.25	2.07	0.04
Beech	19.82	6.5%	4.56	0.11	2.4	0.43	1.02	0.01
Birch (Downy/Silver)	2.05	0.7%	1.94	0.08	1.56	0.195	2.325	0.165
Coast Redwood	1.11	0.4%	4.21	0.21	2	0	0.95	0.05
Common Alder	1.05	0.3%	2.71	0.5	2.22	0.66	3.9	0.2
Corsican Pine	1.36	0.4%	2.1	0.43	4.38	0.47	1.39	0.38
Crab Apple	0.05	0.0%	2.32	0.2	3.16	0.18	1.68	0.09
Douglas Fir	87.1	28.4%	2.78	0.18	2.62	0.41	1.79	0.12
Grand Fir	11.33	3.7%	4.01	0.19	2.33	0.33	1.57	0.3
Hornbeam	1.4	0.5%	3.97	0.12	2.66	0.16	1.65	0.06
Hybrid Poplar	0.34	0.1%	1.27	0.27	1.77	0.23	1.35	0.26
Japanese Larch	0.02	0.0%	1.38	0.21	3	1	1.58	0.43
Lawsons Cypress	1.38	0.4%	3.67	0.38	2.06	0.58	1.02	0.02
Mixed Broadleaves	56.76	18.5%						
Mixed Conifers	1.31	0.4%						
Monterey Pine	0.24	0.1%	2.97	0.03	3	0	1	0
Norway Spruce	0.09	0.0%	4.45	0.5	1.75	0.41	1.22	0.12
Oak (Robur/Petraea)	27.94	9.1%	2.45	0.28	2.95	0.31	1.89	0.18

Other Pines	0.45	0.1%	2.59	0.275	2.985	0.23	1.545	0.19
Pedunculate/ Common Oak	1.51	0.5%	2.45	0.28	2.95	0.31	1.89	0.18
Red Oak	0.46	0.1%	2.75	0.18	2.88	0.12	1.12	0.06
Rowan	0.26	0.1%	2.73	0.21	2.11	0.34	1.76	0.13
Scots Pine	6.1	2.0%	1.67	0.33	4.34	0.47	2.63	0.08
Sessile Oak	6.58	2.1%	2.73	0.27	3.02	0.15	1.2	0.2
Sitka Spruce	10.26	3.3%	3.85	0.36	1.52	0.15	1.99	0.22
Small-Leaved Lime	1.8	0.6%	4.18	0.16	2.75	0.15	1.83	0.16
Sweet Chestnut	2.94	1.0%	3.15	0.23	3.46	0.18	1.32	0.28
Sycamore	0.64	0.2%	3.73	0.21	2.75	0.16	1.1	0.08
Western Hemlock	49.28	16.1%	4.96	0.07	1.17	0.17	0.95	0.05
Western Red Cedar	3.93	1.3%	4.73	0.15	2.23	0.25	1.01	0.04
Wild Cherry/Gean	5.72	1.9%	3.33	0.33	2.66	0.22	1.19	0.17
Wild Service Tree	0.12	0.0%	3.38	0.2	3.74	0.13	1.04	0

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