Forest Research

# Portsmouth i-Tree Eco Technical Report

The Research Agency of the
Forestry Commission

Forest Research is the leading UK organisation engaged in forestry and tree related research. The Agency aims to support and enhance forestry and its role in sustainable development by providing innovative, high quality scientific research, technical support and consultancy services.

i-Tree is a state-of-the-art, peer-reviewed software suite from the USDA Forest Service that provides urban and community forestry analysis and benefits assessment tools, including i-Tree Eco. The Forest Service, Davey Tree Expert Company, National Arbor Day Foundation, Society of Municipal Arborists, International Society of Arboriculture, and Casey Trees have entered into a cooperative partnership to further develop, disseminate and provide technical support for the suite.

A project for Portsmouth City Council.

**Citation**

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**Images**

Taken in 2024 on behalf of the project by Barton Hyett Associates Arboricultural Consultants, Portsmouth City Council, and Forest Research.

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# Key Definitions

**Urban forest**: 'all the trees in the urban realm – in public and private spaces, along linear routes and waterways, and in amenity areas. It contributes to green infrastructure and the wider urban ecosystem' (Doick et al., 2016).

**i-Tree Eco**: a software application which quantifies the structure and environmental effects of urban trees and calculates their value to society. It was developed as the urban forest effects (UFORE) model in the 1990's to assess impacts of trees on air quality and has since become the most complete tool available for analysing the urban forest. Eco is widely used to discover, manage, make decisions on and develop strategies concerning trees in urban landscapes – www.itreetools.org.

**Ecosystem services:** benefits provided to people by the natural environment – such as clean air, food, places for exercise, and connection to our surroundings.

**Social and cultural values:** the non-material benefits people obtain from ecosystems, or the non-material values that people place on them. Examples are recreation, physical and mental health, opportunities for tourism, aesthetic appreciation, spiritual experience, and sense of place.

**Appendix B** provides a list of the common names for the trees detailed in this report.

# Executive Summary

Urban trees provide vital benefits that contribute to living comfortably in built-up areas. These benefits, called ecosystem services, include improving local air quality, reducing flooding, providing habitat for wildlife, and creating pleasant and healthy places.

As ecosystem services are often not marketable, they are generally undervalued, and inventories limited. This can lead to poor decision making about the management and maintenance of the components of the natural environment that provide them.

To gain knowledge about the structure and composition of Portsmouth's tree population, a sample-based survey was undertaken in the summer of 2024. 253 plots were surveyed across urban and surrounding rural areas and the data was processed using i-Tree Eco.

i-Tree Eco is one of a suite of tools developed by the USDA Forest Service and partners. It combines a sampling and surveying methodology with a statistical model to extrapolate survey data to a whole study area, and a numerical model of tree biological function and ecosystem service provision.

This report provides a detailed description of the structure, composition, and condition of Portsmouth's trees in summer 2024, and demonstrates the importance of the tree population to local people. It captures a moment in time and does not account for how the tree population will change in the future.

It is estimated that there are more than **111,800 trees** in Portsmouth. These trees provide annual benefits worth **£1.7 million per year**. This annual value includes just three ecosystem services: avoided surface runoff, carbon sequestration, and air pollution removal, and is an underestimate of the total annual value as many ecosystem services cannot yet be quantified or monetised. To replace the public amenity the trees provide would cost **£4.5 billion**.

This is the second i-Tree Eco project to incorporate measurements of **social and cultural values** and attitudes to trees in a survey of the local community. Local people value trees because of their importance for **wildlife**, their contribution to **mental and physical wellbeing** and **air pollution removal**, and because they provide a **connection to nature and peaceful refuge**.

# Headline Facts and Figures

| Structure and composition of Portsmouth's urban forest in 2024 | | |
|---|---|---|
| Estimated total number of trees | 111,800 | Pg. 62 |
| Estimate of total tree canopy cover (%) | 8.9% | Pg. 56 |
| Number of tree species surveyed | 65 | Pg. 62 |
| Three most common species | *Acer pseudoplatanus*, *Fraxinus excelsior*, *Crataegus monogyna* | Pg. 62 |
| Land uses where a greater percentage of surveyed trees were found | Residential, Park or greenspace, Retail or commercial | Pg. 58 |
| Percentage of surveyed trees in DBH size classes | 7–20 cm: 42%<br>20–40 cm: 37%<br>40–60 cm: 13%<br>>60 cm: 8% | Pg. 72 |
| Percentage of trees in good or excellent condition | 68% | Pg. 79 |
| Top pest and disease threat | Sooty bark disease of maple | Pg. 116 |

| Estimated ecosystem service provision amount and value in 2022 | | | |
|---|---|---|---|
| Avoided runoff | 35,000 $m^3$ per year | £86,000 per year | Pg. 87 |
| Pollution removal[1] | 20 tonnes per year | £166,000 per year | Pg. 93 |
| Net carbon sequestration | 1,440 tonnes per year | £1.4 million per year | Pg. 105 |
| Total annual benefit | | £1.7 million per year | |
| Carbon storage | 32,700 tonnes | £30.7 million | Pg. 101 |
| Replacement cost | Amenity value of all trees: £4.5 billion<br>Structural value of all trees: £64 million | | Pg. 111 |

[1] Pollution removal by trees and shrubs

## Key Conclusions

- Portsmouth's tree population is dominated by ***Acer pseudoplatanus and Fraxinus excelsior***. Both populations exceed the recommended 10% maximum for a single species. Owing to their large populations, large sizes, and dense foliage, they are currently the top two species for delivery of many ecosystem services: avoided runoff, air pollution removal, carbon storage and carbon sequestration.
- Of the trees recorded in the survey ***Salix caprea*** supports the highest number of invertebrate species. Focused consideration on biodiversity during species selection can further increase the provision of pollen and nectar as food for wildlife.
- 39% of the land surveyed during the tree survey was classified as residential. **Trees in private gardens** and on residential streets are the most common locations of trees visible from the people survey. Many respondents said their gardens already have trees, or they would be willing to consider planting a tree. Community engagement in a garden tree planting and care scheme could build the perceived value of private trees and provide opportunities for people to contribute environmental benefits to their neighbourhoods. This could help Portsmouth reach its target to double tree canopy cover to 19.6% over the next 25 years.
- Respondents to the survey who live in the most deprived areas of Portsmouth were underrepresented in the survey. **Seeking out their values and perspectives** about trees is vital to confirm the results from this study for those communities, and to target tree planting that delivers benefits that are important across the widest sectors of society.
- People value trees in Portsmouth for many reasons. Some of the most important include for **wildlife**, **physical and mental health**, **connection to nature**, and **aesthetic reasons**.

- People valued the management of trees for many reasons with top reasons including **providing shade**, **reducing flooding**, **improving air quality**, providing **wildlife habitat**, and reducing **damage from leaf/branch fall**. Just over half of respondents said they do not visit places with trees in Portsmouth as often as they would like to. Making space for woodlands and trees within urban neighbourhoods, so that people can pass through them on their way to school, work, and shopping, will help to improve access to the benefits these places provide.
- The **diversity of Portsmouth's tree population is lower than ideal**. Local people expressed preferences for a mixture of conifer and broadleaf or primarily broadleaf, and for a mixture of large and small trees. Strategic diversification of Portsmouth's tree population will also increase resilience to climate change and pests and disease, help to ensure continued provision of ecosystem services, and deliver social and cultural values to local people. Effective diversification requires the use of non-native tree species, so communication and engagement will be important.
- Survey respondents expressed strong willingness to **take actions for trees** in Portsmouth. Four-fifths indicated interest in joining tree related events or campaigns or in joining a community group to care for trees, and 39% of respondents with a garden would consider planting a tree there. There is a community of people who want to help, provided there are the right kinds of opportunities.
- Survey respondents also expressed hopes for the future of trees in the city. They displayed a strong desire to see more trees.
- Directing resources toward the **maintenance of the trees on Portsmouth City Council land** could **improve their health and life span** helping the long-term suitability of Portsmouth urban forest.

# 1. Introduction

Urban forests help to create healthy and liveable urban places. Eighty-three percent of the UK's population live in urban areas (Government Office for Science, 2021). In towns and cities, we may experience flash flooding, urban heat islands, air and noise pollution, limited access and connection to nature, poor biodiversity, and poor physical and mental health. Urban trees can provide an effective nature-based solution to these negative impacts of urbanisation (Davies et al., 2017).

Portsmouth is a compact city located on the southern coast of England. It is the second most densely populated local authority in England outside of London (Office for National Statistics, 2023), with 75% of the population inhabiting Portsea Island, separated from the mainland by the narrow, tidal Portsea Creek and bordered by the M27 motorway. The City of Portsmouth covers a 23.2 square mile administrative area of land and sea, which is characterised by a unique mosaic of uses from residential, industrial, commercial, to a varied coastline of natural habitats; saline lagoons, wetlands, saltmarsh, flower-rich grazing marshland, and vegetated shingle beaches. Southsea and Eastney public beaches to the south of the city border The Solent, and several large public greenspaces are in coastal areas including Milton Common, Southsea Common, and Great Saltern Recreation Ground.

Located on the southeastern side of Portsmouth Harbour, the west of Portsea Island houses Portsmouth International Port, Historic Dockyards, Gunwharf Quays shopping centre, and a Naval Base. His Majesty's Naval Base Portsmouth is one of the three Royal Navy operating bases in the United Kingdom and occupies an area of 121 hectares to the west of the city (Naval Dockyards Society, 2015), land owned by the Ministry of Defence. Other predominately industrial areas of the city are situated in the north-eastern corner of Portsea Island. The city is also home to the University of Portsmouth, with academic buildings and student accommodation concentrated in the areas of Southsea and Milton. The University has a student population of over 28,000 (University of Portsmouth, 2024) and is one of the city's largest employers.

The development of the Horsea Island Open Space is underway on a former landfill site to the northwest of the study area. It is aiming to help address the deficit of public greenspace for Portsmouth residents. The project has progressed through the Partnership for Urban South Hampshire's Green Infrastructure Implementation Plan, and since 2018 has seen the planting of 50,000 young trees. With an estimated establishment rate of more than 75%, these new trees are on track to become new woodland habitats. There are further ambitions to incorporate grassland habitat and wildflower meadows to promote biodiversity, in addition a public transport and cycle network to facilitate sustainable and active travel to the open space.

In 2022, Portsmouth City Council (PCC) was awarded two years of funding through the Woodland Creation Accelerator Fund (WCAF) to increase staff and consultancy capacity to accelerate tree planting within the city. The WCAF is part of DEFRA's Nature for Climate Fund which supports local authorities in tree planting and woodland creation. This funding maximises the opportunity and drive to deliver green spaces for nature and people, through the best-practice management of the existing treescape and evidenced based planting of new trees within Portsmouth.

In their Greening Strategy and Delivery Plan, PCC have outlined the need to implement and manage a green infrastructure programme that will adapt to changes in climate. The Council have set a target of doubling tree canopy cover to 19.6% over the next 25 years, focusing on planting efforts that will maximise benefits to communities, having identified the requirement of trees to reduce the urban heat island (UHI) effect and improve air quality (Portsmouth City Council, 2023). The Strategy and Plan will help guide the delivery of a 'greener, healthier, and fairer Portsmouth,' an ambition which led to the declaration of a climate emergency in 2019. Over 4,000 new trees have been planted in parks and greenspaces since the declaration, in addition to new street tree projects and the Council's tree replacement programme across highways and greenspaces.

Portsmouth City Council are now working to produce an Urban Forest Master Plan, which will set out the Council's vision for a resilient treescape across Portsmouth. The Master Plan will detail actions required to deliver increased tree canopy cover and ensure processes and resources are in place to ensure trees thrive as long as possible across the city. The results of the i-Tree Eco survey presented in this report are helping guide the Urban Forest Master Plan, due to be complete by April 2025.

## 1.1 Ecosystem service provision

Ecosystem services are the direct and indirect benefits that people derive from nature. They can be categorised as:

- provisioning, such as food and raw materials
- regulating, such as carbon sequestration and water purification
- supporting, such as habitat for species
- and cultural, such as recreation, mental and physical health (MEA, 2005; UK NEA 2011).

Ecosystem services link humans and their wellbeing to the natural environment. They are essential to human life. Quantifying, and putting a monetary value on, ecosystem services provided by trees highlights their worth in urban and rural settings. In a time of prolonged budgetary constraints and increasing competition for space in the urban realm, monetising ecosystem services enables comparison with the cost and value of other potential uses of land. Trees are valuable in their own right and a monetary value placed on trees will always be an underestimate, but it provides an opportunity for the voices of those who champion trees to be heard.

This project examines only a sub-set of all the ecosystem services that trees provide. Table 1 lists the services considered here, and Table 2 gives examples of further ecosystem services that we cannot yet quantify or value.

Table 1. Ecosystem services measured as part of the project, and their significance to Portsmouth.

| Ecosystem service | What urban trees do | Relevance to Portsmouth |
|---|---|---|
| Avoided surface water runoff | Tree canopies intercept rainfall and reduce the amount that reaches the ground. Trees take up water from the soil and their roots encourage infiltration. Together these functions reduce surface water flooding. | Storm Eunice caused floods and major disruption to Portsmouth in February 2022. Extreme weather events like these will occur more frequently and with more intensity as our climate changes. |
| Air pollution removal | Trees can help reduce overall exposure to air pollutants harmful to human health, such as nitrogen dioxide ($NO_2$) through absorption or interception. Trees can also reduce temperatures which reduces the rate at which some pollutants (e.g. ozone, $O_3$) are formed (Jacob & Winner, 2009). | Portsmouth has previously experienced levels of nitrogen dioxide higher than the legal limit, however through the City Council's Air Quality Strategy (2017-2027) progress is being made to tackle air pollution including the launch of a Clean Air Zone in November 2021. |
| Carbon storage and sequestration | Trees absorb carbon dioxide for photosynthesis, which produces glucose. Glucose is used for respiration or growth. Growth results in storage of carbon in the tree's woody material. Trees can continue to store and sequester carbon throughout their lifetime. | Portsmouth City Council declared a Climate Emergency in 2019 and committed to achieving net zero carbon emissions in operations by 2030. The Council has won and been commended for a number of regional Energy Efficiency Awards since this declaration. |
| Habitat provision | Trees are vital sources of food and shelter for a variety of flora and fauna. Trees in urban areas can boost people's engagement and feeling of connection with nature. Woodland trees can provide wildlife corridors to facilitate movement between sites. | Portsmouth is very densely populated but has several significant sites around the city for wildlife, such as Hilsea Lines. However, isolated trees and woodlands limit habitat connectivity and opportunities to support more species. |
| Amenity and other social and cultural values | Visual amenity is the overall pleasantness of the views people enjoy of their surroundings (Landscape Institute, 2013). Trees are an essential component of visual amenity (Ministry of Housing, Communities & Local Government, 2021). | Portsmouth is a densely populated city with large areas of residential, industrial, and commercial property that is land under private ownership. Trees on both private and public land can improve equitable provision of amenity wellbeing for all communities and individuals. |

Table 2. Ecosystem services provided by urban trees that were not measured as part of this project, and their significance to Portsmouth

| Ecosystem service | What urban trees do | Relevance to Portsmouth |
|---|---|---|
| Historic value | Trees can be a link to the past, creating a historical context to a place, and contributing to the local landscape character and sense of place. | A number of city residential development and several industrial developments are underway in Portsmouth. Planting trees as part of these developments can create a link between old and new urban treescapes. Care and management to ensure new trees reach maturity will help them become the historical trees of the future. |
| Educational value | Engaging with nature can be a brilliant way of learning, for children and adults alike. Trees and woodlands present many opportunities to be used as educational tools to learn about the natural world. | The Portsmouth and Southsea Tree Warden Network actively promotes trees and engages city residents through publishing tree trails and delivering events and activities, such as tree planting projects at local primary schools and across the community. |
| Noise reduction | When planted densely in wide shelterbelts, trees can significantly reduce the noise and apparent loudness of passing traffic and other industrial noise. | Noise pollution has an impact on amenity, health, productivity, and the natural environment. Local sources of noise pollution include built-up areas of the city and the M27 and M275 motorways. |
| Temperature regulation | Trees can contribute to local cooling through transpiration and shading. Temperature regulation by trees is particularly important in towns and cities, to mitigate the urban heat island effect. | In the UK, hot summers are expected to become more common (Met Office, 2022), with the temperature increase predicted to be between 3.7°C and 6.8°C (based on UKCP local 2.2km projections). Strategic tree placement could help to cool the local air temperature by 2–8°C (Doick & Hutchings, 2013). |
| Recreation | Green infrastructure, including trees, can lead to increased uptake in physical activity, and subsequently improve physical and mental health (Kondo, et al. 2018). | There are large health inequalities between the least and most deprived communities in Portsmouth. Access to green spaces can help reduce these differences. |

## 1.2 Social and cultural values

Trees are important to people for many reasons including physical and mental health, connection to nature, aesthetics, and connection to place. The importance of access to trees has been emphasised in recent years due to the COVID-19 pandemic and growing awareness and concern around climate change and biodiversity loss.

It is, therefore, important to consider why treescapes matter to people – or their social and cultural value. This project has explored how people perceive trees in Portsmouth, the benefits they provide, their spatial distribution across sections of the population, and their opinions on and involvement with tree management. Results from this element of the project can inform decisions on treescape expansion and resource management as well as foster better engagement between people and the city treescape.

## 1.3 Project aims

- To gain a baseline understanding of the distribution and composition of Portsmouth's tree population
- To value some of the ecosystem services provided by Portsmouth's trees
- To gain understanding of the importance of Portsmouth's trees to local people

## 1.4 Using this report

This technical report provides detailed baseline information on the structure and composition of Portsmouth's tree population and the benefits it delivers. It may be used to help inform strategic thinking and future decision-making with regards to Portsmouth's tree resource.

This report has been produced for Portsmouth City Council, but can also be used by:

- People writing strategies and policies

- People involved in planning to incorporate resilient and sustainable tree cover into new and existing developments
- Landowners who are looking to increase tree cover and resilience on their land
- People who are interested in local trees for improving their own and others' health and wellbeing
- People interested in local nature conservation.

### Limitations

- The v6 i-Tree Eco model provides a snapshot of the size, composition, and condition of an urban forest. To be able to assess changes in the urban forest over time, repeated i-Tree Eco studies, or comparable data collection, would be necessary.
- i-Tree Eco uses air pollution data from regional air quality monitoring stations and the data used therefore represents an area-wide average, not localised variability.
- i-Tree Eco is a useful tool providing essential baseline data required to inform management and policymaking in support of the long-term health and future of an urban forest but does not report on these factors itself.
- i-Tree Eco demonstrates which tree species and size class(es) are currently responsible for delivering which ecosystem services. Such information does not necessarily imply that these tree species should be used in the future.
- Planting and management must not rely solely on i-Tree Eco results, but also be informed by:
    - Site-specific conditions, such as soil properties, and available growing space
    - The aims and objectives of the planting or management scheme
    - Local, regional, and/or national policy objectives

    - Current climate and future climate projections and associated threats; and
    - Guidelines on species composition and size class distribution for a healthy resilient urban forest.
- The people survey was distributed to those who live, work and study in Portsmouth and promoted through a wide variety of online channels by PCC. However, the survey does not capture a representative cross section of the public in Portsmouth; rather those who responded were self-selecting which can mean that people interested in trees were more likely to respond.

For further guidance, refer to the Urban Tree Manual (Defra, 2022a).

## 1.5 Further information

Further details on i-Tree Eco and the full range of i-Tree tools for urban forest assessment can be found at: www.itreetools.org.

To download reports on previous UK i-Tree Eco studies visit i-Tree Eco - Forest Research.

Engagement with trees in the urban environment creates opportunities for members of the general public and community groups to become citizen scientists. Interested readers are referred to Treezilla: the Monster Map of Trees (www.treezilla.org).

# 2 Methodology

## 2.1 Social and cultural values methodology

This is the second i-Tree Eco study to include key characteristics of an urban treescape which can be measured and indicate or quantify a flow of potential social and cultural ecosystem services (SCES), or social and cultural values. The following two characteristics were chosen on the basis that they could be combined with existing i-Tree Eco methodology, would improve calculation of amenity value, and could be integrated into the project design:

- Public visibility

  Viewing trees and other types of greenery have been linked with a variety of SCES including better physical & mental health, learning, and productivity. Having an understanding of the public visibility of trees may create opportunities to increase engagement with trees and raise the profile of trees as an essential component of communities.

- Public accessibility

  Broadly, greater access to trees means greater benefits for people including physical and mental health benefits. Understanding people's access to trees, in terms of perceived and physical ease of access and barriers preventing access, can help identify where accessibility might be improved.

To explore the social and cultural values of trees in Portsmouth, data were collected through an online questionnaire of the public and via the tree surveyors. The survey questions were designed to cover a variety of topics, some of which were based on previous work exploring public perceptions of urban trees (Ambrose-Oji et al., 2021) and others developed in discussion with Portsmouth City Council (PCC). The topics in the questionnaire include:

- Perceptions of trees
- Preferences for trees
- Management of trees
- Action for trees
- Uses and values of trees

We also asked about whether people lived, worked, or studied in Portsmouth to explore if in some cases peoples' preferences and perceptions differed depending on this. To obtain respondents, the survey was actively shared on a wide number of online platforms and media by PCC (e.g. press release, local newspapers, PCC newsletters, PCC community champions, Instagram, Facebook, LinkedIn, PCC website, X (formerly Twitter), Tree Wardens, and museum school holiday events). The survey was open from August 10th until the end of September.

Data pertaining to the two characteristics of public visibility and public accessibility, were collected in the tree survey and in the people survey (Table 3).

Table 3. Visibility, accessibility, and deprivation data collected in the people survey and during the tree survey.

<table>
<tr><th>Variable</th><th>Tree survey</th><th>People survey</th></tr>
<tr><td>Public visibility</td><td>What is the public visibility of the tree?<br>- Tree fully visible from at least one direction, on or immediately adjacent to public land<br>- Tree clearly visible from a public location, but with somewhat reduced visual contribution to public amenity<br>- Tree visible from a public location, but with significantly reduced visual contribution to public amenity</td><td>How many trees can you see when looking out from your home?<br>Would you like to be able to see more or fewer trees from your home?<br>Thinking about the trees you can see from your home, where are they located?<br>- Private gardens<br>- Residential streets<br>- New housing developments<br>- Community gardens<br>- Allotments<br>- Parks and recreation/sports grounds open to the public<br>- Public service and amenity areas</td></tr>
</table>

| | | |
|---|---|---|
| | - Tree not visible from a public location | - Workplaces<br>- Woodlands<br>- Roadsides and roundabouts<br>- Railway lines<br>- Waterfront<br><br>(The same questions were asked for those that work and study in Portsmouth) |
| Public accessibility | What is the public accessibility of the tree?<br>- Tree publicly accessible<br>- Tree not publicly accessible | |
| Physical accessibility | Describe the access route to the tree:<br>- Road (motor vehicles)<br>- Paved or tarmac footway<br>- Other smooth footpath<br>- Surfaced cycleway<br>- Natural or semi-natural footpath or bridleway<br>- No path<br>- Other (please specify) | How often do you usually visit places with trees in Portsmouth?<br><br>Do you visit places with trees in Portsmouth as often as you would like to?<br><br>Thinking about visiting trees in Portsmouth, are you concerned or worried by any of the following? And do these affect how often you visit places with trees, or which places you visit?<br>- Fear of crime<br>- Fear of dogs<br>- Being on my own / isolated<br>- Poor lighting / lack of street lighting<br>- Visiting after dark<br>- Getting lost<br>- Traffic<br>- Fear of encountering prejudice from other people<br>- Poorly maintained sites<br>- Hurting myself<br>- Anti-social behaviour<br>- Other people that may be there<br>- Lack of facilities<br>- Other |

## 2.2 Sampling

This i-Tree Eco study takes a random sample approach to data collection. Sampling locations called plots (11.3 metre radius circles) are distributed across the area of interest, and data is collected in each plot. The data collected in the plot is representative of the whole study area and can be extrapolated to provide information on the total number of trees, the ecosystem services they provide, and more.

In a truly random sample plots are not necessarily distributed evenly across the geographic area and can clump together in small areas. In the heterogeneous urban environment, with a wide variety of land uses characteristics, this can lead to over- or under-representation of some areas in the data. To minimise this effect, a grid was overlain on the study area boundary, and a plot was placed randomly inside each grid square. The grid was constructed to ensure that the sampling density is appropriate to the study, in this case 253 plots across the study area (Figure 1). One backup plot was also placed randomly in each grid square, to be used in the event of the primary plot being inaccessible (see Figure 59 in Appendix A).

### 2.2.1 Study area

The study area for Portsmouth covers 3,964 hectares (Table 4). This value excludes large areas of water, representing instead the area of dry land within Portsmouth rather than the area on a map.

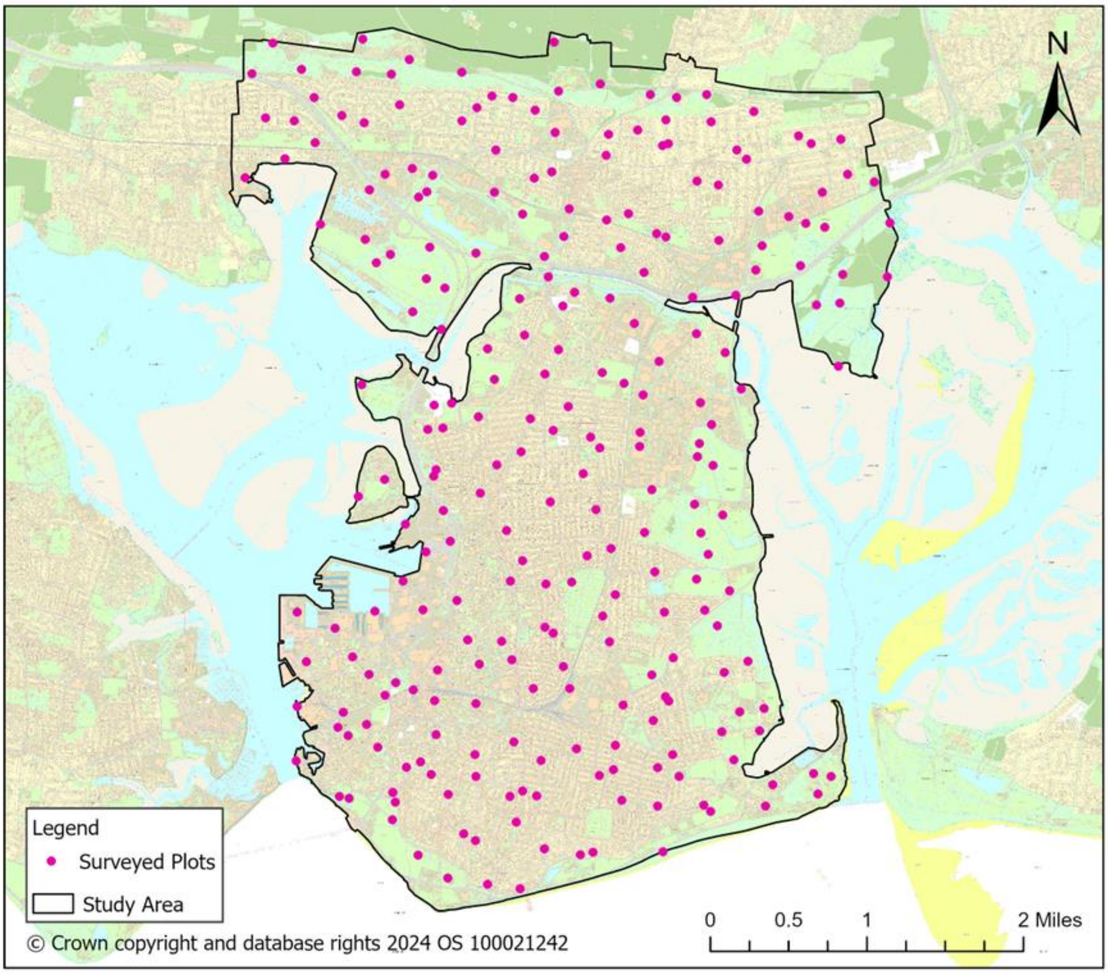


Figure 1. Map of the Portsmouth area and surveyed plots.

## 2.2.2 Stratification

The Portsmouth i-Tree Eco study has been stratified using two methods in order to analyse the survey data across land owned and not owned by PCC and also across four distinct areas of Portsmouth. The people survey also explored differences across deprivation levels.

### 2.2.2.1 Four areas of Portsmouth stratification

The four areas were specified by PCC as they group wards with similar characteristics such as excess heat, air quality, socio economic considerations and housing types together. With these similar characteristics any interventions such as tree planting can be designed and tailored to suit those areas and bring about the benefits needed on a local as well as city-wide scale. Shapefiles for these areas, provided by PCC, were clipped to the study area boundary.

Figure 2 shows the four stratification areas and Table 4 details the size, the number of plots surveyed and the plot densities in each area.

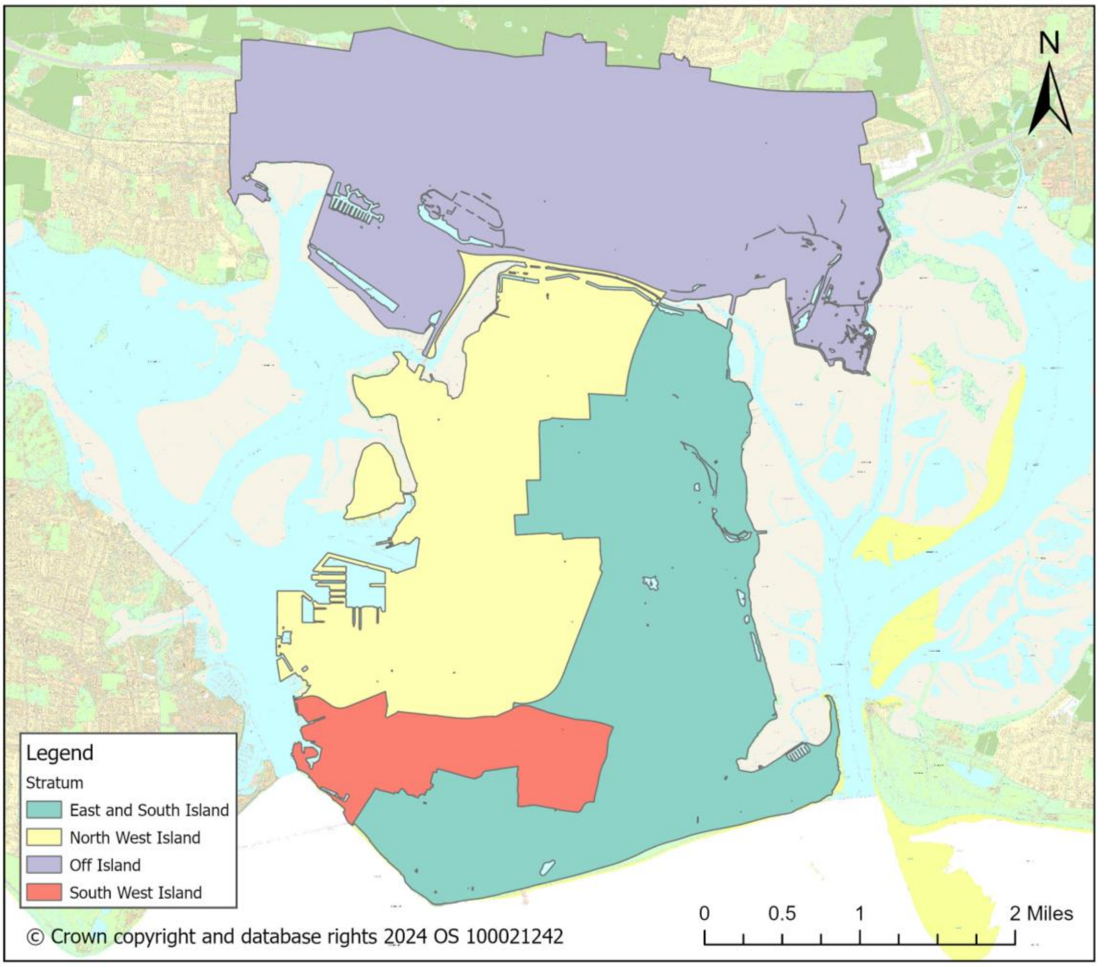


Figure 2. Map of Portsmouth’s four stratification areas.

Table 4. Total area, number of plots, and plot density of each of the four areas in Portsmouth.

| Area name | Area (hectares) | Number of surveyed plots | Plot density (1 plot per [] hectares) |
|---|---|---|---|
| South West Island | 262 | 21 | 12 |
| North West Island | 966 | 62 | 16 |
| Off Island | 1,500 | 93 | 16 |
| East and South Island | 1,236 | 77 | 16 |
| **Study area** | 3,964 | 253 | 16 |

### 2.2.2.2 PCC and Non-PCC land stratification

The study area was also divided into areas of land owned by PCC and not owned by PCC. This allowed analysis of data and comparisons of results across these two categories. Shapefiles for these areas, again provided by PCC, were clipped to the study area boundary. Figure 3 shows the PCC and Non-PCC land ownership across Portsmouth and Table 5 gives details of the total size of the PCC and non-PCC areas and the plots that were surveyed.

Table 5. Total area, number of plots, and plot density of PCC and non-PCC land.

| Land ownership | Area (hectares) | Number of surveyed plots | Plot density (1 plot per [] hectares) |
|---|---|---|---|
| PCC land | 1,387 | 87 | 16 |
| Non-PCC land | 2,577 | 166 | 16 |
| **Study area** | 3,964 | 253 | 16 |

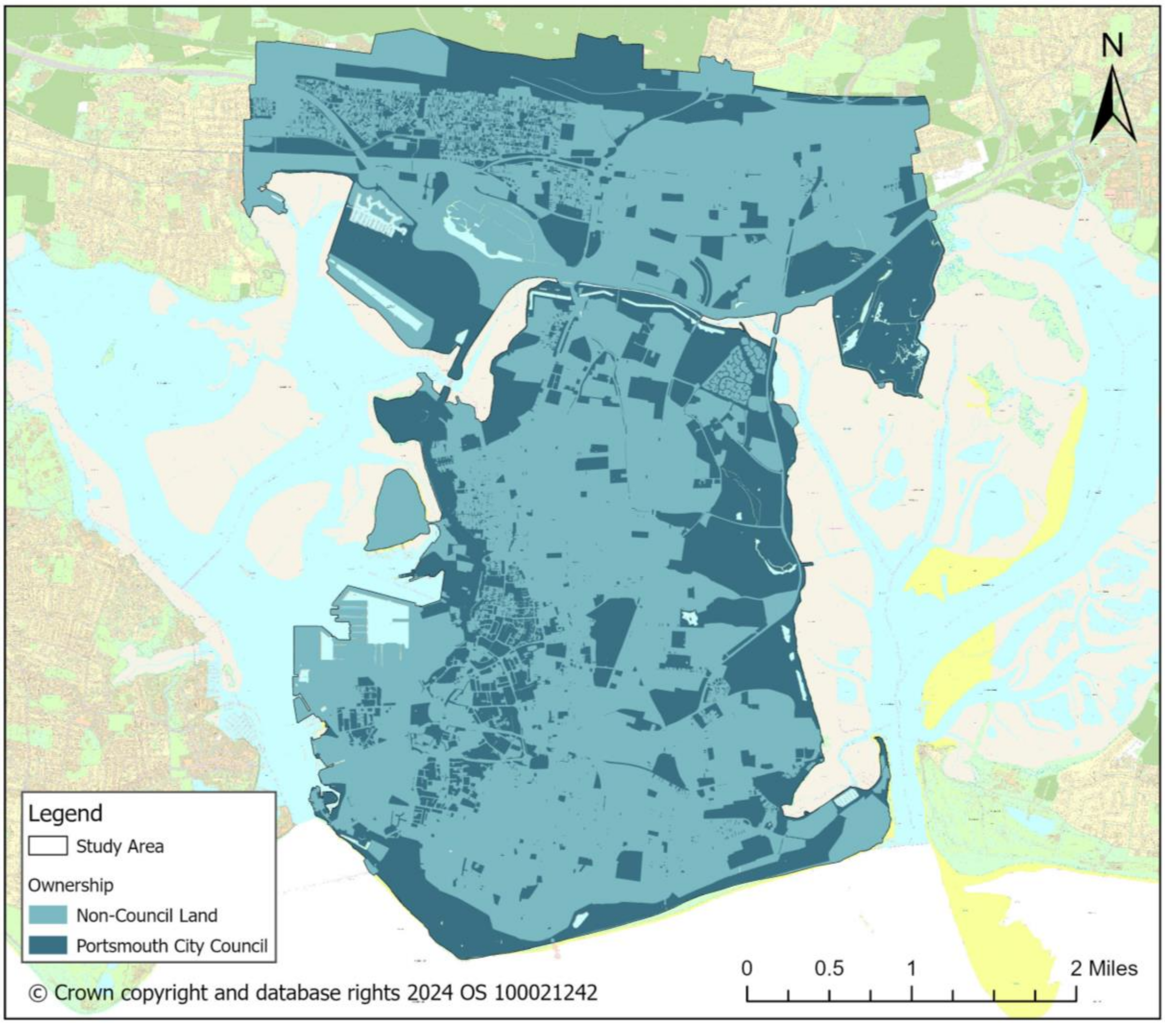


Figure 3. Map of land ownership stratification areas: Portsmouth City Council ownership and non-council land.

### 2.2.2.3 Indices of multiple deprivation and postcode stratification

As part of the people survey, we explored whether there were differences in people's responses to the survey based on whether they lived in more or less deprived areas. The English indices of multiple deprivation (IMD) measure relative deprivation in small areas called lower super output areas (LSOA). The indices measure seven different facets of deprivation:

- Income deprivation
- Employment deprivation

- Education, skills, and training deprivation
- Health deprivation and disability
- Crime
- Barriers to housing and services
- Living environment deprivation

IMD is a single number metric that combines these facets. The lower the number, the more deprived the area relative to other areas in the country. IMD data can be classified into five ranks (quintiles), with quintile 1 being the most deprived and quintile 5 the least deprived.

IMD data are released by National Statistics for the Ministry of Housing, Communities & Local Government. The IMD data used here are from the 2019 English indices of deprivation (Office for National Statistics, 2019). We used postcodes as a means of identifying which IMD quintile survey corresponds to survey participants. For those participants that provided full, valid postcodes, quintiles were identified using an online tool hosted by the Department for Levelling Up, Housing and Communities[2].

## 2.3 Field data collection

Not all plots were accessible to surveyors. Their distribution across the study area means they land on buildings, woodlands, parks, streets, small areas of inland water such as ponds and fountains. This variety of ground cover and land uses is an important aspect of an i-Tree Eco survey. In an i-Tree Eco study, when a plot is inaccessible surveyors switch to the backup plot. If the backup is also inaccessible the plot is removed from the survey. In total, 253 plots were surveyed in this study, zero plots were excluded. Table 6 lists the data collected about each plot.

[2] https://imd-by-postcode.opendatacommunities.org/imd/2019

Table 6. Plot data collected in the survey

| Variable | Description |
|---|---|
| Date | Date |
| Surveyor name(s) | Names of surveyors |
| Photographs | Photograph of plot |
| % plot surveyed | Percentage of the plot that was surveyed |
| % Tree cover | Percentage of total plot overhung by tree canopies |
| % Shrub cover | Percentage of total plot covered by shrubs |
| Ground covers | Types of ground cover present in plot, and their percentages |
| Land uses | Types of land uses present in plot, and their percentages |
| Comments | Comments about plot and trees |

Shrubs were defined as woody plants with a stem diameter smaller than 7 cm, and a height at of at least 1 m. Smaller shrubs and other types of plant in the plot were recorded as ground cover.

Trees were defined as woody plants with a stem diameter at breast height (DBH) (here defined as 1.5 m) of at least 7 cm. All trees whose trunks were entirely inside the plot boundary were surveyed. Trees located on or near the plot boundary were surveyed if at least half of their trunk diameter was inside the boundary. Trees whose trunks were outside the boundary, but whose crowns overhung the plot, were included in plot tree cover. Table 7 lists the data recorded about each tree in the survey.

Table 7. Tree data collected in the survey.

| Variable | Description |
|---|---|
| Tree ID number | ID number for each tree in plot, starting at 1 for each new plot |
| Land use | Which land use is the tree in |
| Species | Species name of the tree |
| DBH | Diameter at breast height (1.5 metres) |
| Height to crown base | Height from ground to base of crown, in metres |
| Height to live top | Height from ground to highest live part of tree, in metres |
| Total height | Height from ground to highest part of tree |
| Live crown width (N-S) | Width of live parts of crown in north-south direction, in metres |
| Live crown width (E-W) | Width of live part of crown in east-west direction, in metres |
| Crown light exposure | Sides of the crown exposed to direct or indirect light (0 to 5) |
| % Crown missing | Percentage of the crown volume that is not occupied by leaves and branches, due to pruning, dieback, defoliation, uneven shape, dwarf or sparse leaves, taking into account species or cultivar characteristics |
| % Crown in good condition | Percentage of the crown volume without dieback, not including normal, natural dieback such as caused by shading in the lower part of a canopy |
| % Impervious ground cover below canopy | Percentage of ground under canopy covered by impervious surface such as tar |
| % Shrub cover below canopy | Percentage of ground under canopy covered by shrubs |
| Life expectancy | Life expectancy of tree in years (in six bands covering less than five years to more than 80 years) |
| Public accessibility | Tree classed as publicly accessible or not publicly accessible |
| Surface type of access route | Type of surface (e.g. natural, smooth) on routes people could use to access the tree (e.g. footpath, road) |
| Public visibility | Tree classed as Fully visible from a public place, to Effectively invisible from a public place |
| Street tree | Yes/no – is the tree growing on a grass verge or pavement by a road |

## 2.4 Calculations

### 2.4.1 Replacement cost and amenity value

Replacement cost is an estimate of the cost of replacing an existing tree, should it be lost due to development, damage, or other reasons for removal. i-Tree Eco provides cost estimates for the like-for-like replacement of trees in urban areas based upon the CTLA (1992) valuation method. See Appendix A for more information.

Urban trees also provide significant amenity value. An amended version of the Capital Asset Value for Amenity Trees (CAVAT) Full Method (Doick, et al. 2018) was also used to assess the value of Portsmouth's trees. CAVAT values are based upon tree size (trunk diameter) and are depreciated for attributes that impact the tree's contribution to amenity. CAVAT includes a Community Tree Index (CTI) factor which adjusts the value to take into account greater amenity associated with higher population density, using official population figures. The CAVAT value relates to the replacement cost of the tree as an amenity asset, rather than as a structural asset (as per CTLA) and has been used by many councils across the UK to support planning decisions. An amended version of the Full Method was used in this study, including measurements of public visibility for improved accuracy. See Appendix A for more details.

### 2.4.2 Pests and diseases

The susceptibility of Portsmouth's trees to pests and diseases was assessed using information on the number of trees within pest/pathogen host groups and the prevalence of the pest/disease within Hampshire or the UK. A risk matrix was used to determine the number of trees that could be impacted by each pest/disease should they become established within the local area, as well as the probability of establishment.

### 2.4.3 Habitat

Trees and shrubs provide valuable habitats and food for many species, including insects, birds, and mammals, as well as non-vascular plants such as moss. An analysis of the number of insects associated with British trees (Kennedy and Southwood, 1984), and relative scores of the value of different tree species for provision of blossom, pollen, fruits, and seeds to UK wildlife (Alexander et al., 2006) were used to examine the relative biodiversity value for urban trees.

Table 8 summarises the calculations for ecosystem services.

Table 8. Summary of calculations

| Variable | Calculated from |
|---|---|
| Number of trees | Total number of trees; an estimate based on an extrapolation from the sample plots. See Appendix A for details of sampling statistics. |
| Tree canopy cover | Total tree cover extrapolated from tree cover (%) measured within plots. |
| Pollution removal value | The amount of pollution removed each year by trees. Value is based on the UK damage costs where available: £8,148 per tonne $NO_x$ (nitrogen oxides), £16,6161 per tonne $SO_2$ (sulphur dioxide), £74,769 per tonne $PM_{2.5}$, and a $PM_{2.5}/PM_{10}$ conversion factor of 0.76 (Defra, 2023a) |
| Avoided runoff | The amount of water not entering the water treatment system because of the presence of trees. Valuation uses the household foul drainage volumetric charge (£2.461 per $m^3$; Southern Water, 2024). |
| Carbon storage and sequestration values | The amount of carbon currently stored in the trees, and the amount absorbed every year. The 2024 value is £269 per tonne of $CO_2e$ (Department for Energy Security and Net Zero, 2023). |
| Replacement cost | The value of the trees based on the physical resource itself (e.g., the cost of having to replace a tree with a similar tree), determined within i-Tree Eco according to the CTLA (Council of Tree and Landscape Appraisers) v9 method. |
| Amenity | The cost of replacing the public amenity that Portsmouth's trees provide, using an amended version of Capital Asset Value for Amenity Trees (CAVAT) Full method. |

### 2.4.4 Canopy cover

i-Tree Eco uses the tree canopy cover percentages from each of the surveyed sample plots. The average canopy cover across all plots is then calculated and used to extrapolate the estimated total canopy cover for the whole study area.

# 3 Results and Discussion

This section of the report presents the results of the survey of local residents, and the i-Tree Eco survey of Portsmouth's tree population. For context Table 9 compares the Portsmouth study to projects in other UK locations.

Table 9. Details from Portsmouth's i-Tree Eco survey compared to four other UK surveys.

| | Portsmouth | Wirral | Belfast | Derby | Greater London |
|---|---|---|---|---|---|
| Study area size (ha) | 3,964 | 15,707 | 13,338 | 7,801 | 159,064 |
| Number of trees | 111,800 | 1,022,000 | 809,000 | 255,000 | 8,421,000 |
| Canopy cover (ha) | 351 | 2,168 | 3,080 | 645 | 22,326 |
| % Tree canopy cover | 8.9% | 13.8% | 14.5% | 8% | 14% |
| Average number of trees per ha | 28 | 65 | 61 | 33 | 53 |

## 3.1 Social and cultural values

This section describes selected results from the people survey and compares these to results from the i-Tree Eco survey. Relevant results from the people survey are also included in later sections and discussed in the context of the i-Tree Eco results.

### 3.1.1 Participant characteristics

In total, 1,026 people responded to the survey. We asked several optional demographic questions; of those responding to these optional questions (please note, some totals do not sum to 100% due to rounding issues):

- 59% identified as female and 38% as male, with the remaining 3% preferring not to say.
- In terms of age, 8% were between 16-34, 56% were 35-64, and 32% were aged 65+, with 3% preferring not to say.
- By ethnic group, 93% responded as white, 1% each as Asian/Asian British and Mixed/multiple ethnic groups and less than 1% as Black/African/Caribbean/Black British, with 4% preferring not to say.
- 31% reported having a long-term physical or mental health condition or illness (lasting or expected to last 12 months or more), with 77% of these saying their ability to carry out day-to-day activities is reduced as a result.
- 79% either own their property outright or with a mortgage, while 14% rent. Of those renting, 22% rent from PCC and 15% from a housing association or similar.
- 80% have access to a private garden. Similar proportions – ranging between 8-10% – have access to a shared garden, a community garden, and/or an allotment, while a further 9% have no access to any kind of garden.

Where participants provided full, valid postcodes it was possible to classify them into one of five IMD quintiles, with quintile 1 being the most deprived and quintile 5 being the least deprived. The same proportion of the sample – 10% - was classified as belonging to each of the most and least deprived quintiles (quintiles 1 and 5 respectively), with a similar proportion (13%) classified as belonging to the second least deprived quintile (quintile 4). Two thirds of participants providing complete, valid postcodes belonged to quintiles 2 and 3 (33% and 34% respectively).

Table 10 presents estimated population data for the five quintiles in Portsmouth. This suggests people who live in the most deprived area of Portsmouth are under-represented in the people survey results and that those living in the least deprived areas are slightly over-represented.

Table 10. Population data for each IMD quintile and the study area.[3]

| IMD quintile | Population | Percentage of total population | Population density / people per km$^2$ | Percentage of respondents to survey |
|---|---|---|---|---|
| 1 | 52,255 | 24% | 5,927 | 10% |
| 2 | 73,964 | 34% | 6,525 | 33% |
| 3 | 58,640 | 27% | 5,503 | 34% |
| 4 | 20,544 | 9% | 3,776 | 13% |
| 5 | 14,716 | 7% | 3,682 | 10% |
| Study area | 220,119 | | 5,469 | |

## 3.1.2 Public visibility

### 3.1.2.1 Public visibility across the four areas of Portsmouth

Figure 4 shows the public visibility of trees surveyed in each of the four areas of Portsmouth. **East and South Island** has the highest proportion of trees that are **less publicly visible**, and which therefore make a lower contribution to visual amenity. **South West Island** has the highest proportion of **fully publicly visible** trees and therefore they make a higher contribution to visual amenity.

[3] Data source: English indices of deprivation 2019.

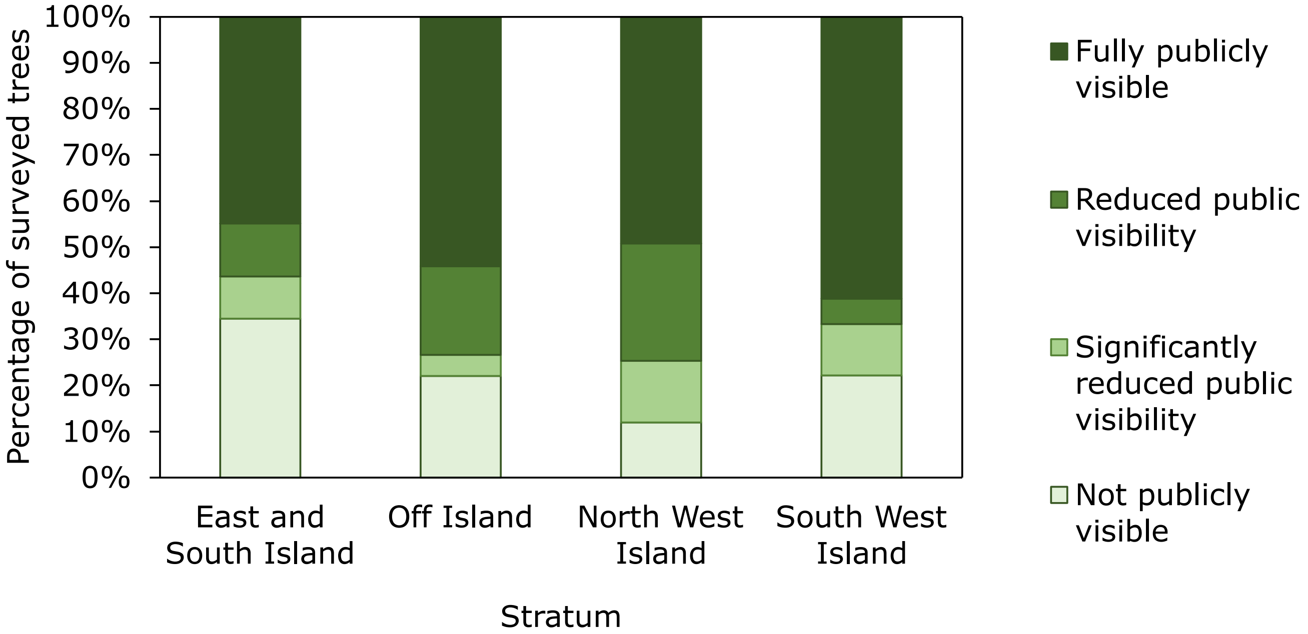


Figure 4. Public visibility of surveyed trees in the four areas of Portsmouth. Surveyed trees only; data not extrapolated to stratum areas.

#### 3.1.2.2 Public visibility on PCC and Non-PCC land

Figure 5 shows the public visibility of trees surveyed on PCC and Non-PCC land in Portsmouth. **Non-PCC land** has the highest proportion of trees that are **less publicly visible**, and which therefore make a lower contribution to visual amenity. **PCC land** has the highest proportion of **fully publicly visible** trees and therefore they make a higher contribution to visual amenity.

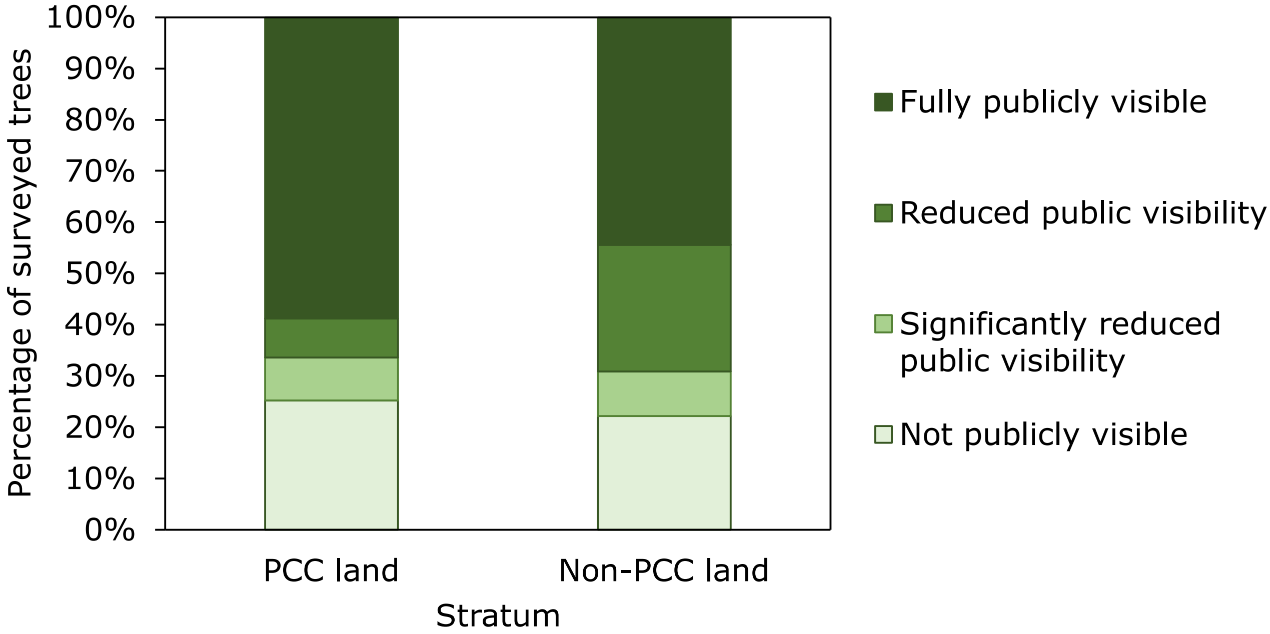


Figure 5. Public visibility of surveyed trees on PCC and Non-PCC land. Surveyed trees only; data not extrapolated to stratum areas.

### 3.1.2.3 Ability to see three trees or more from where people live, work or study

Every urban area is different, and it is difficult to set a single target for urban greenness that is appropriate to every location. However, broad guidelines can be very useful in highlighting where more provision of urban greenspace, including trees, is required. The 3-30-300 rule (Konijnendijk van den Bosch, 2021) is one such guideline. The rule states that cities should aim for the following:

- Everyone should be able to see at least three trees of a decent size from their home.
- Every neighbourhood should have 30% tree canopy cover.
- People should have accessible greenspace within 300 m of their home.

Looking at the people survey data, **75% of respondents** said that they were **able to see three or more trees** when looking out from their home. This differed according to the level of deprivation of the area the participant lived in (Figure 6).

The majority of participants in each IMD quintile could see three or more trees from home, whilst it seems as though respondents in IMD 2 and 3 are more likely to see one or two trees from home compared to those in other quintiles. Apart from those in the least deprived quintile, over 60% of participants in each quintile would like to see more trees near their homes; in contrast, over half of those in quintile 5 said they were content with the number of trees they could see, though 43% would like to see more trees.

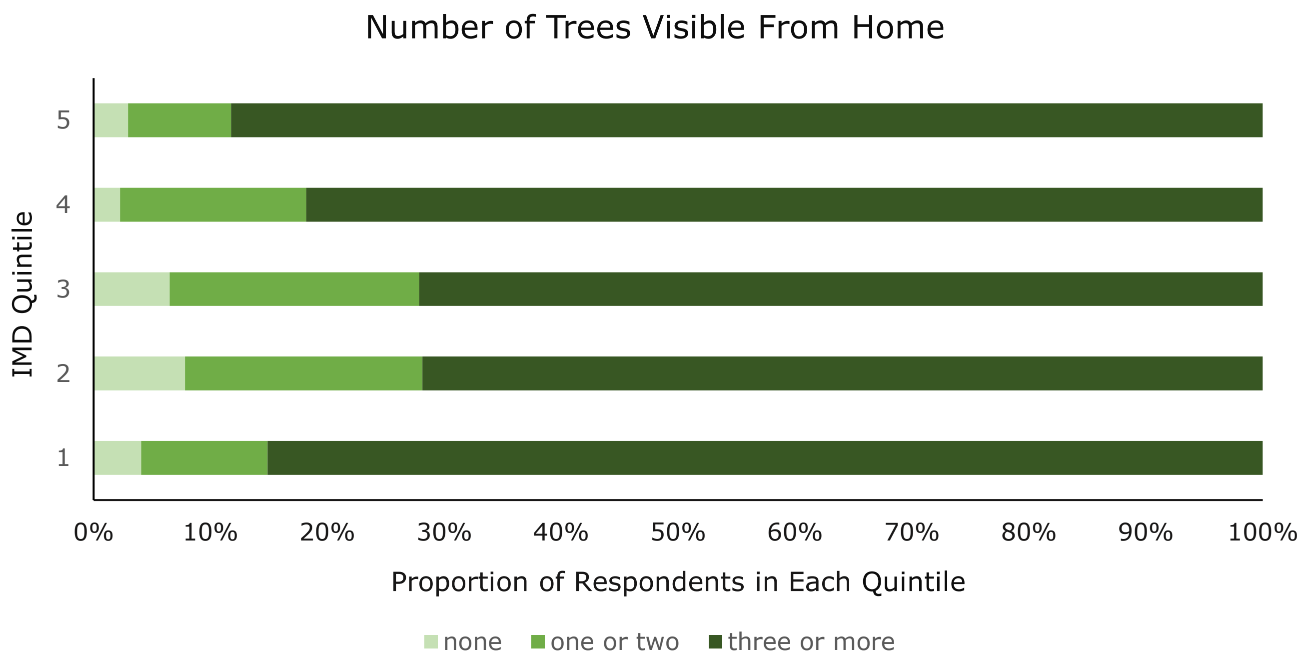


Figure 6. For each IMD quintile, this chart shows the proportion of survey respondents who could see either no trees, 1-2 trees or 3 or more trees from their home. Sample size for each IMD quintile is as follows: Quintile 1, n=82; Quintile 2, n=265; Quintile 3, n=268; Quintile 4, n=99; Quintile 5, n=78.

Where participants provided a full, valid postcode, it was also possible to explore variation by location (Figure 7). 93% of respondents living within Portsmouth but off Portsea island could see three or more trees from their home, whilst 9% of those living in the North West of the island could see no trees from their home.

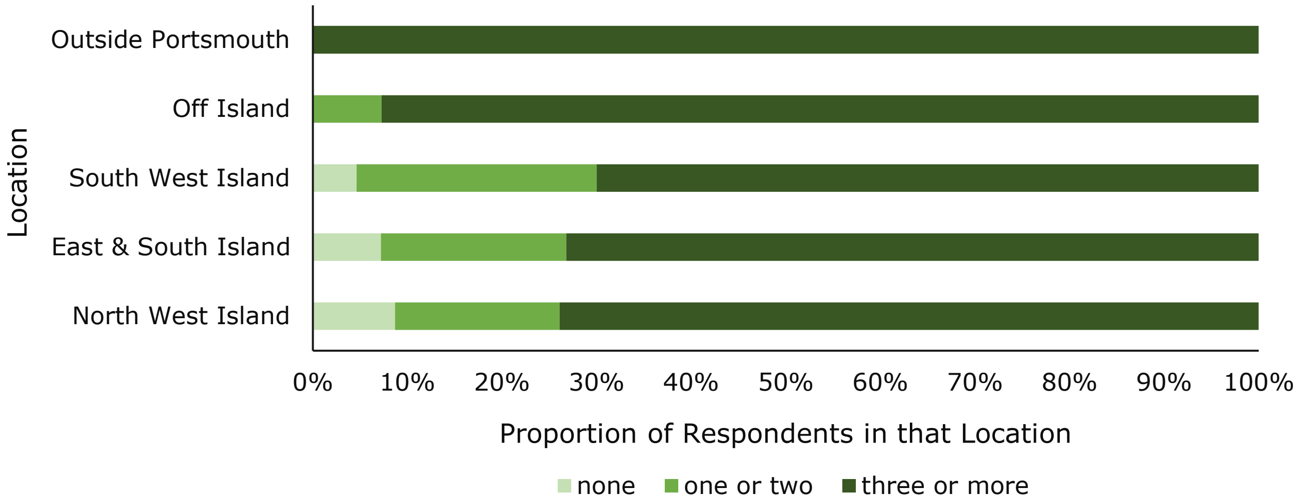


Figure 7. This chart shows the proportion of survey respondents in each location who could see either no trees, 1-2 trees or 3 or more trees from their home. Sample sizes for each location are as follows: Outside Portsmouth, n=8; Off Island, n=110; South West Island, n=130; East & South Island, n=362; North West Island, n=138.

Almost two thirds of all participants (65%) said that they would like to be able to see more trees from their home.

The survey asked the same questions to those that work in Portsmouth. Just over half (55%) said they could see three or more trees when looking out from their place of work, whilst almost a quarter (24%) said they could not see any trees. Almost three quarters (74%) of all respondents working in Portsmouth said they would like to be able to see more trees from their workplace.

The survey also asked these questions to those that study in Portsmouth. Almost three fifths of those studying in Portsmouth said they could see three or more trees from their place of study (59%), whilst almost a fifth said they could not see any trees (19%). 58% of those that study in Portsmouth would like to be able to see more trees from their place of study.

When comparing results across those that live, work and/or study in Portsmouth, it seems as though respondents who only live in Portsmouth (as opposed to live and work, live and study, or live work and study) are more likely to be able to see three or more trees from their home.

#### 3.1.2.4 Locations of trees seen from where people live, work and study

The majority of participants said that they could see trees in private gardens or on residential streets (74% and 44% respectively) from their home, whilst allotments, new housing developments, workplaces, the waterfront or railway lines (reported by 5% or fewer) were the least commonly reported locations for seeing trees from home.

There was some variation in the location of trees visible from homes, workplaces, and places of study in Portsmouth (Figure 8). The top five locations where trees could be seen were fairly consistent across these three cohorts, with the exception that the main location trees could be seen when looking out from work were workplaces (21%).


Figure 8. The five main locations of trees seen from home, compared to results for trees seen from places of work and study in Portsmouth. Sample size for each cohort is as follows: live in Portsmouth, n=958; work in Portsmouth, n=483; study in Portsmouth, n=36.

These findings suggest that for those that can see them, **trees in private gardens, residential streets, and workplaces** make an important contribution to visual amenity and could be a focus for public supported planting and maintenance efforts. However, in interpreting these results, it is important to bear in mind that at least some of these differences may reflect the proximity of participants' homes, places of work or places of study to these specific types of location, not (just) whether there are trees present in those locations.

The results also suggest some variation by IMD quintile in the locations of trees seen from home. It seems that:

- Those in quintile 3 are less likely to see street trees, trees on new housing developments, in amenity areas, or woodland;
- Those in higher quintiles are less likely to see trees on waterfronts or community gardens but more likely to see trees in private gardens; and
- Those in low-to-middle quintiles are less likely to see street trees.

There is also some variation in the likelihood of seeing trees in particular types of location from home when considering whether participants live, work and/or study in Portsmouth. It seems that those who live, work and study in Portsmouth are more likely to be able to see trees in work areas from their home.

When considering trees seen from places of work, it seems that those that both live and work in Portsmouth are less likely to see trees from railways. Those in middle IMD quintiles seem to be less likely to be able to see trees on waterfronts from their place of work in Portsmouth, whilst those in quintile 3 are less likely to be able to see trees from their workplace.

Finally, there is also variability in respondents' likelihood of seeing trees elsewhere from their places of study: it seems as though those that live, work and study in Portsmouth, and those in lower IMD quintiles, are more likely to see trees elsewhere.

### 3.1.3 Accessibility

Accessibility differs from public visibility because people may receive different benefits from being near trees, compared to being able to view them from a distance. Trees in publicly accessible parks and greenspace, along roads and streets, in the grounds of public buildings, and other places where the surveyors did not require permission for access, were judged to be publicly accessible. Trees in private gardens, in schools, Ministry of Defence land and in other private land uses where permission was required for access, were judged to be publicly inaccessible.

#### 3.1.3.1 Accessibility across the four areas of Portsmouth

Figure 9 shows the public accessibility of the trees surveyed in each of the four areas of Portsmouth. **South West Island** has the highest proportion of **publicly accessible trees**. **Off Island** has the lowest proportion of **publicly accessible trees** despite having the highest proportion of parks and greenspace (see Figure 20).

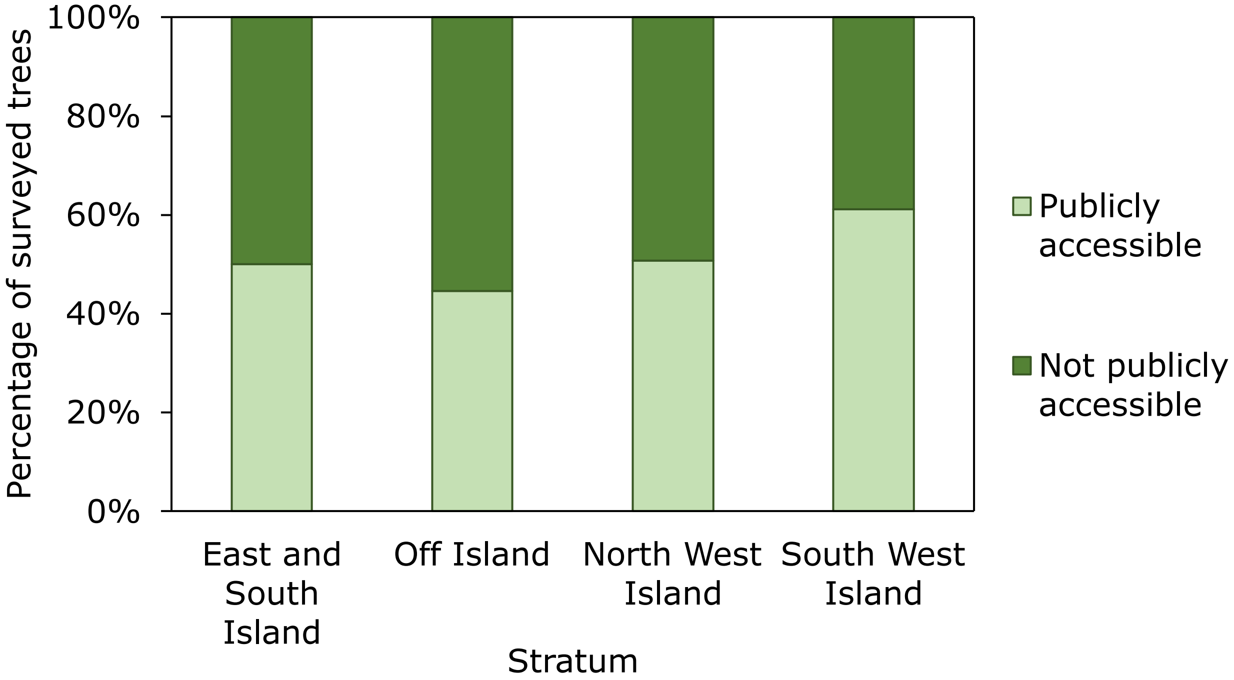


Figure 9. Public accessibility of surveyed trees in the four areas of Portsmouth. Surveyed trees only; data not extrapolated to stratum areas.

#### 3.1.3.2 Accessibility on PCC and Non- PCC land

Figure 10 shows that the public accessibility of the trees surveyed on PCC and Non-PCC land in Portsmouth. The results are almost identical with Non-PCC land having only 1% more publicly accessible trees compared to PCC land.

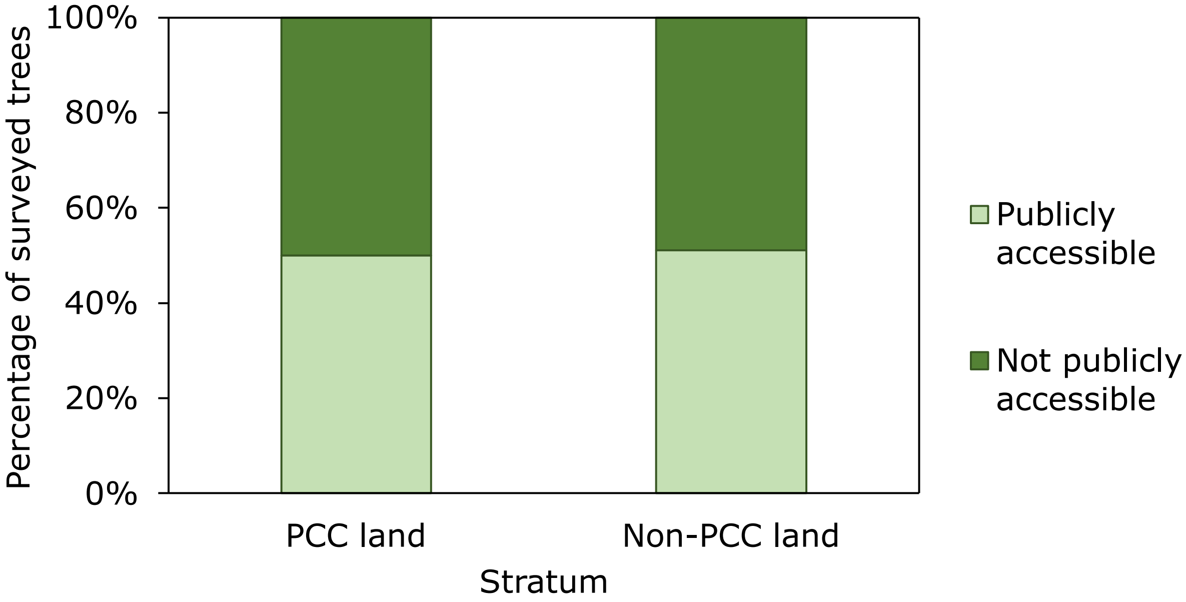


Figure 10. Public accessibility of surveyed trees on PCC and Non-PCC land. Surveyed trees only; data not extrapolated to stratum areas.

Access to trees can result in improved quality of life but the nature of access routes may be a barrier to some people. Figure 11 shows the surface types of access routes to the surveyed trees in the whole study area. Of the trees surveyed the largest proportion (24%) have no path to access the tree. A further 11% of trees can only be accessed by a natural or semi-natural footpath or bridleway, suggesting that access for people with reduced mobility might be restricted for 35% of the trees surveyed. 32% of the trees surveyed were accessible by a paved, tarmac, or other smooth footway.

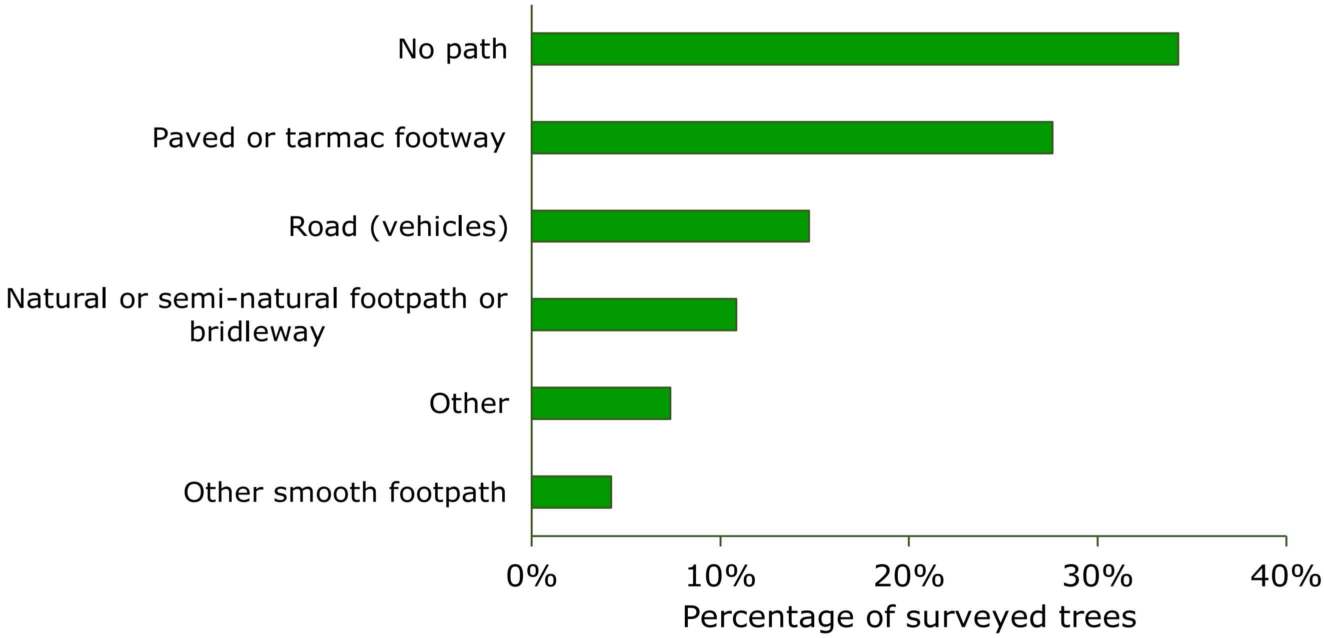


Figure 11. Surface types of access routes to surveyed trees. Surveyed trees only; data not extrapolated to stratum areas.

### 3.1.4 Barriers to visiting trees

The people survey asked participants about barriers to visiting local places with trees. Forty eight percent of participants said that they were able to visit places with trees in Portsmouth as often as they would like to. There were two main causes of concern about visiting trees: visiting after dark (52%), and anti-social behaviour (50%). Whilst 41% said that their concern about visiting after dark affected how often they visit trees, a smaller proportion (31%) said that their concern about anti-social behaviour affected their frequency of visits. Table 11 presents results for the top five concerns, showing the percentage of respondents with each concern and the proportion who say that this concern affects the frequency with which they visit trees.

For these top five concerns, when compared to national statistics relating to visits to green and natural places more broadly (reported in the People and Nature Survey[4]), concerns are higher for Portsmouth respondents.

Table 11. Results for the top five concerns about visiting trees reported by survey respondents, compared to results for the English population published in the People and Nature Survey.

| Concern | English population (People and Nature Survey) | Proportion of Portsmouth respondents with this concern | Proportion of Portsmouth respondents who say this concern affects how often they visit trees |
|---|---|---|---|
| Visiting after dark | 23% | 52% | 41% |
| Anti-social behaviour | 23% | 50% | 31% |
| Fear of crime | 17% | 36% | 24% |
| Lack of facilities | 24% | 31% | 26% |
| Poor lighting | 11% | 27% | 23% |

[4] The People and Nature Surveys for England: Data tables and publications from Adults' survey year 4 (April 2023 - March 2024) - GOV.UK

### 3.1.5 Management of treescapes

The people survey asked respondents to identify the most important reasons for managing trees across three categories. They could select up to three reasons in each category. We have reported below those reasons selected by over 50% of respondents.

In relation to property and services, the top responses were 'to reduce damage and nuisance from fallen leaves or branches' (66%) and 'to reduce the risk of house subsidence' (57%) (Figure 12).

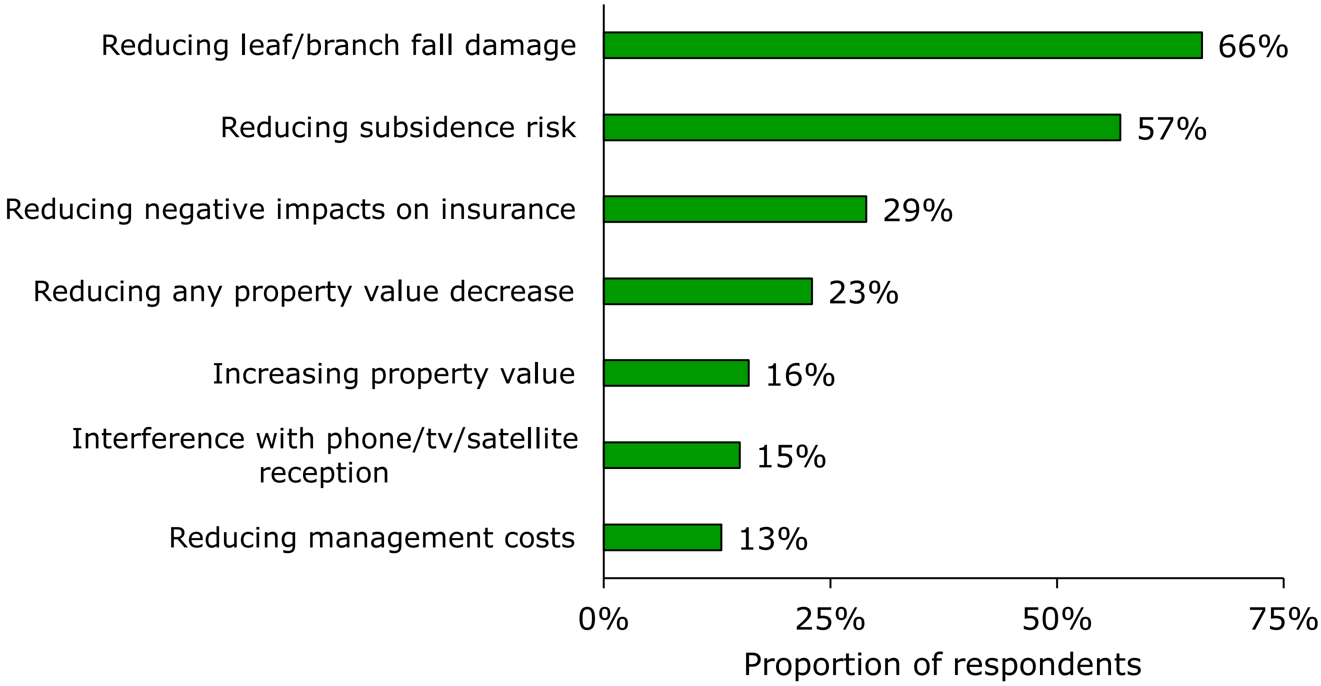


Figure 12. Survey responses to which reasons are most important for managing trees in relation to property and services. Participants could select up to three reasons.

Regarding environmental quality, the most selected responses were 'to improve air quality and reduce air pollution' (75%), 'to create habitat and shelter for wildlife' (73%), 'to supply oxygen and absorb carbon dioxide' (59%), and 'to create pleasant places to live, work and exercise' (54%) (Figure 13).

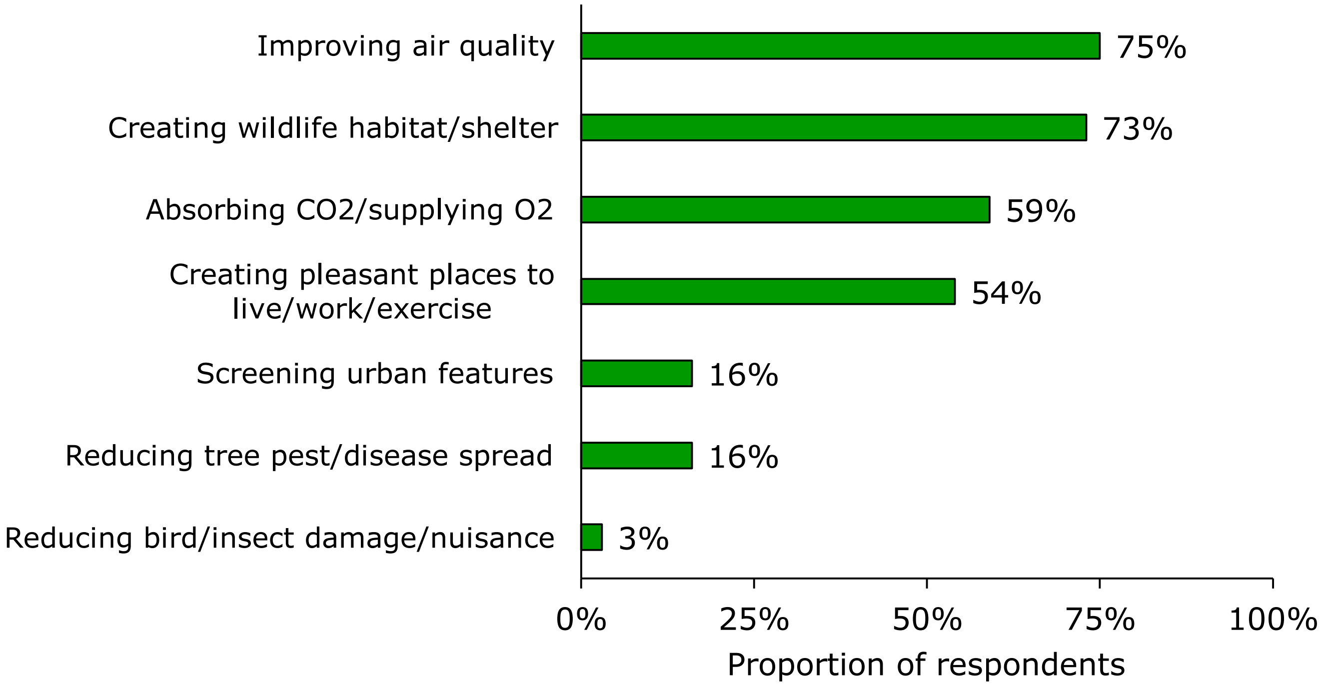


Figure 13. Survey responses to which reasons are most important for managing trees for environmental quality. Participants could select up to three reasons.

In terms of regulating the environment, the most important reasons were ‘to provide shade and cooler air’ (77%), ‘to help to stop flooding’ (61%), ‘to reduce noise’ (58%) (Figure 14).

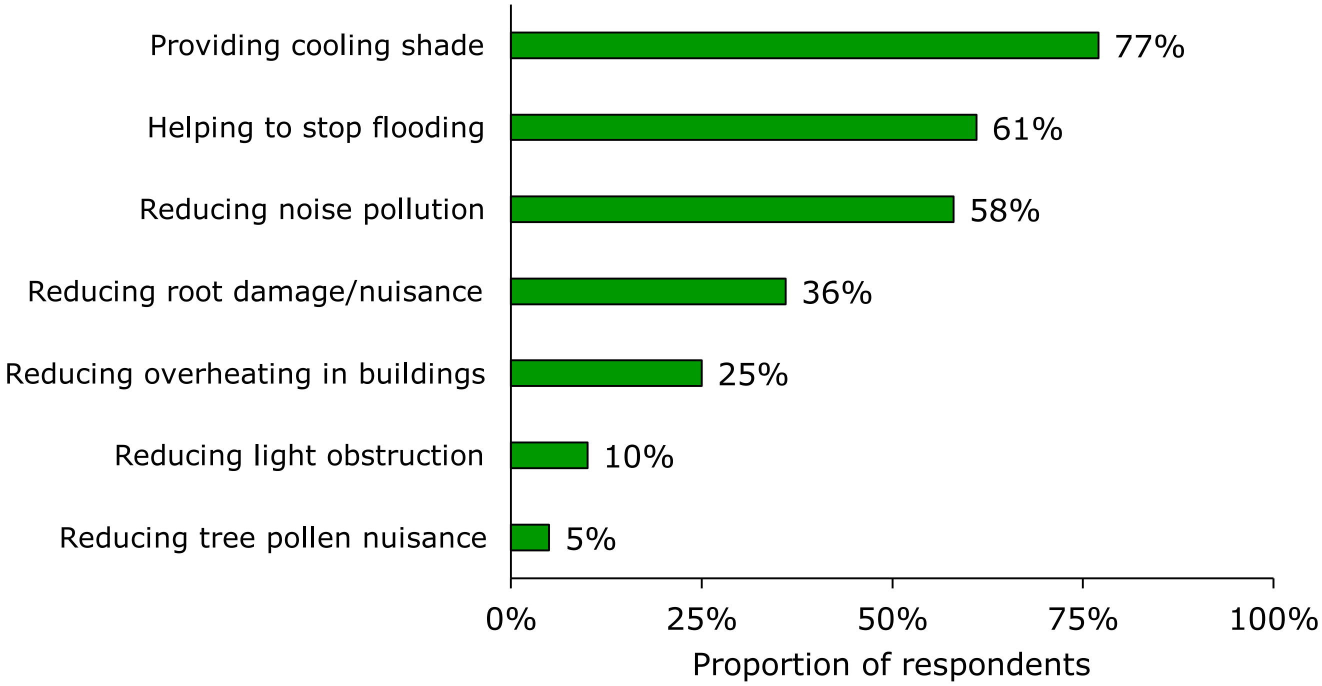


Figure 14. Survey responses to which reasons are most important for managing trees to regulate the environment. Participants could select up to three reasons.

Statistical analysis identified broad similarity in how reasons were scored across the four areas. However, the analysis did show a statistically significant difference for two reasons. Respondents in South West Island consider creating pleasant places to live, work and exercise more important than respondents in North West Island. People that live off Island think reducing overheating in buildings is more important than people elsewhere do.

### 3.1.6 Action for trees

Respondents were asked what actions they might take for trees in the city. If they had a garden themselves, they were asked if they would consider planting a tree there. Of the respondents to this question, 39% said that they would consider planting a tree, while 36% said that the garden already had enough trees. The remaining 25% were unable to plant a tree for various reasons (Figure 15).

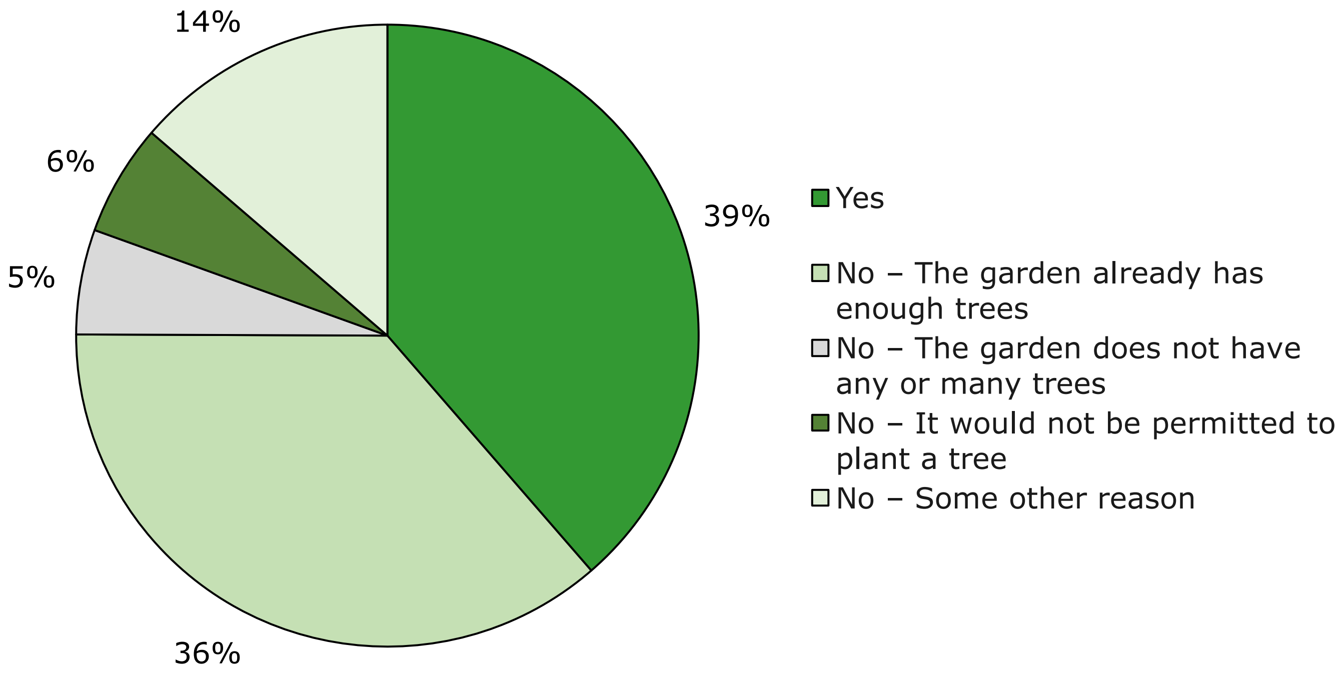


Figure 15. Proportions of survey respondents who would consider planting a tree in their garden

Of those other reasons, almost two thirds said that their garden was too small. The next most common concern was that roots would cause issues for either the householder or neighbours, including issues with obtaining buildings insurance. One tenth of respondents mentioned maintenance issues with a similar proportion mentioning concerns about neighbours or that there were trees on neighbouring properties.

When asked about actions that they could take for trees in Portsmouth, the most common current actions were taking care of trees in their own garden, followed by planting, or taking care of trees in their community garden or allotment. Willingness to undertake new tasks was high, with 88% of those who responded to this question expressing an interest in becoming a tree warden. Over 80% of respondents would also be interested in joining tree related events or campaigns or in joining a community group to care for trees. Of those who gave additional ideas, the most common were to support the care and maintenance of trees through volunteer effort. Also popular with around 10% of respondents were supporting tree growing, education campaigns and memorial, commemorative or adopted trees. Seven percent of respondents were interested in suggesting new sites (see Figure 16).

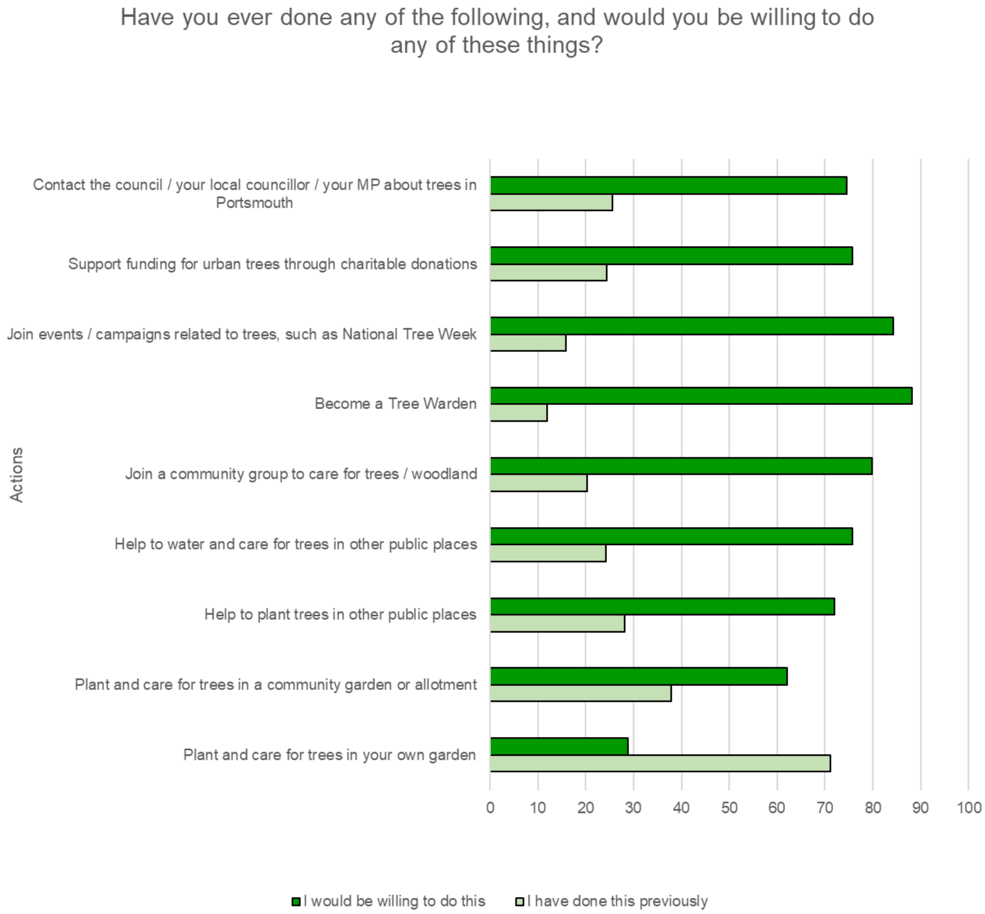


Figure 16 Percentage of survey respondents who have previously or would be willing to take action for trees.

Some respondents had concrete ideas about how to promote care for trees, one describing having won an essay contest long ago:

> *'I won second prize, and a tree was planted in my honour. This event has lived with me forever and I'm still very proud of the tree which is still standing despite the 1987 storms.'*

Others made connections to other policy areas:

> *'Help with a survey on air pollution across the city to see where planting more trees would actively help improve our air.'*

It is important to note however, that not everyone is able to contribute either due to old age, illness, or disability. One respondent also made the important point that for those who are struggling with the cost-of-living crisis, this would be a low priority.

### 3.1.7 Social and cultural values of local trees

Survey respondents were asked to rate how much they agreed or not with 19 statements (on a scale from 0 to 100, where 0 is strongly disagree, and 100 is strongly agree) when considering the social and cultural values of their local treescapes i.e. trees on the street, in parks, along riverbanks or footpaths and in woods (Table 12). **Respondents had strong agreement with all the statements**: all statements had a median score of over 60, indicating that people consider trees and woods to be important in many different ways. Nine statements, including the **importance of treescapes for physical wellbeing, mental wellbeing, treescapes being a peaceful refuge, the importance of treescapes for local wildlife, helping people feel connected to nature, people like being part of a landscape home to wildlife, the importance of old and ancient trees, and trees helping people to see the changing seasons and trees being part of the cultural and historic landscape all** had median value scores of 100. Trees connecting people to memories of their past and making people feel creative and inspired ranked lower but still have a reasonably high median value, meaning that people agreed they were of importance. The statements were developed after a literature review and work with stakeholders and then tested with the public to ensure people could easily understand them. The number of statements were chosen to cover a broad range of social and cultural values that have been identified in previous research, and to bring them together in one place. People in the survey agreed or strongly agreed with all of the statements, highlighting how much treescapes can mean to people.

Table 12. Responses to the 19 statements on the social and cultural values of trees and woods. We show the median score; and show the 25% (lower) and 75% (upper) percentiles of the data (50% of the data points lie within this range). The median score for the first nine statements is 100.

| Social and cultural value statements | Number | Median | Lower quartile | Upper quartile |
|---|---|---|---|---|
| Of their importance for wildlife | 1018 | 100 | 99 | 100 |
| They are good for my mental wellbeing | 1003 | 100 | 90 | 100 |
| Being among them makes me feel more connected to nature | 1002 | 100 | 85 | 100 |
| I like being a part of a landscape which is also home to wildlife | 1001 | 100 | 91 | 100 |
| They contribute to my physical wellbeing | 999 | 100 | 83 | 100 |
| They are part of our cultural and historic landscape | 999 | 100 | 83 | 100 |
| They make me notice the changing seasons | 998 | 100 | 87 | 100 |
| They provide a peaceful refuge for me | 986 | 100 | 77 | 100 |
| Old and ancient trees are especially attractive to me | 986 | 100 | 77 | 100 |
| I feel touched by their beauty | 979 | 98 | 73 | 100 |
| Being among them I feel a sense of freedom | 958 | 94 | 69 | 100 |
| They stimulate my senses | 972 | 92 | 70 | 100 |
| They provide places to spend time with my friends and family | 957 | 86 | 58 | 100 |
| They provide me with places for fun and enjoyment | 958 | 86 | 63 | 100 |
| They can help me learn more about nature | 949 | 82 | 58 | 100 |
| Being among them makes me feel part of something bigger than myself | 942 | 81 | 56 | 100 |
| They provide places for the community to come together | 930 | 75 | 50 | 100 |
| They make me feel creative and inspired | 932 | 71 | 50 | 100 |

| Social and cultural value statements | Number | Median | Lower quartile | Upper quartile |
|---|---|---|---|---|
| They connect me with memories from my past | 936 | 67 | 48 | 100 |

The same statements have been used in an England-wide survey representative of the overall population by age, gender, and region (O'Brien et al., 2023). The England population study involved undertaking an exploratory factor analysis to investigate relationships between the statements, by finding which of the 19 statements correlated with each other and by looking for underlying factors that explained the correlations. Four factors were identified which explained over 70% of the variance in the statements, and which highlight key dimensions of social and cultural values. These were interpreted as: 1) Nature and landscape; 2) Social space; 3) Reflective and creative; and 4) Wellbeing.

The statements have also been used in a survey by Wirral Borough Council as part of its i-Tree Eco study (Walker et al. 2023) and are starting to be used by other local authorities in England. The statements outline the important social and cultural values of treescapes to people and have been created from an evidence review, work with stakeholders and have been tested before being run in a survey in England (O'Brien et al. 2023). The statements show the breadth and variety of the social and cultural values people associate with treescapes and provide a standardised approach for understanding these values that can be used in further studies or in future work to explore change.

Survey participants were also asked the extent to which they agree with four statements about their relationship with trees in Portsmouth. Over four-fifths agreed that Portsmouth is a better place because of its trees, that they tend to notice the trees in Portsmouth, and that trees should be given more protection from damage and removal (Figure 17). Fewer than one-third agreed they feel more connected with trees in Portsmouth since the COVID-19 lockdowns.

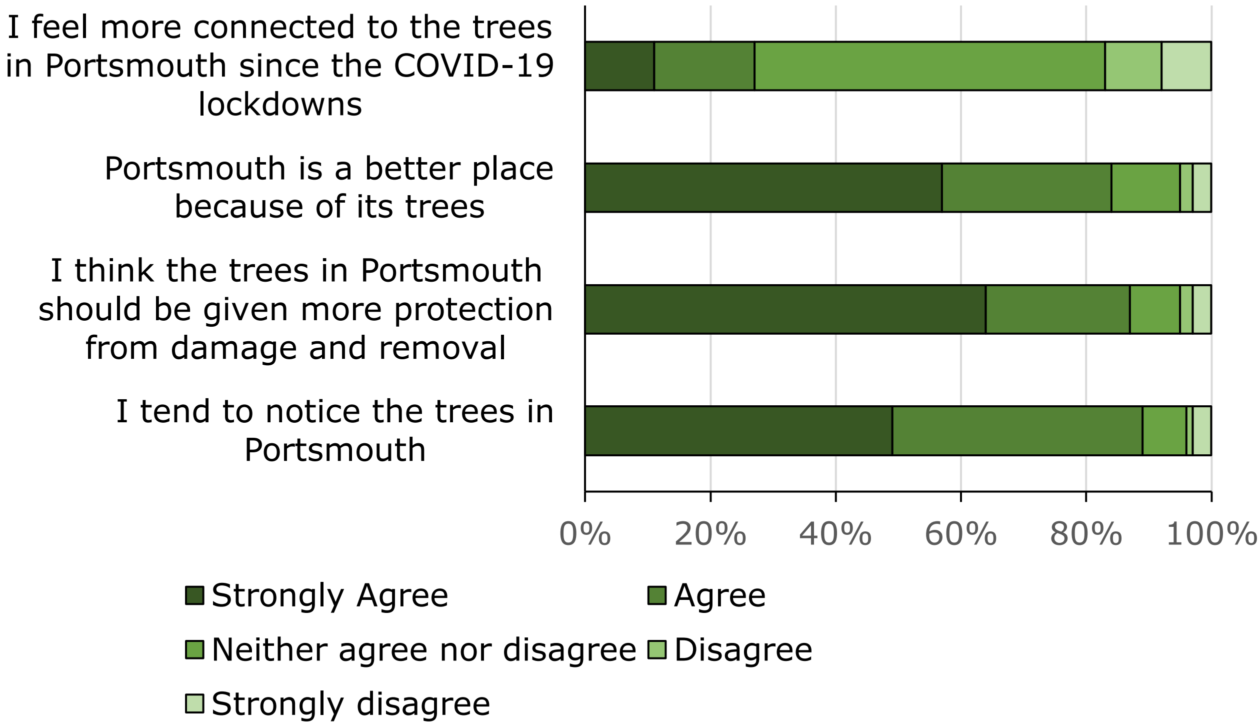


Figure 17. Proportions of survey respondents agreeing with statements about their relationship with trees in Portsmouth

### 3.1.8 Hopes for the future

Respondents were given an opportunity to express their hopes or wishes for the future of the trees in Portsmouth – 562 people responded to this question. Analysis of these data shows a very strong desire for more trees in the city (51% of respondents). Among the many reasons respondents offered for the importance of trees, five are clearly highest priority: wildlife (34 mentions), air quality or pollution (31), to mitigate high temperatures (29), aesthetic reasons (28), and wellbeing and health (23). Other important emerging themes cover the relationship between trees and development, planning, or buildings (60); comments on effective tree management or care (145); and about educating the public about trees (24).

## 3.2 Land cover

### 3.2.1 Canopy cover

There is no single agreed target canopy cover for urban areas in the UK: 20% tree canopy cover can be a good aspiration for inland towns and cities, or 15% for coastal settlements (Doick et al., 2017) such as Portsmouth, the current UK government target is 16.5% of England's total land area (Defra, 2023b), and the 3-30-300 rule suggests that there should be 30% canopy cover in urban areas (Konijnendijk van den Bosch, 2021). The overall tree canopy cover in Portsmouth **is estimated to be 8.9%**.

#### 3.2.1.1 Canopy cover across the four areas of Portsmouth

Figure 18 shows the canopy cover for each of the four areas in Portsmouth. The highest canopy cover in Portsmouth is 11.3% in the North West Island, therefore no areas meet the UK government target of 16.5%. All areas are substantially lower than the 20% canopy cover recommendation.

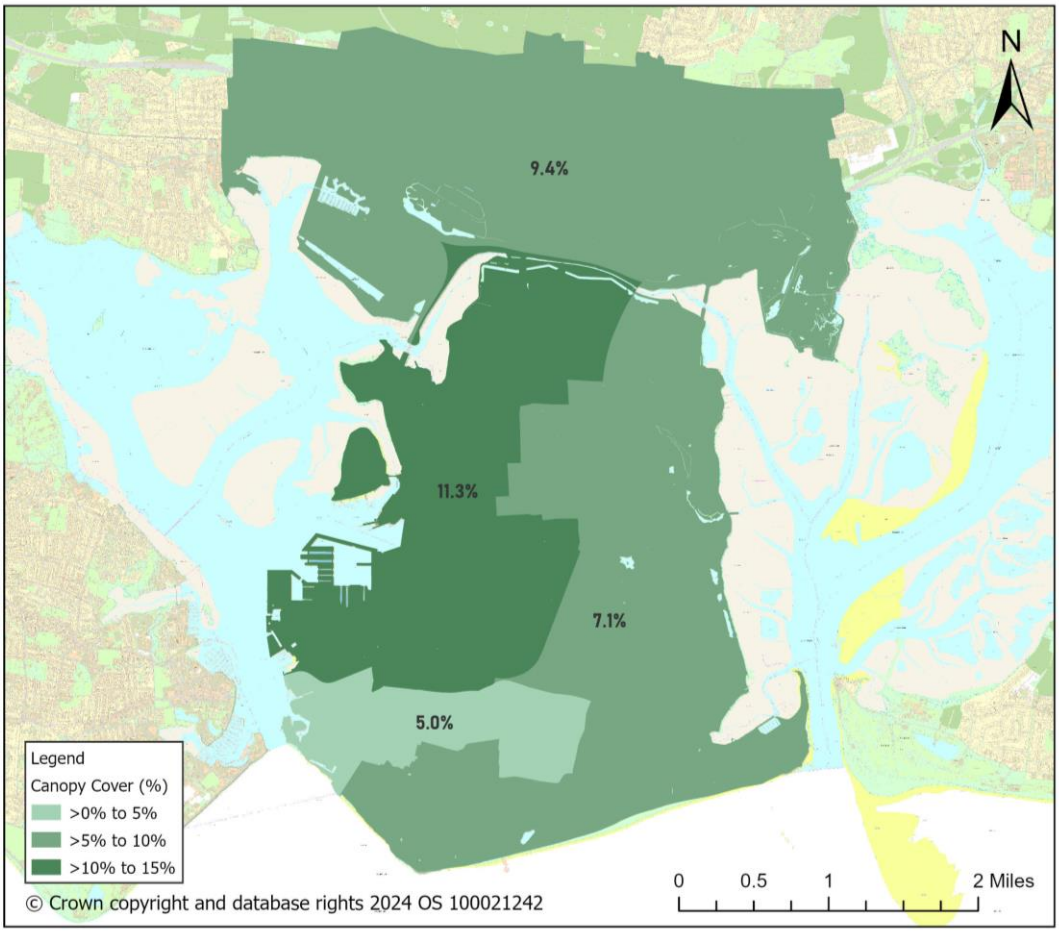


Figure 18. Map of canopy cover percentages across the four areas of Portsmouth.

### 3.2.1.2 Canopy cover on PCC and Non-PCC land

Table 13 shows the canopy cover across PCC and Non-PCC land in Portsmouth. Both PCC and Non-PCC land fall below the 16.5% government canopy cover target.

Table 13. Canopy cover for PCC and non-PCC land across Portsmouth.

| Area | Canopy Cover |
|---|---|
| **PCC land** | 12.8 |
| **Non-PCC land** | 6.7 |

### 3.2.2 Ground cover

51.1% of the ground cover across Portsmouth is impermeable, consisting of buildings, cement, tar, and other impermeable surfaces. The remaining 48.9% is permeable, made up of bare soil, permeable rock, grass, mulch, water, herbaceous plants and ivy.

Impermeable surfaces increase the potential for surface water flooding by preventing, slowing, or reducing infiltration into the soil. Impermeable surfaces such as tar also contribute to local heating of urban environments. A greater proportion of permeable surfaces is therefore favourable. The presence of trees in both permeable and impermeable surfaces reduces surface water flooding, which is discussed further in section 3.4.1.1. See Appendix A for details of the ground cover categories used in the survey.

### 3.2.3 Land use

Figure 19 shows the percentage of surveyed trees in each land use, and the percentage of the total study area used for each land use. The largest proportion of Portsmouth's trees, 40% are in residential areas. Residential is also the largest land use category at 34%. Working with residents to promote the benefits of trees can help protect preexisting trees in these areas and encourage new tree planting in private gardens. The second highest proportion of trees, 23% are in parks and greenspaces. Ensuring these trees are well managed will contribute positively to Portsmouth's tree canopy cover.

Trees on agriculture/farmland, cemeteries, industrial land, and golf courses collectively make up only 5% of Portsmouth's trees. Increasing tree canopy cover in these areas by working with landowners to plant new trees could help contribute to Portsmouth achieving its target of doubling canopy cover over the next 25 years. A detailed spatial evaluation of land use and tree cover within Portsmouth would enable mapping of tree planting opportunities.

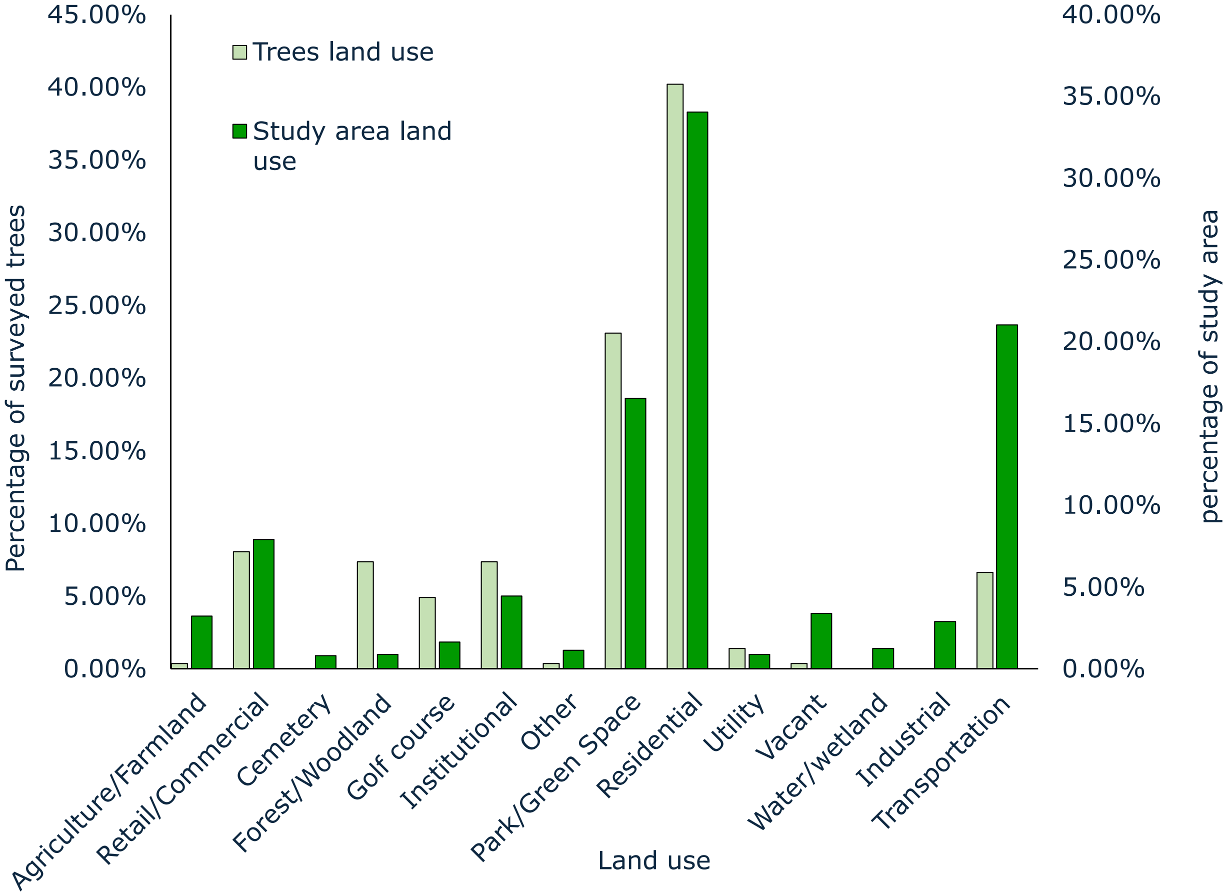


Figure 19. Land uses where surveyed trees were located, the percentage of trees found in each land use, and the percentage presence of land uses in the whole study area.

### 3.2.3.1 Land uses in the four areas of Portsmouth

Figure 20 shows the distribution of land uses in each of the four areas of Portsmouth. Residential makes up the largest proportion of all land uses within each of the four areas. South West Island has the largest proportion of residential land (50%) and road land (24%) use. Off Island has the largest proportion of parks and green space (21%).

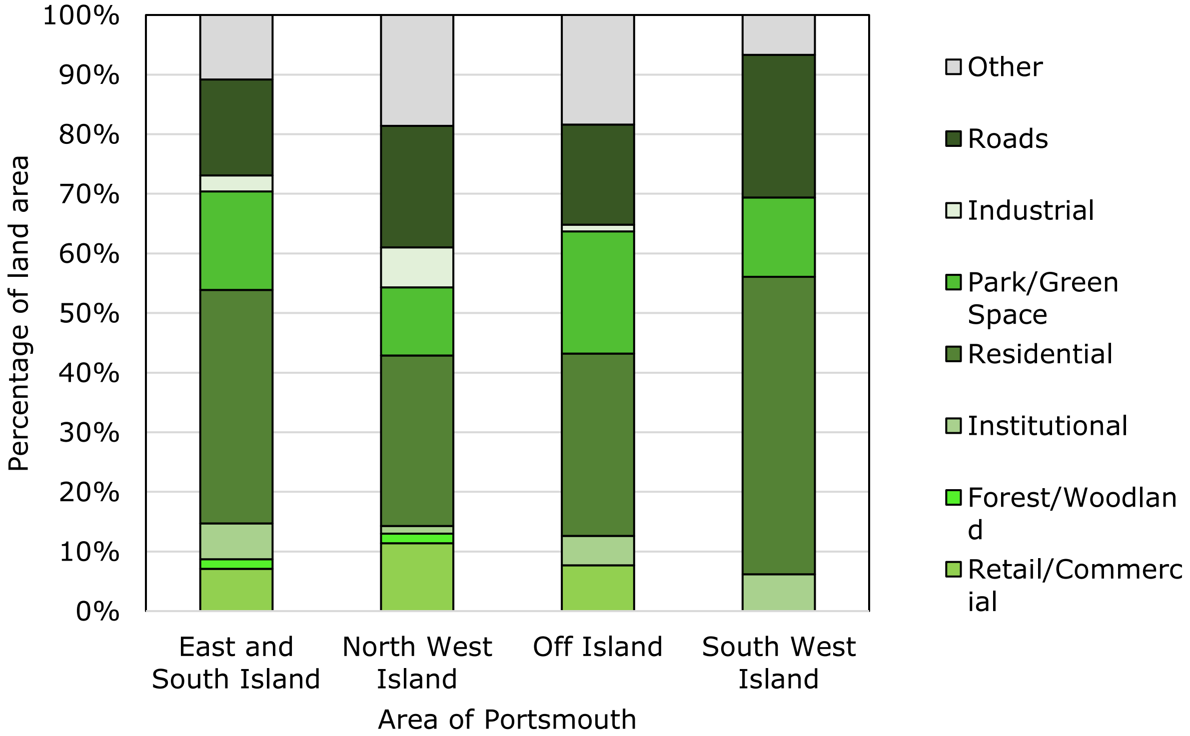


Figure 20. Land use in each area of Portsmouth, extrapolated from survey data. "Other" includes agriculture, cemetery, golf course, other transport (not roads), utility, vacant, water/wetland and land uses recorded as other.

#### 3.2.3.2 Land use on PCC and Non-PCC land

Figure 21 shows the distribution of land uses across PCC and Non-PCC land. At 47% residential makes up the largest proportion of all land uses on Non-PCC land whereas at 40% parks and green space make up the largest proportion of all land use on PCC land. This high percentage of parks and green space on PCC land could provide opportunities for planting to help meet tree planting targets.

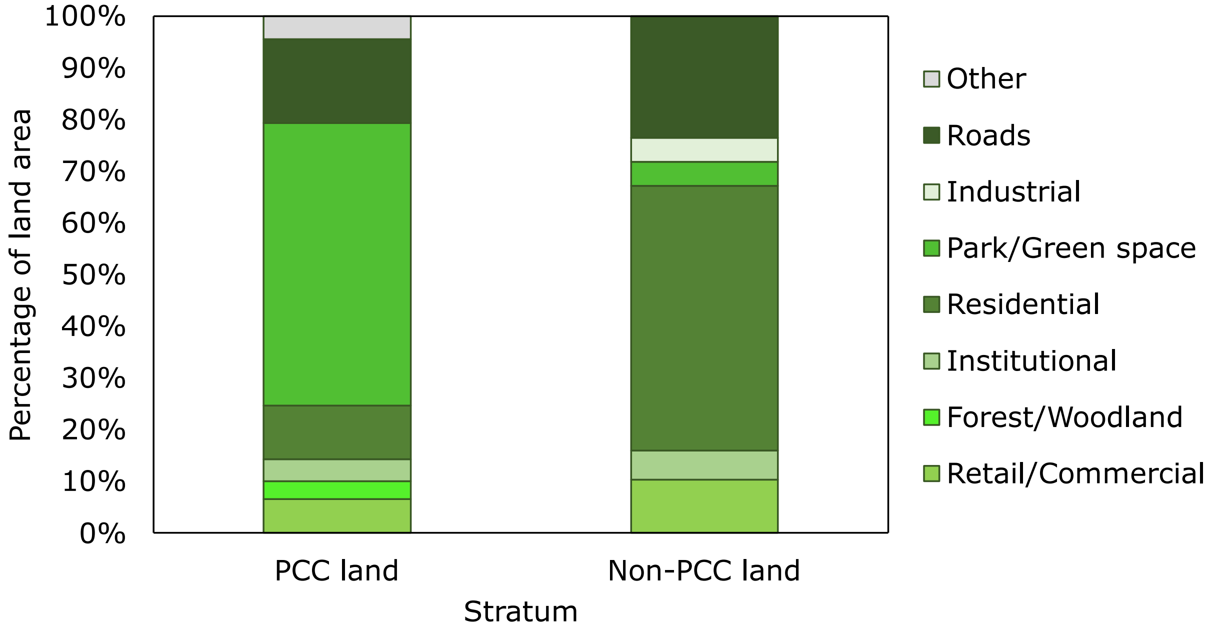


Figure 21. PCC and Non-PCC land use classifications, extrapolated from survey data. “Other” includes agriculture, cemetery, golf course, other transport (not roads), utility, vacant, water/wetland and land uses recorded as other.

# 3.3 Urban Forest Structure

## 3.3.1 Tree numbers

Based on the tree survey it is estimated that there are approximately 111,800 trees in Portsmouth.

## 3.3.2 Species composition

A total of **65 tree species** were recorded across the study area (for a full list of tree species, see (Appendix B). The three most common species were ***Acer pseudoplatanus*** (13.1%), ***Fraxinus excelsior*** (10.6%), and ***Crataegus monogyna*** (5.7%). Figure 22 shows the 10 most common species, which account for 56% of the tree population.

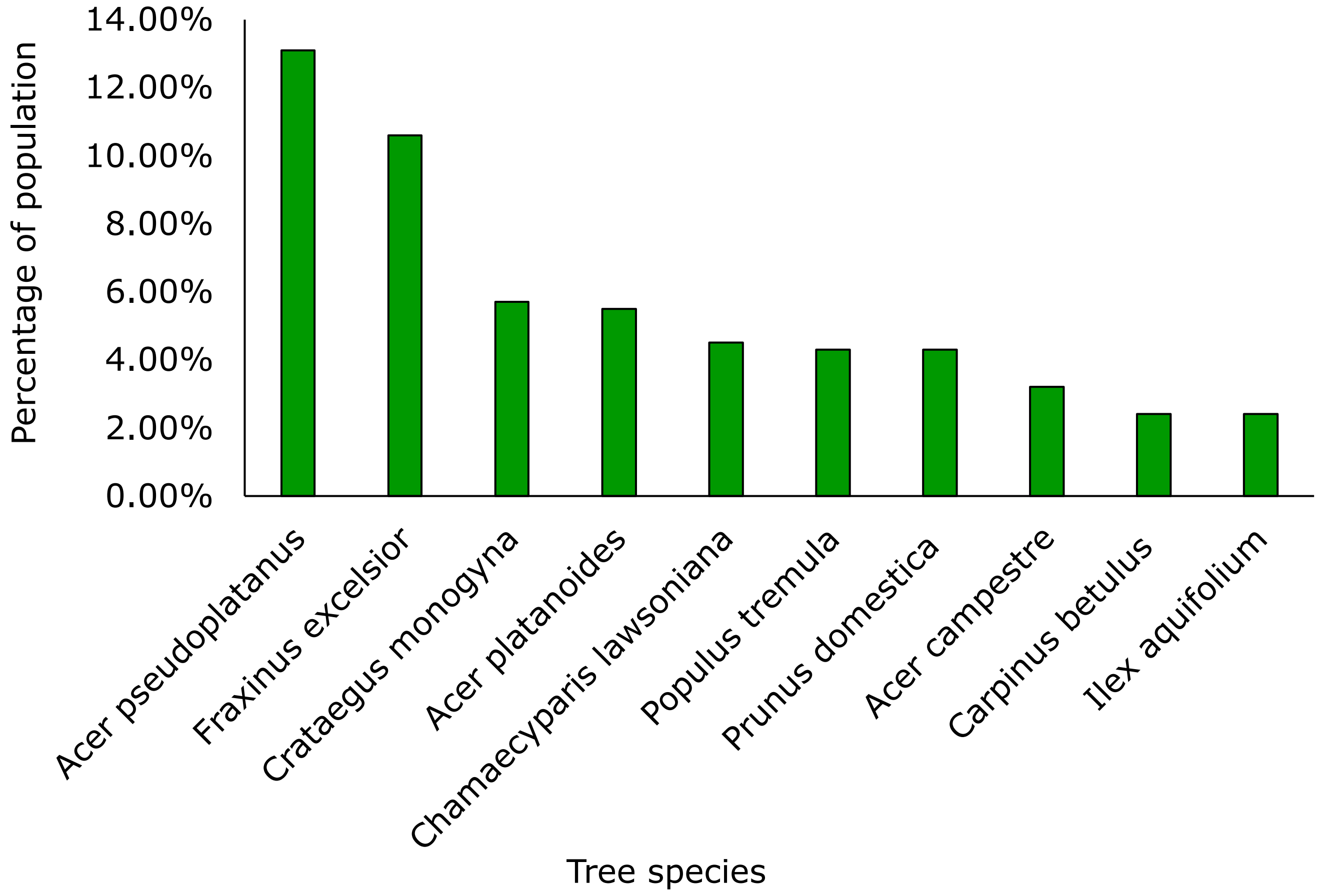


Figure 22. Ten most common species in Portsmouth’s tree population.

### 3.3.2.1 Portsmouth residents' tree preferences

Survey respondents were asked about the types of trees they would like to see in their streets, their neighbourhoods, and across Portsmouth generally. At city level, respondents display a clear preference for a mixture of conifer and broadleaf trees. Closer to home (street and neighbourhood levels), preferences for broadleaf trees and a mixture are more closely matched are both preferred to conifers (alone) (Figure 23).

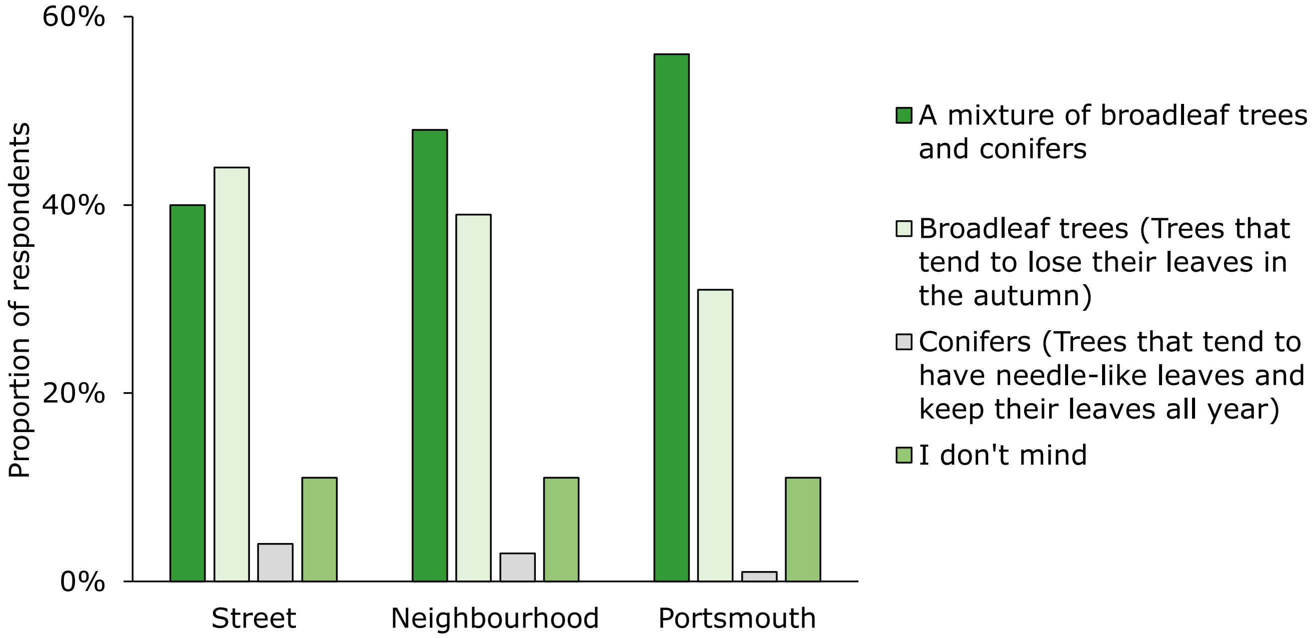


Figure 23. Survey respondents' preferences regarding conifer and broadleaved trees at different spatial levels (proportions)

Additional questions allowed respondents to express preferences for species of tree they would or would not like to see in their neighbourhoods. Four-hundred-and-thirty-eight respondents suggested preferences, with the most common mentions being oak (98 times), birch (67) and cherry (53). Other trees mentioned over twenty times include plane, apple, ash, rowan, and beech. Further, participants also noted a preference for native (70 mentions), fruit trees (69) and blossom (45), with 62 respondents citing trees beneficial to wildlife. Regarding trees they would not like to see, there were fewer responses (276), and fewer specific species listed. Seventy-five respondents mentioned conifers, and 24 sycamore.

#### 3.3.2.2 Species composition across the four areas of Portsmouth

Species composition varies between the four areas of Portsmouth as shown in Figure 24,

Figure 25, Figure 26 and Figure 27. *Chamaecyparis lawsoniana* is the most abundant tree in the South West Island area and is also in the top ten in the East and South Island and Off Island areas. *Acer pseudoplatanus* is the most common tree in the North West Island and Off Island Area. *Populus tremula* is the most common tree in the East and South Island area. *Acer platanoides* is the only tree in the top ten most prevalent trees across all four areas. *Fraxinus excelsior* and *Crataegus monogyna* are both in the top ten in the North West Island, East and South Island and Off Island areas. *Betula pendula* is in the top ten both in the South West Island and Off Island areas. Interestingly *Prunus domestica* was the second most common tree in the East and South Island area but was only recorded in one plot in this area and not recorded in any of the other surveyed plots across the whole of Portsmouth.

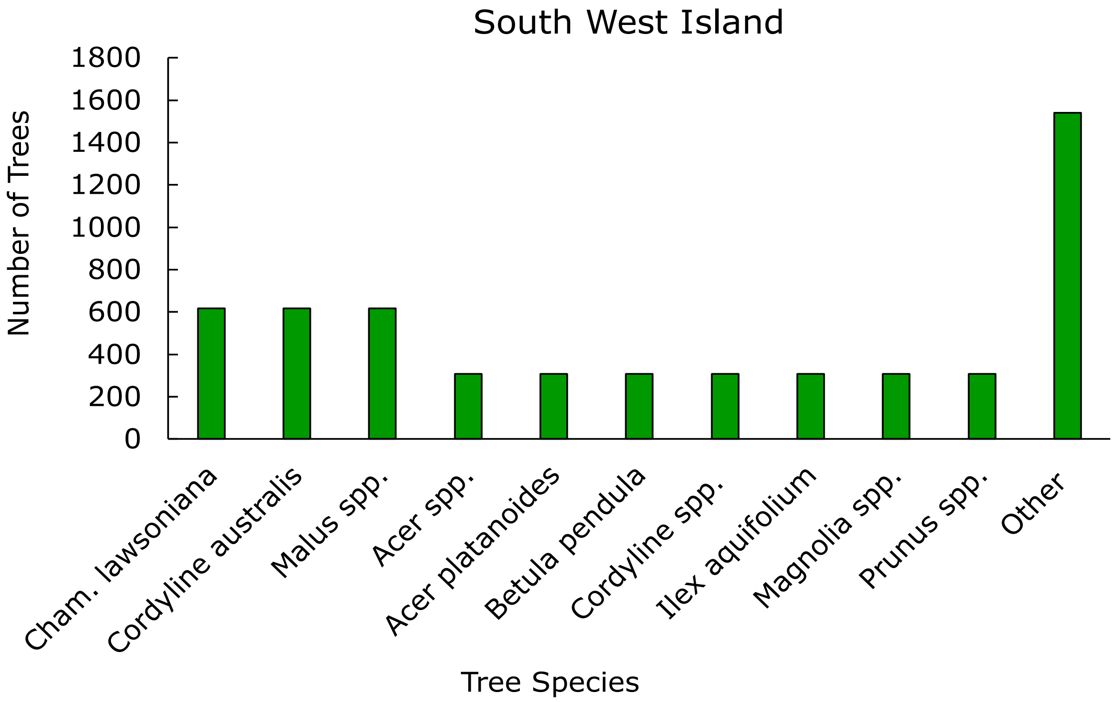


Figure 24. Ten most prevalent tree species in the South West Island area.

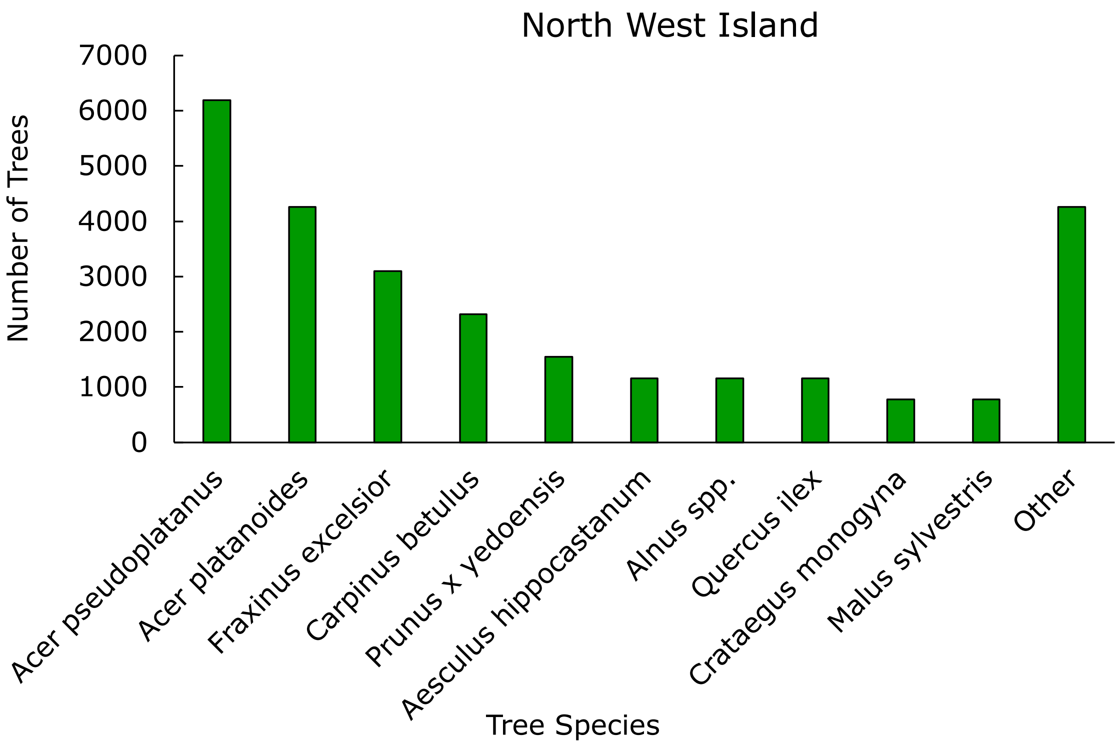


Figure 25. Ten most prevalent tree species in the North West Island area.

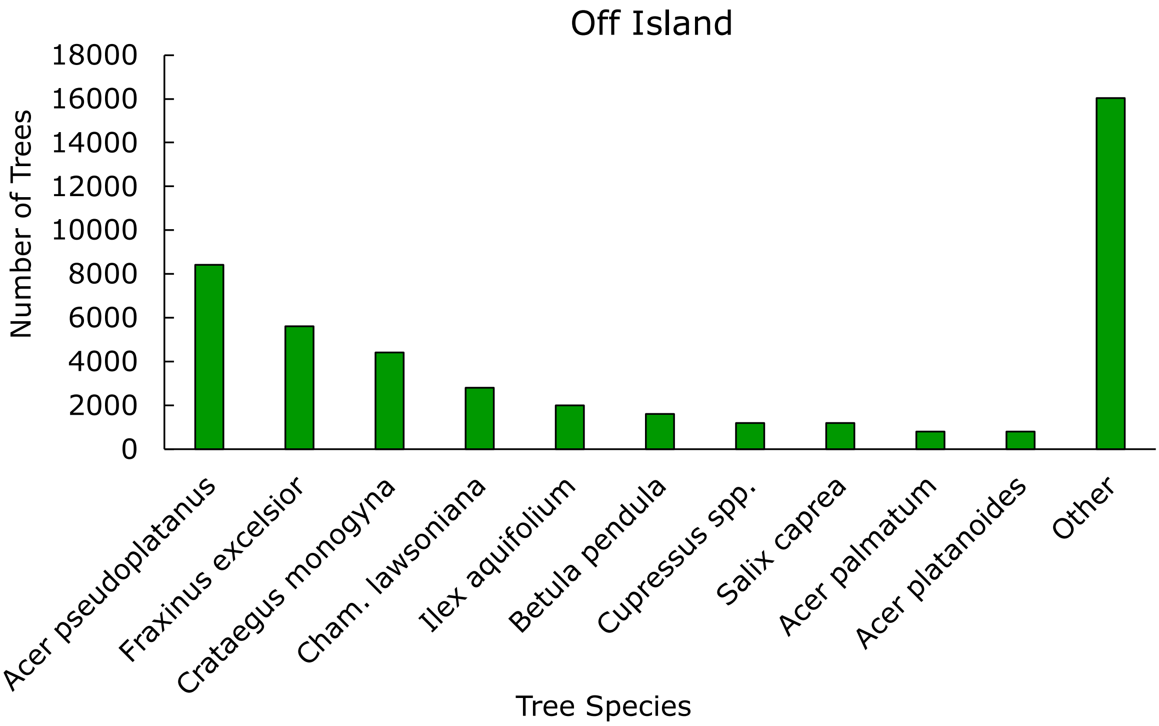


Figure 26. Ten most prevalent tree species in the Off Island area.

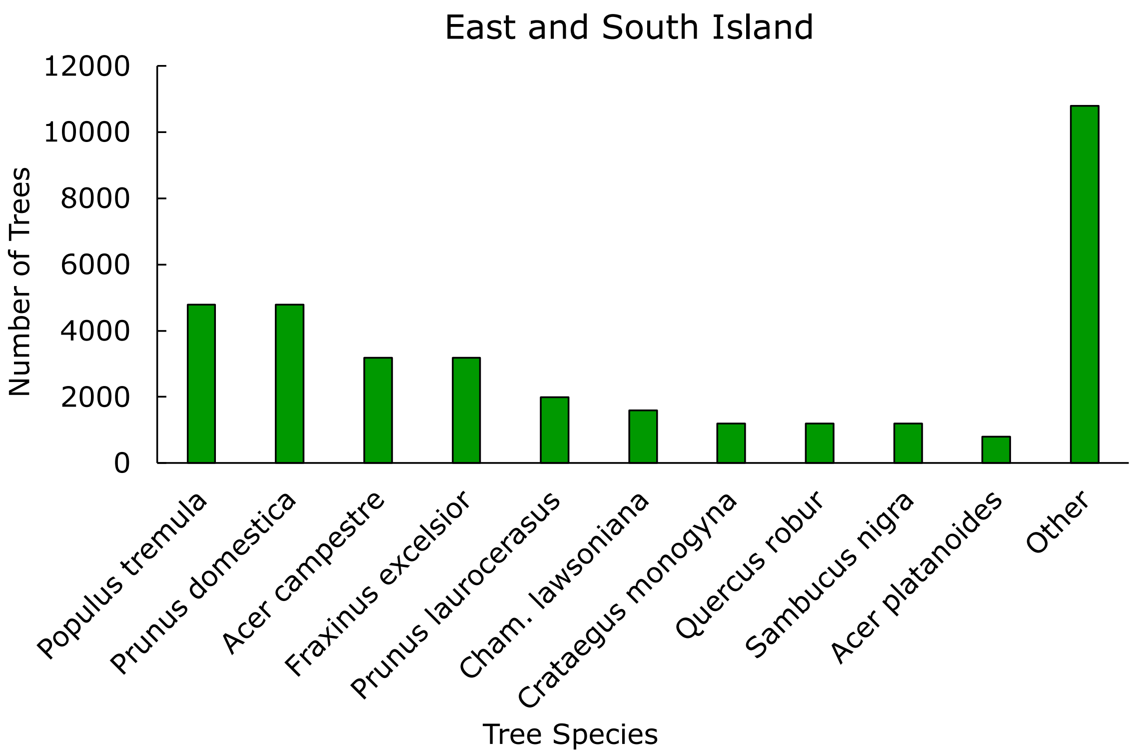


Figure 27. Ten most prevalent tree species in the East and South Island area.

### 3.3.2.3 Species composition on PCC and Non-PCC land

Figure 28 and Figure 29 show that the top ten tree species on both PCC and Non-PCC land contain five of the same species. *Fraxinus excelsior* is the most common tree on PCC land and the second most common tree on Non-PCC land. *Acer pseudoplatanus* is the most common tree on Non-PCC land and is the ninth most common tree on PCC land. *Prunus domestica* is the second most common tree on PCC land but does not feature in the top ten trees on Non-PCC land.

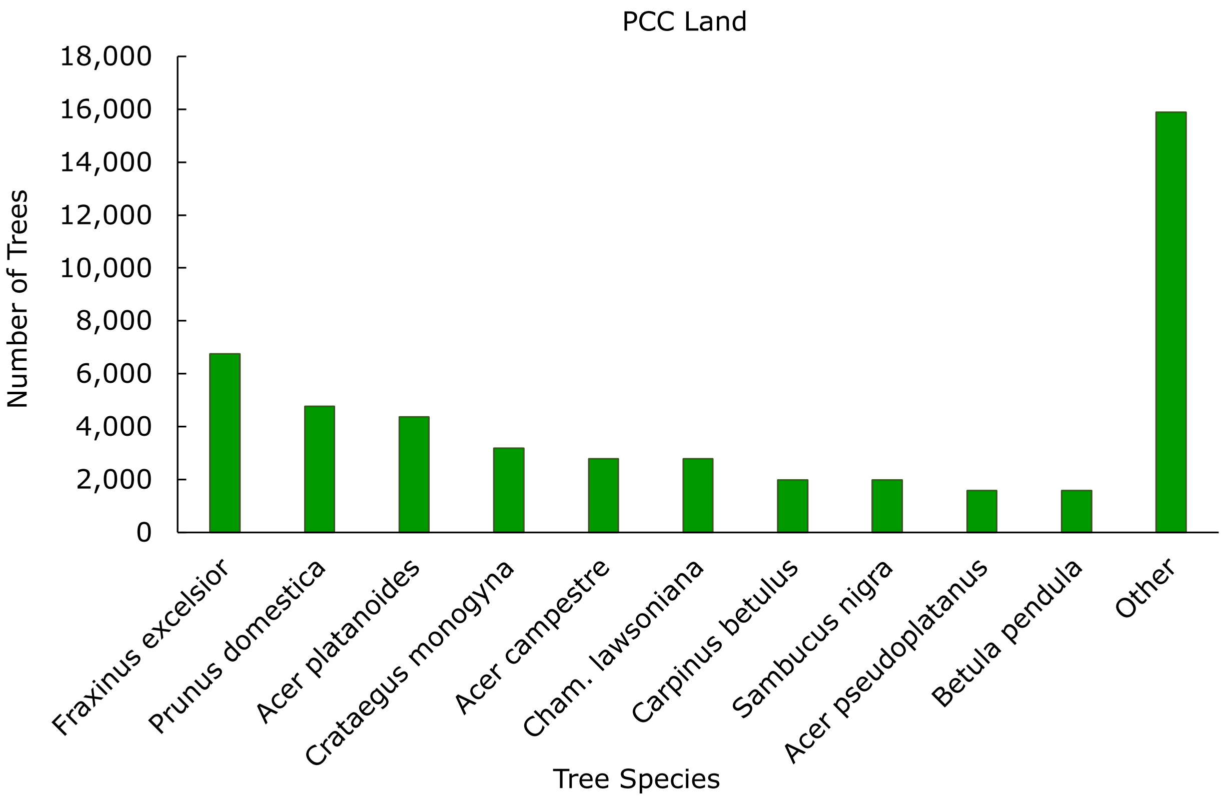


Figure 28. Ten most prevalent tree species on PCC land.

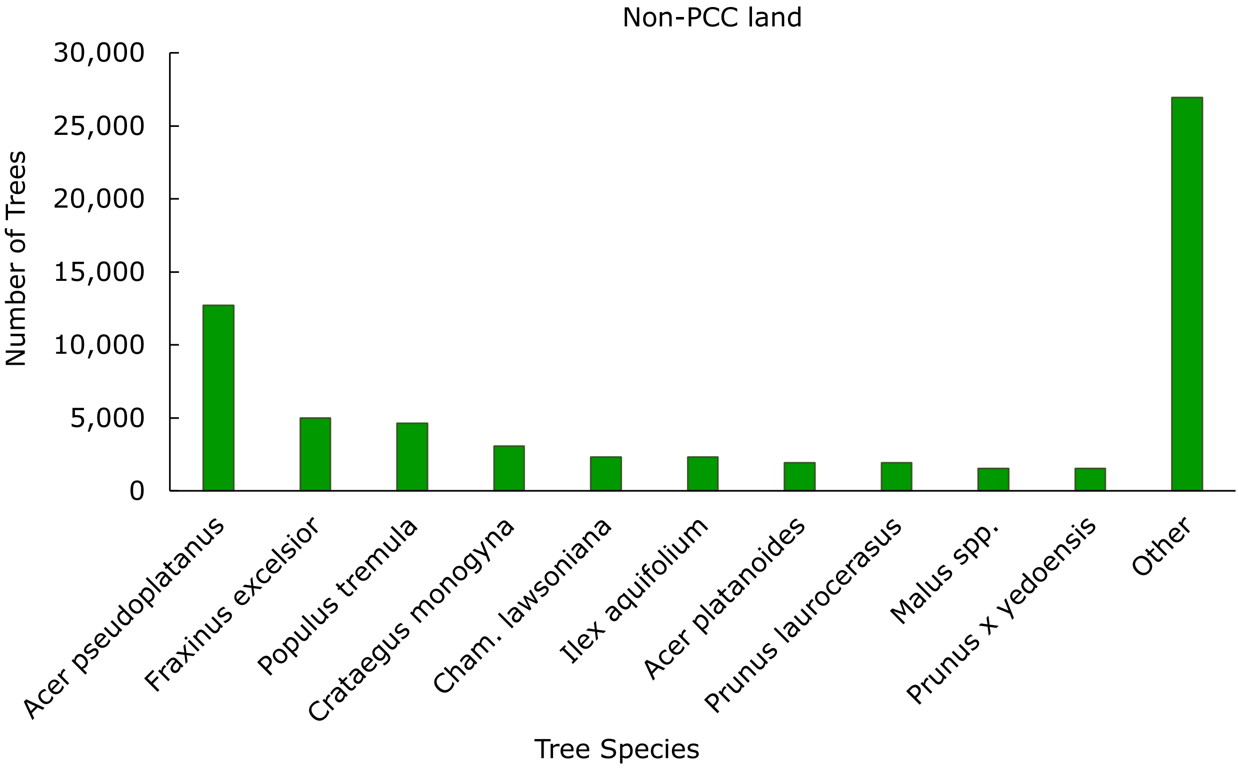

Figure 29. Ten most prevalent tree species on Non-PCC land.

### 3.3.3 Species composition by origin

An estimated **42% of Portsmouth's trees are native to the UK**. A further 25% are naturalised (such as *Acer pseudoplatanus*, *Populus alba*), and 27% are non-native. The other 6% is unknown as these trees were only identified to genus level during the survey. Native species can be an important source of food and habitat for invertebrates and other wildlife. Non-natives also have the potential to provide for local wildlife but may not be suitable for specialist feeders or those that take time to adapt. Where wildlife provision is an important selection factor for future tree planting, further information should be sought on suitability. For future information on food and habitat provided by Portsmouth's trees, see 3.4.4 Habitat provision.

## Native and non-native species

Non-native species can make an important contribution to the urban forest. Forest Research's Climate Matching Tool suggests that by 2070 Portsmouth will have a climate similar to the current climate of the coastal parts of Brittany in northwest France. Native species that currently thrive in Portsmouth's urban forest may no longer be suitable in the future climate: they may not tolerate the additional environmental stresses, and they may be susceptible to pests and diseases whose range and behaviour are expected to change with climate change.

The Right Trees for a Changing Climate database provides information on tolerances of tree species to environmental conditions, and their geographic origin. Along with species guidance from TDAG, it can help to inform species selection for sustainable urban planting.

Non-native species may be essential components of urban forests to ensure delivery of ecosystem services (Sjöman et al., 2016). While native species are more likely to support larger numbers of species, there is emerging evidence to indicate that non-native trees also support biodiversity in urban areas (Schlaepfer et al., 2017).

Respondents to the survey expressed a preference for native species over non-native species. Creating opportunities for engagement and education about the potential importance and resilience of non-native species in urban areas could promote public support for the planting of exotic species.

### 3.3.4 Tree Diversity

Increased tree species diversity (the number of different tree species present and their population sizes) can offer a higher level of resilience to pests and diseases, as there is less potential for large numbers of trees to be affected by an outbreak. There are different approaches to assessing whether an urban forest has a suitable level of species diversity. Santamour (1990) recommended that no species should exceed 10% of the total urban tree population, no genus 20%, and no family 30%. Considering this approach, the following was observed across the study area:

- ***Acer pseudoplatanus* represents 13.1% and *Fraxinus excelsior* represents 10.6% of the total population**, exceeding Santamour's species guideline of 10%
- At 23.6% *Acer* is the only genera to exceed 20% of the population
- No family exceeds 30% of the population

There have since been suggestions of a 5-10-15 rule (Watson, 2017). Considering this approach:

- **Four species exceed the 5% guideline** (*Acer pseudoplatanus, Fraxinus excelsior, Crataegus monogyna, Acer platanoides*)
- **Three genera exceed the 10% guideline** (*Acer, Prunus, Fraxinus*)
- **Two families exceed the 15% guideline** (*Sapindaceae, Rosaceae*)

The diversity of populations can be calculated using the Shannon-Wiener index, which measures the number of different species and their dominance within a population. A further metric, evenness, can be calculated from the diversity index and the number of species in each area. Usually the higher the diversity, the closer the evenness is to 1. See Appendix A for details of the calculation.

#### 3.3.4.1 Species diversity across the four areas of Portsmouth

Table 14 gives the Shannon-Wiener diversity indices and evenness scores for species of tree in each of the four areas of Portsmouth. Although South West Island and North West Island have lower numbers of recorded species compared to Off Island and East and South Island both these areas have a more even distribution of trees of each species. Off Island has the most recorded species but the lowest evenness indicating that a few species dominate the tree population in that area.

Table 14. Shannon-Wiener diversity index scores for tree species found in each of the four areas of Portsmouth.

| Area | Shannon-Wiener Diversity Index Score | Number of species | Evenness |
|---|---|---|---|
| South West Island | 2.7 | 15 | 0.98 |
| North West Island | 2.5 | 19 | 0.90 |
| Off Island | 3.2 | 44 | 0.70 |
| East and South Island | 3.0 | 32 | 0.77 |

#### 3.3.4.2 Species diversity on PCC and Non-PCC land

Table 15 shows that there are just over 1.5 times more tree species on Non-PCC land compared to PCC land with almost identical diversity index and evenness scores. This indicates that both areas have a similar distribution of trees with no individual species dominating in either area.

Table 15. Shannon-Wiener diversity index scores for tree species found on PCC and Non-PCC land.

| Area | Shannon-Wiener Diversity Index Score | Number of species | Evenness |
|---|---|---|---|
| PCC land | 3.2 | 37 | 0.9 |
| Non-PCC land | 3.4 | 57 | 0.8 |

### 3.3.5 Size class distribution

Understanding the distribution of size classes within an urban forest population is important for two primary reasons. One is that it can be used as a proxy for age, and this can help offer insights into the sustainability of an urban forest, and whether there is a need to increase tree planting efforts to address potential shortfalls in tree numbers in the future. Secondly, larger trees deliver a greater amount of ecosystem services than smaller trees (Sunderland et al., 2012; Hand et al. 2019a, 2019b, 2019c). It is therefore important that, wherever practically possible, large mature trees should be retained and large stature trees[5] should be incorporated into new planting. It is also important that trees are supported through to maturity to maximise the ecosystem service delivery of the urban forest.

#### 3.3.5.1 DBH size class distribution

One way to understand the distribution of different sized trees across a population is by assessing DBH. Richards (1983) suggested the ideal street tree distribution to ensure a healthy stock is:

- 40% of trees with a DBH <20 cm,
- 30% of trees with DBH from 20 to 40 cm,
- 20% of trees with DBH from 40 to 60 cm and
- 10% of trees with DBH >60 cm.

##### 3.3.5.1.1 DBH size class distribution across the four areas of Portsmouth

Figure 30 shows the size class distribution of measured trees in each of the four areas of Portsmouth. North West Island only has 12.8% in the 7-20cm DBH size class while the other three areas all have over the suggested 40% in this range. East and South Island only has 25% in the 20-40cm DBH size class while the other three areas all have over the suggested 30% in this range. None of the four areas have the suggested 20% in the 40-60cm DBH size class. At 17% only North West Island has over the suggested 10% in the above 60cm DBH size class. South West

[5] Large stature tree species are defined as those for which a healthy, isolated 20-year-old specimen growing in good soil conditions is typically over 12 m high (Stokes et al., 2005).

Island has no trees recorded with a DBH above 60cm. The lower numbers of the two largest DBH size classes indicate that **the overall population is smaller (or younger) than ideal**. Similarly, the low number of the smallest DBH size class trees in the North West Island indicates there are not enough young trees in this area. The North West Island could therefore be an area to focus future tree planting efforts in.

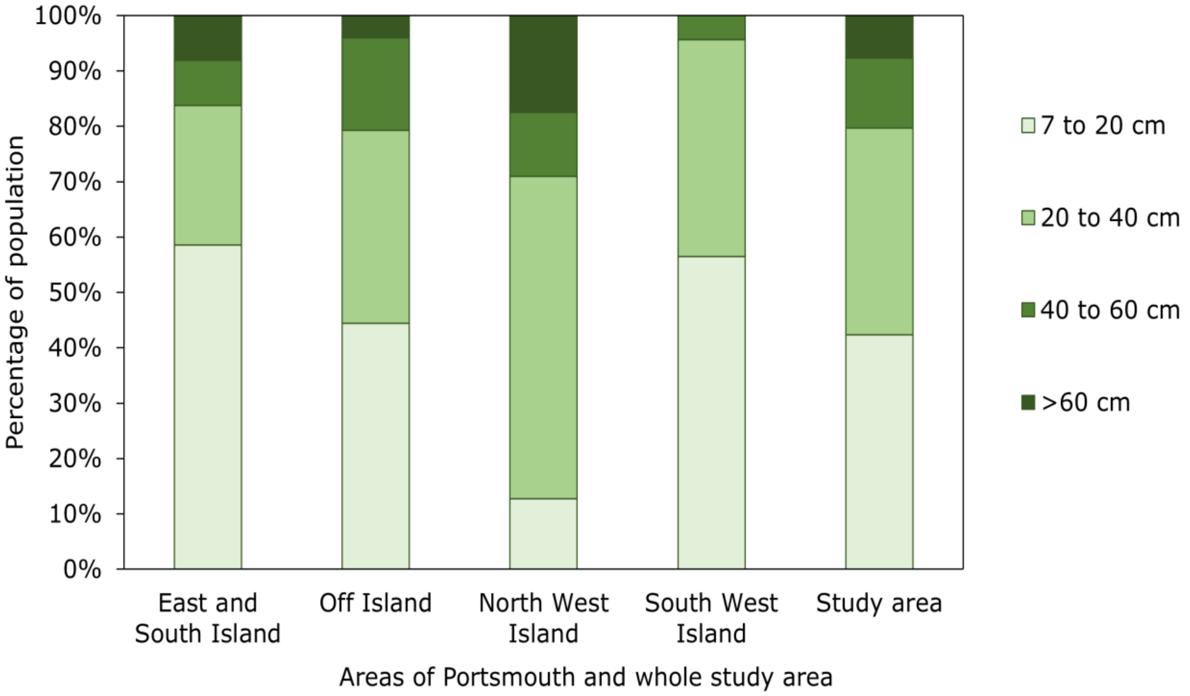


Figure 30. DBH classes of the trees in the four areas of Portsmouth and the whole study area.

### 3.3.5.1.2 DBH size class distribution across PCC and Non-PCC land

Figure 31 shows the size class distribution of measured trees on PCC land and Non-PCC land and the whole study area. The trees on PCC and Non-PCC land meet the recommended proportions of 7-20cm and 20-40cm DBH size classes. However, neither PCC or Non-PCC land have enough trees that meet the recommended proportions of 40-60cm and over 60cm DBH size classes indicating the overall population is smaller (or younger) than ideal.

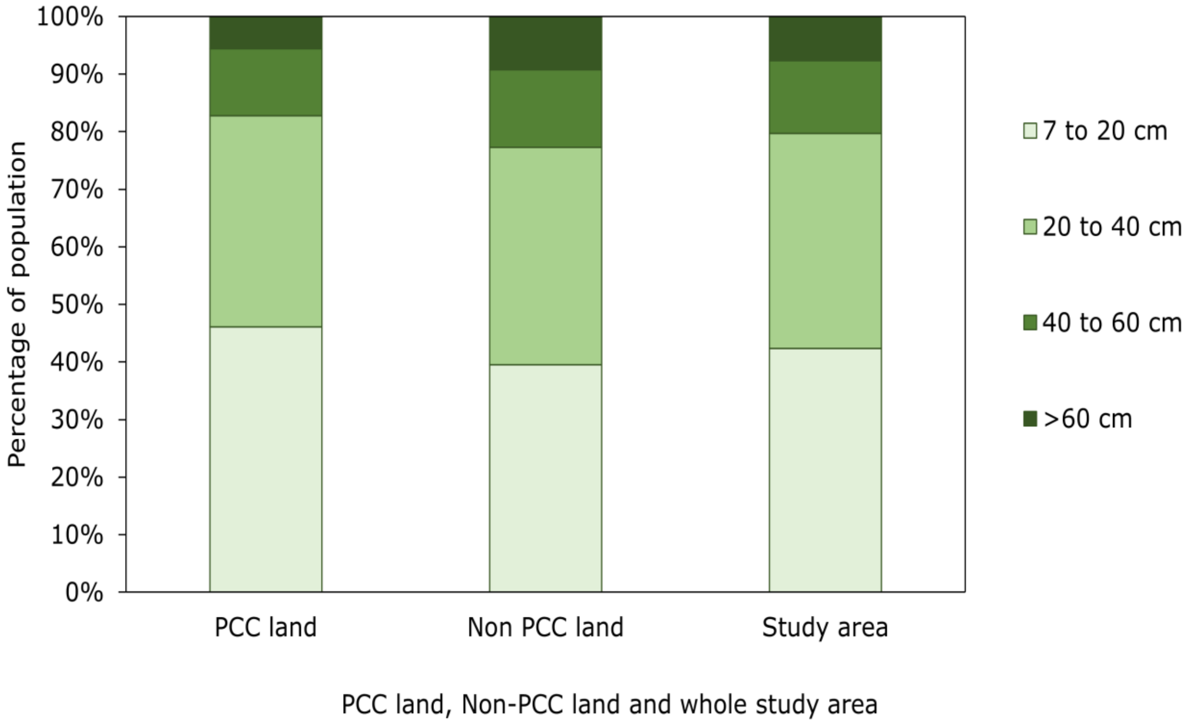


Figure 31. DBH classes of trees on PCC land, Non-PCC land and the whole study area.

### 3.3.5.2 Portsmouth residents' tree size preferences

Respondents to the survey were asked about their preferences for small and large trees, and the sizes of trees they could see from their homes. Sixty-two percent of respondents said they would like to see a mix of small and large species in their street, with 73% and 76% saying the same respectively for the neighbourhood level and Portsmouth generally (Figure 32).

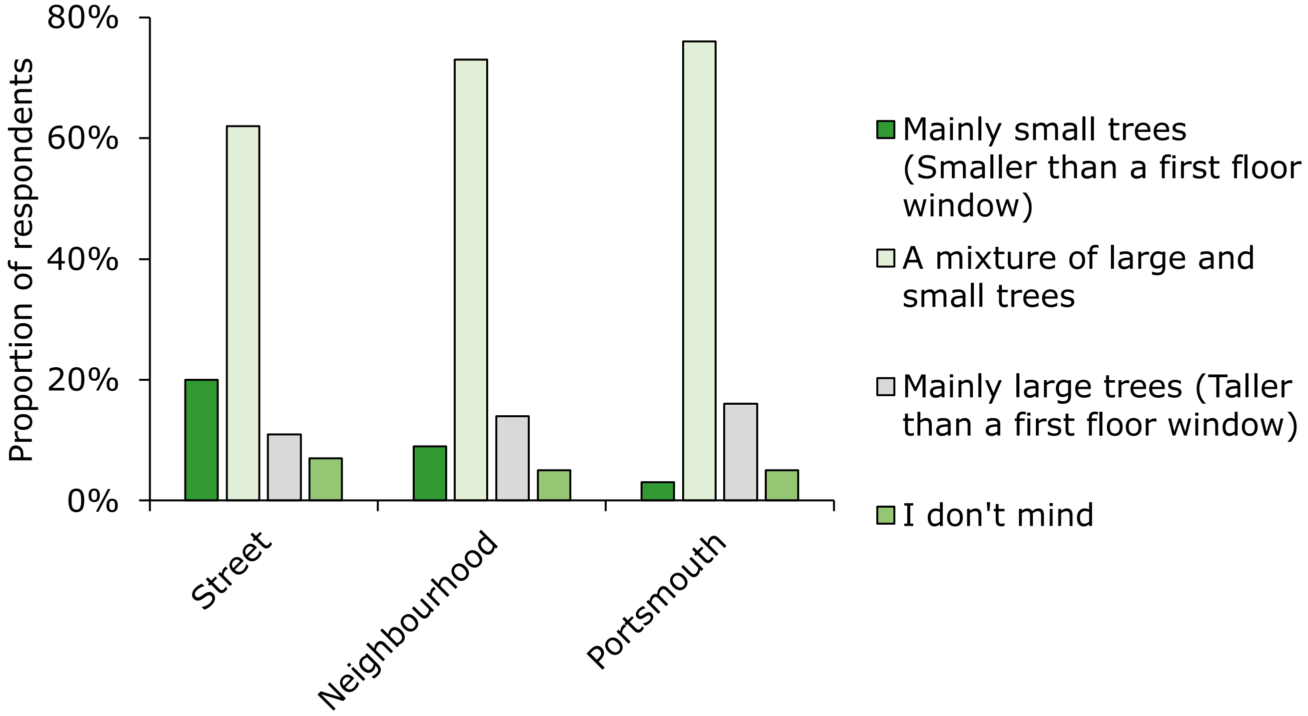


Figure 32. Survey respondents' preferences regarding size of trees across different spatial contexts (proportions)

Statistical analysis suggests that respondents in IMD quintiles 3 and 4 are less likely to be content with the number of large street trees in their neighbourhood (p=0.027) (Figure 33).

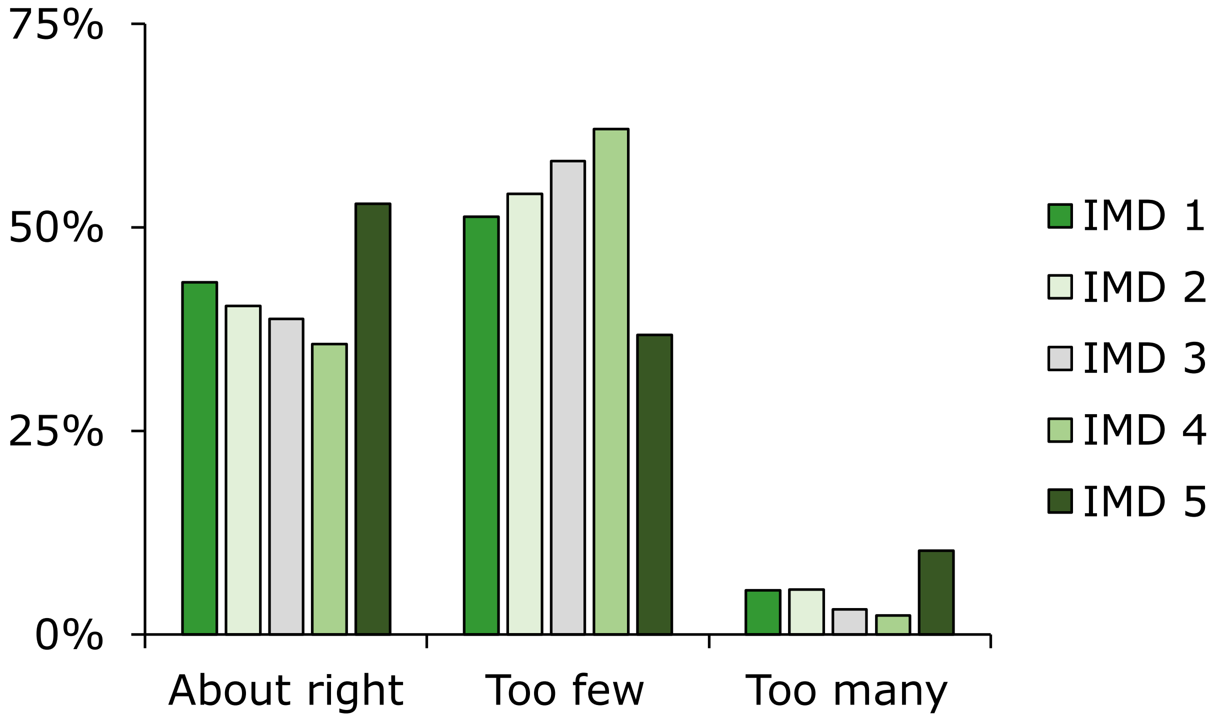


Figure 33. Proportions of respondents saying the numbers of large trees in their neighbourhood is 'about right', 'too few' or 'too many', broken down by the IMD quintiles

Further, it seems people on East & South Island and Northwest Island are more likely to want more large street trees in Portsmouth generally (p=0.024) (Figure 34).

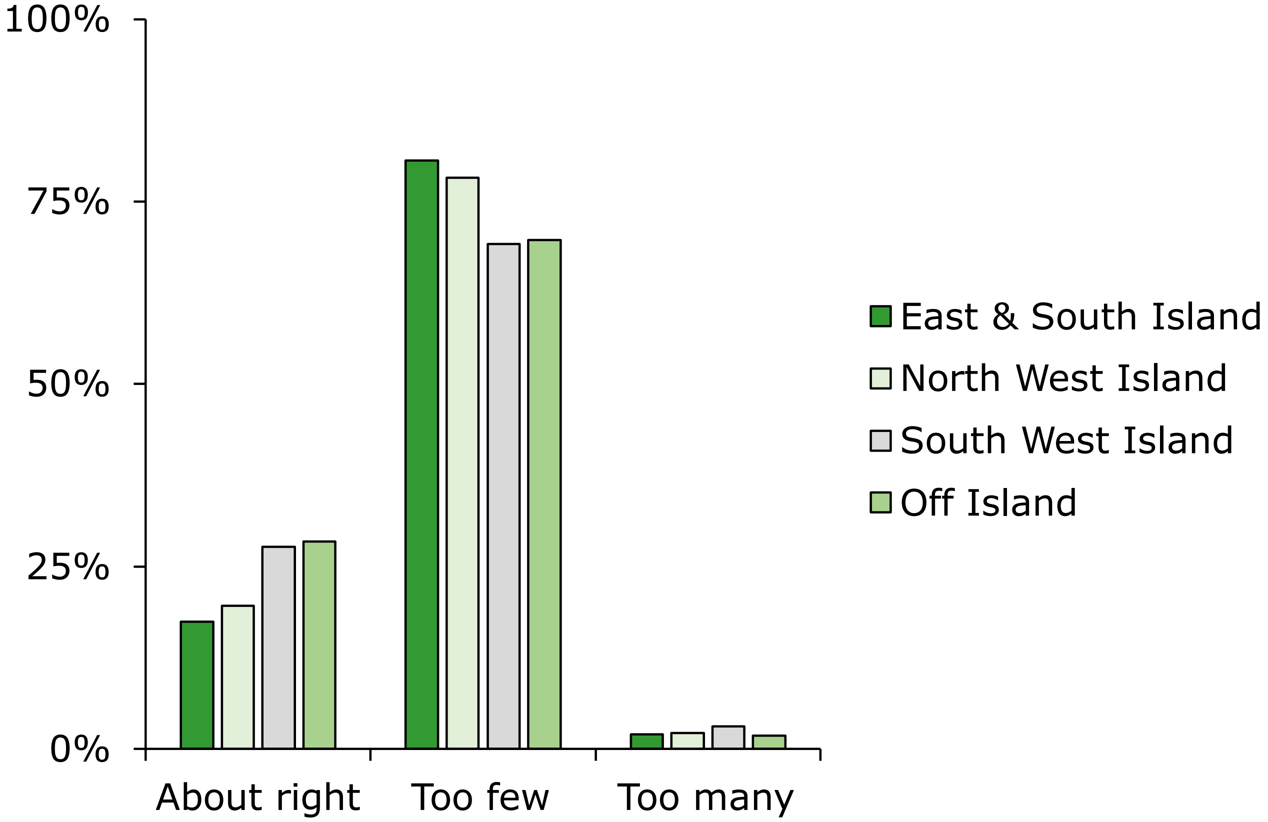


Figure 34. Proportions of respondents saying the numbers of large trees in Portsmouth is ‘about right’, ‘too few’ or ‘too many’, broken down by four areas

Figure 35 shows the percentage of surveyed trees classified as large according to height (greater than 12 m), canopy spread (greater than 10 m), and DBH (greater than 60 cm). Of trees surveyed in the South West Island area, only one large tree with a height greater than 12 m was recorded. Across the whole study area, 30.4% of surveyed trees were >12 m in height. The lack of large trees in the South West Island area in particular is at odds with the wishes of Portsmouth residents who would like to have a mix of large and small trees.

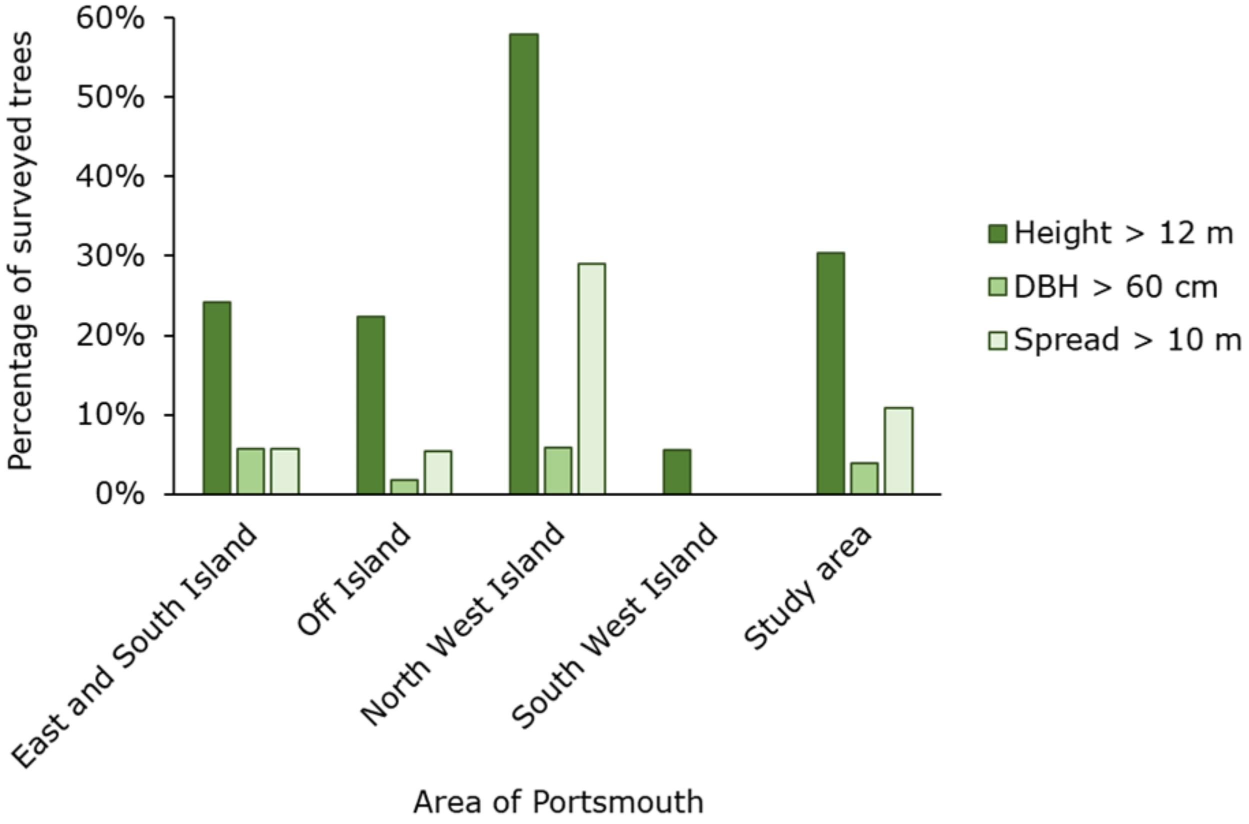


Figure 35. Percentage of surveyed trees classified as large according to height, canopy spread and DBH across the four areas of Portsmouth and the whole study area.

### 3.3.6 Tree condition

Trees in poor condition provide lower ecosystem service delivery and can represent a health and safety concern, and therefore a management and financial burden on a local authority. Poor condition slows or prevents growth and may result in defoliation or crown dieback, reducing the tree's capacity for carbon sequestration, rainwater interception, and air pollution removal (Hand et al., 2019a). A tree in poor condition usually has a lower public amenity value and higher susceptibility to attacks by pests and diseases. However, where their retention is appropriate, dead trees and trees with veteran characteristics such as cavities and deadwood are important for providing habitat for birds, bats, lichens, fungi, and invertebrates.

Tree condition is an important metric for giving an estimate of the current state of Portsmouth's tree population. Condition is assessed by assigning scores relating to loss of leaves and the dieback of branches within the tree's crown. The results of this assessment could be a useful indicator of the possible presence of pests or diseases, unsuitable or poor management, unfavourable site conditions, or may warrant further investigation to understand whether there are any attributable causal factors.

Of Portsmouth's total tree population, 44% were in excellent condition, 24% in good condition, 15% in fair condition, 11% in poor condition, 3% in critical condition, and 1% were dying. 83% of Portsmouth's trees are therefore in the excellent, good and fair categories. As a comparison 91% of Derby's trees and 82% of Wirral's trees were rated as excellent, good, or fair. Portsmouth's trees are therefore in a similar condition to trees surveyed for other i-Tree reports in England.

Figure 36 shows the ten most common species across the whole study area, and the proportion of each species classified into each condition rating. All of the ten most common species have trees in excellent condition. All off the surveyed *Populus tremula* and *Prunus domestica* trees were in excellent condition. Of the top 10 species the species with the overall worst condition is *Crataegus monogyna*, with 43% of the population rated as poor, critical or dying.

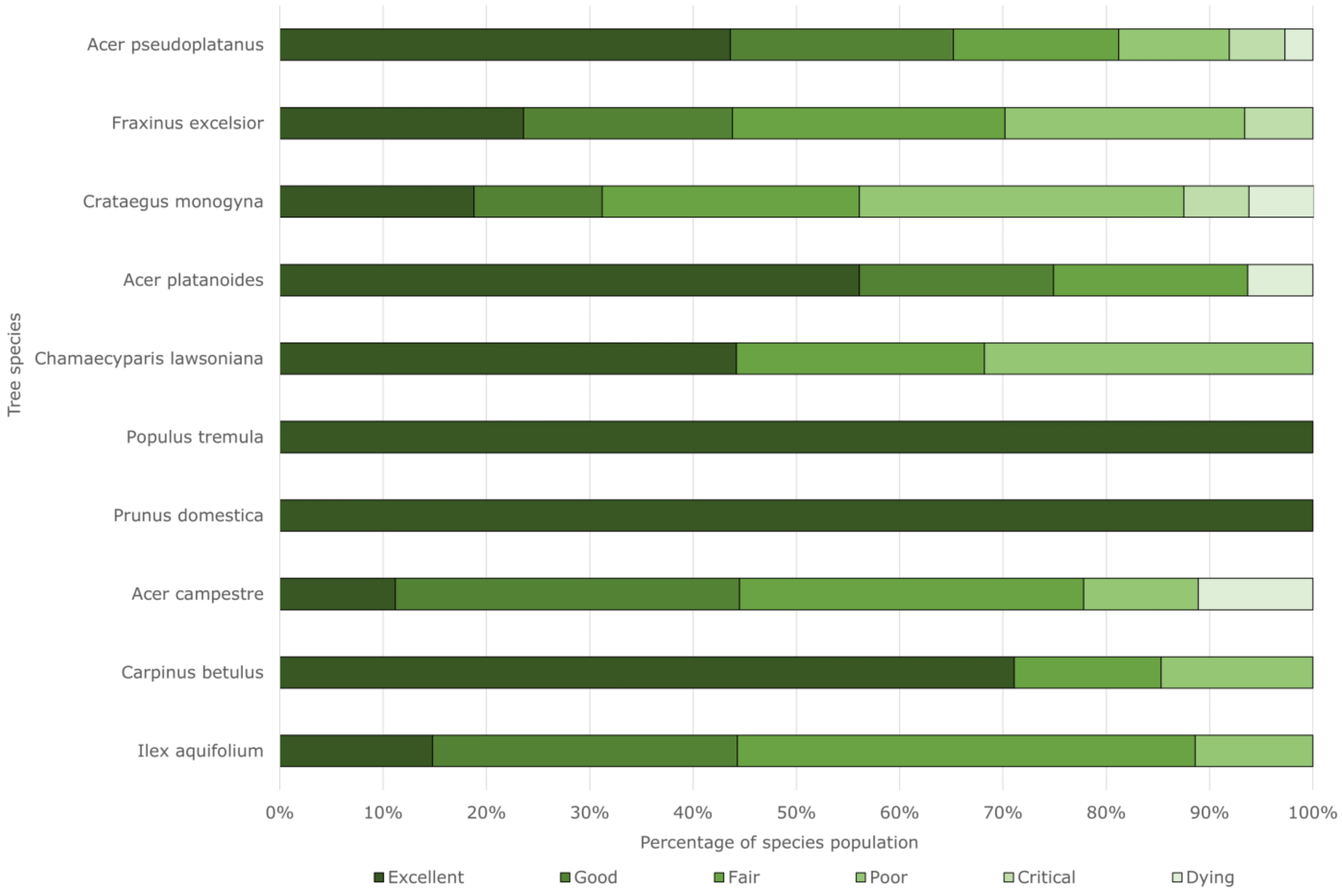


Figure 36. Percentages of the ten most common trees in the study area classified according to their overall condition.

### 3.3.6.1 Tree condition across the four areas of Portsmouth

Figure 37 shows the condition rating for trees in each of the four areas. The trees in the South West Island area are in the best condition with all surveyed trees recorded as excellent, good or fair. Ranging from 10% to 12% all four areas have a similar number of trees in poor condition. East and South Island has the largest proportion of dead and dying trees (4%).

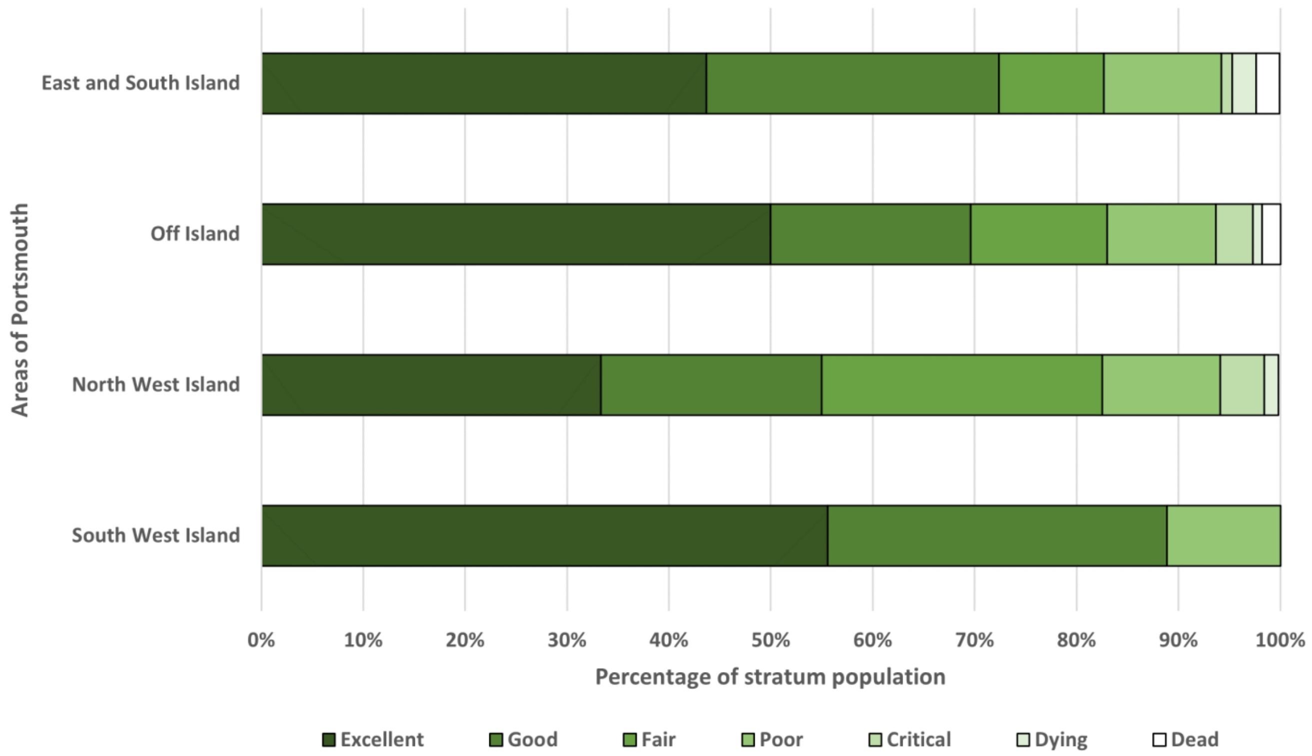


Figure 37. Percentage of tree populations in each of the four areas of Portsmouth classified according to their overall condition.

### 3.3.6.2 Tree condition on PCC and Non-PCC land

Figure 38 shows the percentages of the tree population classified according to their overall condition on PCC and Non-PCC land. 79% of the trees on Non-PCC land are in excellent or good condition compared to only 53% on PCC land. 10% of the PCC trees are poor, critical, dying or dead compared to 2% of trees on Non-PCC land. Directing resources toward the maintenance of the trees on PCC land could improve their health and life span helping the long-term suitability of Portsmouth urban forest.

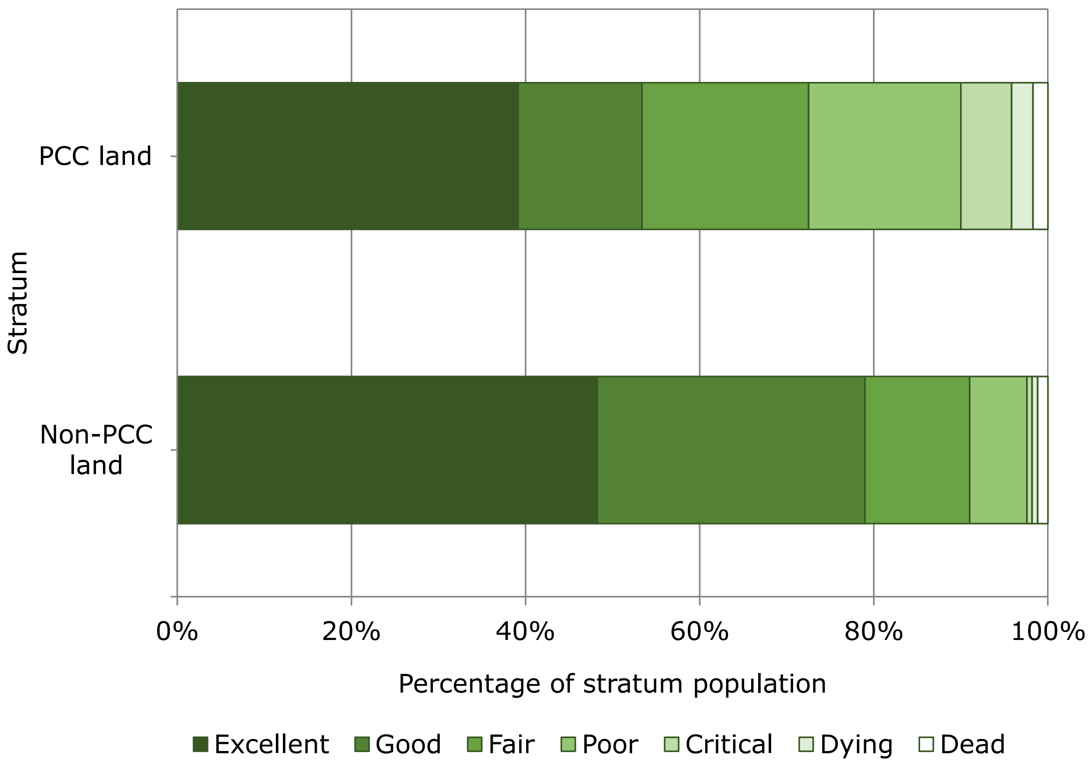


Figure 38. Percentage of tree populations classified according to their overall condition on PCC and Non-PCC land.

### 3.3.6.3 Perceptions of tree condition amongst Portsmouth residents

Survey respondents were more likely to think that the trees in their street were healthy compared to trees across Portsmouth (Figure 39). In each spatial context (street, neighbourhood, and across Portsmouth) only 2% of respondents thought that 'most trees appear to be unhealthy'.

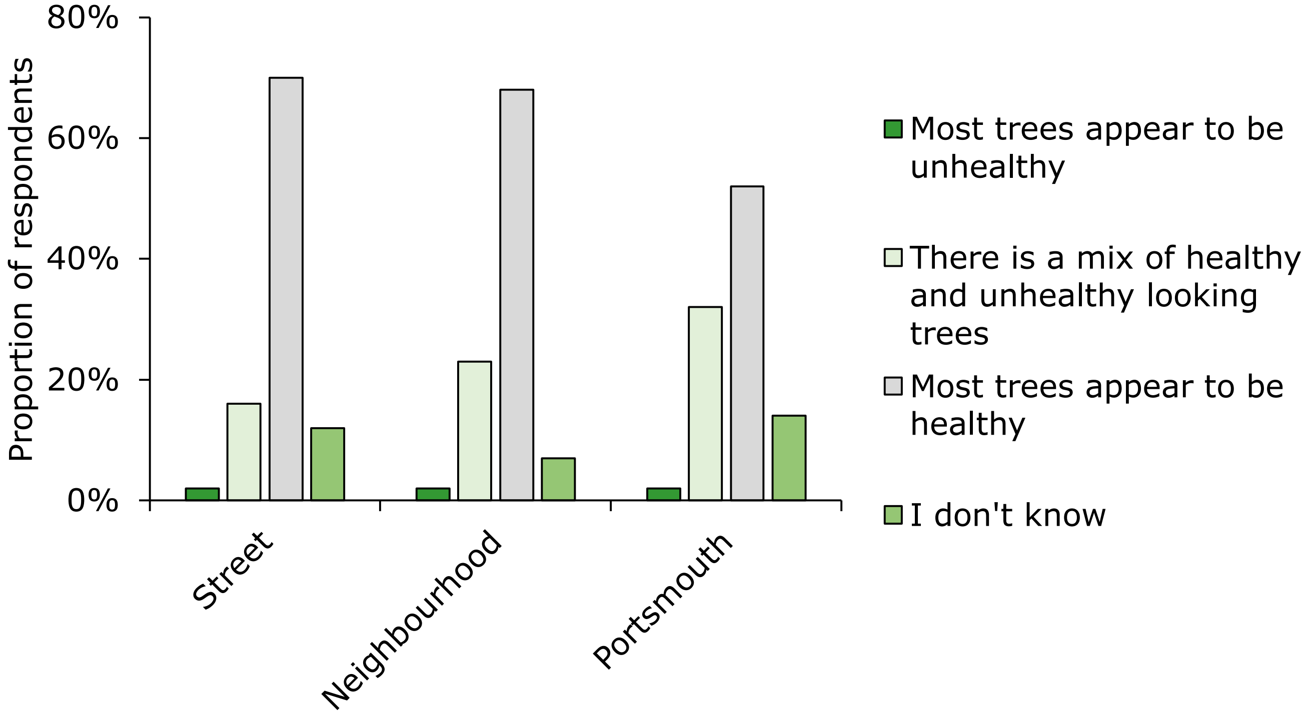


Figure 39. Survey respondents' perception of tree health in their street, neighbourhood, and across Portsmouth.

### 3.3.7 Leaf area and importance value

Leaf area is the total surface area of leaves found within a tree's crown. Leaves are an important component in provision of ecosystem services; larger leaf area often results in greater benefit provision.

Importance value is a measure of how dominant a species is in its environment. It is a standard tool used in forest inventories. A high importance value indicates that a species is well represented because of a large number of individuals, large-sized individuals, or large leaf area contribution. i-Tree Eco calculates importance value as the sum of leaf area expressed as a percentage of the total leaf area, and the number of individuals of a species expressed as a percentage of the total number of trees. Trees with dense canopies and trees with large leaves tend to rank highly. A full list of importance values for all species in the study is given in Appendix B. Figure 40 gives the population, leaf area, and importance value for the ten most dominant species.

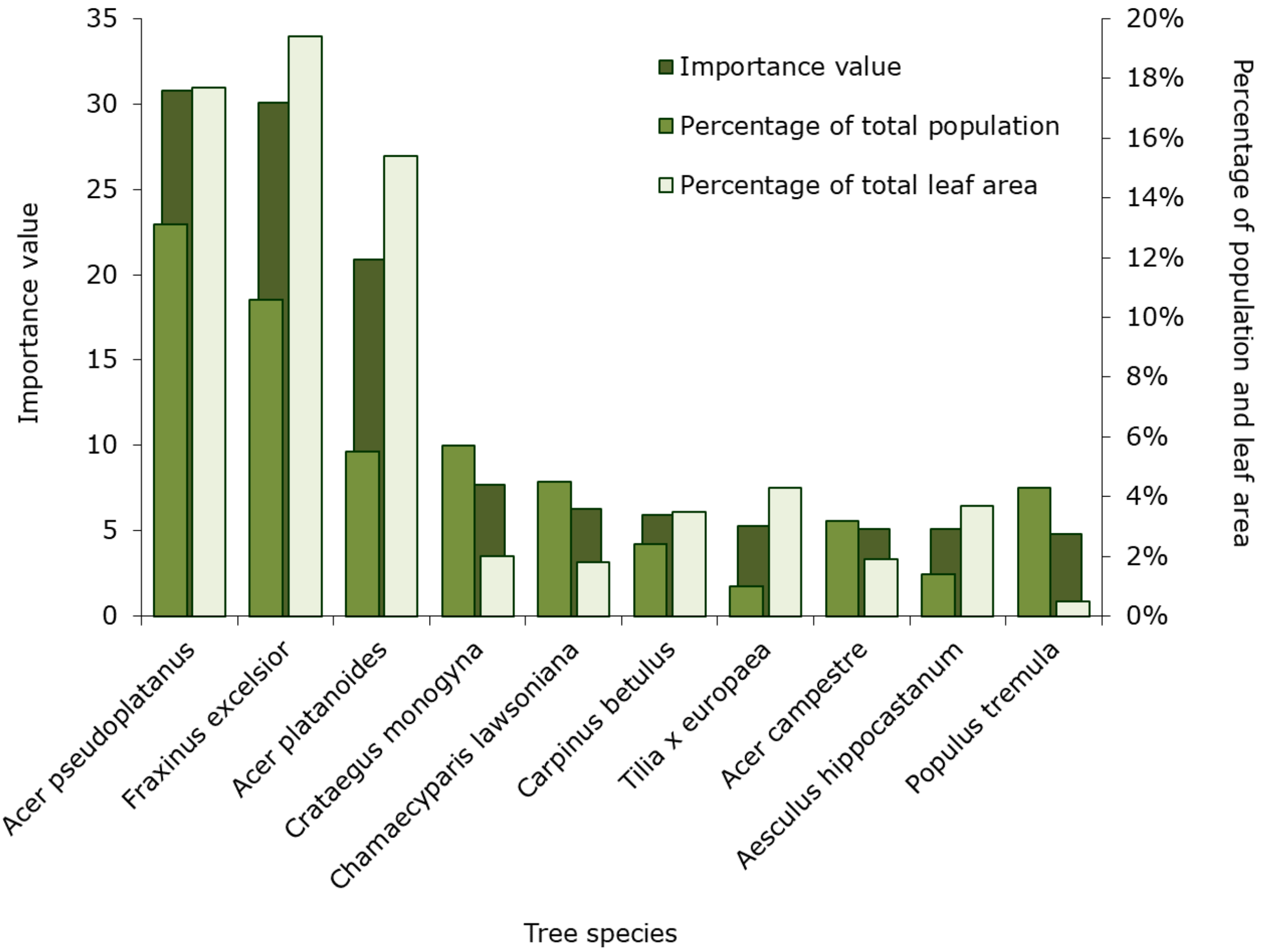


Figure 40. Importance value of the ten most dominant species in Portsmouth's tree population.

***Acer pseudoplatanus*** represents 13% of the tree population, and 18% of the total leaf area, owing to its large size and dense foliage. It ranks highest in importance value, followed by *Fraxinus excelsior* and *Acer platanoides*. Note that *A. platanoides* represents less than 6% of the tree population, but its dense crowns make it an important species for ecosystem service delivery, conversely, *C. monogyna* represents a similar proportion of the tree population but has a much smaller importance value due to its size and small leaf area.

## i-Tree Eco importance value

The science that underpins i-Tree Eco reveal a direct relationship between leaf area and the provision of ecosystem services. Thus, in i-Tree Eco, importance value is the sum of leaf area and population size. If the most common trees have larger leaves or large tree canopies, then they tend to rank higher in importance.

The term importance value can lead to assumptions that these are the tree species that should form the core of any future planting strategy. This relationship is also termed the dominance value, showing which species are currently delivering the most benefits based in their population and leaf area.

Maintaining a healthy population of these trees is important for the current provision of ecosystem services to society. Therefore, where large stature trees, such *Acer pseudoplatanus* and *Acer platanoides,* are currently found, it will be important to make provision to retain these trees to maturity.

# 3.4 Ecosystem Services

## 3.4.1 Avoided surface water run off

### The Issue

In urban areas a high proportion of land is covered by impermeable surfaces. This increases the risk of surface water flooding, resulting in damage and disruption, high water treatment charges, and sewage releases into watercourses. As discussed in Section 3.2.2, 51.1% of the ground cover across Portsmouth is impermeable.

### How trees can help

The canopies of trees intercept rainfall. Water evaporates from the leaf surfaces, which reduces the total amount that reaches the ground. Water falls from the leaf surfaces at a slower rate than rainfall, smoothing out the peak of potential surface flooding. Transpiration is the process of water being taken up from the soil by a tree's roots, being transported to the canopy, and being released into the atmosphere through stomata. The roots of trees create voids and channels in soil and encourage water infiltration. These functions are combined into the hydrological model within i-Tree Eco (Hirabayashi, 2013), which calculates the overall amount of surface water runoff that is avoided due to the presence of trees and other vegetation.

In the people survey, 61% of respondents selected 'to help stop flooding' as one of the top three reasons (from a choice of seven) for managing trees to regulate the environment (Figure 14).

The **total volume of avoided runoff each year by all trees in Portsmouth is 35,000 m$^3$**, equivalent to 14 Olympic swimming pools, with an annual value exceeding **£86,000.** The value is calculated using the Southern Water foul water drainage charge of £2.461 per m$^3$ (Southern Water, 2024). Figure 41 shows the annual avoided runoff and the associated value for ten species that contribute most to avoided runoff in Portsmouth. ***Fraxinus excelsior*** alone prevents 6,800 m$^3$ of surface runoff per year, worth an estimated £16,700. *F. excelsior* represents 10.6% of the tree population, and 19.4% of the total leaf area (Figure 40).

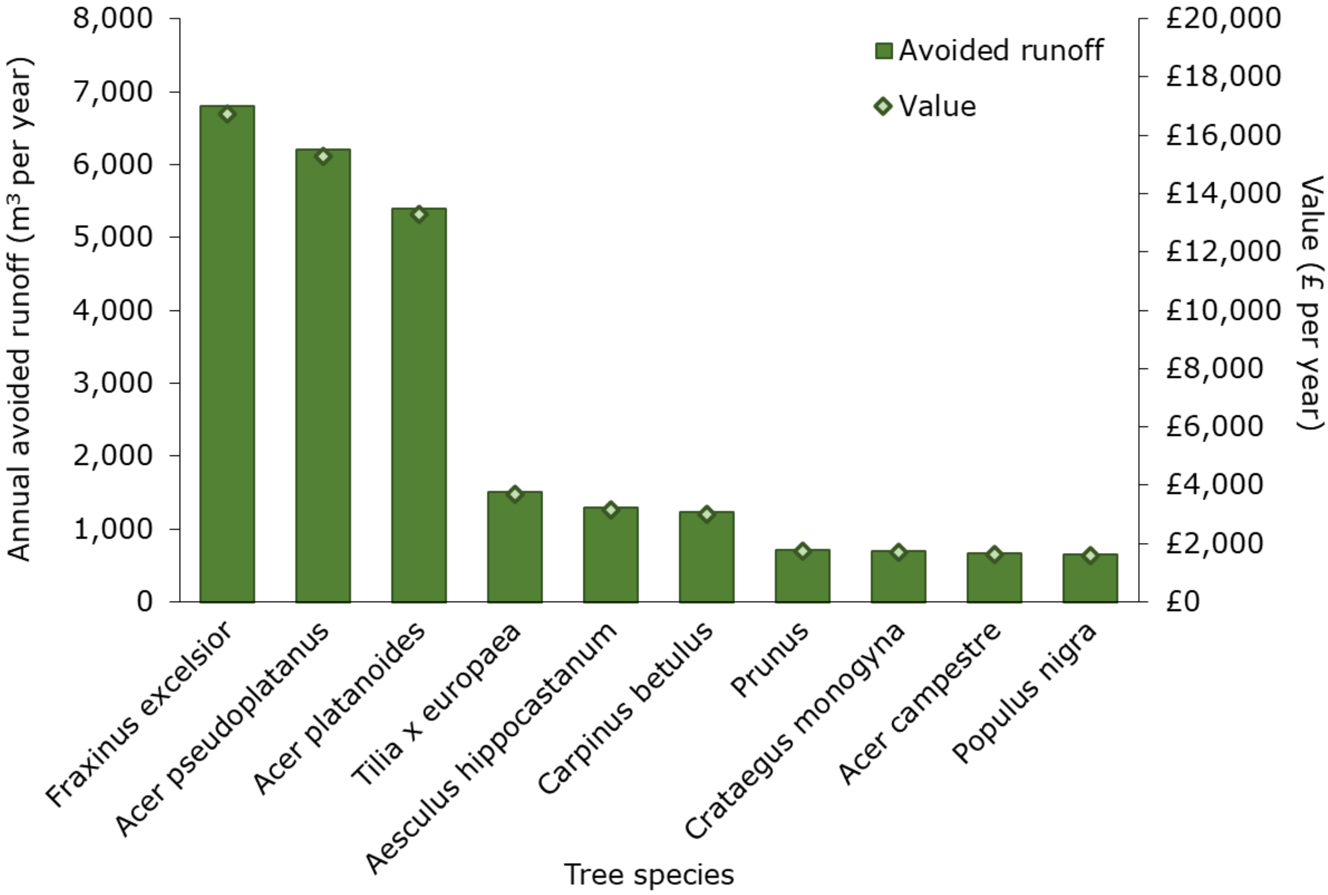


Figure 41. Annual avoided runoff and value for the ten species that contribute most to avoided runoff in Portsmouth.

#### 3.4.1.1 Avoided runoff across the four areas of Portsmouth

Figure 42 shows the total amount of avoided runoff each year by trees and also the value of this service across the four areas of Portsmouth. The North West Island area of Portsmouth has the highest canopy cover which in part accounts for the highest annual avoided runoff with a value of £17,856. The South West Island area of Portsmouth has the lowest canopy cover and also fewest large trees which in part results in the lowest annual avoided runoff with a value of £1,047. The South West Island area also has the largest proportion of roads and residential housing compared to the other areas of Portsmouth; impermeable surfaces in built-up areas exacerbate the problem of surface water flooding.

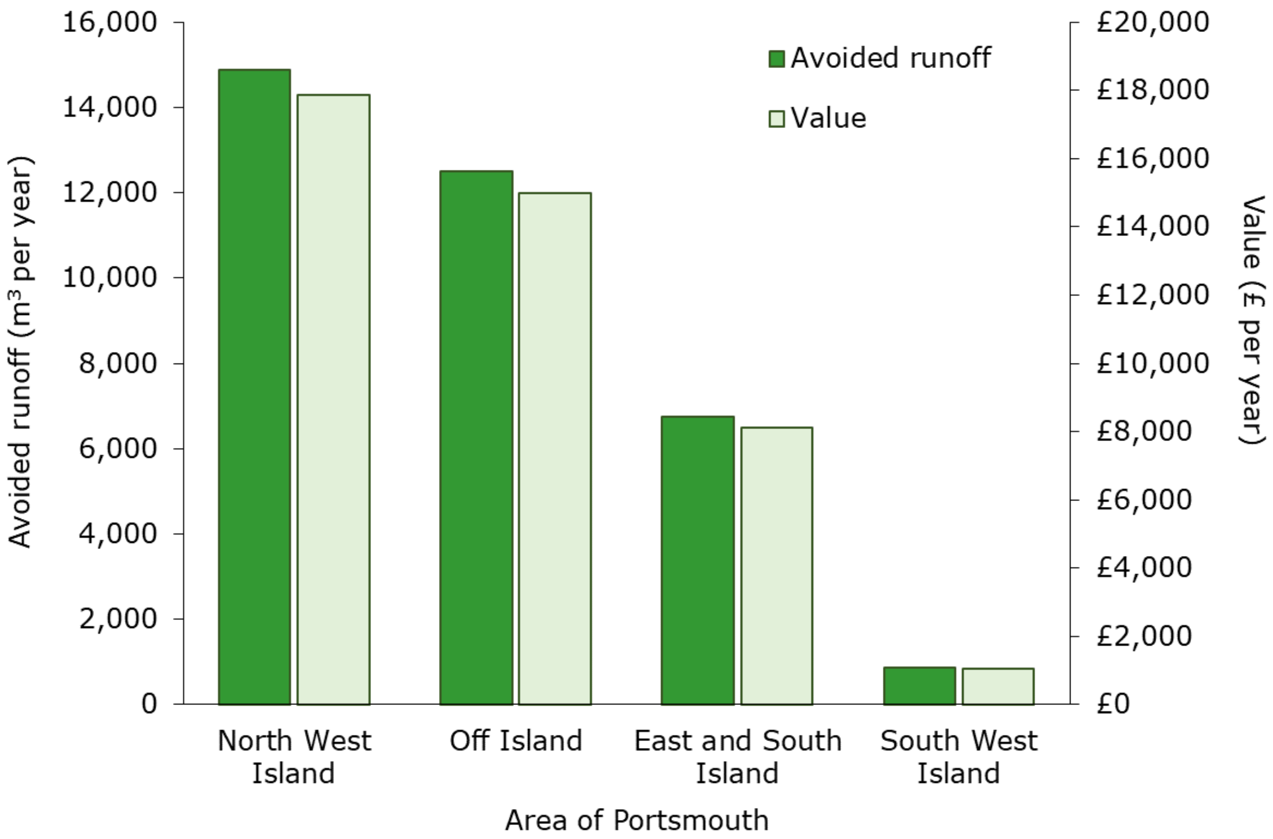


Figure 42. Annual avoided runoff and associated values for trees in the four areas of Portsmouth

Figure 43 shows the leaf area density and the avoided runoff for the trees in each of the four areas of Portsmouth. The North West Island has the highest leaf area density equating to a value of £18.49 per hectare. Having the highest leaf area density despite being the second smallest of the four areas (966 hectares) is a key factor in why the North West Island area has the highest avoided runoff. The leaf area density of trees in the South West Island is lowest equating to a value of only

£4.00 per hectare. Having the lowest leaf area density and being the smallest of the four areas (262 hectares) is a key factor in why the South West Island area has the lowest avoided runoff.

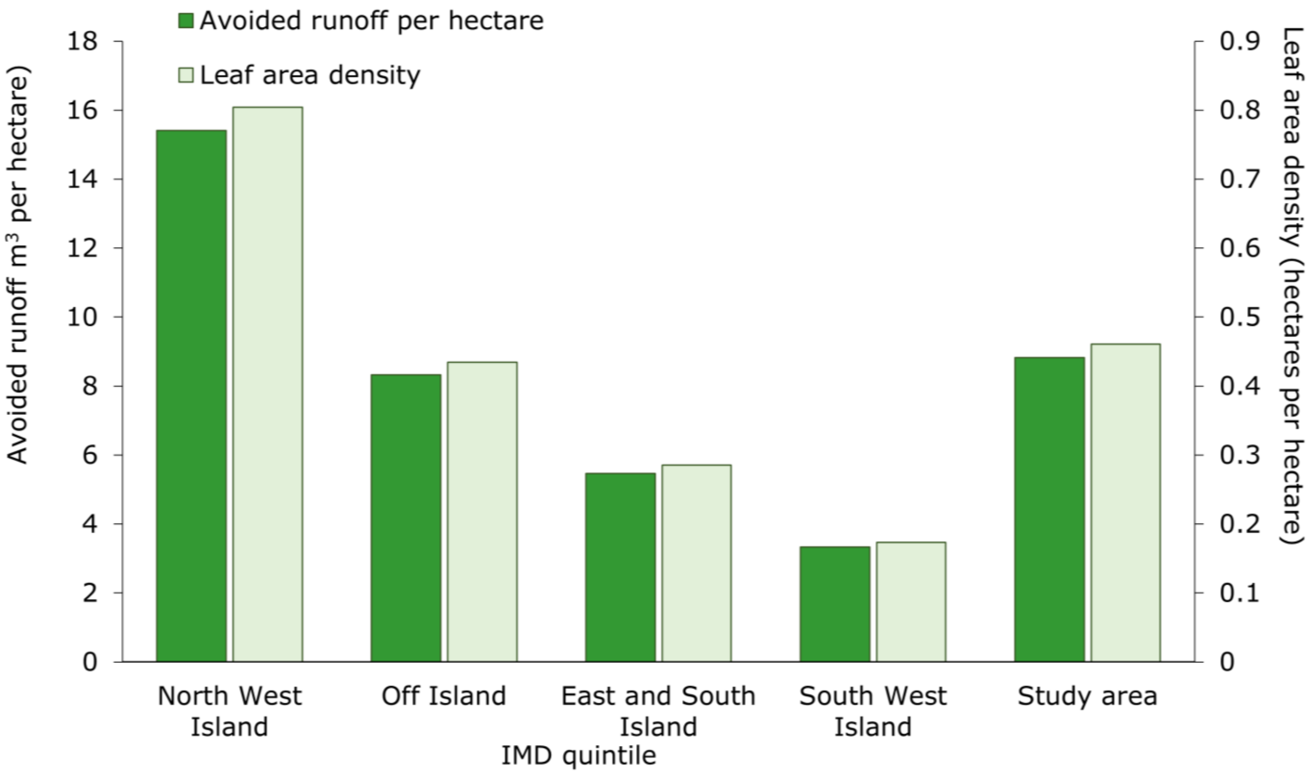


Figure 43. Value per hectare of avoided runoff and leaf density in the four areas of Portsmouth and the whole study area.

### 3.4.1.2 Avoided runoff on PCC and Non-PCC land

Figure 44 shows the total amount of avoided runoff each year by trees and the value of this service on Non-PCC land (£45,700) and on PCC land (£40,023). It also shows these values are similar despite PCC land only accounting for 35% of the total land cover within the city. This is due to the higher leaf area density of trees on PCC land. This equates to a value £28.85 per hectare of avoided runoff on PCC land compared to a value of £17.75 per hectare on Non-PCC land (Figure 45).

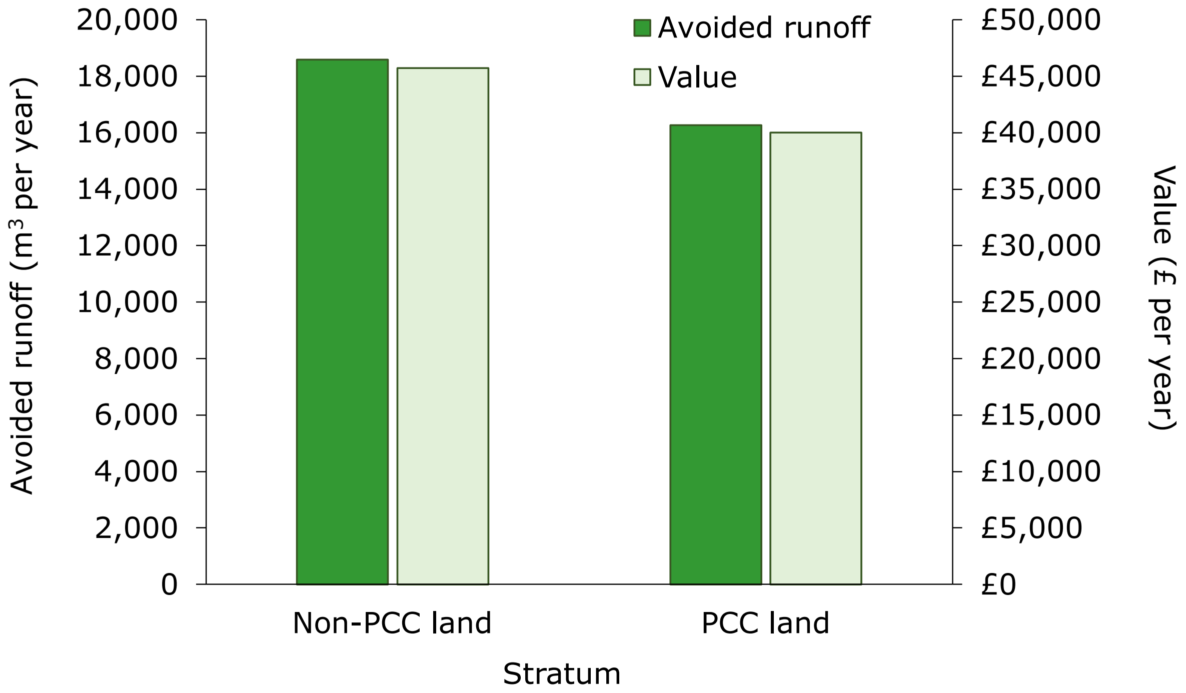


Figure 44. Annual avoided runoff and associated values for trees on PCC and Non-PCC land

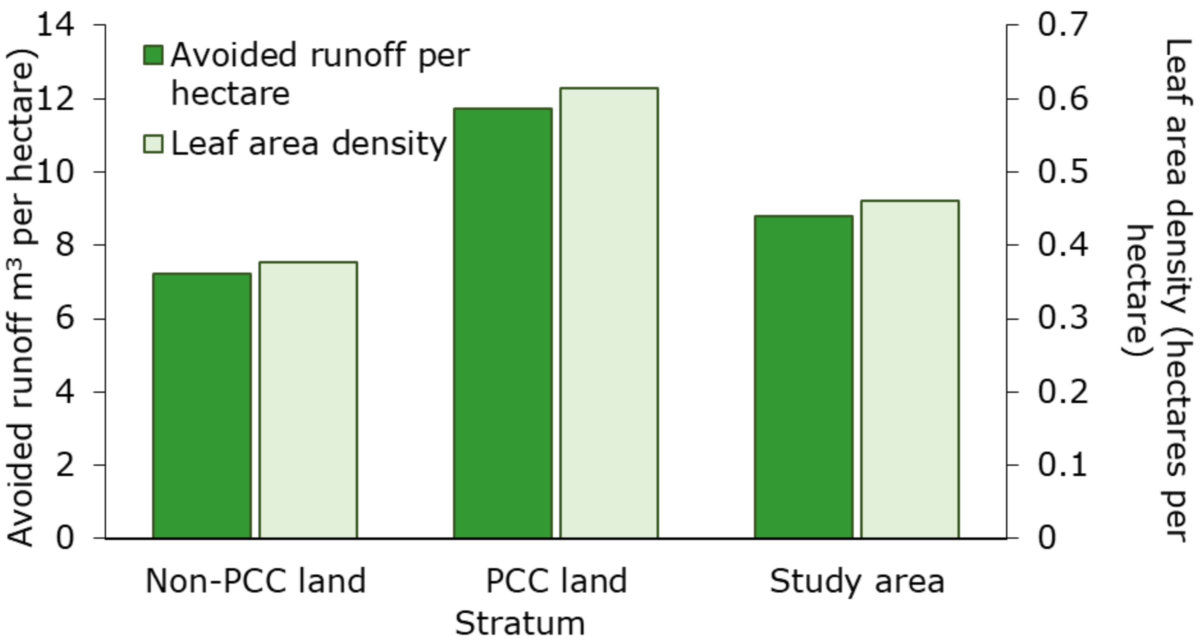


Figure 45. Value per hectare of avoided runoff and leaf density on PCC and Non-PCC land and the whole study area.

## Reducing flooding in Portsmouth

Respondents to the survey said that helping to stop flooding was a **high priority** for management of trees in Portsmouth. Climate change in the UK is expected to lead to increasingly rainy winters, and more frequent intense summer rainfall events (Met Office, 2022). These factors increase the risk of flooding which in urban areas is further exacerbated by a higher proportion of impermeable surfaces such as roads and buildings. The resulting surface water runoff can quickly overwhelm drainage systems and lead to flooding.

In a natural environment, rain which falls onto vegetation is delayed in reaching the soil. Rainwater which reaches the surface infiltrates the soil. The rate at which this happens depends on the type of precipitation and the soil structure, but tree roots can promote infiltration. Once in the soil, water may be drawn up again by plant roots and returned to the atmosphere by transpiration, reducing the chance of saturation.

In a built-up environment interception and infiltration are limited by the presence of buildings, roads, and other hard surfaces, increasing the likelihood of surface flooding. Urban trees intercept rainwater and reduce the rate at which water reaches the ground, and promote soil infiltration, easing pressure on drainage infrastructure.

Trees can be incorporated into Sustainable Urban Drainage Systems (SUDS). Urban trees frequently suffer drought stress; tree planting as part of a SUDS scheme can take advantage of the supply of water created by the semi-natural catchment and storage features.

### 3.4.2 Air pollution removal

#### The Issue

Air pollution poses a serious threat to human health (WHO, 2022). Table 16 summarises the health effects and sources of air pollutants. Exposure to air pollution increases the risk of stroke, heart disease, lung cancer, and respiratory diseases such as asthma. There are also links to diabetes, dementia, mental health, and birth outcomes. Long-term exposure to air pollution was linked to a greater risk of hospitalisation because of severe symptoms of COVID-19 (Walton et al., 2022.

Table 16. Air pollutants and their health effects.

| Pollutant | Health Effects | Source |
|---|---|---|
| Nitrogen dioxide ($NO_2$) | Shortness of breath, chest pains | Fossil fuel combustion, predominantly cars (44%) and power stations (21%) |
| Ozone ($O_3$) | Irritation to respiratory tract, particularly for asthma sufferers | Gas-phase reactions in the presence of sunlight |
| Sulphur dioxide ($SO_2$) | Impairs lung function, forms acid rain that acidifies freshwater and damages vegetation | Fossil fuel combustion; predominantly burning coal (50%) |
| Carbon monoxide (CO) | Long term exposure is life threatening due to its affinity with haemoglobin | Carbon combustion under low oxygen conditions (e.g. in petrol cars) |
| Particulate matter ($PM_{2.5}$ and $PM_{10}$*) | Carcinogenic, responsible for tens of thousands of premature deaths each year[6] | Various sources: cars (20%) and residential properties (20%) are major contributors |

#### How trees can help

Urban trees cannot overcome the sources of pollution, but they can reduce people's exposure in three ways. The first is dispersion: trees can act as roadside barriers that decrease the concentration of pollutants downstream of the source by

[6] Source: https://www.air-quality.org.uk/18.php.

disrupting airflow and increasing turbulence. The second is deposition: trees absorb gases through leaf stomata and absorb gases and particles onto their surfaces (Defra, 2018). The third is local cooling: trees and greenspaces reduce the urban heat island effect, slowing the production of some secondary pollutants such as ozone ($O_3$) (Jacob and Winner, 2009). Deposition is the focus of air pollution removal by trees in the i-Tree Eco model.

In the people survey, 75% of respondents selected 'to improve air quality and reduce air pollution' as one of the top three reasons (from a choice of seven) for managing trees for environmental quality (Figure 13).

Figure 46 shows the annual removal of air pollutants, and the associated value for $NO_2$, $SO_2$, $PM_{2.5}$ and $PM_{10}$*. $PM_{2.5}$ is particulate matter smaller than 2.5 microns wide; $PM_{10}$* is particulate matter larger than 2.5 microns and smaller than 10 microns wide. Values have been calculated using the 2023 UK damage costs (Table 8). **The total annual value of air pollution removal by Portsmouth's trees and shrubs is £166,000 a year**.

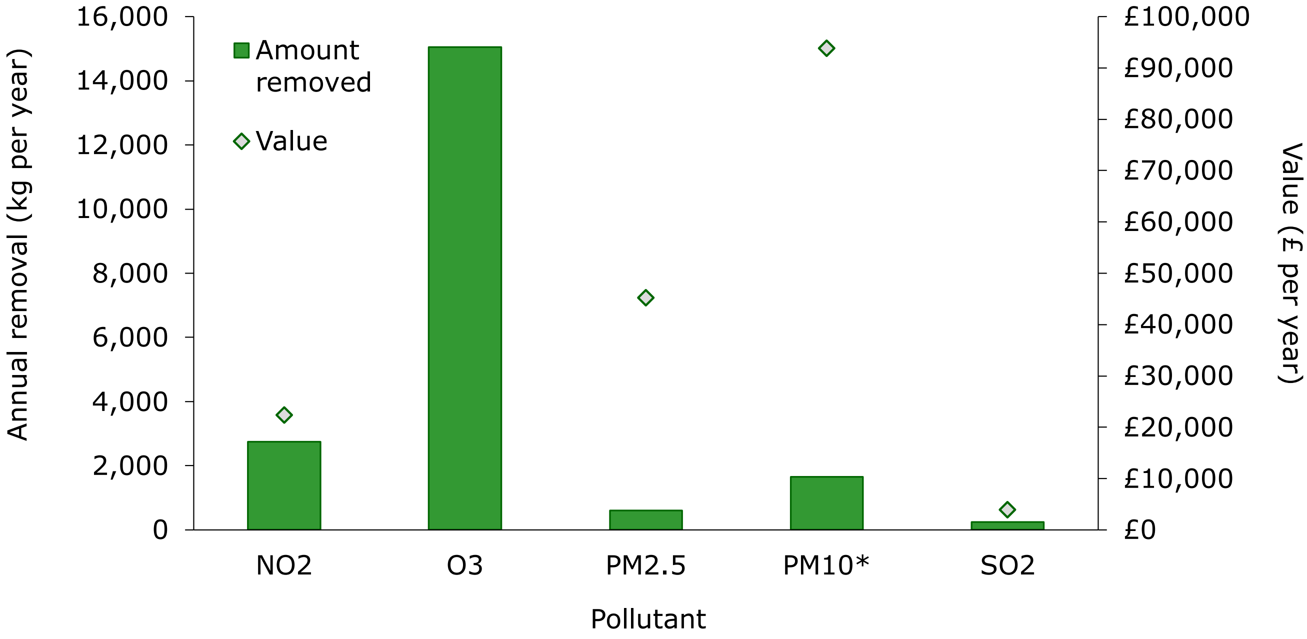


Figure 46. Annual removal of air pollutants by Portsmouth's trees and shrubs, and the associated value.

Figure 47 shows leaf area and pollution removal for the ten species that remove the most pollution in Portsmouth. Only deposition is taken into account in the i-Tree Eco model, and there is a strong link between leaf area and pollution removal, with *Fraxinus excelsior* providing the greatest benefit.

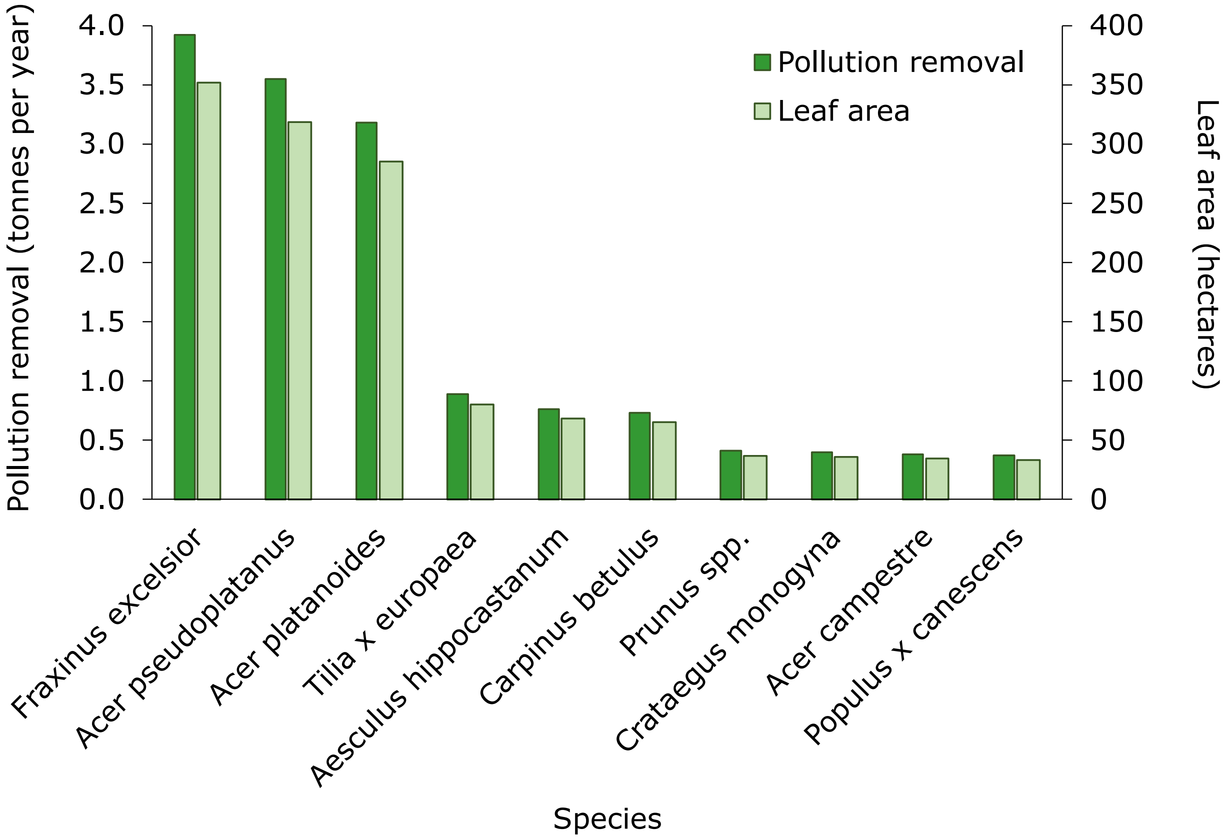


Figure 47. Annual pollution removal and leaf area for the ten species that remove the most air pollution per year in Portsmouth.

The rate of deposition of pollutants onto the surfaces of trees, and through leaf stomata, depends on the concentration of the pollutant, the type of vegetation, and the density of the vegetation. Figure 48 shows the monthly pollution removal by trees and shrubs in Portsmouth, demonstrating that this benefit is mostly delivered in summer, when deciduous trees are in leaf.

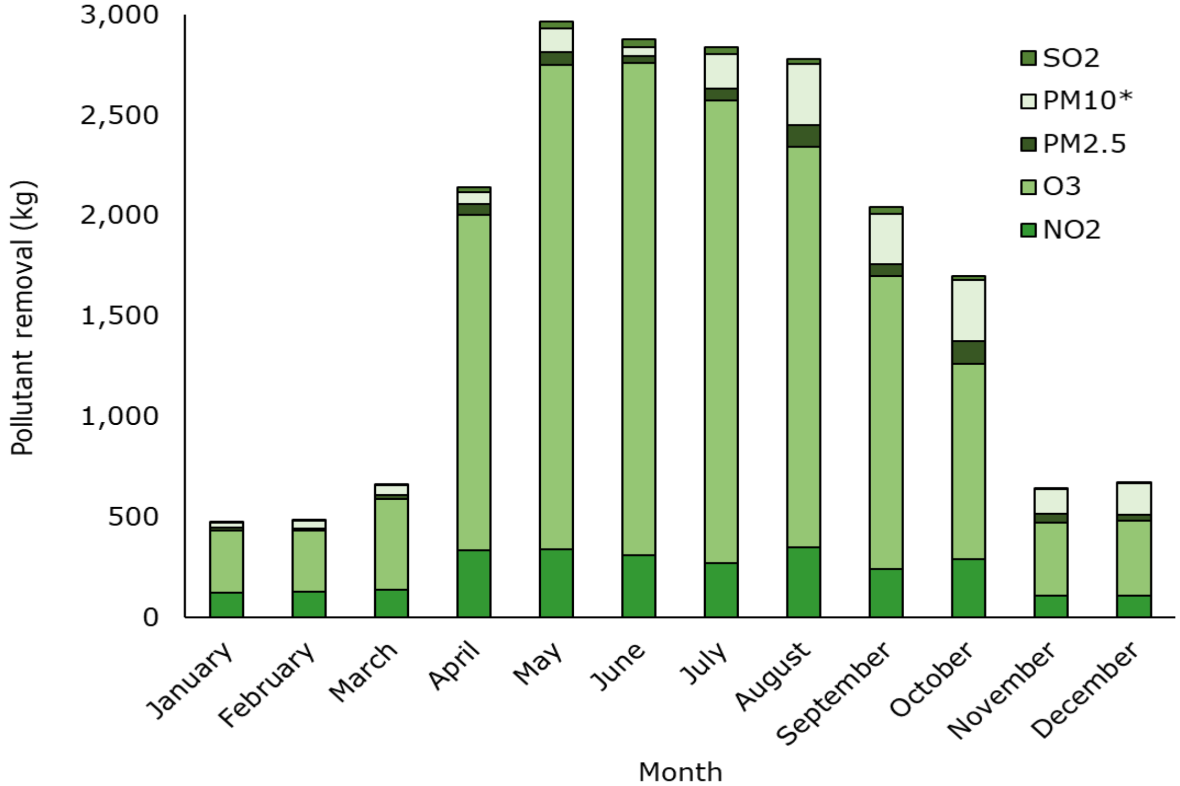

Figure 48. Monthly air pollution removal by trees and shrubs in Portsmouth.

The strong link between leaf area and air pollution removal manifests itself in inequitable provision of air pollution removal across Portsmouth: **the areas with the lowest leaf area receive the least benefit** (Figure 43).

#### 3.4.2.1 Air pollution removal across the four areas of Portsmouth

Figure 49 shows the annual air pollution removal and leaf area by trees across the four areas of Portsmouth. North West Island has the highest leaf area (8040 $m^2$ per hectare) and therefore the highest annual air pollution removal (9 kg per hectare per year). South West Island has the lowest leaf area (1737 $m^2$ per hectare) and therefore the lowest annual air pollution removal (1.9 kg per hectare per year). The low number of large sized trees in the South West Island area (Figure 30) could also be a contributing factor to the low annual pollution removal by trees in this area.

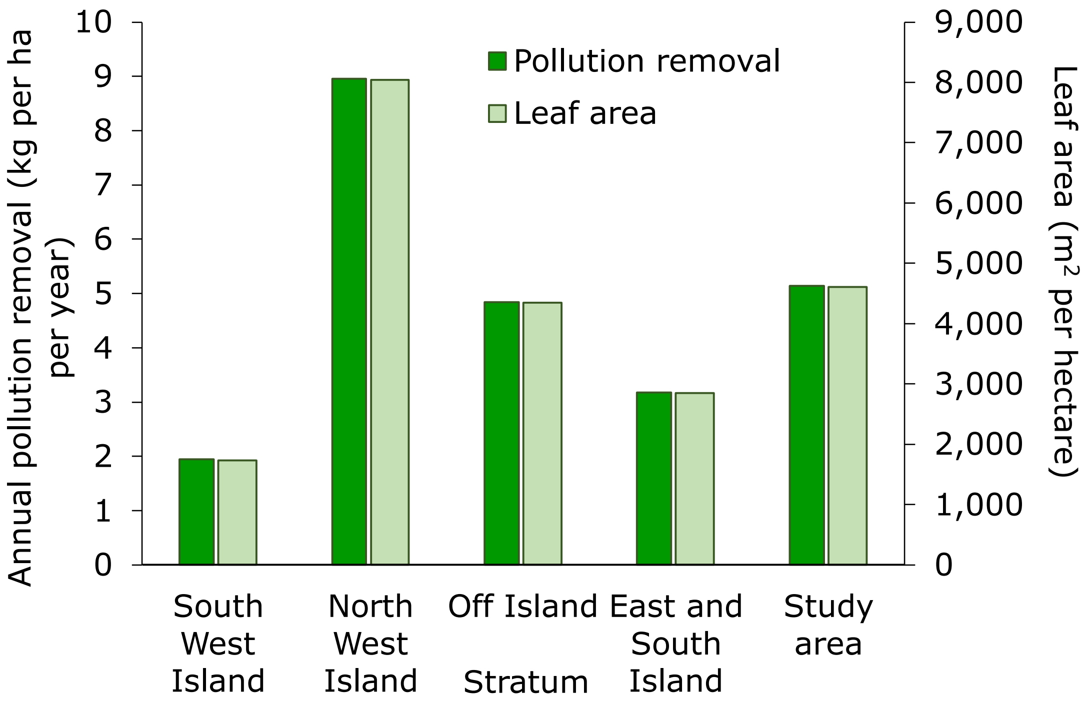


Figure 49. Annual pollution removal per hectare and leaf area per hectare in the four areas of Portsmouth and across the study area.

### 3.4.2.2 Air pollution removal on PCC and Non-PCC land

Figure 50 shows the annual air pollution removal and leaf area by trees on PCC and Non-PCC land. PCC has the highest leaf area (6127 $m^2$ per hectare) and therefore the highest annual air pollution removal (6.8 kg per hectare per year). Non-PCC land has the lowest leaf area (3770 $m^2$ per hectare) and therefore the lowest annual air pollution removal (4.2 kg per hectare per year).

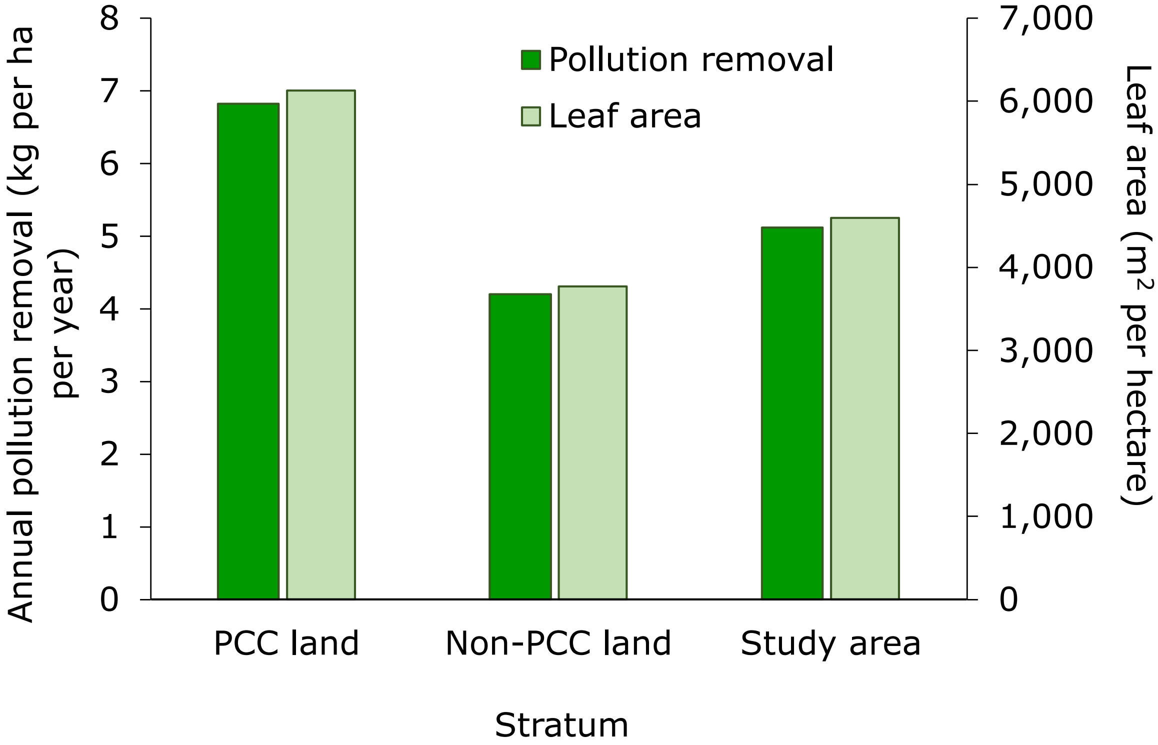


Figure 50. Annual pollution removal per hectare and leaf area per hectare on PCC land, non-PCC land, and across the study area.

## Air pollution removal by Portsmouth's urban trees

Respondents to the survey said that improved air quality was one of the **top priorities** for management of trees in Portsmouth. The primary source of pollution in urban areas is from vehicular road transport, from exhausts and mechanical wear and tear. The concentration of air pollutants tends to be highest immediately on or adjacent to a busy road and decreases with increasing distance from the road until it reaches the background level at several hundred metres from the road (Hagler et al., 2011).

The position and density of vegetation has a large impact on its effectiveness at removing air pollution (Defra, 2018). Trees that trap pollutants near their source, such as a closed canopy over a road, can increase rather than decrease concentrations. Trees that act as a barrier between the source of pollution and, for example, active travel routes, can reduce the concentrations that people are exposed to. Careful consideration of the mode of pollution reduction and the **location of trees in relation to the sources of pollution** can therefore achieve the desired reduction in concentrations (Janhäll, 2015; Pearce et al., 2021). The prototype GI4RAQ platform enables design of street vegetation to reduce exposure to emissions.

Some tree species can have a negative effect on air pollution by emitting gases called Volatile Organic Compounds (VOCs). When these combine with reactive oxides of nitrogen ($NO_x$) they can contribute to the production of other pollutants such as $O_3$.

**Urban woodlands are particularly effective** at absorbing particulate matter (Fowler et al., 2004; McDonald et al., 2007). The 2022 woodland natural capital accounts (Office for National Statistics, 2022) estimated that in 2020 UK woodlands removed 310,400 tonnes of air pollution with an associated value to society of £1 billion.

### 3.4.3 Carbon storage and sequestration

#### The Issue

Anthropogenic emissions of carbon dioxide ($CO_2$) have resulted in a global increase in temperature and will cause further increases. The rise in temperature has serious and wide-range effects on our climate and on the whole planetary system. These effects are felt at the local level, and local organisations are taking action to reduce emissions and increase resilience.

#### How trees can help

Approximately half the dry weight of woody biomass in trees is carbon. As trees grow they lay down wood fibres, locking away carbon from the atmosphere in the process. As long as a tree is alive it can store and sequester carbon. If the tree dies and decomposes or is burned for fuel the stored carbon is released back into the atmosphere. As well as planting new trees for carbon sequestration, it is vitally important to maintain existing trees to ensure the carbon stored in them is stored for as long as possible.

Following the declaration of a climate emergency in 2019 and the ambition to create a 'greener, healthier, and fairer Portsmouth', Portsmouth City Council aims to plant 86,500 trees, doubling trees under Council management and leading the doubling of the city's canopy cover from 9.8% to 19.6% over the next 25 years.

In the people survey, 59% of respondents selected 'to supply oxygen and absorb carbon dioxide' as one of the top three reasons (from a choice of seven) for managing trees for environmental quality (Figure 13).

#### 3.4.3.1 Carbon Storage

The total mass of carbon currently stored in Portsmouth's trees is **32,700 tonnes**. This is equivalent to 119,970 tonnes of $CO_2$. Of the trees that were surveyed, the tree that stores the most carbon is a 20 m tall ***Populus nigra*** with a DBH of 110 cm, located on the western boundary of Drayton Park, Off Island in the north east of the city. It stores 3.8 tonnes of carbon with a value of £3,526.

The carbon in trees can be valued within the framework of the UK government's carbon valuation method (Department for Energy Security and Net Zero, 2023). This is based on the abatement costs of meeting the UK's carbon reduction targets. There are three pricing scenarios: low, central, and high. These are used to reflect uncertainties in determining future carbon values, including in relation to future fuel prices. Based on the central value carbon for 2024[7], the current value of the carbon stock contained in Portsmouth's trees is **£30.7 million**.

Figure 51 shows carbon storage and estimated tree numbers for the ten species that store the most carbon in Portsmouth. ***Acer pseudoplatanus, Fraxinus excelsior and Acer platanoides*** store the most carbon. These are all large trees that are dominant in Portsmouth's tree population. Although *Crataegus monogyna* is the ninth most common trees in Portsmouth, due to its small size it stores less carbon than lager stature trees such as *Populus nigra* or *Quercus ilex*.

[7] The 2024 central value $CO_2$ is £269 per tonne (Department for Energy Security and Net Zero, 2023).

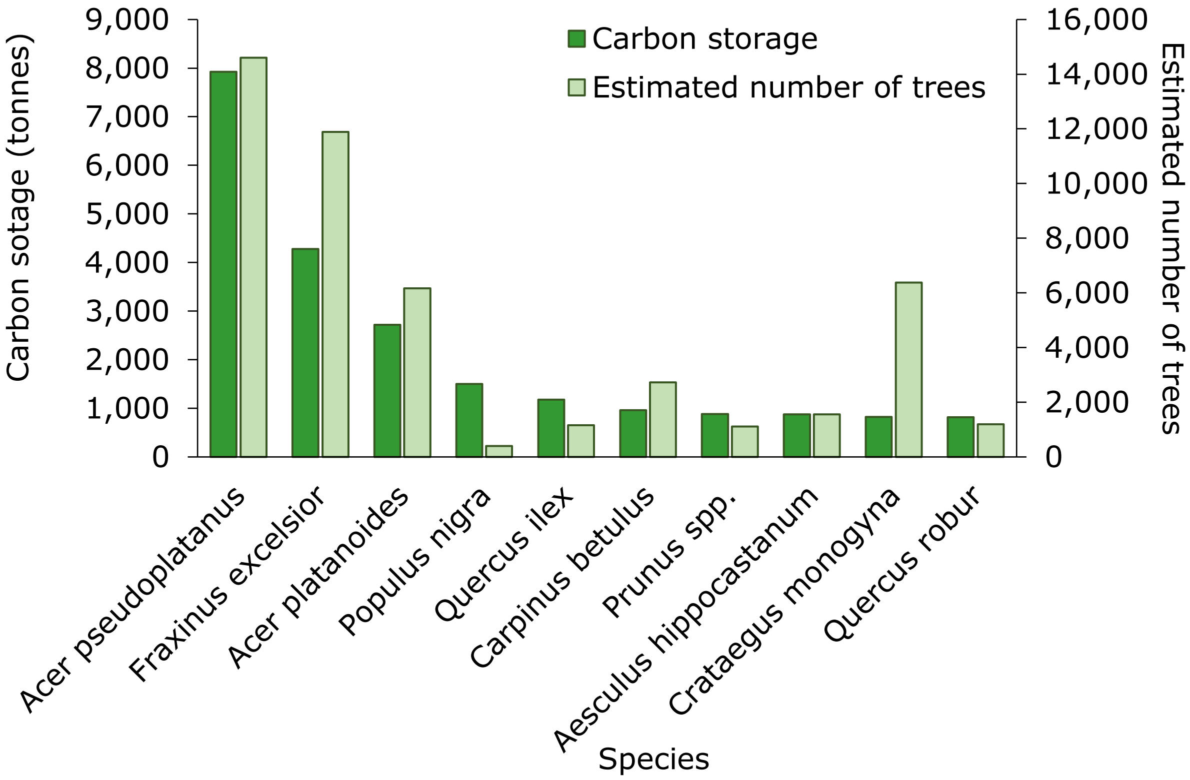


Figure 51. Carbon storage and estimated number of trees for the ten species that store the most carbon in Portsmouth.

#### 3.4.3.1.1 Carbon storage across the four areas of Portsmouth

Figure 52 shows the amount and value of the carbon stored in the trees in each of the four areas of Portsmouth and the whole study area. North West Island has the highest carbon storage (13,137 kg per hectare) with a value of £12,332 per hectare. North West Island also has the highest proportion of large trees with DBH greater than 60 cm (Figure 30). South West Island has the lowest carbon storage (2,244 kg per hectare) with a value of £2,107 per hectare. No trees that were surveyed in the South West Island area had a DBH greater than 60cm (Figure 30).

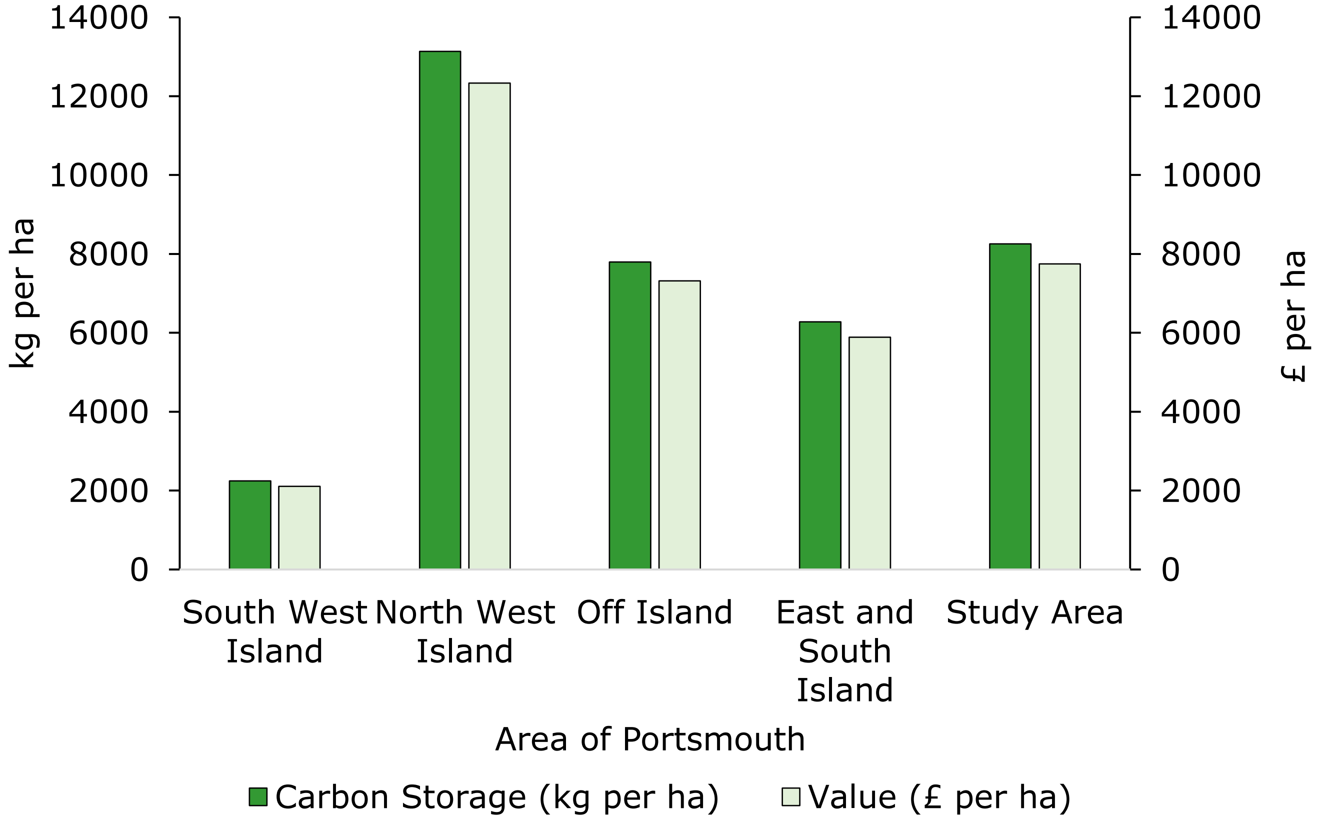


Figure 52. Carbon storage per hectare, and value per hectare, by trees in each of the four areas of Portsmouth and the study area as a whole.

### 3.4.3.1.2 Carbon storage on PCC and Non-PCC land

Figure 53 shows the amount and value of the carbon stored in the trees on PCC and Non-PCC land and the whole study area. PCC land has the highest carbon storage (9,345 kg per hectare) with a value of £9,219 per hectare. Non-PCC land stores 7,568 kg per hectare with a value of £7,466 per hectare. The amount of carbon stored in the trees in each of the two areas is similar which could be explained in part by the size classes of the trees being similar across both areas (Figure 31).

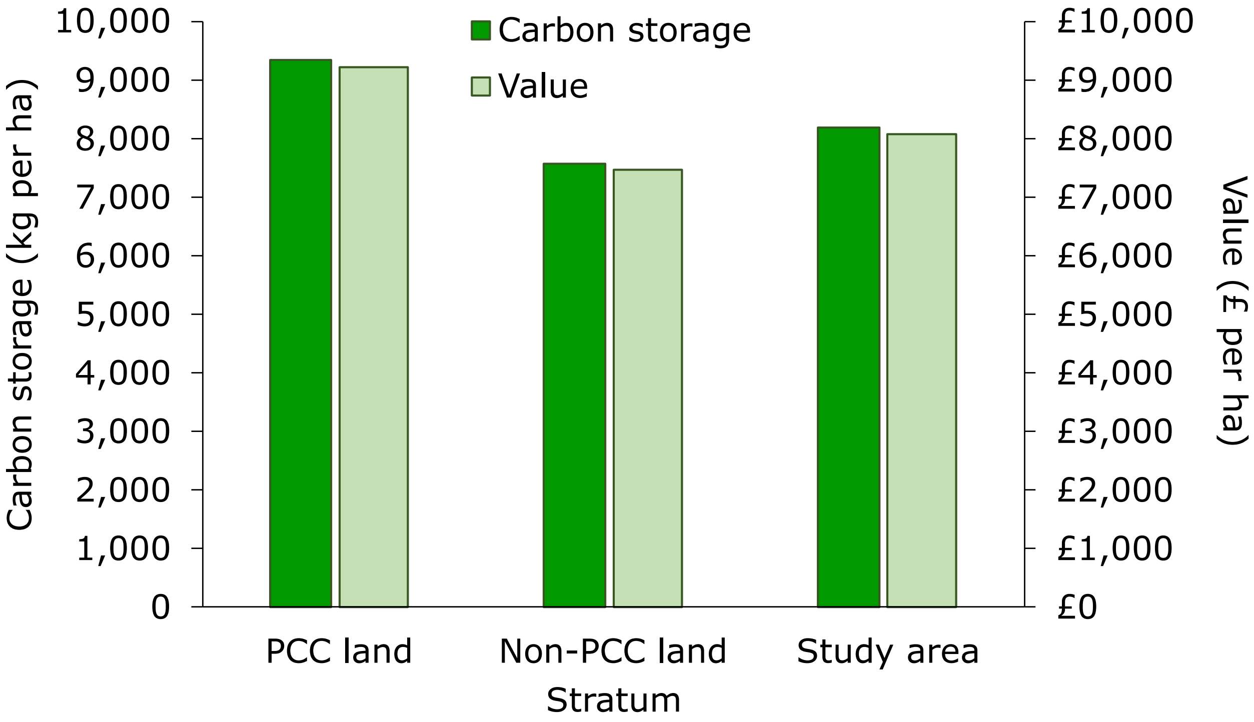


Figure 53. Carbon storage and value per area for PCC land, non-PCC land, and the study area.

### 3.4.3.2 Carbon sequestration

**1,440 tonnes** of carbon is sequestered by Portsmouth's trees annually. This is equivalent to **5,309** tonnes of $CO_2$ which is worth **£1.4 million** per year at the 2024 central carbon value. Figure 54 shows the annual net carbon sequestration and estimated numbers of trees for the ten species that sequester the most carbon in Portsmouth. **Large stature, numerous trees dominate the top ten**, with the addition of *Betula pubescens* and *Crataegus monogyna*. Of the trees recorded during the survey, the tree which sequesters the most carbon each year is the same 20 m tall *Populus nigra* in Drayton Park that also stores the most carbon. Carbon sequestration for most tree species increases with age (Stephenson et al., 2014), as the tree adds a similar thickness of wood each year to an increasing diameter (White, 1998). This means that on an individual basis the largest trees in a population tend to sequester the most carbon. However, new tree planting also has an important role to play. Once established young trees planted close together grow quickly and can sequester more carbon per area of land (Pugh et al., 2019). They are also important as replacements for the old trees that will eventually be lost from the population.

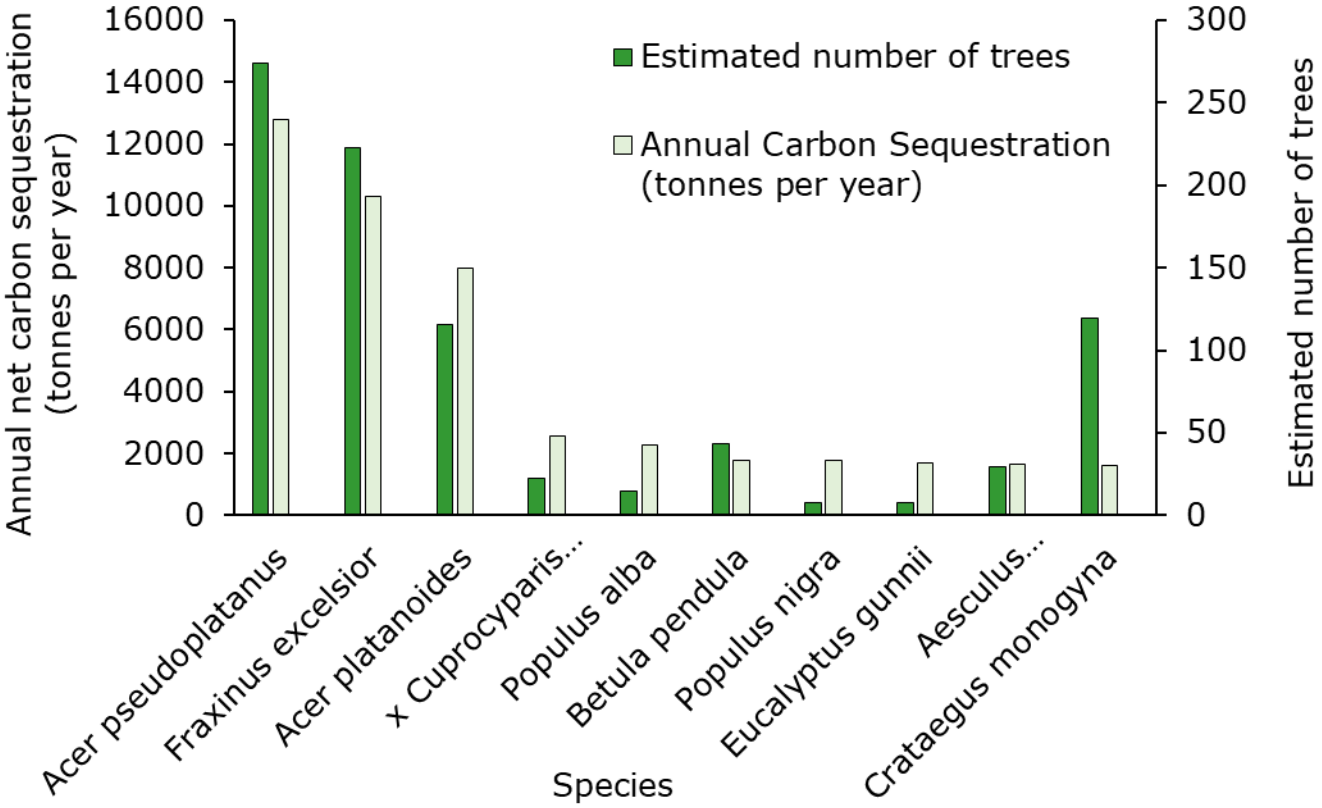


Figure 54. Annual net carbon sequestration and estimated number of trees for the ten tree species that sequester the most carbon in Portsmouth.

### 3.4.4 Habitat provision

#### The Issue

The UK is in an ecological crisis having lost nearly half of its biodiversity since the Industrial Revolution due to the expansion of agriculture and built infrastructure. The UK now ranks in the bottom 10% of the world’s countries for its biodiversity and is the worst ranking country from the G7 (Natural History Museum, 2021). Climate change may accelerate the decline of biodiversity further: up to 37% of species present in 20% of the Earth's terrestrial surface will be ‘committed to extinction’ by 2050 (Thomas et al., 2004).

Action is needed and supporting nature in UK cities can be part of the solution. This can help create habitats for wildlife as well as strengthening citizen’s connection with nature, and so improving their health and wellbeing (Sandifer et al., 2015).

#### How trees can help

Trees are instrumental for creating safe habitats within towns and cities for other flora and fauna (Smith et al., 2006; Nielsen et al., 2014), particularly during spring to autumn when trees are in full canopy and produce flowers and fruits and when migrating species are present (Paker et al., 2014).

Trees located in different land uses, such as streets, domestic gardens or parks can all play a significant role (Lundquist et al., 2022). A greater wildlife richness is normally recorded in urban areas with a greater number of tree species (Paker et al., 2014). Native tree species are considered to have a higher biodiversity value (Helden et al., 2022) however non-native tree species can be also useful in housing and generating food for wildlife, such as for pollinators (Baldock et al., 2015). Larger and older trees have also been found to be more beneficial for wildlife (Knight et al., 2012; Nielsen et al., 2014). Therefore, aiming for greater diversity in the urban forest, in terms of the range of planting locations, species and tree sizes and ages, is required to offer the greatest range of possible habitats.

In the people survey, 73% of respondents selected 'to create habitat and shelter for wildlife' as one of the top three reasons (from a choice of seven) for managing trees for environmental quality (Figure 13. Survey responses to which reasons are most important for managing trees for environmental quality. Participants could select up to three reasons.).

Portsmouth has a rich biodiversity due to its varied mosaic of coastal and terrestrial habitats. The Council manages seven sites that are, or have part of their area, designated a Site of Importance for Nature Conservation, one of the most varied of which being Hilsea Lines – a green corridor that separates Portsea Island from the mainland that is mosaic of freshwater and brackish ponds, marshland, tidal zones, hedgerows, and woodlands. Farlington Marshes in the north-east of the city are of international significance for migratory wildfowl and wading birds (Hampshire & Isle of Wight Wildlife Trust, 2024) including Amber and Red classified species under the UK Conservation status such as Brent Geese, Teals, and Dunlins. Portsmouth City Council's Greening Strategy and Plan recognises the role of green infrastructure for nature recovery. Functional biodiversity gains are considered a priority area for action when delivering new GI projects, and the Plan seeks to reduce fragmentation of habitats and improve connectivity.

Portsmouth's urban forest can play a significant role in this aim. The current provision of biodiversity value by Portsmouth's trees was assessed for three aspects of biodiversity: foliage invertebrate richness, pollen and nectar provision, and fruit and seed provision. These indicators can be useful in future planting aimed at boosting the urban forest's value to wildlife, by helping target species with high value which are low in abundance.

The information on the number of invertebrates associated with tree species was gathered from Kennedy and Southwood (1984). The information on the species' ability to provide pollen, nectar, fruits, and seeds to wildlife was rated following the ranking attributed by Alexander et al. (2006), which scores trees from a high value

(5) to a low value (0). While these metrics provide a useful indicator of the relative biodiversity value of different tree species, it is important to note that they are gathered from various sources using different methods and from different locations, and most importantly are not specific to trees in urban areas.

Figure 55 shows that of the tree species considered, the most abundant species in Portsmouth (*Acer pseudoplatanus*) is one of the worst for supporting insects. The top four tree species for supporting insects (*Salix caprea, Quercus robur, Betula pendula and Betula pubescence)* all represent relatively low proportions of the overall tree population in Portsmouth. The best species for supporting insects from those considered is ***Salix caprea***, supporting in total 450 species. This species only represents 1.1% of the Portsmouth tree community, so there is scope to improve the delivery of this benefit.

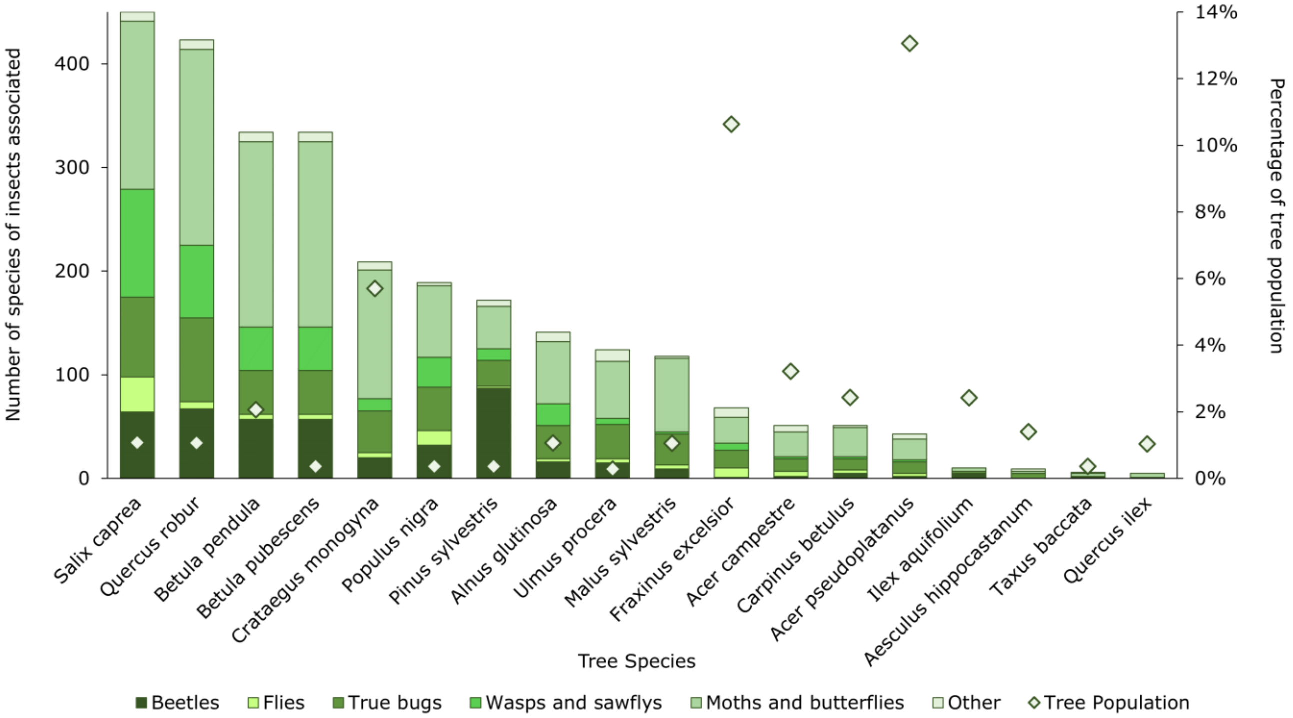


Figure 55. Foliage invertebrates supported by tree species, and tree species abundance within Portsmouth's population.

Table 17 ranks the provision of pollen, nectar, fruit and seeds for selected tree species, species groups or genera in Portsmouth. Five out of the ten most common tree species in Portsmouth (***Acer pseudoplatanus, Crataegus monogyna, Prunus domestica, Acer campestre, Ilex aquifolium***) score relatively highly for the provision of pollen of nectar. Maintaining these trees and planting more of the other high scoring species such as *Salix caprea, Malus sylvestris* and *Aesculus hippocastanum* could further improve the provision of pollen and nectar in Portsmouth. Three out of the ten most common tree species (***Crataegus monogyna, Prunus domestica*** **and** ***Ilex aquifolium***) score relatively highly for the provision of fruit and seeds.  Maintaining these trees and planting more of the other high scoring species such as *Betula pendula, Quercus robur, Q. ilex* and *Alnus glutinosa* could improve this food source further.  Note that *Prunus spp.* and *Crataegus spp*. perform well at supplying nectar and pollen as well as seeds and fruits.

Table 17. Ranking for the provision of pollen and nectar and fruits and seeds for selected tree species, species groups, or genera[8] in Portsmouth.

| Species | % population | Provision of pollen & nectar | Provision of fruits & seeds |
|---|---|---|---|
| *Acer pseudoplatanus* | 13.1 | 4 | 1 |
| *Fraxinus excelsior* | 10.6 | 1 | 1 |
| *Populus spp.* | 6.0 | 1 | 1 |
| *Crataegus monogyna* | 5.7 | 5 | 4 |
| *Prunus spp. (cherries)* | 4.6 | 4 | 5 |
| *Prunus domestica (plum)* | 4.3 | 4 | 4 |
| *Acer campestre* | 3.2 | 4 | 1 |
| *Carpinus betulus* | 2.4 | 1 | 3 |
| *Betula pendula and B. pubescens* | 2.4 | 1 | 4 |
| *Ilex aquifolium* | 2.4 | 5 | 4 |

[8] Alexander et al. list species, species groups, and genera in their wildlife value rankings.

| | | | |
|---|---|---|---|
| *Salix caprea and S. fragilis* | 1.4 | 5 | 1 |
| *Malus sylvestris and M. domestica* | 1.4 | 4 | 4 |
| *Aesculus hippocastanum* | 1.4 | 4 | 1 |
| *Quercus robur* | 1.1 | 1 | 5 |
| *Alnus glutinosa* | 1.1 | 1 | 4 |
| *Quercus ilex* | 1.0 | 1 | 5 |
| *Tilia x europaea* | 1.0 | 4 | 1 |
| *Sorbus aria and S. intermedia* | 0.6 | 4 | 4 |
| *Taxus baccata* | 0.4 | 1 | 4 |
| *Quercus cerris* | 0.4 | 0 | 0 |
| *Pinus sylvestris* | 0.4 | 1 | 4 |
| *Ulmus procera* | 0.3 | 1 | 1 |

## 3.5 Replacement Cost and Amenity Value

### 3.5.1 CTLA valuation

Portsmouth's urban forest has an estimated replacement value of £63 million according to the CTLA Appraisers (1992) valuation method (Cullen, 2007). This is the estimated cost of replacing all of Portsmouth's trees should they be lost to disease, development, or other removal. This method does not take into account the condition or amenity value of the trees; the trunk area is used as a proxy for tree size. See Appendix A for more details.

### 3.5.2 CAVAT valuation

The trees in Portsmouth's urban forest have an estimated public amenity asset value of **£4.5 billion**. This valuation was calculated using an amended version of CAVAT Full Method (FM) (Doick et al., 2018), extrapolated from the measured trees to the whole study area. This method takes into account the size and condition of trees, their public visibility, and their life expectancy. See Appendix A for further details on the CAVAT method. ***Acer pseudoplatanus*** represents 13% of the measured trees, and contributes 20.3% of their total amenity value, at an estimated **£870,919**. The tree with the single largest amenity value is the 20 m tall ***Populus nigra*** with a DBH of 110 cm, just 3% of the crown missing, and 100% of existing crown in good condition. It's CAVAT value is **£280,424.** Table 18 gives CAVAT values for the ten most valuable measured species in the survey, based on measured data only. This is the same tree that sequesters the most carbon per year and stores the most carbon.

Table 18. CAVAT values of the ten most valuable species, based on measured trees only, not extrapolated to the whole study area.

| Species | CAVAT value[9] | Percent of total measured value | Percent of measured population |
|---|---|---|---|
| *Acer pseudoplatanus* | £870,919 | 20.3% | 12.9% |
| *Fraxinus excelsior* | £543,396 | 12.7% | 10.5% |
| *Acer platanoides* | £362,284 | 8.5% | 5.6% |
| *Populus nigra* | £280,424 | 6.5% | 0.3% |
| *Tilia x europaea* | £198,766 | 4.6% | 1.0% |
| *Quercus robur* | £187,666 | 4.4% | 1.0% |
| *Quercus ilex* | £124,218 | 3.0% | 1.0% |
| *Carpinus betulus* | £180,497 | 2.9% | 2.4% |
| *Populus alba* | £112,482 | 2.6% | 0.7% |
| *Crataegus monogyna* | £99,440 | 2.3% | 5.6% |
| All Other Species | £1,442,201 | 33.7% | 58.7% |

Figure 56 shows CAVAT values (for measured trees only) on different land uses across the study area. 39% of the measured trees were on residential land, which accordingly has a high total CAVAT value (£1,444,646). 23% of the measured trees were in parks or greenspaces, which also have a high CAVAT value (£1,443,740).

[9] CAVAT values for species are based on measured trees only, not extrapolated to the whole study area.

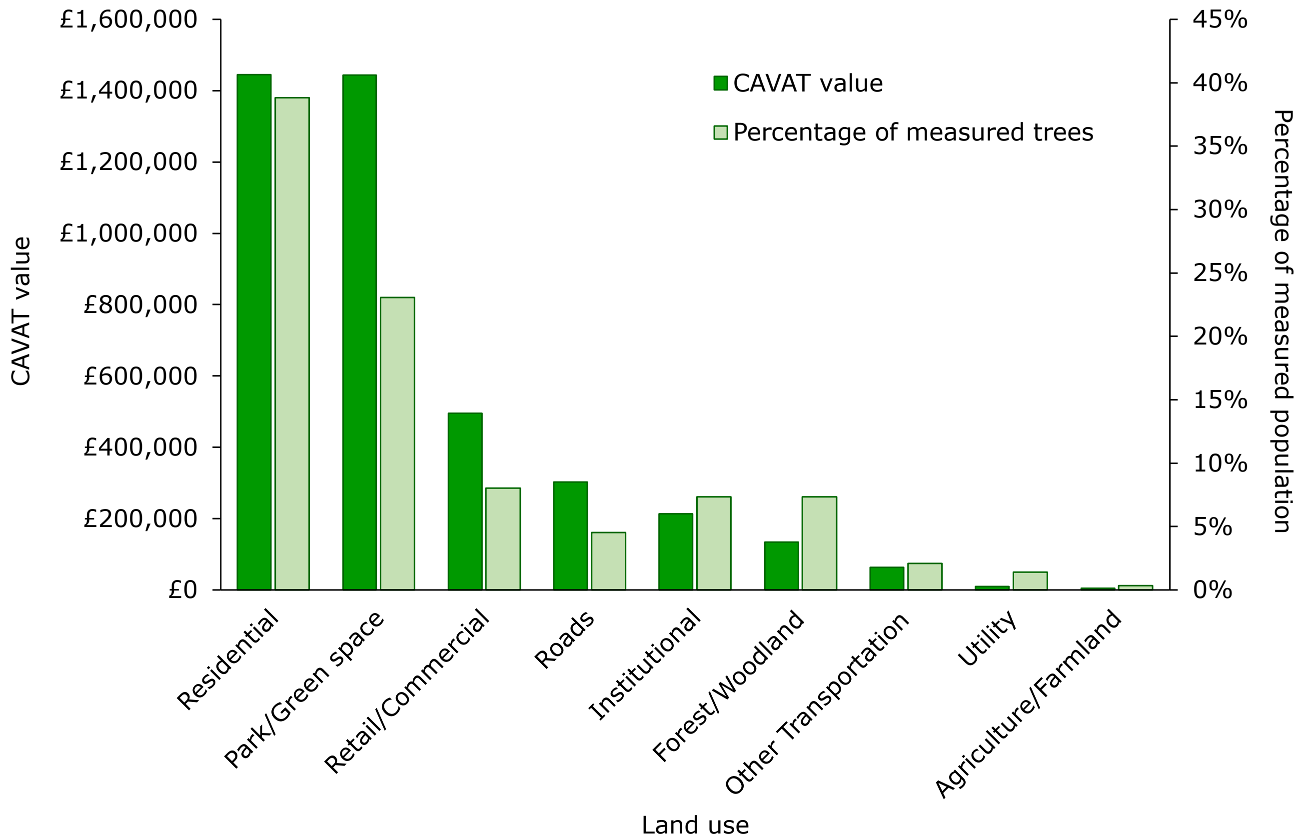


Figure 56. CAVAT value (for measured trees only) and tree numbers as percentage of total in recorded land use categories.

### 3.5.2.1 CAVAT values across the four areas of Portsmouth

Figure 57 shows the extrapolated CAVAT values per unit area for the four areas of Portsmouth. Trees in the North West Island area have the highest CAVAT value (£1,940,259), and trees in the South West Island area have the lowest CAVAT value (£282,005).

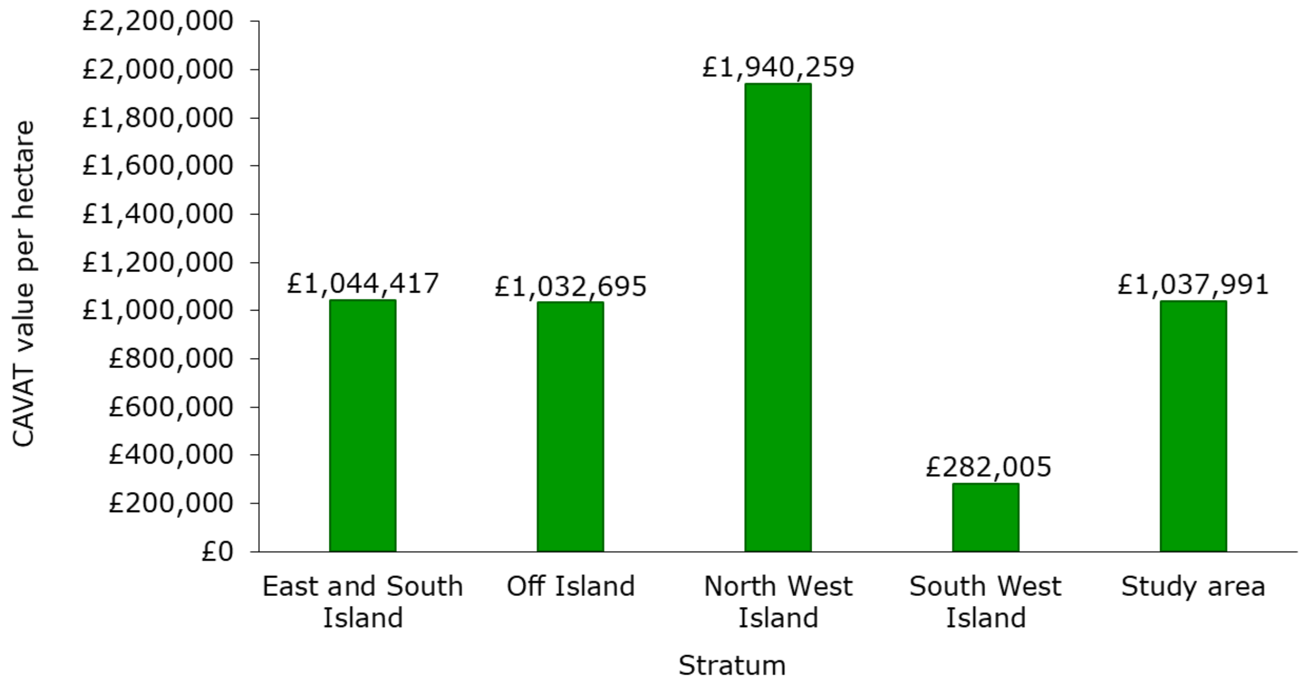


Figure 57. Extrapolated CAVAT values per hectare for the four areas of Portsmouth and for the study area.

#### 3.5.2.2 CAVAT values on PCC and Non-PCC land

Figure 58 shows the extrapolated CAVAT value per unit area for PCC land, non-PCC land, and for the study area. Trees on Non-PCC land have the highest CAVAT value (£1,205,223), and trees on PCC land have the lowest CAVAT value (£986,156).

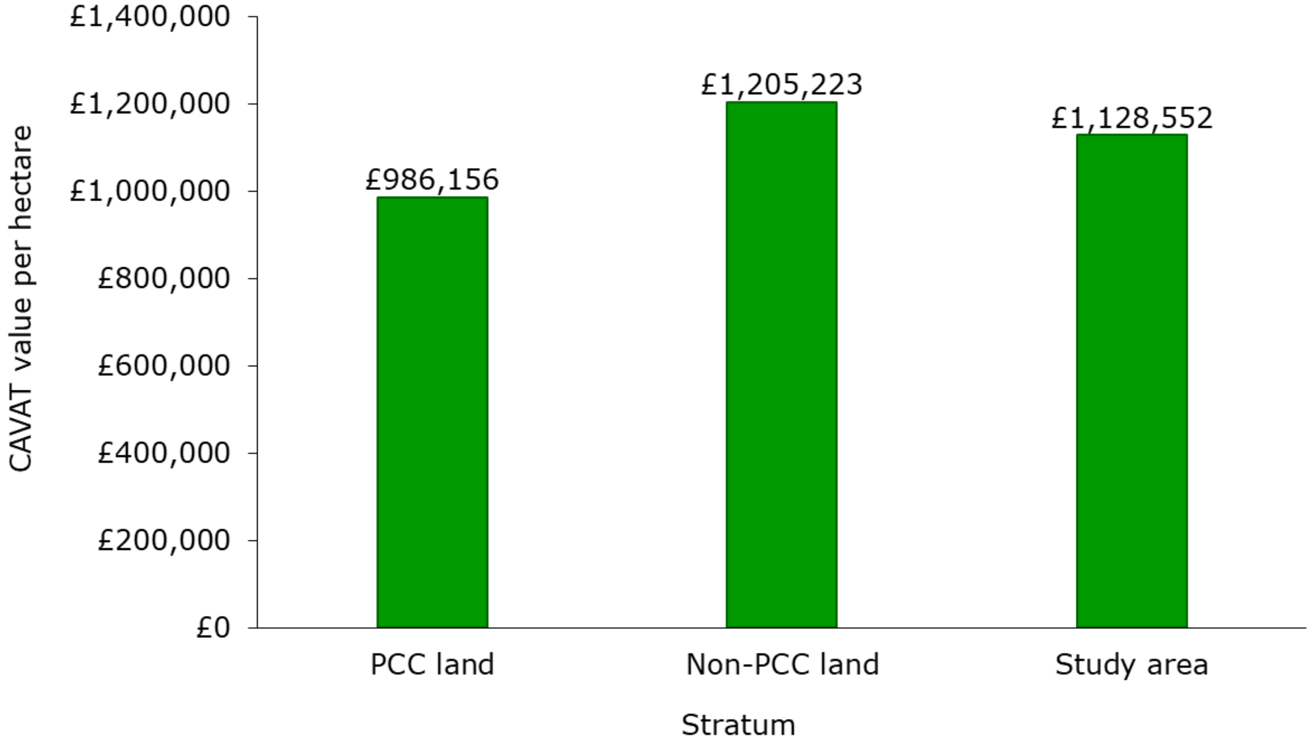


Figure 58. Extrapolated CAVAT values per hectare for PCC land, non-PCC land and the study area.

## 3.6 Pests and Diseases

### The Issue

Pests and diseases are a serious threat to tree populations. Damage and death to trees reduces the benefits they provide to people and has a further economic burden because of the requirement to manage unhealthy and potentially unsafe trees. It is important to consider the impacts of existing and potential pests and diseases when planning and managing an urban forest. It is likely that climate change will result in the introduction of pests and diseases not yet present in the UK. Warmer temperatures are likely to affect the geographical range, development rate and seasonal timing of life-cycle events of insects and will have an impact on their host plants and natural enemies (Wainhouse and Inward, 2016). The changing climate of the UK is predicted to increase growth or spore release of root pathogens, and to make trees more susceptible to infection (Frederickson-Matika and Riddell, 2021).

### 3.6.1 Pests and diseases in Portsmouth

**Chalara ash dieback** (*Hymenoscyphus fraxineus*) is present in Portsmouth[10]. *Fraxinus excelsior* is the second most common tree in the city making up 10.6% of the total tree population (an estimated 11,894 trees). The amenity (CAVAT) value of the ash trees measured in the survey is £543,396. The amenity value of all the ash trees in Portsmouth will be many times this number. Due to the large number of Ash trees and their substantial mature size the *F. excelsior* population provides a high level of ecosystem delivery in Portsmouth. As detailed in Section 3.4 Ash trees provide the highest avoided surface water runoff with an annual value of £16,735, the greatest annual benefit for air pollution removal (3.92 tonnes out of a total of 20.3 tonnes provided by all trees in Portsmouth) and sequesters the second highest amount of carbon with an annual value of £181,094. Table 19 gives the current

[10] https://chalaramap.fera.co.uk/

condition ratings of *Fraxinus excelsior* in Portsmouth's tree population showing 29.8% are already in the poor or critical categories. As Charla ash dieback continues to progress through the Ash population in Portsmouth the benefits these trees provide will likely diminish substantially. Planning for these losses will be an important aspect of ensuring the long-term sustainability of Portsmouth's urban forest and the benefits it provides. There is evidence to suggest that early pruning of infected branches can help to maintain the vitality of young trees (Marciulyniene et al., 2017). See Appendix C for more details.

Table 19. Condition ratings of *Fraxinus excelsior* in Portsmouth's tree population.

| Condition rating | Percentage of *Fraxinus excelsior* population |
|---|---|
| Excellent | 23.6% |
| Good | 20.20% |
| Fair | 26.4% |
| Poor | 23.2% |
| Critical | 6.6% |
| Dying | 0% |
| Dead | 0% |

**Ramorum disease**, also known as sudden oak death, is caused by the algae-like water mould *Phytophthora ramorum*. The pathogen has been previously identified in Hampshire but it is thought to have been eradicated[11]. Ramorum is a highly destructive disease, causing damage and death to more than 150 plant species. It has the potential to affect 41.8% of Portsmouth's tree population. See Appendix C for more details.

**Sooty bark disease of maple** is an increasingly common fungal disease affecting *Acer* species, especially *A. pseudoplatanus*. It is caused by a fungus called *Cryptostroma corticale* which enters the tree through bark wounds and results in prolific growth of spores under the bark, loss of bark from the trunk, and ultimately

[11] https://cdn.forestresearch.gov.uk/2022/02/pr_outbreak_map_at_Dec_2022.pdf

dieback and death of the tree. *A. pseudoplatanus* is the most common tree in Portsmouth making up 13.1% of the total tree population. It provides the highest amount of carbon sequestration and storage and the second largest benefit for avoided surface water runoff and air pollution removal. Loosing significant numbers of these trees to Sooty Bark Disease could therefore have serious negative implications for ecosystem service delivery by trees in Portsmouth. The spores have the potential to cause an inflammatory lung disease in people working with affected timber, or people with compromised immune systems. Monitoring for its presence in Portsmouth would be a worthwhile undertaking.

These and other pests and diseases have been considered in terms of the likelihood of their spread to Hampshire, the percentage of Portsmouth's tree population they could affect, and the estimated CAVAT value of those trees.

Table 20 shows the risk matrix used to assess the probability of a pathogen affecting trees from a single genus in Portsmouth's tree population. Table 21 shows the risk matrix for pathogens that affect trees in multiple genera. In both cases, the higher the percentage of the tree population and the more likely that the pathogen is already present in the UK, the greater the probability of that pathogen having an adverse impact in Portsmouth. Many pests and diseases can infect a whole range of tree species but only the species recorded in the i-Tree survey were considered here.

Table 20. Risk matrix used for the probability of a pest or disease becoming prevalent in Portsmouth's tree population on a single genus (one or more species).

| **Prevalence** | **% Population** | | |
|---|---|---|---|
| | 0-5 | 6-10 | >10 |
| Not in UK | | | |
| Present in UK | | | |
| Present in Hampshire | | | |

Table 21. Risk matrix used for the probability of a pest or disease becoming prevalent in Portsmouth's tree population on multiple genera.

| **Prevalence** | **% Population** | | |
|---|---|---|---|
| | 0-25 | 26-50 | >50 |
| Not in UK | | | |
| Present in UK | | | |
| Present in Hampshire | | | |

Table 22 gives an overview of some of the established and emerging pests and diseases that could have a significant impact on Portsmouth's urban forest. The percentage of the tree population at risk has been colour coded to highlight the relevant risk from each pathogen. Entries for pests identified in Hampshire and recorded in the Tree Health Diagnostic and Advisory Service (THDAS) database[12] were used to determine if a pest is present in Hampshire. It is possible that a pest or disease could be present in Hampshire but has not yet been observed and therefore has not been reported in the database.

[12] https://treealert.forestresearch.gov.uk/news/140293

Table 22. Pests and diseases with potential impact on Portsmouth's trees. CAVAT values are for measured trees only and are not extrapolated to the study area.

| Pest/Disease | Tree species affected | Prevalence in the UK | Prevalence in Hampshire | Mitigated risk of spreading to Hampshire (or UK if not already present) | Tree population at risk (%) | CAVAT value of trees (£)[13] |
|---|---|---|---|---|---|---|
| Acute oak decline | *Quercus spp. including Q. ilex, robur* and *cerris* | Southern, eastern, and central England; south Wales | Present | Already present | 2.5 | £325,116 |
| Asian longhorn beetle | Many broadleaf species (see Appendix C) | Not present (outbreak in Kent eradicated) | Not present | Low | 69 | £3,202,162 |
| Bronze birch borer | *Betula spp.* including *B. pendula, pubescens* and *utilis* | Not present | Not present | Low | 2.8 | £91,042 |
| Chalara ash dieback | *Fraxinus spp.* including *F. excelsior* | Widespread | Present | Already present | 10.6 | £543,396 |
| Citrus longhorn beetle | Many broadleaf species (see Appendix C) | Not present (numerous interceptions) | Not present | Low | 57.7 | £2,743,256 |
| Dothistroma needle blight | *Pinus spp.* including *P. sylvestris* | Widespread | Not present | Medium | 1.1 | £35,799 |
| Elm zigzag sawfly | *Elm spp.* Including *U. procera), glabra, minor* | Across England | Present | Already present | 1 | £186,979 |
| Emerald ash borer | *Fraxinus spp.* including *F. excelsior* | Not present | Not present | Medium | 10.6 | £543,396 |

[13] Measured trees only, not extrapolated to the study area.

| Pest/Disease | Tree species affected | Prevalence in the UK | Prevalence in Hampshire | Mitigated risk of spreading to Hampshire (or UK if not already present) | Tree population at risk (%) | CAVAT value of trees (£)[13] |
|---|---|---|---|---|---|---|
| Great spruce bark beetle | *Pinus spp.* | Present in Scotland, England, and Wales | Present | Already present | 1.1 | £35,799 |
| Horse chestnut bleeding canker | *Aesculus spp.* including *A. hippocastanum* | Widespread | Present | Already present | 1.4 | £86,601 |
| Mountain ash ringspot disease | *Sorbus acuparia* but may affect other *Sorbus spp.* | Known in Scotland and England | Present | Already present | 0.6 | £4,597 |
| Oak processionary moth | *Quercus spp.* including *Q. robur* | Greater London and surrounding counties | Not present (eradicated) | High | 2.5 | £325,116 |
| Phytophthora kernoviae | Many broadleaf species (see Appendix C) | Scotland, England, and Wales (most cases in Devon and Cornwall) | Not present | Medium | 6.3 | £366,547 |
| Pine processionary moth | *Pinus spp* | Not present (intercepted in southern England) | Not present | Low | 1.1 | £35,799 |
| Ramorum disease | Over 150 plants (see Appendix C) | Scotland, England, and Wales, mostly in western regions | Not present (eradicated) | High | 41.8 | £1,842,102 |
| Red-necked longhorn bettle | *Prunus spp.* | Not present (one case intercepted) | Not present | Medium | 12.7 | £216,029 |

| Pest/Disease | Tree species affected | Prevalence in the UK | Prevalence in Hampshire | Mitigated risk of spreading to Hampshire (or UK if not already present) | Tree population at risk (%) | CAVAT value of trees (£)[13] |
|---|---|---|---|---|---|---|
| Sooty bark disease of maple | *Acer spp.* | Present | Not present | Medium | 23.5 | £1,319,492 |
| Xylella | Wide range of genera (see Appendix C) | Not present (intercepted) | Not present | Low | 23.3 | £1,063,620 |

## Management to reduce the risk of tree pests and diseases

A more diverse tree population is more resilient to the impacts of pests and diseases. Genetically similar trees have susceptibility to damage from biotic and abiotic stresses (Kendal et al., 2014). Having a **wide variety of tree species** means that the loss of a single species has a lower impact (Lohr, 2013) and reducing the dominance of a few species also reduces the risk of spread of pests and diseases through a population (Civitello et al., 2015). **Optimising the growing conditions and therefore health of the trees in the population** also increases their resilience. This will become increasingly important in our future climate, as both environmental stresses and the presence of pests and diseases increase (Riddell and Frederickson-Matika, 2021; Frederickson-Matika and Riddell, 2021).

Where diseases such as Ramorum are present in a tree population, the appropriate action is **containment and removal** of the affected trees. For diseases which are hard to contain, such as Chalara ash dieback, **management of affected trees and monitoring for apparent resistance** may help to retain some of the population. However, prevention is often better than management. Many pests and diseases which are not currently present in the UK, such as Asian longhorn beetle, have the potential to damage many species. The greatest risk of introduction is on imported plant or packing material. **Monitoring imported material and existing trees** for the presence of pests and diseases helps trigger a fast response to eradicate the pest before it becomes a problem, and also helps to inform research targeted at combating emergent threats.

Two initiatives have been established to help researchers understand the presence and spread of tree pathogens in the UK:

**Observatree** (https://www.observatree.org.uk/) is a citizen science early-warning system for tree health.

**TreeAlert** (https://treealert.forestresearch.gov.uk/) is the online system for reporting and gathering information about existing pests and diseases on trees.

# 3 Recommendations

**Canopy Cover**

All areas of Portsmouth fall below the 16.5% UK government target for canopy cover. Increase planting in areas that are lacking in canopy cover, especially in the South West Island area, which has the lowest canopy cover in Portsmouth, to improve benefit provision.

Undertake an assessment of recent trends in canopy cover across Portsmouth, including the causes of change. Where recent trends are for declining cover then greater effort can be focused to reverse the causes of change. This can help Portsmouth reach its target to double tree canopy cover to 19.6% over the next 25 years.

**Tree Diversity**

The diversity of Portsmouth's tree population is lower than ideal with *Acer pseudoplatanus* and *Fraxinus excelsior* dominating the overall tree population. Planting a more diverse range of species can offer a long-term higher level of resilience for Portsmouth's trees from climate change. A more diverse tree population will also be resilient to pests and diseases as there is less potential for large numbers of trees to be affected by an outbreak.

Respondents to the people survey indicated preferences for particular species, including Oak, Birch, Cherry, Plane, Apple, Ash, Rowan, and Beech, but also more broadly for native trees, fruit trees, trees with blossom, and trees beneficial to wildlife.

**Structure**

The low numbers of trees in the two largest DBH size classes indicate that Portsmouth's overall tree population is smaller (or younger) than ideal. Large trees provide the greatest quantity of benefits. Retain large, mature trees wherever possible. Aim to make large, mature trees a part of new developments rather than removing and replacing them. The South West Island area is underrepresented for large trees. Providing care and protection to the younger and smaller trees in this area to grow and become large trees will allow them to deliver greater levels of benefit.

Across the whole of Portsmouth plan for the replacement of trees that will eventually be lost. Where possible, plant species that can reach large stature so that the benefits currently provided by these trees will be replaced.

Sixty-two percent of respondents said they would like to see a mix of small and large species in their street, with 73% and 76% saying the same respectively for the neighbourhood level and Portsmouth generally.

Directing resources toward the maintenance of the trees on Portsmouth City Council land could improve their health and life span helping the long-term suitability of Portsmouth urban forest.

**Planting**

Residential is the largest land use category surveyed in Portsmouth. Trees in private gardens and on residential streets are the most common locations of trees visible from respondents' homes and many respondents said their gardens already have trees, or they would be willing to consider planting a tree. Working with residents to promote the benefits of trees can help protect preexisting trees in these areas and encourage new tree planting in private gardens.

Trees on agriculture/farmland, cemeteries, industrial land, and golf courses collectively make up only 5% of Portsmouth's tree population. Increasing tree canopy cover in these areas by working with landowners to plant new trees could help contribute to Portsmouth achieving its tree canopy target.

The highest proportion of PCC land is parks and green space. These areas have the potential to provide excellent opportunities for tree planting.

A detailed spatial evaluation of land use and tree cover within Portsmouth would enable mapping of tree planting opportunities. Look to plant in areas that experience high pollution, surface flooding, have limited greenspace, or a lack of shade.

**Establishment and Maintenance**

Encourage community care (particularly watering) of young trees through communication, campaigns, signage, and QR codes linked to websites providing guidance and information. Effectively promote tree care related events or campaigns through varied media to reach a range of individuals and members of the community. Tree care activities could include mulching, straightening whips, replacing damaged or missing tree guards, and watering standard trees.

**Carbon storage and sequestration**

Ensure the survival of existing large trees to maintain the carbon storage and sequestration benefit they currently provide. Plant new trees to replace the ones that will eventually be lost, and to increase canopy cover.

Find long-term uses for felled or dead trees, such as standing deadwood, sculptures and carvings, street and park furniture, or seasoning as native hardwood for sale. Chip or season for firewood only if there is no other use for the timber, so that the carbon is stored for as long as possible.

**Wide range of benefits**

As well as planting trees for carbon storage and sequestration, consider other benefits as well. *Salix caprea*, supports 450 different species but only represents 1.1% of the Portsmouth tree community. Taking account of factors such as wildlife provision when selecting planting material will improve the overall benefits the trees in Portsmouth provide.

**Trees in development**

Use CAVAT to highlight amenity values of threatened trees to developers and communities, and to leverage compensation or sufficient replacement planting for amenity trees that are removed by developers. TDAG's guide to delivering trees in planning and development[14] contains recommendations for ensuring that the value of trees is recognised and reflected in new developments.

Utilise community tree groups such as the Portsmouth and Southsea Tree Warden Network to encourage engagement by local people and help to ensure the good health of young trees.

Take opportunities to create areas of accessible urban woodland to bring benefits to people in their day-to-day lives.

**Pests and diseases**

*Acer pseudoplatanus* is the most common tree in Portsmouth and due to its large mature size provides important ecosystem service benefits. However Sooty Bark Disease could put this tree population at risk. Similarly, *Fraxinus excelsior* is the second most common tree in Portsmouth providing the highest amount of avoided surface water runoff and the greatest annual benefit for air pollution removal. Chalara ash dieback is already causing damage to the Ash population across Portsmouth reducing the benefits these trees provide. It is therefore important that plans are put in place to manage tree loses due to pests and disease to ensure the long-term sustainable management of the tree population in Portsmouth.

Establish a tree monitoring programme to give early warning of pests, diseases, and threats to Portsmouth's trees. This could be in the form of community engagement and involvement opportunities, through the Portsmouth and Southsea Tree Warden Network, or a citizen science training and monitoring programme through Observatree.

[14] https://www.tdag.org.uk/trees-planning-and-development.html.

Diverse urban forests are more resilient to pests and diseases. When trees are removed, plant replacements that increase species diversity. Use the Right Trees for Changing Climate database, the TDAG species selection guide, and the Climate Matching Tool in conjunction with the Ecological Site Classification tree selection tool to find species that are likely to thrive in Portsmouth's future climate.

Adopt best practice guidelines for plant biosecurity to minimise the likelihood of introducing pests and diseases through plant and plant material imports.

Healthy trees are more resilient to pests and diseases. Planting trees using best practice, focus on establishment, and ensure good aftercare to maintain healthy trees. Establish an Internet of Things network of soil moisture sensors to determine whether young trees require watering.

# Appendix A

## Supplementary information on methodology

### Sampling

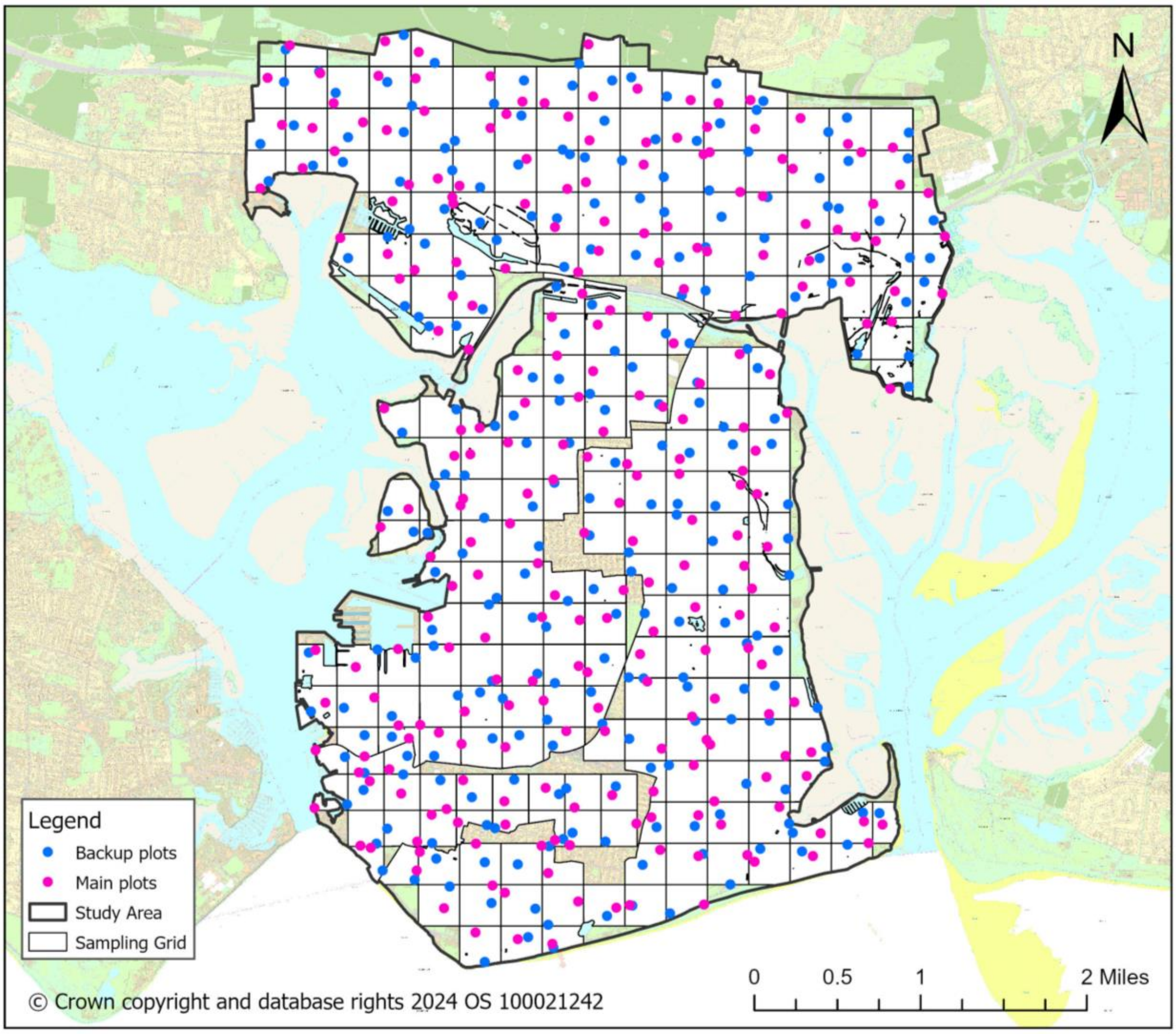


Figure 59.Map of study area, sampling grid, main and backup plots for the Portsmouth i-Tree Eco study.

**People survey results analysis**

Quantitative data were analysed using the software RStudio (ver. 2024.04.2+4764) (Posit team, 2024), and R (ver. 4.4.1) (The R Core Team, 2023a). Plots were created in Excel or in R using the 'ggplot2' package (Wickham & Chang, 2022). Visualisations were stacked frequency bar plots when outcome variables were categories (e.g. too few, conifers, every day, renting). They were mean±95% confidence interval error bar plots when outcomes were two-choice answers (e.g. yes or no). Social and cultural values were numeric (e.g. scores out of 100). Summary descriptive statistics, including mean, median, standard error and 95% confidence intervals were calculated for each question's outcome. For a subset of core questions, summaries were also broken down by explanatory variables of interest: respondents' age categories, genders, IMD quintiles, residential location, property tenure, and whether they live, work and/or study in Portsmouth.

Several statistical analyses were built from outcome and explanatory variables in combinations of interest; specifically, whether outcomes were affected by explanatory variables, and whether there were significant differences between groups within explanatory variables. Within each analysis, of the 1026 participants, only those who responded to each relevant question were included; for example, individuals who did not live in Portsmouth could not answer 'how many trees can you see from home?'. When outcome variables were numeric or two-choice, analyses were Generalised Linear Models built using 'lme4' (Bates et al., 2015), with gaussian or binomial distributions, respectively. When outcome variables were categorial, analyses were Cumulative Link Models built using 'ordinal' (Christensen, 2023). If included as fixed effects, IMD quintile and age group were formatted as ordinal categorical factors while gender, residential location, property tenure and live/work/study in Portsmouth, if included, were formatted as unordered categorial factors. Two-way interactions, how the pattern between an explanatory variable and an outcome is affected by the state of a second explanatory variable were also tested. Whether an explanatory variable significantly affected the outcome variable was assessed using log likelihood tests to see if the explanatory variable's removal from a model made it significantly worse (Thomas et al., 2015); effects were considered statistically significant if p values were <0.05. Subsequent differences/patterns between the fixed effect's groups were assessed through interpreting visualisations and p value tests using 'emmeans' (for categorical fixed effects) (Lenth et al., 2024), or 'stats' (for ordinal fixed effects) (The R Core Team, 2023b).

Qualitative data were thematically analysed in NVivo analysis software or Excel. The researchers inductively coded responses to questions inviting open-text responses, resulting in a set of themes and sub-themes related to the given question. In some cases, the researchers were able to provide a quantification, by summing or providing a proportion of respondents expressing a specific sentiment/theme.

**Land uses**

| Land use category | Description |
|---|---|
| Farmland / Agricultural | e.g. Cropland, pasture, vineyards, nurseries, farms |
| Retail / Commercial | e.g. Shops, businesses, commercial services, distribution, storage, parking not associated with housing or institutions |
| Industrial | e.g. Factories, manufacturing |
| Cemetery | Any small unmaintained areas within cemetery grounds |
| Forest / woodland | Does not include patches of woodland within other land uses, e.g. on golf course. Those are classed by the containing land use. |
| Golf Course | Golf course |
| Institutional | Schools, hospitals, surgeries, government buildings, colleges, etc. |
| Flats / apartments | Buildings for multiple households |
| Park | Unmaintained and developed (maintained) areas |

| | |
|---|---|
| Residential | Buildings for single households (terraces, detached, semi-detached, etc.) |
| Roads | Motorways, major roads, town centre roads, country roads and their verges |
| Other Transportation | Railways and stations, airports, bus stations, etc |
| Utility | Power generation or distribution, sewage treatment, reservoirs, flood control |
| Vacant | Land with no clear intended use. Includes forest-like areas. Classify vacant/abandoned buildings on their original use. |
| Water/Wetland | Streams, rivers, lakes, natural or constructed. Classify small constructed pools based on adjacent land use. |
| Other | Used sparingly |

**Ground covers**

| Ground cover category | Description |
|---|---|
| Buildings | All buildings including sheds, garages, etc. including those with green roofs |
| Cement | Pointing, mortar, concrete etc. |
| Tar | Tarmac / asphalt (pavements, roads, driveways, etc.) |
| Rock | Pervious rock surfaces such as gravel, brick, flagstone walkways or patios, paved areas, gravel, wide stone walls |
| Other impervious | Any hard surfaces that don't fit into other categories, e.g. decking; large solid rock outcrops, swimming pools, manhole covers, artificial turf |
| Bare soil | Bare ground, naturally occurring sand |
| Mulch / plant matter | Bark chip, leaf litter under trees and shrubs, other organic mulch |
| Unmaintained grass | Grass that doesn't get cut |

| | |
|---|---|
| Grass | Grass that gets cut or mown, including long grass on roadside verges that are cut once per year |
| Herbaceous plants and ivy | Any plants that are not grass, a 1m tall shrub, or a tree |
| Water | Natural ponds, rivers, reservoirs, lakes, sea etc. Excludes temporary standing water. Artificial ponds with impervious lining should be classed as Other impervious. |

### Shannon-Wiener Diversity Index and Evenness

The Shannon-Wiener diversity index is calculated as:

$$H = -\sum [p_i \times ln(p_i)]$$

Where $H$ is the Shannon-Wiener index and $p_i$ is the proportion of individuals of species $i$ in the whole population:

$$p_i = \frac{n}{N}$$

where $n$ is the number of individuals of a single species, and $N$ is the total number of individuals in the population.

Evenness is calculated as:

$$E = \frac{H}{\ln{(k)}}$$

Where $E$ is evenness, $H$ is the Shannon-Wiener index, and $k$ is the number of species in the population.

### Carbon storage and sequestration

Calculations of carbon storage and sequestration use tree species, DBH, total tree height, percentage of crown in good condition, and crown light exposure data. Carbon storage is estimated by multiplying above- and below-ground tree biomass by 0.5. Carbon sequestration is estimated by incrementally increasing the DBH of trees in the model based on an estimated annual growth rate.

Growth rate is estimated using a base growth rate, the length of the local growing season, species-specific growth rates, tree competition (crown light exposure), tree condition, and tree height.

Gross carbon sequestration is the total amount of carbon taken up by trees each year. An estimate of the release of carbon due to decomposition of dead trees is subtracted from this to give net carbon sequestration. More details are given by Nowak (2020).

**Air pollution Removal**

Air pollution removal estimates are based on modelling of gas exchange and particulate matter interception by trees, shrubs, and grass. i-Tree Eco estimates the hourly dry deposition of air pollutants based on tree, shrub, and grass cover data, weather data, and pollution concentration monitoring data. Pollution monitoring stations for each study location are pre-determined by the i-Tree Eco system. $O_3$, $NO_2$, and $PM_{2.5}$ data are from 2015 from a monitoring station 12.2 km away from the study area; $SO_2$ data are from 2015 from a monitoring station 58.0 km away from the study area; CO data are from 2015 from a monitoring station 186.7 km away from the study area. Weather data are from 2015, from the Hawarden monitoring station in Flintshire. Details of the pollution removal model calculations are given by Nowak (2020).

**Avoided Runoff**

i-Tree Eco model calculations of avoided runoff are based on leaf and bark area data and local hourly weather data. i-Tree Eco estimates hourly rain interception, evaporation from leaf surfaces, potential evapotranspiration, transpiration, and surface runoff. Estimates of each process are calculated with the current tree population, and then without trees in order to estimate the impact of trees on surface runoff. Impervious cover beneath trees is held constant at 25.5%. Further details are provided by Nowak (2020).

**CTLA**

Depreciated Replacement Cost (DRC) methodology is a way of estimating the current cost of replacing an asset (such as a tree) with a modern equivalent, less deductions for physical deterioration, obsolescence, and optimisation (RICS, 2018). DRC is an appropriate valuation method when there is no comparative market-based price that represents the value of the asset, which is the case with trees (RICS, 2018).

In i-Tree Eco, the replacement value of all trees in the study is calculated using the Council of Tree and Landscape Appraisers (CTLA) Trunk Formula Method (TFM). The CTLA is a North American consortium of "green" industry organisations (Cullen, 2007). The TFM is a DRC method commonly used in the United States as a measure of compensatory value, which can be thought of as the cost of replacing trees that have been lost, or the monetary settlement which could be paid to compensate for their damage, death or removal (Nowak et al., 2002).

The Trunk Formula Method (TFM) is suitable for trees that are too large to be replaced like-for-like. The compensatory value is calculated by multiplying a "basic value" by condition and location factors between 0 and 1 (Nowak et al., 2002):

Compensatory Value = Basic Value × Condition factor × Location Factor

The basic value is determined by the replacement cost of a tree at the largest transplantable size, the cross-sectional areas of the stem of the subject tree ($TA_A$) and of the transplantable tree ($TA_R$), a basic price, and a species value (Nowak et al., 2002):

Basic Value = Replacement Cost + [Basic Price × ($TA_A$ – $TA_R$) × Species Value]

Replacement Cost, Basic Price and Species Values are derived from the Royal Institute of Chartered Surveyors (RICS), and Barchams and Hilliers catalogues. Species Value takes into account the suitability of the tree species to the local environment.

Condition factors are based on crown dieback recorded during the survey (Nowak et al., 2002):

| Crown Dieback | Condition rating | Condition factor |
|---|---|---|
| < 1% | Excellent | 1 |
| 1–10% | Good | 0.95 |
| 11–25% | Fair | 0.82 |
| 26–50% | Poor | 0.62 |
| 51–75% | Critical | 0.37 |
| 76–99% | Dying | 0.13 |
| 100% | Dead | 0 |

i-Tree Eco takes a simplified approach to location factor, based on land use type recorded in the survey (Nowak et al., 2002):

| Land Use | Location factor |
|---|---|
| Golf course | 0.8 |
| Commercial/Industrial | 0.75 |
| Cemetery | 0.75 |
| Institutional | 0.75 |
| Parks | 0.6 |
| Residential | 0.6 |
| Transportation | 0.5 |
| Forest | 0.5 |
| Agriculture | 0.4 |
| Vacant | 0.2 |
| Wetland | 0.1 |

**CAVAT**

In addition, and separate to the replacement value calculated within i-Tree Eco, we calculate an asset value of Portsmouth’s trees using CAVAT (Capital Asset Value for

Amenity Trees). CAVAT is a DRC method developed in the UK (Doick et al., 2018) and is designed for use with urban amenity trees.

Like the CTLA method, CAVAT uses the cross-sectional area of the tree, and a unit value, to arrive at a theoretical cost of a replacement tree, and then decreases or increases that value to account for the individual characteristics of the subject tree. An amended CAVAT Full method is used here:

$$\text{CAVAT value} = \text{Base Value} \times \text{CTI Factor} \times \text{Location factor} \times \text{Crown structural factor} \times \text{Crown functional factor} \times \text{Life Expectancy factor}$$

The Base Value is determined by multiplying the cross-sectional stem area (TA) by the Unit Value Factor[15], which is determined from UK nursery prices and an allowance for tree planting cost:

$$\text{Base Value} = \text{TA} \times \text{Unit Value Factor}$$

The Community Tree Index (CTI) Factor takes into account the local population density and appreciates (increases) the value for densely populated areas. For Portsmouth, this results in multiplication of the Basic Value by 1.5.

| Data | Value | Source |
|---|---|---|
| Unit value | £24.59 | CAVAT documentation |
| CTI factor | 150% | CAVAT documentation |
| Location factor | Public visibility | i-Tree Eco survey |
| Crown structural factor | Percent missing | i-Tree Eco survey |
| Crown functional factor | Percent condition | i-Tree Eco survey |
| Life Expectancy | Life Expectancy | i-Tree Eco survey |

15 The latest Unit Value Factor can be found on the CAVAT resources webpages at https://www.ltoa.org.uk/resources/cavat.

The location factor is based on the public visibility of the tree:

| Public visibility | Location factor |
|---|---|
| Fully visible from at least one direction, on or immediately adjacent to public land | 1 |
| Tree clearly visible from a public location, but with somewhat reduced visual contribution to public amenity | 0.75 |
| Tree visible from a public location, but with significantly reduced visual contribution to public amenity | 0.5 |
| Tree effectively invisible from any public location | 0.25 |

The crown structural factor is based on the percent of the crown missing, which is recorded during i-Tree Eco surveys:

| Percent of crown missing | Crown structural factor |
|---|---|
| 0% | 1 |
| 1% - 5% | 1 |
| 5% - 10% | 0.9 |
| 10% - 15% | 0.9 |
| 15% - 20% | 0.8 |
| 20% - 25% | 0.8 |
| 25% - 30% | 0.7 |
| 30% - 35% | 0.7 |
| 35% - 40% | 0.6 |
| 40% - 45% | 0.6 |
| 45% - 50% | 0.5 |
| 50% - 55% | 0.5 |
| 55% - 60% | 0.4 |
| 60% - 65% | 0.4 |
| 65% - 70% | 0.3 |
| 70% - 75% | 0.3 |

| | |
|---|---|
| 75% - 80% | 0.2 |
| 80% - 85% | 0.2 |
| 85% - 90% | 0.1 |
| 90% - 95% | 0.1 |
| 95% - 99% | 0 |
| 100% | 0 |

The crown functional factor is determined by the percentage of the crown in good condition, which is recorded during i-Tree Eco surveys:

| Percentage of crown in good condition | Crown functional factor |
|---|---|
| 100% | 1 |
| 95% - 99% | 1 |
| 90% - 95% | 0.9 |
| 85% - 90% | 0.9 |
| 80% - 85% | 0.8 |
| 75% - 80% | 0.8 |
| 70% - 75% | 0.7 |
| 65% - 70% | 0.7 |
| 60% - 65% | 0.6 |
| 55% - 60% | 0.6 |
| 50% - 55% | 0.5 |
| 45% - 50% | 0.5 |
| 40% - 45% | 0.4 |
| 35% - 40% | 0.4 |
| 30% - 35% | 0.3 |
| 25% - 30% | 0.3 |
| 20% - 25% | 0.2 |
| 15% - 20% | 0.2 |
| 10% - 15% | 0.1 |
| 5% - 10% | 0.1 |
| 1% - 5% | 0 |
| 0% | 0 |

The Life Expectancy Factor is determined from the life expectancy of the tree recorded during the survey:

| Life Expectancy | Life Expectancy Factor |
|---|---|
| 0 years (dead) | 0 |
| <5 years | 0.1 |
| 5 - <10 years | 0.3 |
| 10 - <20 years | 0.55 |
| 20 - <40 years | 0.8 |
| 40 - <80 years | 0.95 |
| =>80 years | 1 |

Details about the full CAVAT method are given in Doick et al. (2018).

**Key differences between CTLA and CAVAT**

- The CTLA equation uses an actual price of the largest available transplantable replacement tree and adds to this a theoretical cost of the additional cross-sectional area required to reach the size of the subject tree
- CAVAT does not take into account an actual price of a replacement tree, and instead multiplies the cross-sectional stem area of the subject tree by the Unit Value
- Land use and species suitability are considered by this i-Tree Eco version of CTLA and not by the amended CAVAT version
- Population density, crown size, and life expectancy are considered by the amended CAVAT version and not by the i-Tree Eco version of CTLA

# Appendix B

## Supplementary data

### Full species list and importance values

| Species | Common name | Percentage of total population | Percentage of total leaf area | Importance value |
|---|---|---|---|---|
| Acer pseudoplatanus | Sycamore | 13.1% | 17.7% | 30.80 |
| Fraxinus excelsior | European Ash | 10.6% | 19.4% | 30.10 |
| Acer platanoides | Norway Maple | 5.5% | 15.4% | 20.90 |
| Crataegus monogyna | Hawthorn | 5.7% | 2.0% | 7.70 |
| Chamaecyparis lawsoniana | Lawson Cypress | 4.5% | 1.8% | 6.30 |
| Carpinus betulus | Hornbeam | 2.4% | 3.5% | 5.90 |
| Tilia x europaea | Common Lime | 1% | 4.3% | 5.30 |
| Acer campestre | Field Maple | 3.2% | 1.9% | 5.10 |
| Aesculus hippocastanum | Horse Chestnut | 1.4% | 3.7% | 5.10 |
| Populus tremula | Aspen | 4.3% | 0.5% | 4.80 |
| Prunus domestica | Common Plum | 4.3% | 0.4% | 4.70 |
| Betula pendula | Silver Birch | 2.1% | 1.6% | 3.70 |
| Prunus | Cherry | 1% | 2.0% | 3.00 |
| Ilex aquifolium | Holly | 2.4% | 0.3% | 2.70 |
| Quercus ilex | Holm Oak | 1% | 1.6% | 2.60 |
| Cupressus | Cypress | 1.8% | 0.9% | 2.60 |
| Populus x canescens | Grey Poplar | 0.7% | 1.8% | 2.50 |
| Populus alba | White Poplar | 0.7% | 1.6% | 2.30 |
| Quercus robur | English Oak | 1.1% | 1.1% | 2.20 |
| Populus nigra | Black Poplar | 0.4% | 1.9% | 2.20 |
| Prunus x yedoensis | Yoshino Cherry | 1.4% | 0.7% | 2.10 |
| Prunus laurocerasus | Herry Laurel | 1.8% | 0.2% | 2.00 |
| Alnus | Alder | 1% | 0.9% | 1.90 |
| Sambucus nigra | Elder | 1.8% | 0.1% | 1.90 |
| Malus | Apple | 1.6% | 0.2% | 1.90 |
| Salix fragilis | Crack Willow | 0.4% | 1.4% | 1.80 |
| Prunus avium | Wild Cherry | 1.4% | 0.3% | 1.70 |
| x Hesperotropsis leylandii | Leyland cypress | 1.1% | 0.5% | 1.60 |
| Liquidambar styraciflua | Sweetgum | 0.3% | 1.2% | 1.50 |
| Prunus cerasifera | Cherry Plum | 1% | 0.5% | 1.50 |
| Ulmus x hollandica | Dutch Elm | 0.4% | 1.1% | 1.50 |
| Salix caprea | Goat Willow | 1.1% | 0.4% | 1.50 |
| Acer | Maple | 0.6% | 0.7% | 1.40 |

| | | | | |
|---|---|---|---|---|
| Pyrus calleryana | Callery pear | 0.6% | 0.7% | 1.40 |
| Eucalyptus gunnii | Cider Gum | 0.4% | 1.0% | 1.30 |
| Alnus glutinosa | Black Alder | 1.1% | 0.2% | 1.30 |
| Betula pubescens | Downy Birch | 0.4% | 0.9% | 1.30 |
| Malus sylvestris | Crab Apple | 1.1% | 0.1% | 1.20 |
| Cornus | Dogwood | 0.4% | 0.8% | 1.20 |
| Ulmus | Elm | 0.4% | 0.8% | 1.10 |
| Prunus serrulata | Japanese Cherry | 1.1% | 0.0% | 1.10 |
| Corylus colurna | Hazel | 0.4% | 0.7% | 1.00 |
| Pinus pinaster | Maritime Pine | 0.7% | 0.2% | 1.00 |
| Laurus nobilis | Bay Laurel | 0.7% | 0.2% | 0.90 |
| Cordyline australis | Cabbage Palm | 0.9% | 0.0% | 0.90 |
| Pinus sylvestris | Scots Pine | 0.4% | 0.5% | 0.80 |
| Acer palmatum | Japanese Maple | 0.7% | 0.1% | 0.80 |
| Pittosporum | Cheesewood | 0.7% | 0.0% | 0.70 |
| Quercus cerris | Turkey Oak | 0.4% | 0.4% | 0.70 |
| Acer rubrum | Red Oak | 0.4% | 0.3% | 0.70 |
| Corylus | Hazel | 0.4% | 0.2% | 0.60 |
| Cornus kousa | Dogwood | 0.3% | 0.2% | 0.60 |
| Prunus padus | Bird Cherry | 0.3% | 0.2% | 0.60 |
| Laburnum | Golden Chain Tree | 0.4% | 0.1% | 0.40 |
| Betula utilis ssp. jacquemontii | West Himalayan birch | 0.4% | 0.1% | 0.40 |
| Cotinus coggygria | Smoke Tree | 0.4% | 0.1% | 0.40 |
| Araucaria araucana | Monkey Puzzle | 0.4% | 0.1% | 0.40 |
| Abies nordmanniana | Nordmann Fir | 0.4% | 0.0% | 0.40 |
| Cotoneaster frigidus | Tree Cotoneaster | 0.4% | 0.0% | 0.40 |
| Rhus typhina | Staghorn Sumac | 0.4% | 0.0% | 0.40 |
| Prunus serrula | Tibetan Cherry | 0.4% | 0.0% | 0.40 |
| Ficus carica | Fig | 0.4% | 0.0% | 0.40 |
| Magnolia grandiflora | Evergreen Magnolia | 0.4% | 0.0% | 0.40 |
| Sorbus aria | Whitebeam | 0.4% | 0.0% | 0.40 |
| Cotoneaster | Cotoneaster | 0.4% | 0.0% | 0.40 |
| Taxus baccata | Yew | 0.4% | 0.0% | 0.40 |
| Gleditsia triacanthos | Honey Locust | 0.4% | 0.0% | 0.40 |
| Malus domestica | Apple | 0.4% | 0.0% | 0.40 |
| Chamaerops | European Fan Palm | 0.4% | 0.0% | 0.40 |
| Thuja plicata | Western Redcedar | 0.3% | 0.0% | 0.40 |
| Ulmus procera | English Elm | 0.3% | 0.0% | 0.30 |
| Magnolia | Magnolia | 0.3% | 0.0% | 0.30 |
| Cordyline | Cordyline | 0.3% | 0.0% | 0.30 |
| Sorbus intermedia | Whitebeam | 0.3% | 0.0% | 0.30 |
| Yucca | Yucca | 0.3% | 0.0% | 0.30 |

# Appendix C

## Supplementary information on pests and diseases

**Acute oak decline**

Acute oak decline (AOD) is caused by multiple agents, especially bacteria. It mainly affects mature trees (>50 years old) of both native oak species (*Quercus robur* and *Q. petraea*), but symptoms have also been identified on younger oaks and additional species, including *Q. cerris* and *Q. ilex*. Some affected trees can die in as little as 4–6 years after symptoms have developed. Over the past few years, the reported incidents of stem bleeding and exit holes of the associated beetle *Agrilus biguttatus*, indicating potential AOD infection, have been increasing.

**Asian longhorn beetle**

The Asian longhorn beetle (*Anoplophlora glabripennis*) is a major pest in China, Japan, and Korea, where it kills many broadleaved species. There are established populations of Asian longhorn beetle (ALB) in parts of North America and there have been outbreaks in Europe. Where the damage to street trees is high, felling, sanitation and quarantine are the only viable management options.

In March 2012 an ALB outbreak was found in Maidstone, Kent, England. The Forestry Commission and Fera removed more than 2,000 trees from the area to contain the outbreak. The main risk of another outbreak comes from untreated wood packaging material from China, as in 2012. No further outbreaks have been reported in the UK. The known host species include:

- *Acer spp.*
- *Aesculus spp.*
- *Albizia julibrissin*
- *Alnus spp.*
- *Betula spp.*
- *Carpinus spp.*
- *Cercidiphyllum japonicum*
- *Corylus spp.*
- *Fagus spp.*
- *Fraxinus spp.*
- *Koelreuteria paniculata*
- *Malus spp.*

- *Platanus spp.*
- *Populus spp.*
- *Prunus spp.*
- *Pyrus spp.*
- *Robinia pseudoacacia*
- *Salix spp.*
- *Sorbus spp.*
- *Styphnolobium japonicum*
- *Quercus palustris*
- *Quercus rubra*
- *Ulmus spp.*

**Bronze birch borer**

The Bronze birch borer (*Agrilus anxius*) is a wood-boring beetle that feeds on the inner bark and cambium of birch trees. The disruption to water and nutrient flow that occurs as a result means that trees can die within a few years after symptoms appear. At current, the Bronze birch borer is present across North America, including the United States, where it is native, and Canada. Bronze birch borer has caused extensive mortality of Betula spp. planted as street and ornamental trees in towns and cities, due to its ability to colonize most birch species and cultivars.

**Chalara ash dieback**

Chalara ash dieback is caused by the fungus *Hymenoscyphus fraxineus.* The fungus reproduces on the leaf stalks of the previous year's fallen leaves. Spores are released in summer and can be spread up to 10 miles on the wind. The fungus penetrates the leaf cuticle and spreads along leaf veins to twigs and branches, where it colonises bark, sapwood, and pith, leading to death of cells (Marciulyniene et al., 2017). The disease is present throughout the UK, and at present there is no management approach that can fully prevent its spread. Planning for eventual replacement of ash trees lost to the disease will help to ensure continued delivery of the benefits they provide. For further information and an interactive distribution map, see Forest Research's resources on Chalara ash dieback.[16]

[16] https://www.forestresearch.gov.uk/tools-and-resources/fthr/pest-and-disease-resources/ash-dieback-hymenoscyphus-fraxineus/

### Citrus longhorn beetle

The citrus longhorn beetle (*Anoplophora chinensis*) is a wood-boring beetle which is extremely damaging to a wide range of broadleaved trees and shrubs in its natural range of China, Japan, the Korean peninsula, and South-East Asia. Beetle larvae feed on the pith and vascular systems of the lower trunk and roots of a tree. The tunnels they create leave the tree susceptible to infections by other organisms.

Beetles have been found around the world in ornamental trees imported from Asia. There have been no outbreaks in the UK but numerous interceptions of individual beetles, mostly associated with *Acer palmatum*. Known hosts include:

- *Acer spp.*
- *Aesculus spp.*
- *Alnus spp.*
- *Betula spp.*
- *Carpinus spp.*
- *Citrus spp.*
- *Corylus spp.*
- *Cotoneaster spp.*
- *Fagus spp.*
- *Malus spp.*
- *Platanus spp.*
- *Populus spp.*
- *Prunus spp.*
- *Pyrus spp.*
- *Salix spp.*
- *Ulmus spp.*

### Dothistroma needle blight

Dothistroma needle blight is a disease of conifer trees, especially *Pinus spp.*, caused by the fungus *Dothistroma septosporum.* It is also known as red band needle blight because of the discoloration it causes to foliage, and results in defoliation, reduced growth, and in some cases death of the tree. In the UK it has been found on *P. nigra*, *P. contorta*, *P. sylvestris*., *P. ponderosa*, and *P. muricata*. Until the 1990s the disease was primarily found in the southern hemisphere. Since then there has been a rapid increase of its incidence in Europe and North America. It is now found in many UK forests containing susceptible species.

### Elm zigzag sawfly

The larvae of the Elm zigzag sawfly (*Aproceros leucopoda*) feed on leaves of trees in the Ulmus genus. It gets its common name from the characteristic zigzag pattern the larvae make on the leaves as they feed. Under the right conditions the pest can severely defoliate trees. This can be detrimental to the trees' health and to other foliage-feeding invertebrate species which depend on elm trees. Elm zigzag sawfly is a native of eastern Asia but is now found in many parts of Europe. In the United Kingdom it has been reported across South East England including Hampshire and further north in the East Midlands.

**Emerald ash borer**

Emerald ash borer (EAB) is likely to have a major impact on our already vulnerable ash population in the UK if established. There is no evidence to date that EAB is present in the UK, but the increase in global movement of imported wood and wood packaging heightens the risk of its accidental introduction. EAB is present in Russia and Ukraine and is moving west and south at a rate of 30-40 km per year, perhaps aided by vehicles (Straw et al., 2013). EAB has had a devastating effect in the USA due to its accidental introduction and could add to pressures already imposed on ash trees from diseases such as Chalara dieback of ash.

**Great Spruce bark beetle**

The Great spruce bark beetle (*Dendroctonus micans*) is a non-native pest of spruce and pine trees (species in the Picea and Pinus genuses). The beetles damage trees by tunnelling into the bark of living trees to lay their eggs. The larvae which emerge from the eggs feed on the inner woody layers. This weakens, and in some cases can kill, the tree. The pest is found in forests throughout mainland Europe as far east as Siberia. It is now established in parts of Great Britain, including Wales, western England, and southern Scotland.

**Horse chestnut bleeding canker**

Horse chestnut bleeding canker is a bark disease of *Aesculus spp.*, usually caused by the bacterium *Pseudomonas syringae* pv. *aesculi*. There has been a recent upsurge in incidences in many parts of the UK. In 2007, 74% of horse chestnut trees in urban areas of south-east England had signs of the disease (Forestry Commission, 2008). The disease causes bark infections which bleed a dark sticky fluid. It affects trees of all ages and can lead to death, but trees can also have periods of remission and can recover. Horse chestnut trees are also susceptible to leaf miner (*Cameraria ohridella*) and leaf blotch (*Phyllosticta paviae*).

**Mountain ash ringspot associated virus**

The European mountain ash ringspot associated virus is a pathogen that attacks the leaves of *Sorbus* trees, causing mottling and discolouration, and in extreme cases increasing the tree's susceptibility to other pests and diseases, reducing the productivity of the tree, and leading to its gradual decline. The main host is *S. aucuparia*, but *S. aria*, *S. torminalis* and *S. domestica* are known to be affected, and the virus has been reported on ornamental *Sorbus* species. It is thought that the virus can move between hosts via grafting wounds and cuttings, and it is unclear whether mites are also involved in the spread of the virus to new hosts. In Europe symptoms have been reported in Czechia, Finland, Germany, Poland, Russia, and Sweden.

**Oak processionary moth**

Oak processionary moth (OPM) (*Thaumetopoea processionea*) was accidentally introduced to Britain in 2005 and there are now established OPM populations in most of Greater London and in some surrounding counties. An OPM population in Hampshire was eradicated in 2023[17]. It is thought that OPM has been spread through imported nursery trees. The caterpillars cause serious defoliation of oak trees, their principal host, which can leave them more vulnerable to other stresses. The caterpillars have urticating (irritating) hairs that can cause serious irritation to

17 https://forestry.maps.arcgis.com/apps/webappviewer/index.html?id=c647b00b75d34647aeb5a9d07eca9785

the skin, eyes and bronchial tubes of humans and animals. They are considered a significant human health problem when populations reach outbreak proportions, such as those in the Netherlands and Belgium in recent years. Whilst the outbreak in London is beyond eradicating, the rest of the UK maintains its European Union Protected Zone status (PZ) and restrictions on moving oak trees are in place to minimise the risk of further spread.

**Phytophthora kernoviae**

*Phytophthora kernoviae* is a water mould which can cause disease on the above-ground parts of a wide range of trees, shrubs, and other plants. It causes bleeding cankers on oak and beech tree trunks, and necrosis on the leaves of rhododendrons and magnolias. The winter bark of infected trees produces large quantities of spores which spread the disease, but research suggests that only trees within 5 metres of heavily infected plants (e.g. rhododendron) are at risk, and that infected trees may not be contagious and can recover from infection. Most cases in the UK are located in south-west England, but the disease can also be found in other parts of the UK. Susceptible trees include:

- *Fagus sylvatica*
- *Liliodendron tulipifera*
- *Quercus ilex*
- *Prunus laurocerasus*
- *Ilex aquifolium*
- *Pinus radiata*
- *Magnolia spp.*
- *Rhododendron spp.*
- *Quercus robur*

**Pine processionary moth**

Caterpillars of the pine processionary moth (*Thaumetopoea pityocampa*) pose a threat to the health of pine trees (*Pinus spp.*) and some other conifer species by feeding on foliage. This can weaken the trees and make them more susceptible to other pests and diseases and to environmental stresses. Like Oak processionary moth, the larvae also pose a hazard to human and animal health. Pine processionary moth is native to southern Europe, North Africa, and parts of the Middle East. Unusually, the larvae of this species hatch in late summer or autumn and feed throughout winter. Local temperature and solar radiation are both important factors when considering climate suitability for this species. Owing to warming winters it has spread north as far as Hungary, Switzerland, and France. It is not known to be present in the UK although occasional single moths and a transient population have been found and eradicated in southern England.

**Ramorum disease**

*Phytophthora ramorum* is a water mould, a fungus-like organism that can attack a wide range of trees and other plants. The collective name for the diseases it causes are referred to as Ramorum disease or sudden oak death (note that the genetic forms of *P. ramorum* present in the UK have had little effect on our native oak species *Quercus robur* and *Q. petraea*). For details of symptoms on trees visit Forest Research's Ramorum manual.[18] The disease was first found on a plant in a garden centre in Sussex in 2002, and the first incidence on a mature tree in the UK was in 2003. Ramorum disease has been found and eradicated in Hampshire. The pathogen can be spread on footwear, vehicles, tools, and machinery, by the movement of infected plants, and in rain, mist and air. It is a particular problem for

[18] https://www.forestresearch.gov.uk/tools-and-resources/fthr/pest-and-disease-resources/ramorum-disease-phytophthora-ramorum/phytophthora-manual-2-identification-and-symptoms-of-ramorum-disease/

larch forests. *P. ramorum* affects but is not limited to the following genera and species:

- *Abies alba*
- *A. grandis*
- *A. procera*
- *Acer pseudoplatanus*
- *Aesculus hippcastanum*
- *Betula pendula*
- *Castanea sativa*
- *Chamaecyparis lawsoniana*
- *Fagus sylvatica*
- *Fraxinus excelsior*
- *Ilex aquifolia*
- *Larix spp.*
- *Magnolia spp.*
- *Picea sitchensis*
- *Pseudotsuga menziesii*
- *Quercus cerris*
- *Q. ilex*
- *Q. petraea*
- *Q. robur*
- *Q. rubra*
- *Salix caprea*
- *Sequoia sempervirens*
- *Sorbus aucuparia*
- *Taxus baccata*
- *Tsuga heterophylla*

**Red-necked longhorn beetle**

The red-necked longhorn beetle (*Aromia bungii*) is a highly damaging pest of trees, particularly in the *Prunus* genus. Larvae tunnel through the bark of trees and into the phloem, interrupting the flow of nutrients. Trees are weakened and become more susceptible to other pests and diseases, and severe infections can result in death. The beetle is thought to be native to China, Korea, Taiwan, and Vietnam. No outbreaks have occurred in the UK, but individuals were found on wooden pallets in a warehouse in 2008, and intercepted.

**Sooty bark disease of maple**

Sooty bark disease of maple is caused by a fungus called *Cryptostroma corticale*, which is thought to have originated in North America. It primarily affects *Acer* species, particularly *A. pseudoplatanus*, *A. campestre*, *A. platanoides*, and *A.*

*negundo*. The fungus enters the tree through wounds, and spores grow in profusion under the bark of the tree or stacked logs, resulting in wilting, dieback, and death. Patches and strips of bark fall off the trunk and exposes thick layers of spores. The spores cause inflammation of the lungs in humans, and great care must be taken when working with infected trees (Braun et al., 2021). The fungus has been found to grow fastest at warmer temperatures and in trees subject to water stress, suggesting that sooty bark disease caused by the fungus is associated with hot, dry summers (Dickenson and Wheeler, 1981; Ogris et al., 2021). The disease was first found in the UK in 1945 and has the potential to become increasingly significant in our changing climate.

**Xylella**

*Xylella fastidiosa* is a bacterium that has the potential to cause significant damage or death to a range of broadleaf trees and commercially grown plants. The bacterium has been found in parts of Europe and can be spread through the movement of infected plant material and through insects from the Cicadellidae and Ceropidae families. There are four known subspecies: *Xylella fastidiosa* subsp. *multiplex, Xylella fastidiosa* subsp. *fastidiosa*, *Xylella fastidiosa* subsp. *pauca* and *Xylella fastidiosa* subsp. *Sandyi.* The subspecies *multiplex* is thought to be able to infect the widest variety of trees and plants, including *Quercus robur* and *Liquidambar styraciflua*. Known hosts include:

- *Acer pseudoplatanus*
- *A. rubrum*
- *Alnus spp.*
- *Cornus spp.*
- *Ficus carica*
- *Laurus nobilis*
- *Liquidambar styraciflua*
- *Olea europaea*
- *Prunus spp.*
- *Quercus robur*
- *Q. rubra*
- *Ulmus glabra*

**Pests and diseases resources**

Defra plant health portal UK Plant Health Information Portal - UK Plant Health Information Portal (defra.gov.uk)

Defra Plant health risk register UK Plant Health Risk Register

Forest Research Pest and disease resources pests and diseases resources and advice - Forest Research

TreeCheck About TreeCheck | Department of Agriculture, Environment and Rural Affairs (daera-ni.gov.uk)

Observatree An early warning system for tree health and tree disease - Observatree

TreeAlert TreeAlert - Forest Research

Current and future Climate Matching Tool Climate Matching Tool

Ecological Site Classification tree selection tool Ecological Site Classification (ESC) - Forest Research

The Right Trees for Changing Climate database Right Trees For a Changing Climate (righttrees4cc.org.uk)

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