i-Tree Eco Vale of Glamorgan

Understanding the Vale's Tree Resource: Technical Report

The Research Agency of the Forestry Commission

Forest Research

Forest Research is the Research Agency of the Forestry Commission and 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.

Treeconomics

Treeconomics is a social enterprise, whose mission is to highlight the benefits of trees. Treeconomics works with businesses, communities, research organisations and public bodies to achieve this.

i-Tree

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.

This project has been undertaken on behalf of:

Vale of Glamorgan Council

VALE of GLAMORGAN
BRO MORGANNWG

Citation

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Copies of this report and other corresponding documents can be downloaded from:

https://www.valeofglamorgan.gov.uk/en/index.aspx

Images

Taken on behalf of the Project by Devon Tree Services (taken September 2021)

Contents

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' (Davies et al., 2017).

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

Natural capital: refers to the elements of the natural environment – such as the trees and shrubs of an urban forest - that provide goods, benefits and services to people, such as clean air, food and opportunities for recreation (Natural Capital Committee, 2014). As the benefits provided by natural capital are often not marketable, they are generally undervalued, and inventories limited. This can lead to poor decision making about the management and maintenance of natural capital.

A full Glossary is provided on pages 86-88

Executive Summary

Trees are a valuable resource that can provide a wide range of benefits to people and the environment. These benefits, known as ecosystem services, can help to reduce the impact of people on the landscape and lessen some of the effects of the changing climate. Such ecosystem services include capturing and storing carbon, providing habitat for wildlife, improving local air quality, reducing flooding and improving social cohesion in communities.

Effective and sustainable management of treescapes is important for the continual provisioning of these benefits. Management and maintenance of trees can affect the vitality, structure and composition of the total tree stock, and significant losses of trees due to threats such as pests and disease can also impact ecosystem service delivery. To inform management practice and tree planting, it is important to understand the current state of this resource.

To gain such an understanding requires a substantial information gathering exercise. As part of the 'i-Tree Eco Vale of Glamorgan' project, a total of 681 plots were surveyed throughout the Vale of Glamorgan, and information collected on the trees within them, and the land they are situated on. This included trees in urban and rural areas.

i-Tree Eco, a tool used worldwide for assessing and evaluating tree resources, was used to better understand the trees that are found throughout the Vale of Glamorgan; what species are present, where they are and what condition they are in. The information can act as a baseline which can help to understand the challenges and threats, set appropriate goals, and monitor progress.

This report provides a detailed breakdown of the structure, composition and condition of the Vale of Glamorgan's trees, and demonstrates the importance of the tree resource to local people.

It is estimated that there are **more than 1.7 million trees in the Vale of Glamorgan**. The Vale of Glamorgan's urban forest (all trees within the Vale's towns and built-up areas) provides ecosystem services worth **in excess of £2.05 million each year**. This includes avoided water runoff, carbon sequestration and the removal of three types of air pollution. As such, this value estimation is still an underestimate, many of the ecosystem services provided by trees could not be assessed as part of this project.

It is important to note that the results of this project are a snapshot in time and do not consider how and why the Vale of Glamorgan's tree resource may change over time.

This project was funded by the Vale of Glamorgan Council and carried out by Forest Research and Treeconomics. Fieldwork was conducted by Forest Research's Technical Services Unit (TSU) and Devon Tree Services. Our thanks go to the Vale's landowners and residents for granting us access to their property to undertake the survey work.

Headline Facts and Figures

Table 1. The estimated structure and composition of the Vale of Glamorgan's tree resource in 2021

Structure and composition of the Vale of Glamorgan's tree resource in 2021				
	Urban		Rural	
Estimated total number of trees	143,400	Pg.27	1,606,000	Pg.61
Estimated average tree density (trees per ha)	39.7	Pg.27	47.3	Pg.61
Estimate of total tree canopy cover (%)	13%	Pg.28	14%	Pg.61
Number of tree species surveyed	59	Pg.31	40	Pg.63
Top three most common species surveyed	Common ash, Sycamore, Common Hawthorn	Pg.31	Common ash, Common hawthorn, Sycamore	Pg.63
Land uses where a greater percentage of surveyed trees were found	Residential, Park, Commercial/Industrial	Pg.29	Agriculture, Vacant, Park	Pg.61
Proportion of surveyed trees of different sizes (by DBH*)	7-20 cm: 45.4% 20-40 cm: 32.2% 40-60 cm: 14.9% >60 cm: 7.5%	Pg.35	7-20cm: 44.4% 20-40cm:37.2% 40-60cm:13.2% >60cm: 5.3%	Pg.64
Proportion of trees in good or excellent condition	72%	Pg.55	43%	Pg.67
Top pest and disease threat	Present: Ash dieback Potential: Asian Longhorn Beetle	Pg.60	Present: Ash dieback Potential: Asian Longhorn Beetle	Pg.70

* DBH: Diameter at Breast Height

Table 2. The estimated amount and value of some of the ecosystem services delivered by the Vale of Glamorgan's urban trees in 2021

Estimated ecosystem service provision amount and value provided by the Vale of Glamorgan's urban forest in 2021			
Avoided runoff	78,438m^3	£135,838 per yr	Pg. 41
Pollution removal	36 tonnes per yr	£212,481 per yr	Pg. 43
Carbon storage	57,314 tonnes	£51,467,972	Pg. 47
Net carbon sequestration	1977 tonnes per yr	£1,775,346 per yr	Pg. 47
Replacement cost	Amenity value of all trees: £1,551,402 Structural value of all trees: £126,101,683		Pg. 53
Total annual benefit	**£2.05 million** (air pollutant removal, net carbon sequestration and avoided runoff, equivalent to £569/ha, or £15.16 per capita[1]		

1. Based upon the 2020 mid-year estimate of the whole of the Vale of Glamorgan population, which was 135,295 (Welsh Government, 2021)

Using this report

This technical report provides detailed baseline information on the structure and composition of the Vale of Glamorgan's trees, and the benefits they deliver. It may be used to help inform strategic thinking and future decision-making with regards to the Vale's tree resource.

This report has been produced for Vale of Glamorgan Council, but can also be used by:

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

This report forms part of set of documents produced as part of the 'i-Tree Eco Vale of Glamorgan' project. These include:

- Understanding the Vale's tree resource: Summary Report
- Guiding future tree planting
- Trees in the Vale of Glamorgan (Infographic)

An appendices section has been included within this report to provide further detail on the information captured and analysed as part of this project.

Key Conclusions

- There is an over-reliance on Common ash in both the urban and rural tree population. In light of ash dieback, this presents a threat to the overall resilience and sustainability of the Vale of Glamorgan's tree resource and the benefits it provides.
- Much of the Vale of Glamorgan's urban forest is privately owned, with over half of all trees surveyed located on residential property. Strategic tree management should consider prioritising engagement with the local community to enhance and protect existing tree cover.
- There is little difference in tree canopy cover values for both rural and urban areas, both of which are below the reported averages for Wales and fall short of published recommended canopy cover targets.
- The Vale of Glamorgan's rural area is dominated by agricultural land, comprising over four fifths of all plots surveyed. This presents potential opportunities to increase tree cover and ecological connectivity through further woodland planting and agroforestry.

Introduction

Trees form a core component of our urban and rural spaces and have a unique ability to deliver a range of environmental and societal benefits on a scale greater than many forms of engineered infrastructure. These benefits, termed ecosystem services, range from improving air quality, alleviating flooding, sequestering and storing carbon, to reducing temperatures in urban areas, and enhancing our natural environment, local communities and economy (Figure 1 and

Table 3).

The delivery of these ecosystem services is particularly important in our towns and cities. Vast areas of urban spaces are dominated by hard, impermeable infrastructure, contributing to the urban heat island effect (the phenomenon where urban areas are warmer than their surrounding countryside) and increasing surface water runoff. With over 80% of the UK's population living in towns and cities (Defra, 2021), these impacts are widespread and are projected to worsen under the changing climate. It is no wonder that with an increasing focus on climate change mitigation, local authorities and other organisations responsible for caring for the environment seek to use trees as a tool to alleviate some of the impacts of the changing climate.

There has been a surge in tree planting over the last few years, particularly more so since many local authorities up and down the UK declared climate emergencies. This has also led to increased public interest in trees, as well as an uptake in planting activities occurring on both public and private land. Increasing tree cover through planting more trees is an important aspect of ensuring a sustainable tree resource. However, it is important to understand how this ties together with the existing tree stock, as this will inform future tree management, such as planning the workload of maintenance throughout the lifetime of trees, predicting budgets necessary for tree care, and setting schedules for regular health and safety inspections where necessary.

Trees are important assets and need to be treated as an investment. As such, future tree planting needs to be informed to ensure that planting activities are not in vain, and do not result in widespread failures in tree establishment through poor tree and site matching or lack of aftercare. Such instances can present significant costs and losses of the intangible monetary benefits that trees can provide if nurtured to maturity (Hand, et al., 2019).

Mature trees are a cornerstone of the tree resource. In particular, large, mature trees are capable of providing greater quantities of some ecosystem services. This is because typically, leaf area (the total surface area of a tree canopy) is directly related to the amount of benefit provided, so for example, the larger a tree's leaf area the greater the amount of air pollution or rainfall can be held in the canopy of the tree. It is therefore important that protection and good management of the existing tree population is implemented, so that growing trees to maturity can be prioritised to enable them to function to their greatest potential. Such management should complement the planting of new trees to increase canopy cover and to replace trees as they become over-mature and die, or succumb to pests, diseases or other stresses.

Figure 1. A summary of the benefits provided by trees that have been measured and valued for the Vale of Glamorgan's urban areas as part of this project.

Rainfall interception and avoided surface water run-off

The Problem
In urban areas in particular, a higher proportion of impermeable surfaces, such as tarmac, can increase the risk of surface water flooding, which can lead to higher costs to treat the resulting sewage discharge.

What trees can do
The canopies of trees can intercept rainfall and reduce the amount that reaches the ground and forms floodwater runoff. Where trees are planted in areas of higher permeable cover, tree roots also contribute to flood prevention by taking up water.

Relevance to the Vale of Glamorgan
In December 2020, a 1 in 20-year rainfall event led to the internal flooding of 18 properties in Sully and also affected other residences and local transportation links. The flooding was attributed to run-off from nearby fields, which quickly led to the drainage network reaching full capacity (JBA Consulting, 2021). Following this, action to mitigate such events happening again was recommended, and it is suggested that trees can form part of such alleviation schemes.

Air pollution removal

The Problem
Air pollution is often linked to poor health outcomes, particularly respiratory conditions (e.g. asthma), and can even lead to premature death. It is estimated that the effects of long-term exposure to air pollution equate to 1,000-1,400 deaths in Wales each year (PHE, 2018; PHW, 2020).

What trees can do
Trees can help reduce overall exposure to air pollutants harmful to human health, such as nitrogen dioxide (NO2) through absorption or interception. Trees can also reduce local temperatures which reduces the rate at which some pollutants (e.g. ozone) are formed (Jacob & Winner, 2009)

Relevance to the Vale of Glamorgan
The Vale of Glamorgan has historically had one Air Quality Management Area (AQMA), which was declared for NO_2 in Penarth in 2013. Following a successful 3-year period whereby all objectives were met, the AQMA was revoked in 2021. However, it remains important that improvements to air quality are considered. Retention, and replacement where necessary, of trees along transport networks that receive both high pedestrian footfall and busy traffic should be prioritised.

Carbon storage and sequestration

The Problem
Increasing levels of carbon dioxide (CO_2) in the atmosphere are significantly contributing to climate change, which is predicted to bring about increased summer temperatures and more winter rainfall and storms.

What trees can do
Reducing CO_2 emissions could help reduce the impact of climate change. CO_2 can be removed from the atmosphere by trees and stored within their woody components. Trees can continue to sequester carbon throughout their lifetime.

Relevance to the Vale of Glamorgan
The Vale of Glamorgan has one of the highest ecological footprints in Wales, at 3.53 global hectares per capita. The county's carbon footprint is also high, at 11.48 tonnes of CO_2 equivalent per capita, which ranks it 7th out of Wales's 22 local authorities (GHD, 2015). The Vale's carbon land requirements are 64% - slightly higher than the Welsh average (63%), suggesting increased tree planting would be beneficial.

Figure 1 (cont.). A summary of the benefits provided by trees that have been measured and valued for the Vale of Glamorgan's urban areas as part of this project.

Habitat provision

The Problem
Changes in land management practice, invasive species, urbanisation, and pollution are key drivers of net loss in UK biodiversity (UK National Ecosystems Assessment, 2011).

What trees can do
Trees are vital sources of food and habitat for a variety of flora and fauna. Trees in urban areas in particular can boost people's engagement and feeling of connection with nature. Woodland trees can provide wildlife corridors to facilitate movement between sites.

Relevance to the Vale of Glamorgan
There are more than 22 Sites of Special Scientific Interest (SSSIs) in the Vale. The county hosts a rich biodiversity, with many different habitats and species, as well as a designated Heritage Coastline that spans 19km in length (Wales Biodiversity Partnership, 2022). However, there is a large amount of agricultural land in the Vale which may not be supporting as many species as it could, and there are many isolated fragments of woodland that limit habitat connectivity.

Amenity value

The Problem
The demand for grey infrastructure to support the UK's growing population can consume greenbelt land, lead to loss of canopy cover to make space for new development and as a result reduce the overall amenity value that trees and green infrastructure can provide.

What trees can do
Trees and green and blue infrastructure such as shrubs, green spaces and water bodies, that are visually accessible can contribute significantly to the amenity value of an area. This can also be linked to improved mental health outcomes and feelings of happiness.

Relevance to the Vale of Glamorgan
The Vale of Glamorgan's Community Strategy (2011-2021) outlines the need to protect and enhance the quality of the built and natural environment as one of its 10 priority outcomes. Enhancing the Vale's existing green infrastructure and limiting that which is lost to further development is important to allow opportunities for the general public to access nature. This is likely to be particularly important to the north of the Vale of Glamorgan, around Llantrisant, and in St Athan, which were identified as Strategic Opportunity Areas as part of the Wales Spatial Plan in 2008.

Table 3. A summary of further ecosystem services provided by trees, which were not measured as part of this project.

Ecosystem service	What urban trees do	Relevance to the Vale of Glamorgan
Cultural and historical 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.	Some ancient trees of interest including oaks, ash, horse chestnuts and sycamores, can be found within Dyffryn Gardens (Ancient Tree Forum, 2017). There are still many mature trees within Penarth and Barry, linking these areas to their Victorian seaside resort past.
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.	Forest school programmes are an important mechanism of learning in the Vale of Glamorgan. The rangers at Porthkerry Country Park play a key role in delivering nature-based activities and educational programmes at the Forest Lodge.
Noise reduction	When planted densely in wide shelterbelts, trees can significantly reduce the noise and apparent loudness of passing traffic and other industrial noise.	In 2019, it was estimated that 738.2 million vehicle miles were travelled in the Vale of Glamorgan (Department for Transport, 2022). Whilst there are no major road networks within the Vale, noise pollution mitigation is still important to reduce the incidence of noise-related health problems such as Noise Induced Hearing Loss, stress and high blood pressure.
Temperature regulation	Trees can contribute to local cooling through evapotranspiration and shading. Temperature regulation by trees is particularly important in towns and cities, to mitigate the urban heat island effect.	The Met Office expects hot summers to become more common (2021), 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 (Forest Research, 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 10 parks in the Vale of Glamorgan that have been recognised with a green flag award (Vale of Glamorgan Council, 2022). Continuing to maintain these greenspaces to this high standard is important for local residents who use the parks for recreation.

Understanding the structure and composition of the trees within the Vale of Glamorgan provides the opportunity to explore the current asset's species diversity, size distribution and susceptibility to pests and diseases. This is important for understanding the management needs of the overall tree resource, whilst also providing a clear baseline from which future tree planting can be guided, and further opportunities identified to diversify the tree population.

The project also provides the Vale of Glamorgan Council with information that can be used to engage with the local community, and to demonstrate the importance of trees in urban and rural landscapes. There is already the benefit of current enthusiasm and momentum within the local community, for example, through the preparation of a Tree Strategy for Penarth, by Penarth Civic Society. Community engagement is an important aspect of managing trees near to people, and projects that have involved members of the local community have yielded many benefits (see Moffat and Doick, 2019). One such benefit is that community engagement provides the opportunity to implement action that may be brought about by the findings of this project, and to build upon the findings further with continual monitoring and the input of specific local knowledge.

Project aims

- To gain a current baseline understanding of the extent, composition, and condition of the Vale of Glamorgan's tree resource in rural and urban areas
- To value some of the ecosystem services that the Vale of Glamorgan's urban trees can provide
- To inform target-setting for increasing tree canopy cover, and the development of a tree strategy that considers the effective management and enhancement of the Vale of Glamorgan's trees
- To increase awareness of the importance of trees in the Vale of Glamorgan and the benefits they can provide.

What difference can i-Tree Eco make?

i-Tree Eco software has been used within this project to collect information on the Vale of Glamorgan’s tree resource and quantify the value of the county’s urban forest. i-Tree Eco has been used to gain a comprehensive understanding of over 30 urban forests across the UK since it was introduced to the UK in 2011. Some of the benefits that have arisen following the completion of an i-Tree Eco project include:

- In Cardiff, i-Tree has helped with planning related to Ash dieback and has highlighted the importance of the city’s urban forest, particularly in relation to the pressures of development, land sales and infrastructure improvements. It has also been an important resource for feeding into the One Planet Cardiff strategy, which has in turn led to the ~£1m Coed Caerdydd project which will see thousands of trees planted across the city.
- Increased investment in the management of the urban forest, such as securing two £25k budget increases in 2 years in Torbay, and the creation of an arboricultural officer post in Wrexham.

For further information on the impacts of some of the i-Tree Eco projects completed over the last 10 years, see the review ‘Evaluation of i-Tree Eco surveys in Great Britain’ by Hall, et al., 2018; Hand and Doick, 2018.

Data limitations

i-Tree Eco presents a first estimate of the tree resource and the benefits it provides. The valuations presented within this report are limited to the urban area of the Vale of Glamorgan only. This is because the ecosystem services that are currently measured within i-Tree Eco do not ‘carry across’ to the rural area of the Vale of Glamorgan.

The ecosystem services measured within i-Tree Eco are only a few of the many benefits that trees provide. As such, the valuations presented within this report should be treated as a conservative estimate of the full value of benefits that the Vale of Glamorgan's urban forest provides. It is also important to realise that:

- The v6 i-Tree Eco model provides a snapshot-in-time picture 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 requires air pollution data from a single air quality monitoring station and the data used therefore represents an urban area average, not localised variability.
- i-Tree Eco is a useful tool providing essential baseline data required to inform management and policy-making 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.

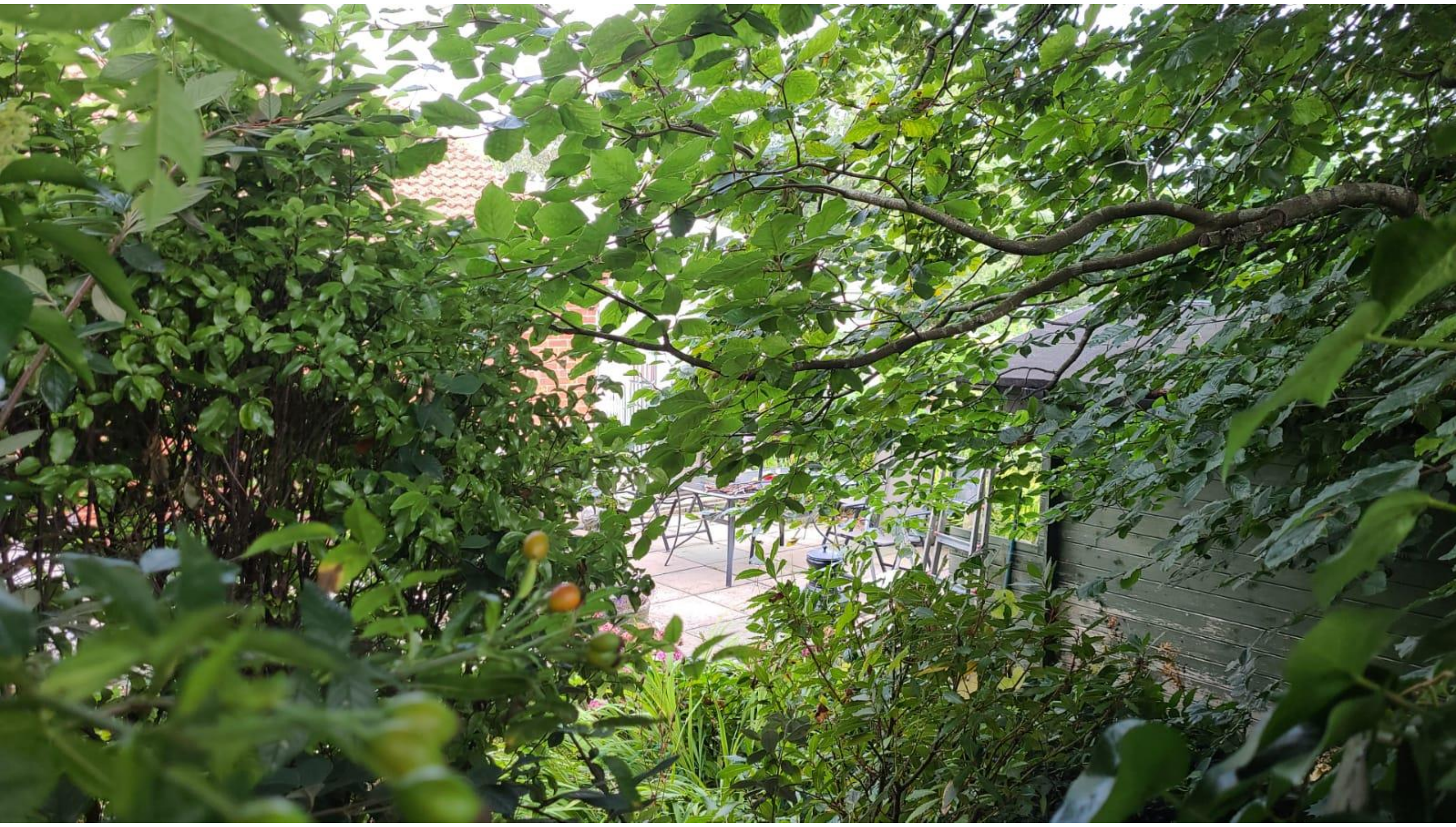
For further guidance, refer to the Urban Tree Manual (Defra, 2018).

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. The website also includes many of the reports generated by the i-Tree Eco studies conducted around the world.

For further details on i-Tree Eco in the UK, on-going i-Tree Eco model developments, training workshops, or to download reports on previous UK i-Tree Eco studies visit www.forestresearch.gov.uk/research/i-tree-eco and www.treeconomics.co.uk.

The identification, measurement, mapping and caring of trees in the urban environment create 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) and the UK Canopy Cover mapping project on Forest Research's website (https://www.forestresearch.gov.uk/research/i-tree-eco/urbancanopycover/).



Methodology

i-Tree Eco uses a plot-based method of sampling, whereby plots (circular areas of land of 0.04ha in size) are distributed throughout the survey area. It is within these plots that data are collected. i-Tree Eco software then extrapolates this data to represent the entire study area.

Sampling strategy

The Vale of Glamorgan was split into two distinct areas: the urban and the rural (Figure 2). For each area, a grid was overlaid onto a map and plots were randomly distributed within each grid square. This allowed reasonable assumption that there would be spatial representation, and that it would avoid the potential for clumping with true random sampling.

Figure 2. Map of the total study area, with plot distribution for both urban and rural areas

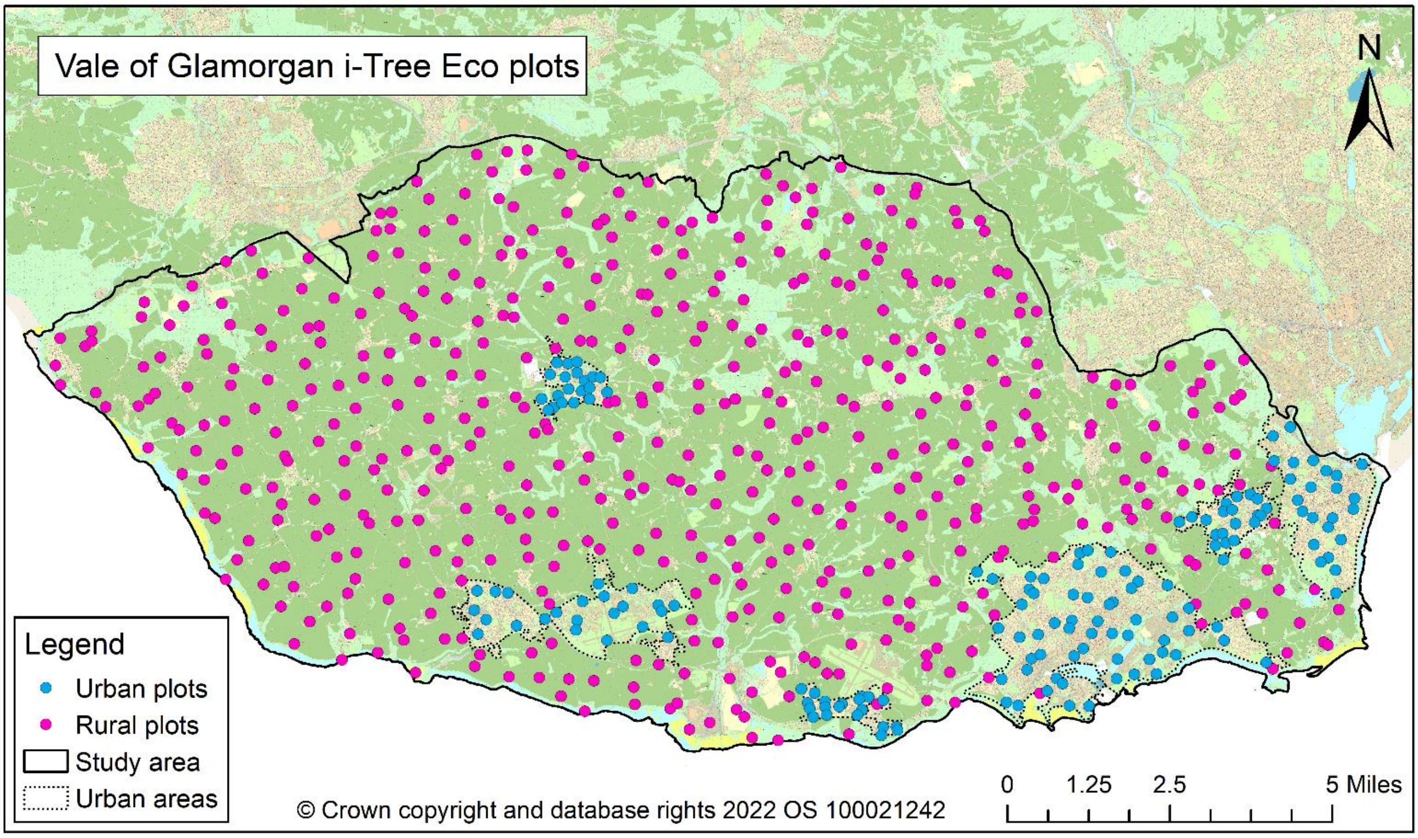


Table 4 below lists the urban areas that were included within the study. Each urban area was treated as a separate stratum to allow comparisons between towns. The urban area was 3,609ha in total. A minimum of 20 plots per stratum was required to allow for i-Tree Eco analysis. Plot density was the determining factor when deciding on the number of plots to be distributed for each locality.

Table 4. Urban areas that were included within the Vale of Glamorgan's i-Tree Eco survey

Urban Area Name	Area (ha)	Number of plots	Plot density (plot/ha)
Cowbridge	160	20	1/8ha
Llanwit major and St Athan (contiguous)	682	23	1/29.7ha
Barry and Barry Island (contiguous)	1707	57	1/29.9ha
Rhoose	136	20	1/6.8ha
Penarth	712	24	1/29.7ha
Murch	212	20	1/10.6ha
	Total Number of plots	164	

All land outside of the urban areas but within the county boundary was classed as rural. This included those smaller urban areas on or near the border of Bridgend and Cardiff. The rural area was 33,980ha in total, and 517 plots were distributed resulting in a plot density of 1 plot every 65ha. Whilst this plot density is lower than that of the urban areas, existing data suggested a high proportion of the land use in the rural area was agricultural, and therefore, the more homogenous nature of the rural area deemed it acceptable to have a sparser plot distribution.

Data collection

The data collection methods differed for urban and rural areas. For urban areas, a comprehensive list of data was collected for each plot to allow for full analysis of structure, composition and the value and amount of ecosystem services provided. For rural areas, the data collected were more limited, to enable higher plot repetition, but sufficient data were collected to be able to describe the structure and composition of the rural tree stock. The data collected include:

Urban areas:

- Land use type, e.g. park, residential
- Ground cover (%), e.g. grass, tarmac
- Tree and shrub cover (%)
- The % of plot that could have trees planted in it
- Information on the trees present within the plot, including:
    - Number of trees and their species
    - Size of the trees, including height, canopy spread and diameter at breast height (DBH) of the trunk (measured at 1.5m above ground level)
    - The condition of the tree, including fullness of the canopy
    - The amount of light the tree canopy is exposed to
    - The estimated life expectancy of the tree

Rural areas:

- Land use type
- Tree cover (%)
- The % of the plot that could have trees planted in it
- Information on the trees present within the plot including:
    - Number of trees and their species
    - DBH of the trunk
    - The condition of the tree

For rural areas plots with no tree cover, and for which recent aerial imagery was available, were filtered out and remotely surveyed to assess land use type.

Replacement cost and amenity value

i-Tree Eco provides valuation estimates for the like-for-like replacement of trees in urban areas based upon the CTLA (1992) valuation method. These are described as 'replacement costs' when presented in the results and offer a 'structural value' of the tree. Urban trees also have the potential to provide significant amenity value. As such, an amended version of the Capital Asset Value for Amenity Trees (CAVAT) Quick Method (Doick, et al. 2018) was also used to assess the value of the Vale of Glamorgan's urban forest. CAVAT values are based upon tree size (trunk diameter) and are depreciated for attributes that impact its contribution to amenity. CAVAT includes a Community Tree Index (CTI) factor which adjusts the CAVAT 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.

Pests and diseases

The susceptibility of the Vale of Glamorgan's trees to pests and diseases was assessed using information on the number of trees within pest/pathogen target groups and the prevalence of the pest/disease within the Vale of Glamorgan 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.

Habitat provision

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. A review of the value of different tree species to UK wildlife by Alexander et al. (2006) was used to examine the relative biodiversity value for urban trees. Alexander et al. review a wide range of biodiversity values, giving trees a score from 5 (high value) to 0 (low value) and three examples are shown in this report (foliage invertebrate value, blossom and pollen value, and fruit and seed value). The assessment was supplemented with information from Southwood (1961), Kennedy & Southwood (1984), and RHS (2018a).

Other calculations that have been used within the project are summarised within Table 5 below.

Table 5. Summary of calculations

Variable	Calculated from
Number of trees	Total number of trees; an estimate based on an extrapolation from the sample plots
Tree canopy cover	Total tree cover extrapolated from tree cover (%) measured within plots
Pollution removal value	Based on the UK central damage costs where available: £6,385 per tonne NO_x (nitrous oxides), £13,026 per tonne SO_2 (sulphur dioxide) and £74,403 per tonne $PM_{2.5}$ (particulate matter) (Defra, 2020).
Avoided runoff	The amount of water held in the tree canopy and re-evaporated after the rainfall event (avoided runoff) and not entering the water treatment system. The value used was the household standard volumetric rate of sewerage charges set by Welsh Water (£1.73 per m^3) in 2021/22.
Carbon storage and sequestration values	The baseline year of 2021 and the respective value of £254 per tonne (DBEIS, 2021)
Replacement cost (direct replacement)	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), the value is determined within i-Tree Eco according to the CTLA (Council of Tree and Landscape Appraisers) v9 method.
Replacement cost (amenity valuation)	Using the Capital Asset Value for Amenity Trees (CAVAT) Quick method (amended).

Survey findings – Vale of Glamorgan's Urban Forest

This section of the report presents the results of the i-Tree Eco survey of Vale of Glamorgan's urban forest (collectively Cowbridge, Llanwit major and St Athan, Barry and Barry Island, Rhoose, Penarth and Murch).

Throughout this chapter, some comparisons of previous i-Tree Eco studies in Wales are drawn. However, the area surveyed varies notably with each location, and as such direct comparisons should not be wholly relied upon. These studies include:

- Newport (Buckland et al., 2020)
- Cardiff (Hand et al., 2019)
- Bridgend (Doick et al., 2016b)
- Wrexham (Rumble et al., 2015)

Table 6. Outputs from the Vale of Glamorgan's i-Tree Eco survey of its urban areas compared to five other Welsh surveys.

	Vale of Glamorgan	Newport	Cardiff	Bridgend	Wrexham
Study area size (ha)	3,609	4,854	14,064	4,440	3,833
Number of trees	143,400[1]	259,900	1,410,000	439,000	364,000
Plot density (one per […] ha)	22[2]	24	71	22	19
Canopy cover (ha)	469[3]	582	2,658	533	652
% Tree canopy cover	13%	12%	19%	12%	17%
Average number of trees per ha	40	54	100	99	95

1. This represents 1 tree per resident (based upon the 2020 mid-year estimate of the Vale of Glamorgan's population, which was 135,295, Welsh Government, 2021)
2. Plot density differed between each urban area surveyed. This figure presents an average plot density for the entire urban forest. For more information on the plot density per strata, see Table 4.
3. This is approximately 5 x the size of Porthkerry Country Park which covers 89 ha (Vale of Glamorgan Council, 2021)

Canopy Cover

The **tree canopy cover of the Vale of Glamorgan's urban forest is estimated to be 13%.** This is higher than the canopy cover recorded in Newport and Bridgend (12% and 12% respectively), but lower than that of Cardiff (19%) and Wrexham (17%). It is also lower than the reported 2013 average of 16.3% for Welsh urban areas (NRW, 2016), but slightly higher than the previously estimated canopy cover of 12.3% for Vale of Glamorgan in 2013. The 2013 NRW study used the same boundaries as those that were used to identify urban areas for this study. For a further breakdown of estimated canopy cover per each urban area in the Vale of Glamorgan, see Table 9.

Ground Cover

The ground cover in the Vale of Glamorgan's urban areas mainly consisted of permeable materials (51%), with the most widespread ground cover being grass (maintained). This figure is lower than Cardiff (59% permeable cover), but higher than Newport (46% permeable) and Bridgend (49% permeable). Impermeable surfaces can increase the potential for surface water flooding through reducing and slowing the infiltration of rainfall into the soil. Impermeable surfaces can also contribute to local heating of the urban environment, therefore greater presence of permeable cover is favourable. Urban trees can contribute to the alleviation of these impacts through intercepting rainfall and regulating the local climate.

Land use

Error! Reference source not found.a and 3b illustrate the proportion of land use of the plots that were measured, and the proportion of land uses where trees were found.

Residential land makes up the highest percentage across the whole of the Vale of Glamorgan's urban areas, at 49%. This is also the land use with the greatest proportion of tree'd plots (58%).

Land use can be roughly split into public and private ownership. Land uses that might be considered as publicly owned include parks, cemeteries and transportation. Based upon this loose classification, the percentage of tree'd plots found on publicly owned land is estimated to be at 18%. The high proportion of assumed privately owned land presents potential risks and challenges for management. Private ownership means less input into management decisions, replacement tree selection and placement, and can make it more difficult to retain tree cover. An appropriate tree policy that considers the management of trees, particularly in private residences, could be beneficial. It may also help to undertake a more detailed spatial evaluation of the land use within Vale of Glamorgan's urban areas, using GIS to map existing and potential tree cover opportunities.

Figure 3a. Proportion of total plot area within the Vale of Glamorgan's urban areas that was classified by the different land use types.

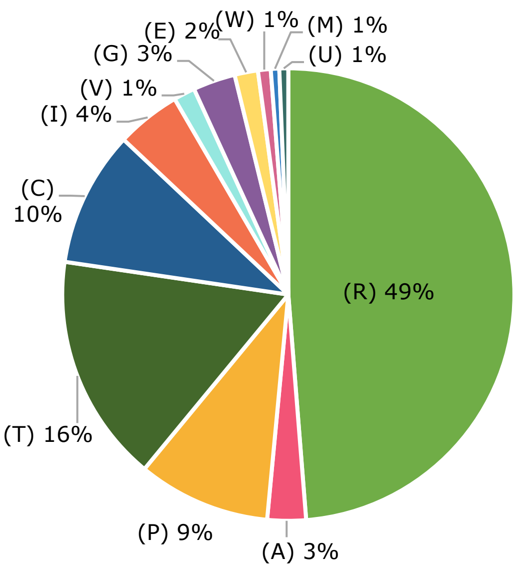
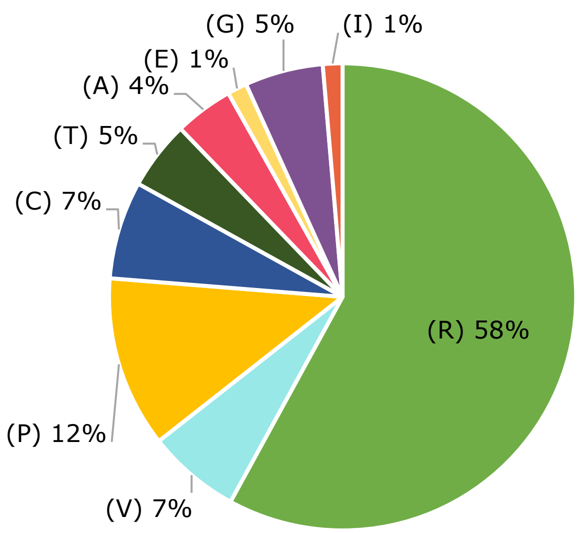


Figure 3b. Proportion of tree'd plot area within the Vale of Glamorgan's urban areas that were classified by the different land use types.



Key:

A = Agriculture	P = Park
C = Commercial/industrial	R = Residential
E = Cemetery	T = Transportation
G = Golf course	U = Utility
I = Institutional	V = Vacant
M = Multi-family residential	W = Water/wetland

Table 7. Tree data for the different land use types surveyed in the Vale of Glamorgan's urban areas

	Land use type											
	Agricultural	Cemetery	Commercial	Golf Course	Institutional	Multi-family residential	Park	Residential	Transportation	Utility	Vacant	Water/ Wetland
Percentage of all plots	2.8%	1.7%	9.7%	3.0%	4.6%	0.6%	9.5%	48.7%	16.3%	0.6%	1.5%	0.9%
Percentage of plots with trees present	4.1%	1.4%	6.8%	5.4%	1.4%	N/a	11.9%	58%	4.7%	N/a	6.4%	N/a
Average canopy cover (%) of plot	43.8%	47.5%	21.4%	39.5%	42.5%	N/a	40.9%	18.1%	26.5%	N/a	27.4%	N/a
Average plot plantable area (%)	52.5%	3.5%	5.7%	34.2%	25%	N/a	19.8%	27.1%	5%	N/a	10.5%	N/a
Number of trees measured	12	4	20	16	4	N/a	35	171	14	N/a	19	N/a
Species richness	9	2	12	7	3	N/a	15	45	8	N/a	5	N/a

Urban Forest Structure

Species composition and diversity

A total of 59 tree species were recorded across each of the urban areas surveyed as part of the study (for a full list of tree species, see appendix II). This is the same number of species identified in Newport, but less than those recorded in Cardiff (73 species), Bridgend (60 species) and the Tawe catchment (88 species).

The three most common species were common ash (*Fraxinus excelsior*) at 10.8%, sycamore (*Acer pseudoplatanus*) at 9.5% and common hawthorn (*Crataegus monogyna*) at 8.1%. The 10 most common species accounted for 60.1% of all the trees surveyed within Vale of Glamorgan's urban forest.

Figure 4a. Top 10 species recorded within the Vale of Glamorgan's urban areas

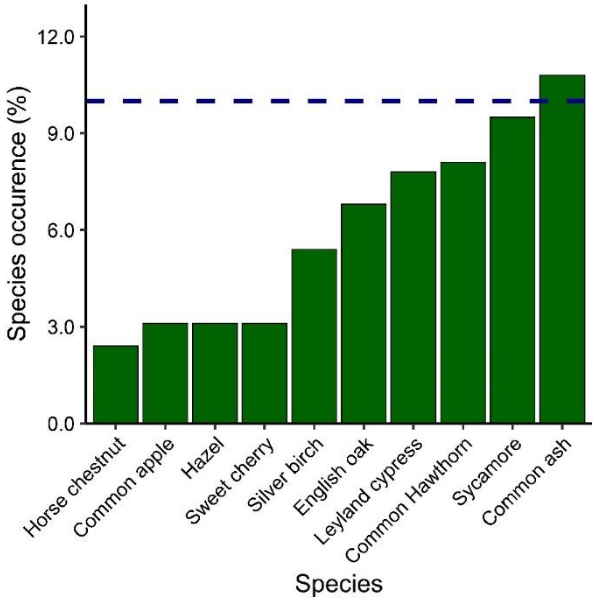
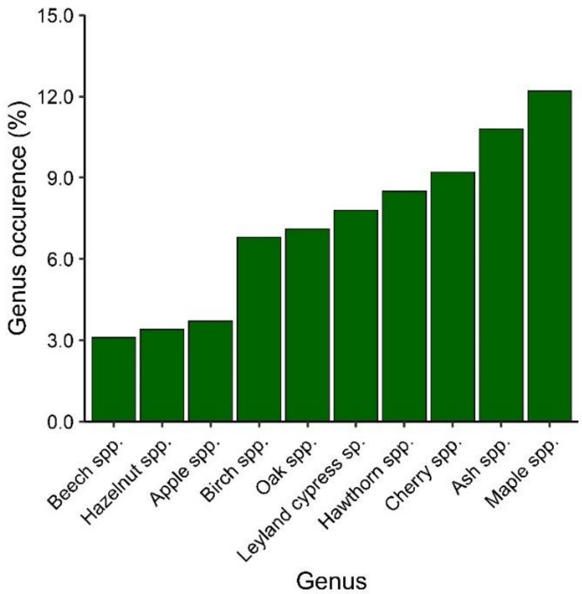


Figure 4b. Top 10 genera recorded within the Vale of Glamorgan's urban areas



Species composition by origin

52% of the trees that were surveyed were native species. Of the remaining trees surveyed, 16% are considered naturalised and 32% non-native. 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. As such, where wildlife provision is an important selection factor for future tree planting, further information should be sought on suitability. Some of the available information and research on this is covered within the document 'Tree Planting Recommendations for the Vale of Glamorgan'. For information on food and habitat provided by the Vale of Glamorgan's urban trees, see page 50.

Diversity index

Increased tree species diversity (the amount of different tree species present and their numbers) can offer a higher level of resilience to pests and diseases, as there is less of an opportunity for large numbers of trees to be potentially affected by an outbreak. Over the years, there have been different approaches to assessing whether there is a suitable level of species diversity. In 1990, Santamour recommended that no species should exceed 10% of the total urban tree population, no genus 20%, and no family 30%. There have since been suggestions of a 5-10-15 rule instead (The Morton Arboretum, 2018). Considering both of these approaches the following was observed across the Vale of Glamorgan's urban areas:

- 1 species exceeded Santamour's 10:20:30 guidelines (Common ash, 10.8%)
- 6 species exceeded 5-10-15 guidelines. These were Common ash (10.8%), Sycamore (9.5%), Common hawthorn (8.1%), Leyland cypress (7.8%), English oak (6.8%) and Silver birch (5.4%)
- There was no genus that exceeded the recommended 10-20-30, but 2 genera exceeded the 5-10-15 guideline. These included *Acer* (12.2%) and *Fraxinus* (10.8%).
- No family exceeded the 10-20-30 guidelines, but Rosaceae made up 24.7% of the total tree population, exceeding the 5:10:15 guideline.

The diversity of populations can be calculated using the Shannon-Wiener index, which measures the number of different species and their dominance within the population. According to the Shannon-Wiener index, the diversity score of the Vale of Glamorgan's urban forest is 3.4 (Table 8), which is lower than the scores for Newport (3.5) and Bridgend (3.6), but higher than that of Wrexham (3.1) and Cardiff (3.3). There was greater diversity of tree species in residential areas (3.4), but lower diversity in cemeteries (0.6) and institutional land, e.g., schools, hospitals (1.0). The primary species found within these less diverse land uses were Wild cherry (*Prunus avium*), English oak (*Quercus robur*) and Sycamore (*Acer pseudoplatanus*).

Table 8. Shannon-Wiener diversity index scores for tree species found on different land use types in the Vale of Glamorgan's urban areas

Land Use	Shannon-Wiener Diversity Index Score
Residential	3.4
Park	2.4
Commercial/Industrial	2.4
Agriculture	2.1
Transportation	1.8
Golf course	1.7
Vacant	1.2
Institutional	1.0
Cemetery	0.6
Overall score	**3.4**

Species diversity and its impact on tree management

To improve urban forest resilience as a whole, understanding where species diversity could be improved can be helpful for informing strategic tree planting and tree management at the local level (within towns and wards). In the Vale of Glamorgan's total urban forest, ash is the most frequent tree species, and exceeds the 5:10:15 and 10:20:30 guidelines. In light of ash dieback, which is widely present in the area, the amount of ash surveyed suggests an over-reliance on the species within the urban forest population.

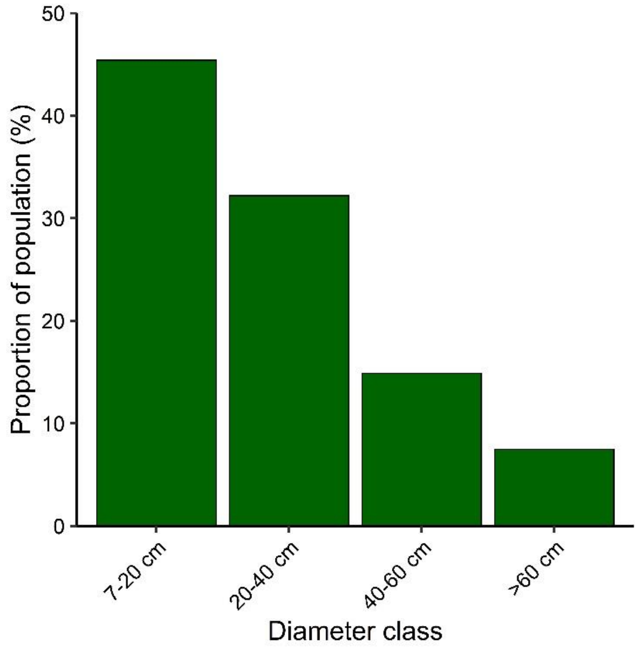
As ash trees will continue to be lost and/or removed as a result of ash dieback, sufficient numbers of trees will be needed to replace those lost. Additionally, a more diverse range of trees should be selected for replacement to enhance overall tree species diversity in the wider urban forest population. Where there is the potential to provide this benefit, such as in woodland and hedgerow settings, the species selection should consider the ecological niche that ash currently fulfils, and aim to continue the provision of at least some of this habitat and/or food. Further information and guidance on this are available in the report 'Tree Planting Recommendations for the Vale of Glamorgan'.

It can be challenging to influence the species selection of trees on privately owned land to encourage greater diversity. Institutional land such as schools, colleges and hospitals may benefit from the help of volunteer groups to increase tree cover on their land, with sufficient steer and guidance from the council to ensure that newly planted trees sit within the management objectives of the landowner and the council.

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 can deliver a greater amount of ecosystem services than smaller trees (Sunderland et al., 2012; Hand et al. 2018, a,b). It is therefore important that where practically possible, large stature trees should be incorporated into new planting. It is also important that trees are supported through to maturity to increase the ecosystem service delivery per tree of the urban forest.

Figure 5. Proportion of the total urban tree population that falls into each DBH class



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 It is estimated that 7.5% of the urban tree population in the Vale of Glamorgan have a DBH larger than 60cm (Figure 5). This is lower than the 10% value recommended by Richards (1983), but higher than that of Newport (6.2%) and Cardiff (6.9%). There is a greater proportion of trees with a DBH of less than 20cm (45.4%). Analysis of the large stature tree species shows that the greatest DBH

Figure 6a. Proportion of trees of large stature that fall into each DBH class

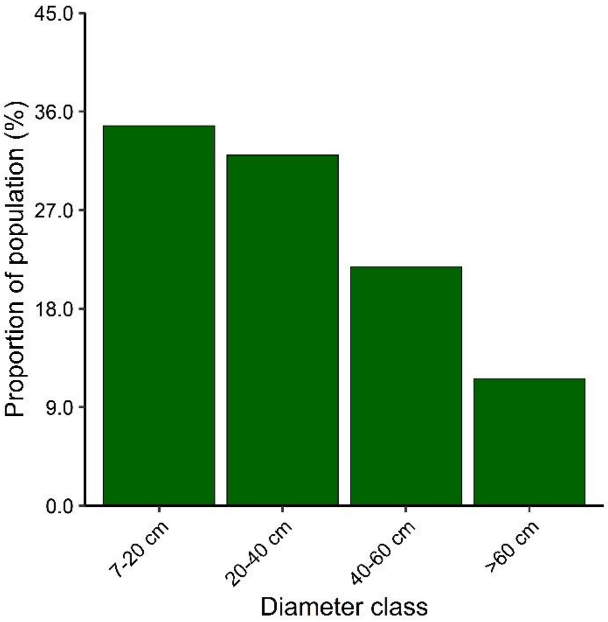
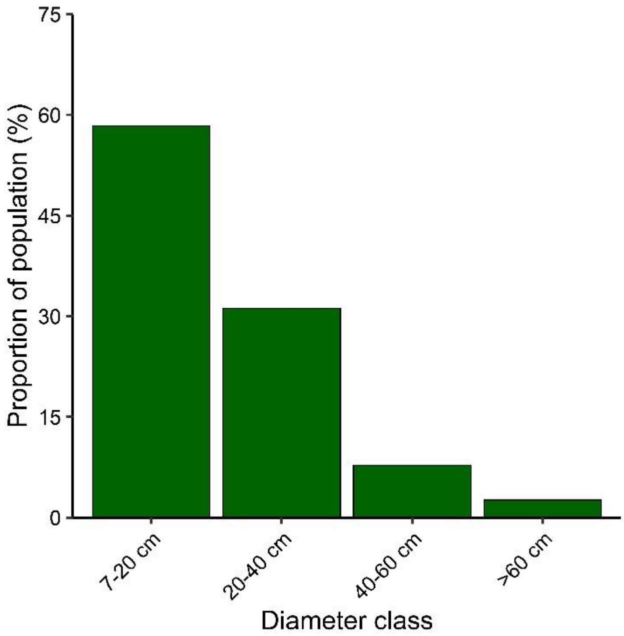


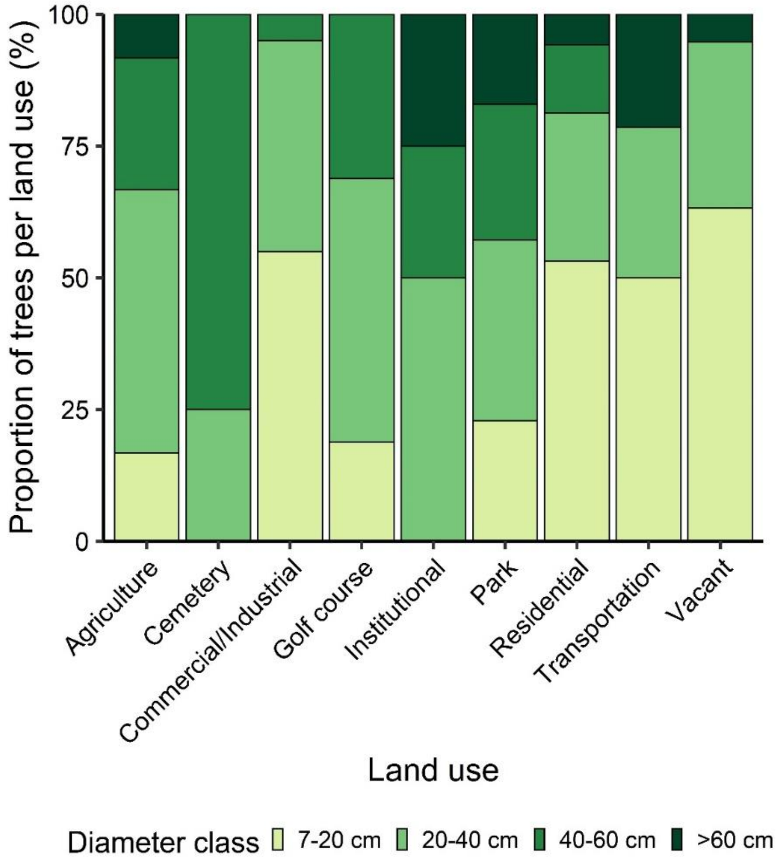
Fig. 6b. Proportion of trees of small stature that fall into each DBH class



band is in the 7-20cm category (Figure 6a), and as such there is a shortage of trees maturing into large diameter trees in the near future (note: Large stature trees are defined as trees that attain a maximum height of greater than 12 metres).

There is a fairly uneven distribution of diameter size classes across the different land use types (Figure 7). There is generally a higher proportion of small (<20cm DBH) and intermediately sized trees (20-60cm DBH), and notably and unusually, there were no large trees surveyed (>60cm DBH) in cemeteries, golf courses or commercial/industrial land. The proportion of large trees is greatest on land described as institutional or transportation use, and it would therefore be beneficial to protect large trees found here where possible, in addition to efforts to increase the number of large DBH trees across the whole spectrum of land uses.

Figure 7. Land use types and their associated proportions of trees that fall within the different DBH size classes



Size matters

The size of tree is a determining factor in the amount of benefit that tree might provide, with larger trees generally providing greater benefit. It is therefore important to retain large stature trees wherever possible, to ensure this continual provisioning. It is also important that large stature trees continue to be planted. However, incorporating large trees in urban areas can be challenging, particularly in areas of higher housing density or limited available greenspaces. In many new residential developments, it has been observed that a majority of newly planted trees are ornamental species of small to medium stature.

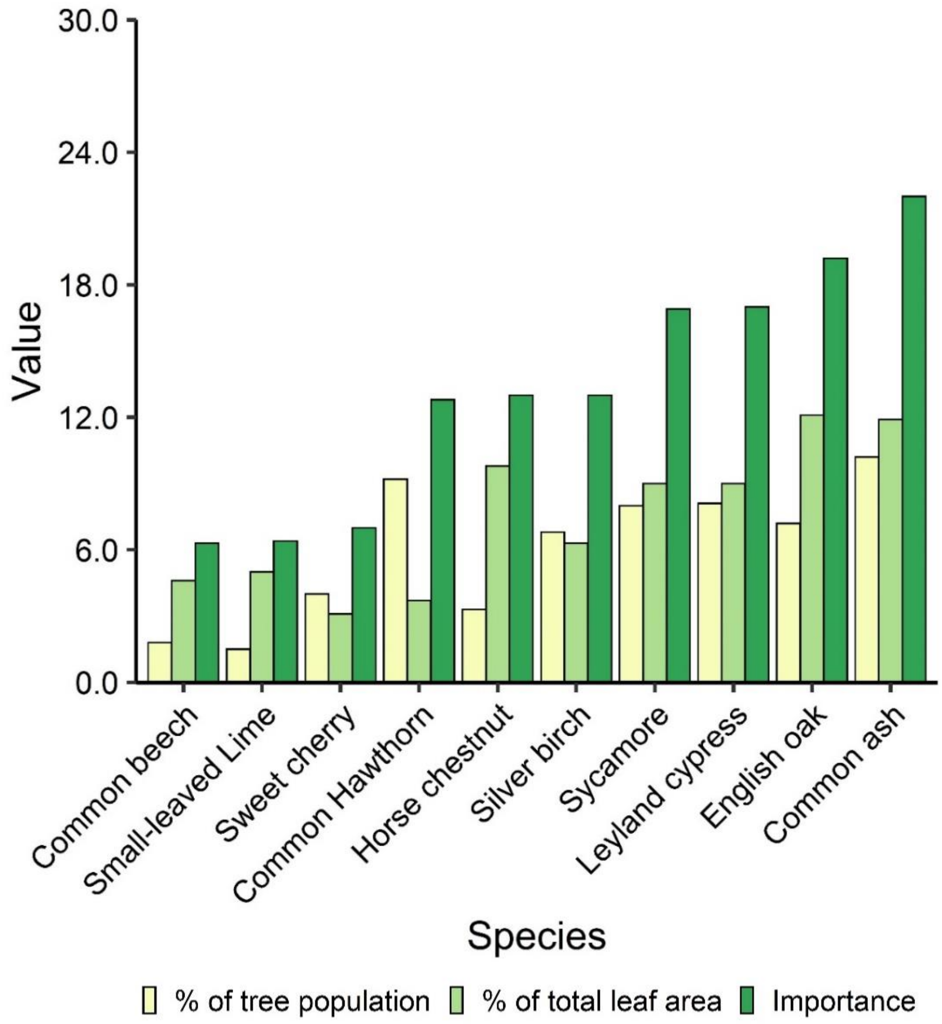
Understanding the age and size distribution can also be beneficial for developing a plan for sustainable replacement. Such a plan could be incorporated into the development of a tree planting strategy for the Vale of Glamorgan, which may help to refine future programmes of tree planting.

Leaf area and 'Importance Value'

Leaf area is the total surface area of leaves found within trees' crowns. Leaves are an important component in ecosystem service provisioning; therefore, a larger, healthier leaf area indicates greater benefit provided.

Importance value is calculated within i-Tree Eco using estimated leaf area per tree and the population size. This gives an indication of which tree species are contributing most to ecosystem service provisioning by the Vale of Glamorgan's urban forest. Trees with denser canopies and/or large leaves tend to rank highly. A list of the importance values for all tree species encountered during the study can be found in the appendices.

Figure 8. The top 10 tree species in the Vale of Glamorgan according to their importance value, along with their associated percentages of population and leaf area



The total leaf area provided by the Vale of Glamorgan's urban trees is 34.4 km^2. **Ash, English oak and Horse chestnut provide the greatest amount of leaf area at 11.8%, 12.0% and 9.7% respectively**.

i-Tree Eco importance value

The science that underpins i-Tree Eco reveals 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.

Also known as the dominance value, the terminology can create assumptions that these are the tree species that should form the core of any future planting strategy. However, this value is used to demonstrate which species are currently delivering the most benefits based on their population numbers and leaf area.

To enable continual provision of ecosystem services to society, maintaining a healthy population of these trees is important. However, ash is one of the highest performing trees in terms of leaf area, and as such other species which are known to yield a similar or larger leaf area should be considered for the replacement of any ash trees lost. Large stature trees, such as English oak and horse chestnut which are currently found to also provide larger leaf area, will be important trees retain for the purposes of benefit provision.

Urban forest structure and composition by locality

Table 9. A breakdown of some of the key structure and composition figures for each urban locality surveyed within the Vale of Glamorgan.

	Locality					
	Cowbridge	Barry and Barry Island	Rhoose	Penarth	Murch	Llanwit major and St Athan
Estimate canopy cover (%)	20.0	8.9	5.5	21.2	20.3	7.7
Estimated total number of trees	11,700	56,900	4,700	34,400	13,900	22,700
Estimated average tree density (trees per ha)	73	33	35	48	65	33
Number of tree species surveyed	27	31	20	19	19	15
Most common species surveyed	Sycamore (15.3%)	Leyland cypress (11.6%)	Leyland cypress and Bird cherry (16% each)	Silver birch (12.8%)	Common ash (18.9%)	Common ash and Common Hawthorn (16.1% each)

Ecosystem services delivered by the Vale of Glamorgan's urban forest

Avoided Surface Water Runoff

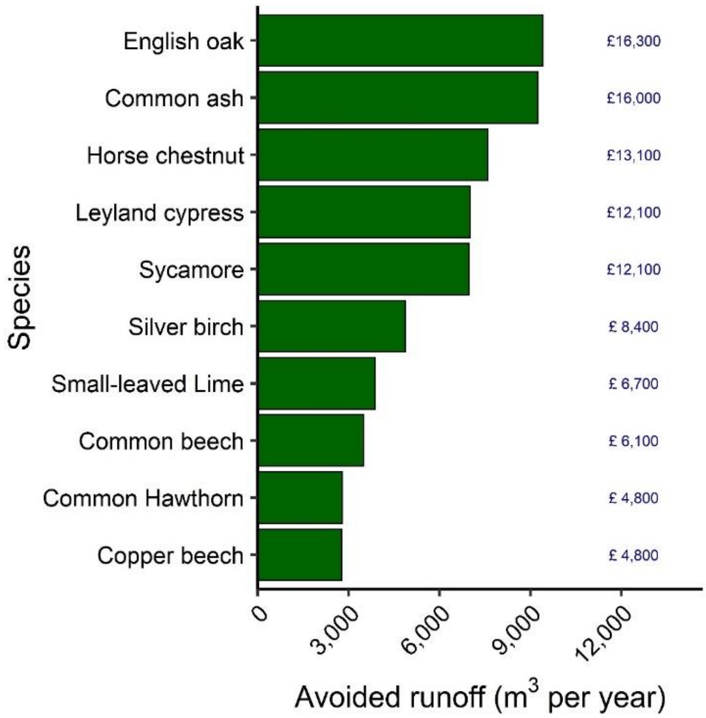
The Problem
In urban areas in particular, a higher proportion of impermeable surfaces, such as tarmac, can increase the risk of surface water flooding, which can lead to higher costs to treat the resulting sewage discharge.

What trees can do
The canopies of trees can intercept rainfall and reduce the amount that reaches the ground and forms floodwater runoff. Where trees are planted in areas of higher permeable cover, tree roots also contribute to flood prevention by taking up water.

Relevance to the Vale of Glamorgan
In December 2020, a 1 in 20-year rainfall event led to the internal flooding of 18 properties in Sully and also affected other residences and local transportation links. The flooding was attributed to run-off from nearby fields, which quickly led to the drainage network reaching full capacity (JBA Consulting, 2021). Following this, action to mitigate such events happening again was recommended, and it is suggested that trees can form part of such alleviation schemes.

Trees in the Vale of Glamorgan's urban forest intercept an **estimated 78,438m^3 of rainfall per year.** This equates to almost 30 times the total water volume capacity of an Olympic sized swimming pool. Based upon the standard volumetric rate for charged for sewerage (using the Welsh Water 2021/22 value of £1.73 per m^3) this saves £135,838 in avoided sewerage charges. English oak intercepts the most water (9,412m^3 per year), contributing to avoided charges amounting to approximately £16,300 (Figure 11).

Figure 9. The top 10 tree species in the Vale of Glamorgan for avoided surface water runoff, and the associated cost saving



Reducing flooding in the Vale of Glamorgan's towns

Climate change in the UK is expected to lead to increasingly rainy winters with more storms. This increases the risk of flooding which is further exacerbated by a higher proportion of impermeable surfaces in urban areas such as roads and buildings. This can lead to a higher volume of surface water run-off which 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 percolates into the soil where it may be drawn up again by plant roots and returned to the atmosphere by evapotranspiration. The rate at which this happens depends on the soil structure, but roots can help water run into the earth instead of straight off the surface, reducing the risk of flooding.

In a heavily built-up environment, there may be very little interception, since any rain which falls onto roofs or roads run straight into gutters and drains which then reaches the rivers quickly. This can lead to both river (fluvial) flooding and surface (pluvial) flooding. Reducing the rate at which rainwater and surface run-off reach the river can reduce the amount of water entering the river system at once, allowing the river to drain more freely for longer. Urban trees can ease the pressure on drainage infrastructure and protect the catchment area from flooding, thanks to their ability to intercept, evaporate, transpire, infiltrate and store rainfall.

This issue can be difficult to combat, and river catchments rarely confine themselves to administrative boundaries, therefore collaboration with those both upstream and downstream is key to making an most impact. Tree planting can be most effective in the mid and upper regions of rivers, along tributaries and in cities along the river course. In the lower reaches of the river, on flood plains, interception is less vital and increasing percolation rates becomes the top priority to allow the land to drain after a flood has occurred.

Air Pollution Removal

The Problem
Air pollution is often linked to poor health outcomes, particularly respiratory conditions (e.g. asthma), and can even lead to premature death. It is estimated that the effects of long-term exposure to air pollution equate to 1,000-1,400 deaths in Wales each year (PHE, 2018; PHW, 2020).

What trees can do
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 local temperatures which reduces the rate at which some pollutants (e.g. ozone, O_3) are formed (Jacob & Winner, 2009)

Relevance to the Vale of Glamorgan
The Vale of Glamorgan has historically had one Air Quality Management Area (AQMA), which was declared for NO_2 in Penarth in 2013. Following a successful 3-year period whereby all objectives were met, the AQMA was revoked in 2021. It is however important that improvements to air quality are considered. Retention, and replacement where necessary, of trees along transport networks that receive both high pedestrian footfall and busy traffic should be prioritised.

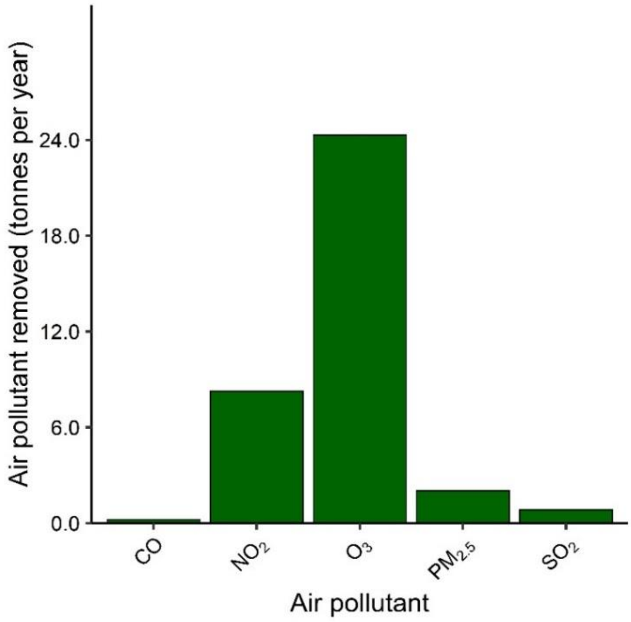
It is estimated that the Vale of Glamorgan's urban forest removes **36 tonnes of airborne pollutants each year**, including NO_2/NO_x (nitrogen dioxide/oxides of nitrogen), O_3 (ozone), SO_2 (sulphur dioxide), CO (carbon monoxide) and PM (particulate matter) (for further information on sources and health implications of these pollutants, see Table 10). Ozone is removed in the greatest quantity, with over 24 tonnes removed per year (Figure 12).

The pollution removed from the atmosphere can be valued to aid interpretation of this data. In both the USA and the UK, pollutants are valued in terms of the damage they cause to society. However, these are valued using different methods in each country: United States Externality Costs in the US (USEC) and in the UK, air quality can be valued using either the impact pathways approach (IPA), damage costs (monetary impact values per tonne of emission) or activity costs (monetary value per KWh energy used) (Defra, 2021). The UK damage costs approach used to value the air pollution removal in this project does not cover all airborne pollutants, and so only valuations for NO_2, $PM_{2.5}$ and SO_2 are provided. This is because of the uncertainty associated with the value of removing some airborne pollutants, and because the value of some pollutants can vary depending on their emission source or because the cost of these other pollutants has not yet been determined by the UK Government.

Table 10. The health effects and source of different types of air pollutants.

Pollutant	Health Effects	Source
NO_2	Shortness of breath, chest pains	Fossil fuel combustion, predominantly cars (44%) and power stations (21%)
O_3	Irritation to respiratory tract, particularly for asthma sufferers	From NO2 reacting with sunlight
SO_2	Impairs lung function, forms acid rain that acidifies freshwater and damages vegetation	Fossil fuel combustion; predominantly burning coal (50%)
CO	Long term exposure is life threatening due to its affinity with haemoglobin	Carbon combustion under low oxygen conditions (e.g. in petrol cars)
PM*	Carcinogenic, responsible for tens of thousands of premature deaths each year	Various sources: cars (20%) and residential properties (20%) are major contributors

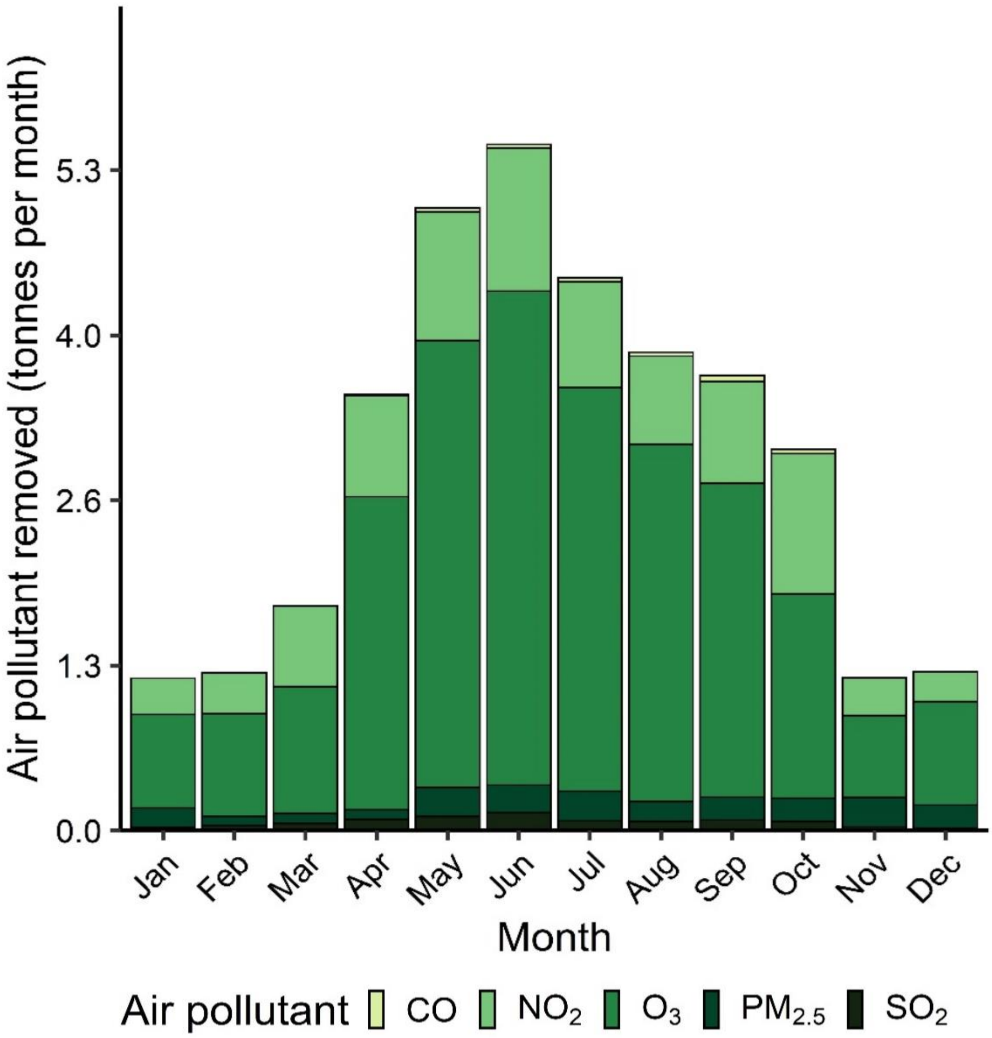
Figure 10. Amount of each air pollutant removed by the Vale of Glamorgan's urban forest



Using the UK damage costs system, **the annual removal of airborne pollutants by trees in the Vale of Glamorgan's urban forest is valued at £212,481 per year.**

The quantity of airborne pollutants removed can vary seasonally, with greater amounts of O_3 removed during the spring and summer (Figure 13). The production of O_3 is more prevalent in warm temperatures (Sillman & Samson, 1995) and so it is more likely that it is present to be removed by trees.

Figure 11. Amount of each air pollutant removed by the Vale of Glamorgan's urban forest each month



Air pollution removal by the Vale's urban trees

Trees can capture particulate matter on leaves and bark. Whilst some species struggle to manage the high levels of particulate matter exuded by cars and other modes of transport in cities, some species are incredibly good at it, for example the London plane tree (*Platanus x hispanica*). London plane trees shed their bark, so particulate matter doesn't build up and smother the tree, making them hardy and resistant to the stress of city living, hence their popularity in London and across the UK.

Trees also sequester other types of pollutants in the form of gases and fumes. This sequestration occurs as the plant respires through small pores in the leaf surface, taking in air to use the carbon dioxide in the process of photosynthesis. Additional chemicals and toxins get trapped within the leaf, which can improve air quality in the immediate area.

The amount of pollution trees can remove is directly linked to the amount of leaf area which the tree has, and some species have more leaf area than others, so species selection is a key consideration for a planting strategy aimed at cleaner air. Trees which can achieve a larger canopy size or have a denser canopy would be preferable to capitalise on this. It is also important to consider that though conifers and other evergreens usually have less leaf area than broadleaf species, evergreens continue to remove pollution all year round, unlike broadleaves. In order to keep air quality high through the winter months, some evergreen species should be included in any planting mix.

As well as species selection, planting location can have a huge impact on the success of a clean air strategy based on green infrastructure. If trees are in the wrong place, too close together, or all the same height, then pollution can get trapped beneath the canopy, particularly along transport corridors and in cities where buildings channel and block out the wind. To combat this, careful planning on tree spacing and planting trees of different species and of different ages is vital.

Carbon Storage and Sequestration

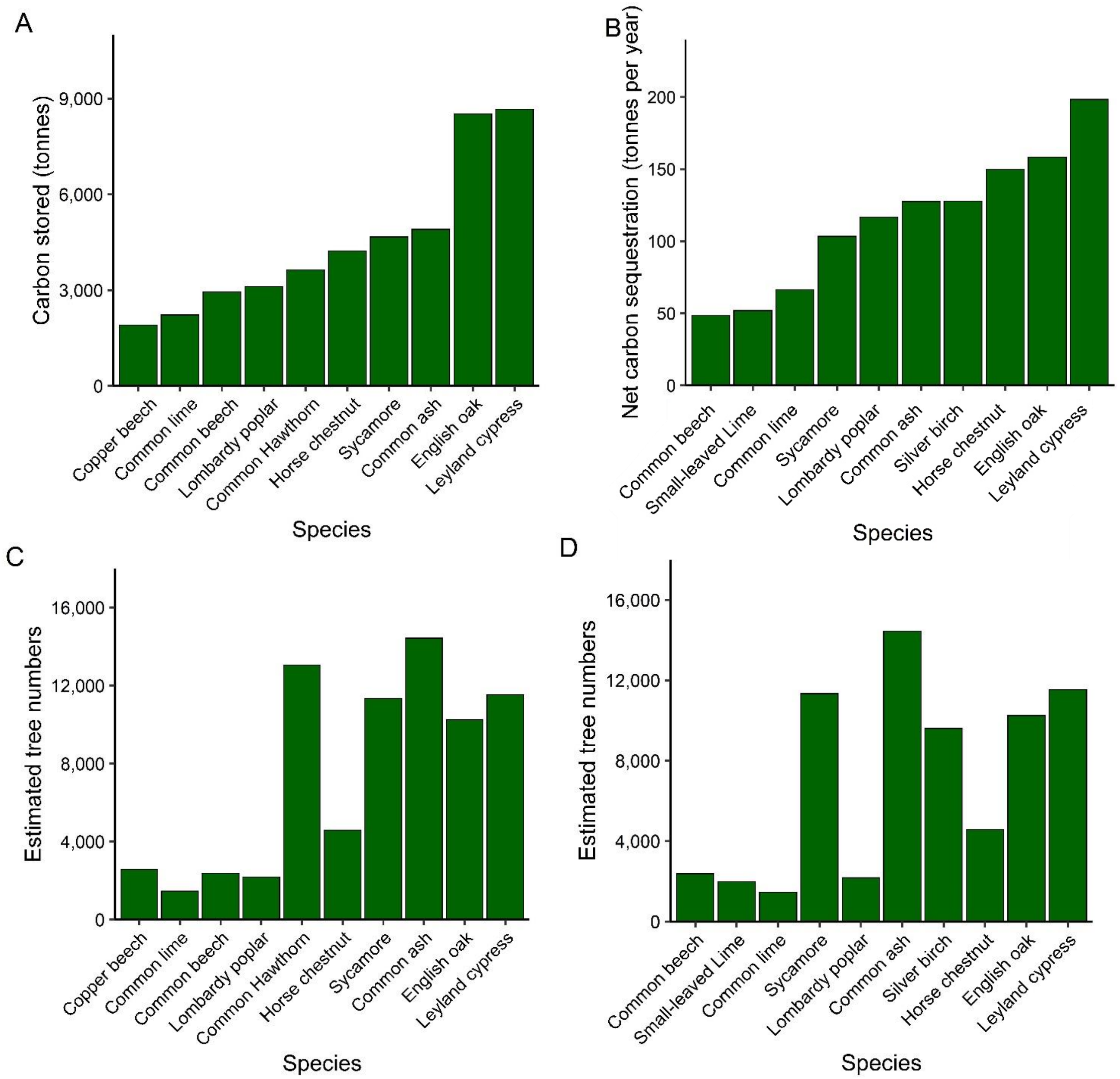
The Problem	**What trees can do**	**Relevance to the Vale of Glamorgan**
Increasing levels of carbon dioxide (CO_2) in the atmosphere are significantly contributing to climate change, which is predicted to bring about increased summer temperatures and more winter rainfall and storms.	Reducing CO_2 emissions could help reduce the impact of climate change. CO_2 can be removed from the atmosphere by trees and stored within their woody components. Trees can continue to sequester carbon throughout their lifetime.	The Vale of Glamorgan has one of the highest ecological footprints in Wales, at 3.53 global hectares per capita. The county's carbon footprint is also high, at 11.48 tonnes of CO_2 equivalent per capita, which ranks it 7th out of Wales's 22 local authorities (GHD, 2015). The Vale's carbon land requirements are 64% - slightly higher than the Welsh average (63%), suggesting increased tree planting would be beneficial.

It is estimated that **the Vale of Glamorgan's urban trees store a total of 57,314 tonnes of carbon** in their woody components. Timber density, quality and amount are important in terms of carbon storage, and larger trees are generally more able to store larger quantities of carbon. Leyland cypress and English oak store the most carbon at 15.1% and 14.9% of all carbon respectively (Figure 14A) and make up 7.8% and 6.8% of the total tree population (Figure 14C).

The **net carbon sequestered by the Vale of Glamorgan's urban forest each year is estimated at 1,977 tonnes annually**. The carbon in trees can be valued within the framework of the UK government's carbon valuation method (DBEIS, 2021). This is based on the abatement costs of meeting the UK's carbon reduction targets. These social values of carbon are split into two types: traded and non-traded. Traded values are only appropriate for industries covered by the European Union Emissions Trading Scheme. Carbon storage or sequestration by trees does not fall within this category so non-traded values are used instead. Within non-traded values, 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 for non-traded carbon for

2021[1], it is estimated that **the carbon in the current tree stock is worth £51.4 million.**

Figure 12. Top 10 species for carbon storage (A), top 10 species for carbon sequestration (B), estimated tree numbers associated with top 10 species for carbon storage (C), estimated tree numbers associated with top 10 species for carbon sequestration (D).



[1] The 2021 value for 1 tonne of carbon is £898, based on the non-traded value of 1 tonne of CO_2 equivalent as £245 (DBEIS, 2021).

Carbon Storage and Sequestration

Plants have the ability to sequester CO_2 through photosynthesis. They can store carbon in soil and in plant biomass; approximately 50% of a tree's dry weight is carbon. Green areas in cities can significantly reduce the atmospheric concentration of CO_2 and can indirectly reduce carbon emissions by offering shading in the summer and insulation in the winter.

Across any area, the amount of carbon sequestered is influenced by the number of trees and their spatial coverage, the age and health of trees, their rate of mortality, their interaction with soil, and the disposal/use of trees at the end of their life. Naturally, the more trees and the more area they cover, the more carbon will be sequestered. Trees sequester carbon at different rates throughout their lifetime; young trees grow quickly and therefore the rate of sequestration is increased. As they mature, the growth rate reduces, as does the rate of sequestration. It is important to keep the population diverse in age and size to maintain sequestration and storage rates when some trees die or are felled, and so sustainable tree planting will help in this aspect.

Approximately 20% of a tree's biomass is below the ground in root systems which can transfer nutrients to and from the surrounding soils, trapping carbon compounds. Additional carbon is stored when leaves fall in autumn, however often in cities the leaves are not given a chance to break down in-situ and therefore this opportunity is not maximised; composting can be a vital carbon sink and can increase soil health.

Carbon storage and sequestration are part of a wider cycle. In order to ensure that the trees in the Vale of Glamorgan are having a positive impact in reducing global atmospheric carbon, they must sequester more carbon than is given off. The cycle extends far beyond the life of the tree, and carbon must be stored for as long as possible. If trees being removed are disposed of in a poorly managed way, the carbon which has built up over the lifetime of the tree can be instantly returned to the atmosphere (for example if the trees are burned). Converting dead or felled trees into lumber or wood products can vastly extend the amount of time carbon is stored for. Wood products can also indirectly reduce carbon emissions by acting as a replacement for a less eco-friendly product made of, for example, plastic or metal.

Habitat Provision

The Problem
Changes in land management practice, invasive species, urbanisation and pollution are key drivers of net loss in UK biodiversity (UK National Ecosystems Assessment, 2011).

What trees can do
Trees are vital sources of food and habitat for a variety of flora and fauna. Trees in urban areas in particular can boost people's engagement and feeling of connection with nature. Woodland trees can provide wildlife corridors to facilitate movement between sites.

Relevance to the Vale of Glamorgan
There are more than 22 Sites of Special Scientific Interest (SSSIs) in the Vale. The county hosts a rich biodiversity, with many different habitats and species, as well as a designated Heritage Coastline that spans 19km in length (Wales Biodiversity Partnership, 2022). However, there is a large amount of agricultural land in the Vale which may not be supporting as many species as it could, and there are many isolated fragments of woodland that limit habitat connectivity.

The biodiversity value of the Vale of Glamorgan's urban trees was assessed using data on a range of biodiversity values of trees. This analysis provides an indicator of the relative value of tree species and their population size in the urban area of the Vale of Glamorgan. High populations of trees which have low biodiversity value may indicate opportunities for changes in the composition of the urban forest to improve its value to wildlife.

In their review, Alexander et al. (2006) scored trees from high value (5) to low value (0) for supporting fungi and epiphytes, providing pollen and nectar, fruits and seeds. The biodiversity value of the Vale of Glamorgan's urban tree population is assessed by reviewing the biodiversity value of the tree species and their population size. Information on the number of invertebrates associated with tree species was gathered from Southwood (1961), Kennedy and Southwood (1981), supplemented for additional species from the Biological Records Centre 'Database of Insects and their Food Plants'. While these values provide a useful indicator of the relative biodiversity value of different trees, it is important to note that these values are gathered from various sources using different methods and from different locations, and in particular, are not specific to trees in urban areas.

Biodiversity values were assessed for three aspects of biodiversity: foliage invertebrate richness, blossom and pollen provision, and seed and nut provision (Figures 15a, 15b, 16a and 16b). These figures illustrate the value of different tree species in supporting wildlife, but also demonstrate that some of the most beneficial tree species are not widely present in the Vale of Glamorgan's towns. Figure 15a shows that **the Vale's hawthorns, oaks and birches support the greatest number of foliage invertebrates**. Figure 15b demonstrates that some of the trees that support a greater number of insect species are not widely present in the Vale's urban areas, for example Willow spp. (0.3% of tree population) and Poplar spp. (0.7% of tree population). It is important to have a diversity in trees which produce pollen and nectar – trees flower at different times of the year and having a variety of tree species to allow for continuity of pollen and nectar availability will help to support a wide array of pollinator species. Figures 16a and 16b demonstrate that willow and hawthorn are again, important for pollinators, and that beech, oaks and cherries provide the most fruits and seeds.

Figure 13 (a) The top 10 tree species by species composition (%) and their associated number of insect species supported (b) The top 10 tree species according to the amount of insect species they support.

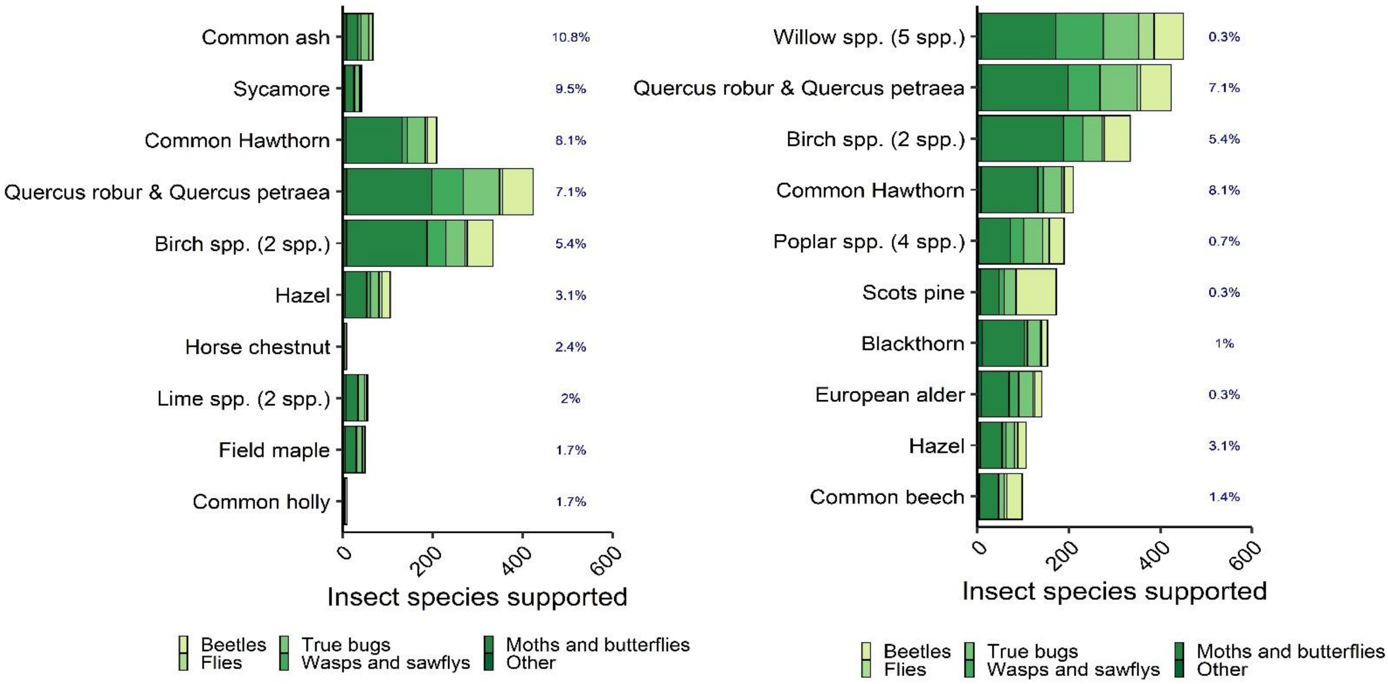
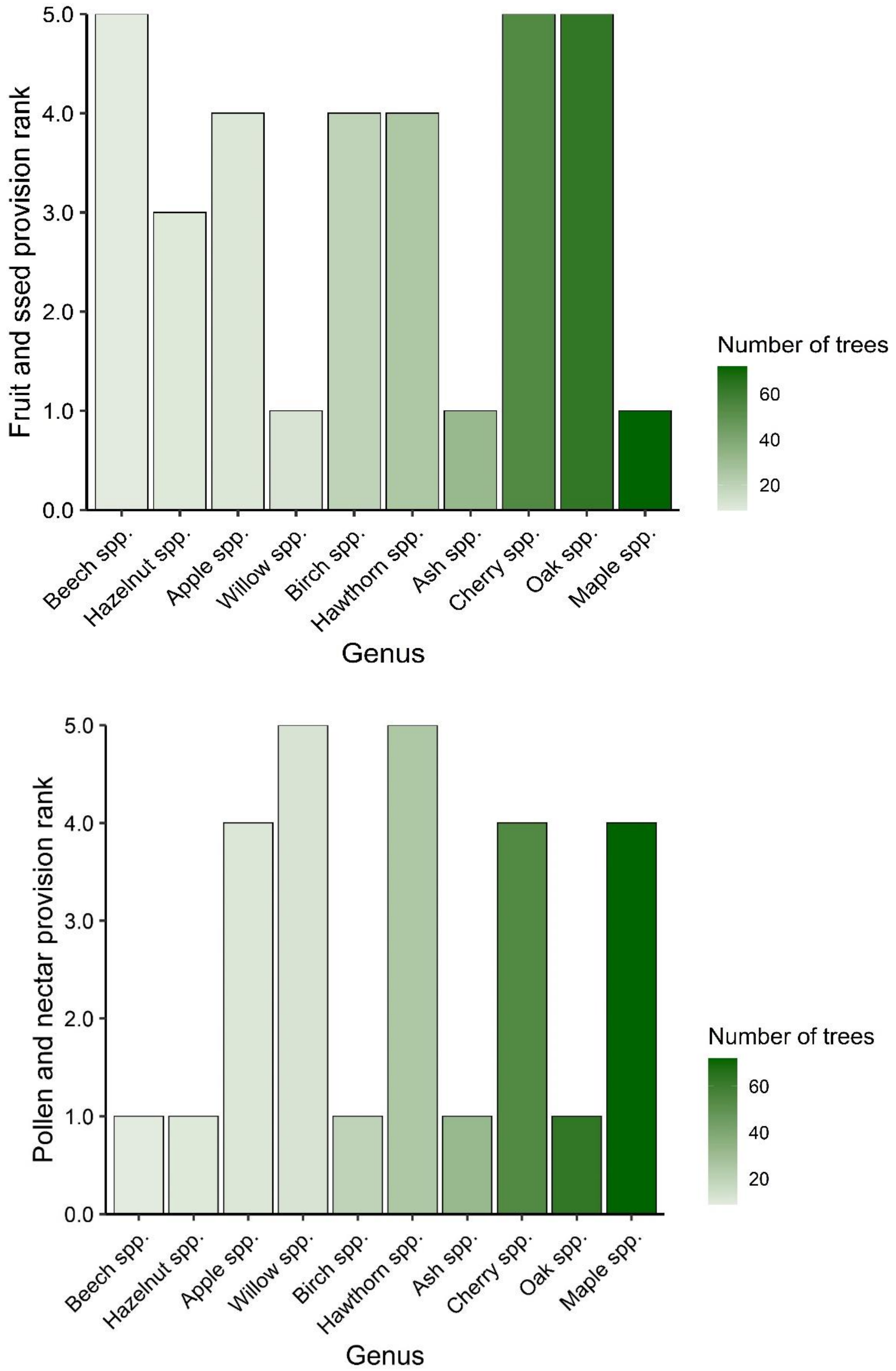


Figure 14. Tree species and their population size ranked from 0-5 for their: (a) provision of fruits and seeds and (b) provision of pollen and nectar.



Replacement Cost and Amenity Value

CTLA Valuation

The Vale of Glamorgan's urban forest has an estimated **replacement (structural) value of £126 million** according to the CTLA Appraisers (1992) valuation method. This is the cost of replacing all of the Vale of Glamorgan's urban trees should they be lost. As such, this method does not take into account the health or amenity value of trees, only the trunk area is considered as a proxy for tree size.

CAVAT Valuation

The Problem
The demand for grey infrastructure to support the UK's growing population can consume greenbelt land, lead to loss of canopy cover to make space for new development and as a result reduce the overall amenity value that trees and green infrastructure can provide.

What trees can do
Trees and green and blue infrastructure such as shrubs, green spaces and water bodies, that are visually accessible can contribute significantly to the amenity value of an area. This can also be linked to improved mental health outcomes and feelings of happiness.

Relevance to the Vale of Glamorgan
The Vale of Glamorgan's Community Strategy (2011-2021) outlines the need to protect and enhance the quality of the built and natural environment as one of its 10 priority outcomes. Enhancing the Vale's existing green infrastructure and limiting that which is lost to further development is important to allow opportunities for the general public to access nature. This is likely to be particularly important to the north of the Vale of Glamorgan, around Llantrisant, and in St Athan, which were identified as a Strategic Opportunity Areas as part of the Wales Spatial Plan in 2008.

The Vale of Glamorgan's urban forest has an estimated **public amenity asset value of £1.5 million**. This valuation was calculated using an amended version of the CAVAT Quick Method (QM) valuation tool (Doick, et al. 2018). This method takes into account the size and health of trees as well as their public accessibility. Oak trees contributed the largest proportion of the total amenity value at 21%, which was approximately £289,000 (**Error! Reference source not found.**). Residential land was associated with the greatest proportion of the total CAVAT value.

Figure 16. Top 10 genera in the Vale of Glamorgan's urban forest for providing amenity value and the associated proportion of the total CAVAT value

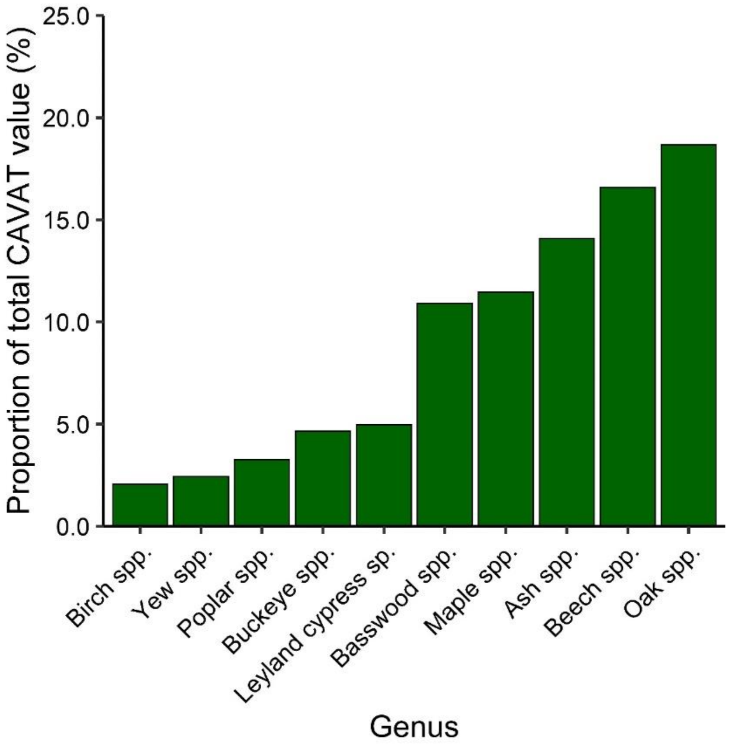
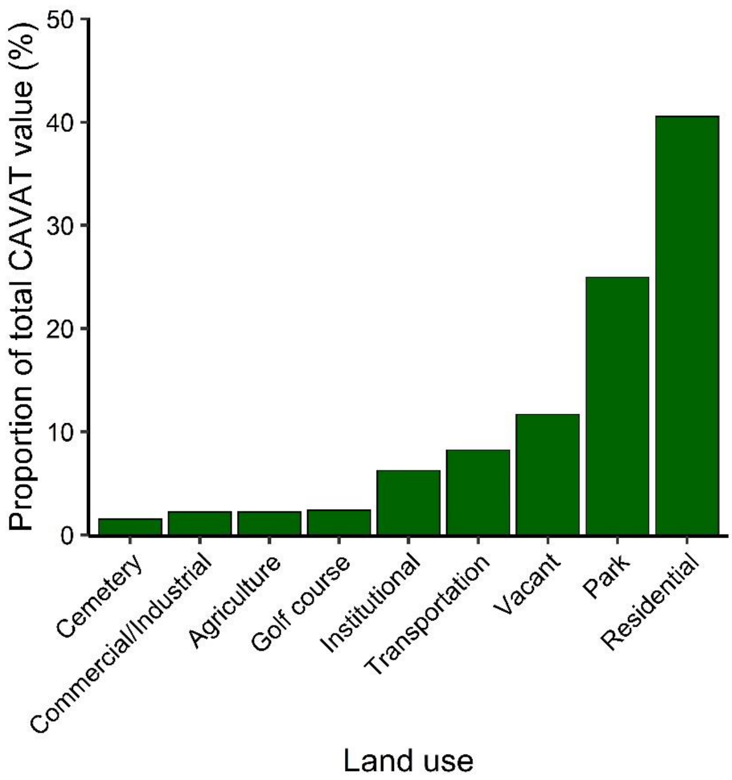


Figure 16. Proportion of the Vale of Glamorgan's urban forest's total CAVAT value provided by each land use



Urban tree Health

Tree Condition

Tree condition is an important metric for giving an estimate of the current state of the Vale of Glamorgan's urban forest. 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. Dieback can lead to a reduction in the amount of ecosystem services provided by that tree, and can also present concern with regards to health and safety, particularly where trees may occupy a prominent position with frequent footfall.

Of the Vale of Glamorgan's urban trees 28.5% were in excellent condition, 43.7% in good and 16.3% in fair condition. A further 11.5% were estimated as being of poor or critical condition or were dying or dead. The land use type with trees in poorest condition was, surprisingly, parks, with 28.7% of the trees in critical or poor condition, or dead (Figure 8).

Tree condition was poorer than that of Newport (55% in

Figure 17. The proportion of total trees that fall into different land use categories and their condition

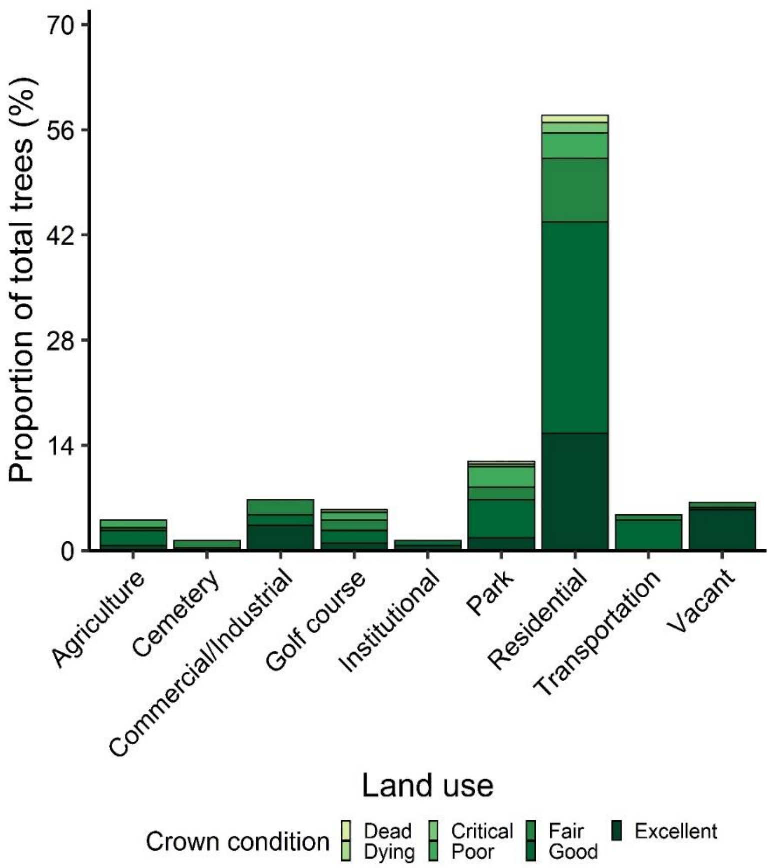
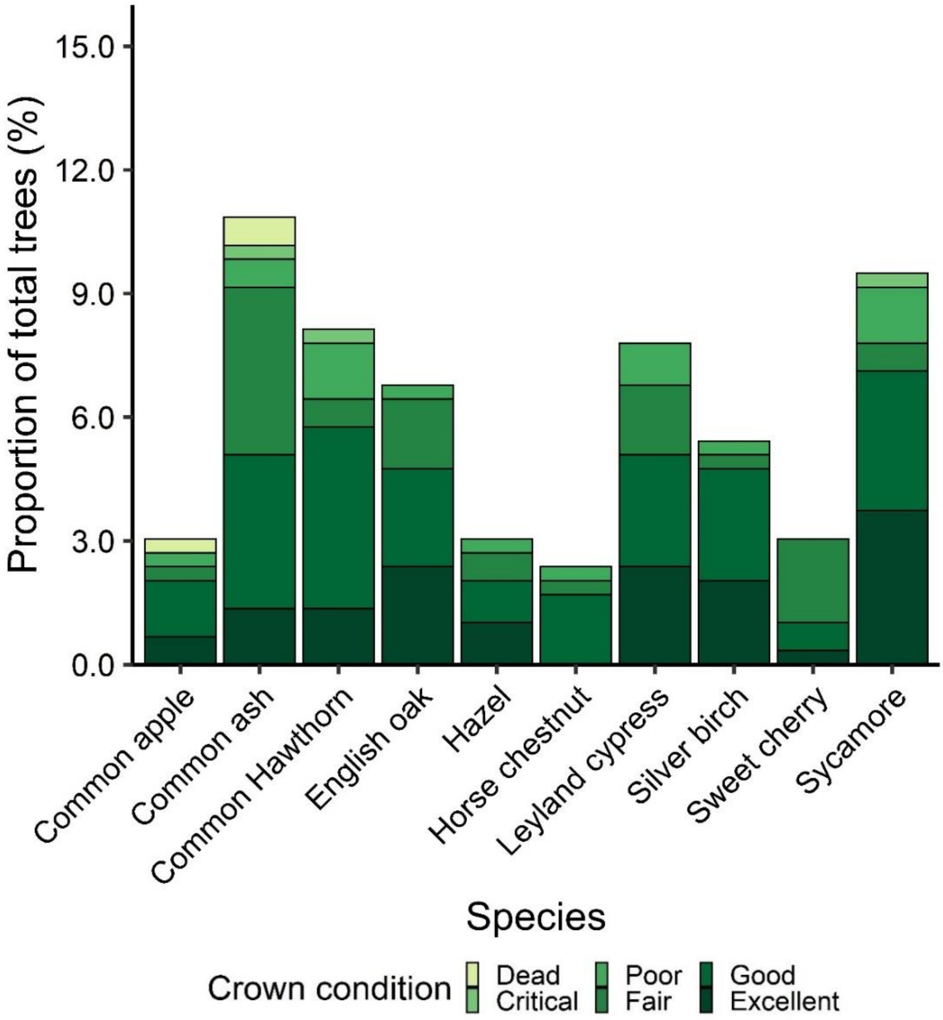


Figure 18. The condition of the top 10 tree species found within the Vale of Glamorgan's urban forest



excellent condition, 6% poor, critical, dead or dying). Cardiff and Wrexham had more trees in excellent condition (49% and 58% respectively) but also had more trees in poor or critical condition, dead or dying (both 13%).

Ash had the highest overall proportion of dead trees (Figure 9), **with 6.2% of the ash trees surveyed recorded as dead**. A further 9.3% were described as being in poor or critical condition, 71.9% in fair or good condition, and 12.5% in excellent condition. Common apple (*Malus* x domestica) also had higher proportions of trees on the poorer end of the scale, with one third of the apple tree population recorded as dead, poor or fair. Sycamore appeared to be in the best condition, with over 74% of the sycamores recorded as in good or excellent condition.

The importance of condition

The loss of functional parts of trees, including leaves, woody components and roots can negatively impact ecosystem service provisioning. This might mean a more limited capacity to intercept rainfall and pollution filtration as a result of a loss in canopy, or reduced amenity value from a dying tree crown.

It is not always possible to ascertain the reasons for a decline in tree health and condition, but often it is attributed to the presence of pests and disease, or poor management or site conditions. It is likely that the higher proportion of poor, critical or dead trees in the ash population, can be attributed to ash dieback. This number will likely grow and has the potential to cause issues if not managed effectively. Ash in poor, critical or dead condition on publicly accessible land presents a possible health and safety risk, and suitable strategy/policy must be in place to facilitate the removal or safety pruning of such trees.

In the wider tree population, understanding tree condition is important to help understand overall urban forest sustainability and resilience, which can in turn inform management going forward. Current, local knowledge is essential for further unpicking the susceptibility of trees to harm, the extent of pests and disease and any other local threats (e.g. vandalism), and implementing effective mitigations and replacement strategies. Regular survey work and monitoring can be beneficial in identifying declining trees and causal factors where possible. If there are local volunteers who are interested in trees, there may be opportunities to get involved with initiatives such as Observatree (www.observatree.org.uk) which could prove beneficial at the local and national level.

Pests and Diseases

Pests and diseases are a very real and serious threat to the sustainability of the UK's urban forests. There have been a few outbreaks over the last 60 years (Dutch Elm Disease, *Phytophthora ramorum*, Ash dieback) which have had and are still having a significant impact on the UK's tree population; Dutch elm disease alone has killed at least 30 million trees in the UK since the 1960s (Webber, 2010). The widespread dieback of trees attributed to certain pests and diseases can have substantial economic costs, as well as implications for health and safety, and a loss of the benefits that trees provide.

The threats associated with pests and diseases are only likely to worsen with the changing climate, as life cycles and natural ranges of new and established species change, and the risk of accidentally introduced pests and diseases becomes greater with increased probability of quick establishment.

Understanding the composition of the tree population can help to identify trees or species groups that may be most at risk, and the possible consequences this might have on the wider urban forest population. Probability risk matrices (Tables 11 and 12) have been developed for assessing the likelihood of the establishment of some pests and diseases that are not currently present in the Vale of Glamorgan. It has also included determining the potential level of impact of some pests and disease that are currently present in the area.

Table 11. Risk matrix used for the probability of a pest or disease becoming prevalent in the Vale of Glamorgan's urban forest on a single genus (one or more species).

Prevalence	**% Population**		
	0-5	6-10	>10
Not in UK			
Present in UK			
Present in South Wales			

Table 12. Risk matrix used for the probability of a pest or disease becoming prevalent in the Vale of Glamorgan's urban forest on multiple genera

Prevalence	**% Population**		
	0-25	26-50	>50
Not in UK			
Present in UK			
Present in South Wales			

Table 13 gives an overview of some of the established and emerging pests and diseases that could have a significant impact on the Vale of Glamorgan's urban forest. The focus has been on assessing pests and diseases that are more severe, i.e. could result in tree death, or present a significant human health risk. Further details on individual pests and disease are provided in the appendices. The table presents an estimate of the population of the Vale of Glamorgan's urban forest at risk from each pest and disease and the associated amenity value of these trees. Whilst this is not an exhaustive list of pathogens that could affect the Vale of Glamorgan's urban trees, it does give an indication of their potential impact. The information contained in the table may be used to inform programmes to monitor the presence and spread of a pest or disease, and strategies to manage the risks that they pose.

Table 13. Selection of pests and diseases and their potential impact on the Vale's urban trees

Pest/Disease	Tree species affected	Prevalence in the UK	Prevalence in Wales	Risk of spreading to the Vale of Glamorgan	Urban forest population at risk	CAVAT value of trees
Acute oak decline	*Quercus robur, Q. petraea, Q. cerris, Q. Fabri*	Mostly central and southern England, with a higher density of cases in the east.	Identified in at least one site in Wales	Medium – High	**7.1%**	£289,626
Asian longhorn beetle	Many broadleaf species (see appendices)	Not known to be present. One outbreak in Kent (2012) was eradicated quickly	None	Medium – climate may be suitable	**59.2%**	£868,274
Bronze birch borer	All *Betula* spp.	None	None	Medium	**6.8%**	£31,803
Chalara dieback of ash	*Fraxinus excelsior, F. angustifolia*	Throughout the UK	Widespread infection throughout Wales	Already present	**10.9%**	£218,568
Emerald ash borer	*F. excelsior, F. angustifolia*	None	None	Medium	**10.9%**	£218,568
Large eight-toothed bark beetle	*Most Picea spp., also reported on some Abies spp., Pinus spp., Larix spp.*	Limited outbreaks in SE England	None	Medium-High	**1%**	£9,328
Oak processionary moth	*Quercus* spp.	Established in Greater London and locally in home counties	None (previous successful eradication efforts)	Medium-High	**7.1%**	£289,626
Xylella fastidiosa subsp. *multiplex**	*Quercus robur, Ulmus glabra, Platanus occidentalis, Q. rubra, Acer pseudoplatanus, Prunus cerasifera*	None (one previous interception in the UK)	None	Medium – climate may be suitable	**16.6%**	£420,418

Survey findings – Vale of Glamorgan's Rural trees

This section of the report presents the results of the i-Tree Eco survey of Vale of Glamorgan's rural tree resource.

It is estimated that there are approximately **1,606,000 trees** in rural Vale of Glamorgan (47.3 trees per hectare).

Canopy Cover

The tree canopy cover of the Vale of Glamorgan's rural area is estimated to be **14%**. This is only 1% higher than the canopy cover recorded for the Vale of Glamorgan's urban areas.

Land use

Agricultural land makes up the highest percentage across the whole of the Vale of Glamorgan's rural area, at 81% (Figure 19a). The greatest proportion of tree'd plots also occurred on agricultural land (Figure 19b). For the purposes of corresponding with the underlying i-Tree Eco models, managed woodland is classified as 'Agricultural' land. Of the 352 plots that contained agricultural land, 83 of these contained tree cover.

Figure 19a. Proportion of total plot area within the Vale of Glamorgan's rural area that was classified by the different land use types.

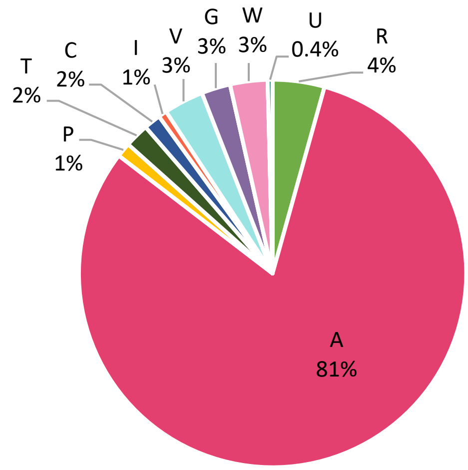
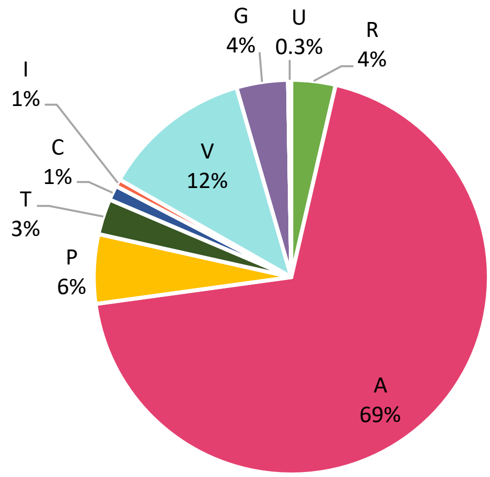


Figure 19b. Proportion of tree'd plot area within the Vale of Glamorgan's rural area that were classified by the different land use types.



Key:

A = Agriculture	P = Park
C = Commercial/industrial	R = Residential
E = Cemetery	T = Transportation
G = Golf course	U = Utility
I = Institutional	V = Vacant
M = Multi-family residential	W = Water

Table 14. Tree data per land use type within the Vale of Glamorgan’s rural areas

	Land use type											
	Agricultural	Cemetery	Commercial	Golf Course	Institutional	Multi-family residential	Park	Residential	Transportation	Utility	Vacant	Water/ Wetland
Percentage of all plots	80.5%	0%	1.4%	2.4%	0.7%	0.0%	1.2%	4.3%	2.0%	0.4%	3.3%	3.1%
Percentage of all plots with trees present	64.2%	N/a	1.4%	4.9%	0.7%	N/a	6.6%	4.2%	3.4%	0.3%	14.3%	N/a
Average canopy cover (%) of plot	54.9%	N/a	32.8%	42%	25.5%	N/a	65.8%	25.1%	32.5%	32.5%	77%	N/a
Average plot plantable area (%)	37.8%	N/a	52.5%	41.9%	70%	N/a	28.1%	41.3%	32.5%	3.5%	16.7%	N/a
Number of trees measured	635	N/a	14	48	7	N/a	65	42	34	3	141	N/a
Species richness	26	N/a	7	13	3	N/a	13	12	8	2	20	N/a

Structure of the rural tree resource

Species composition and diversity

A total of 40 tree species were recorded across the rural area of the Vale of Glamorgan (for a full list of tree species, see appendix II).

The three most common species were common ash (*Fraxinus excelsior*) at 21.8%, common hawthorn (*Crataegus monogyna*) at 13.8%, and sycamore (*Acer pseudoplatanus*) at 7.7%. The 10 most common species accounted for 72.9% of all the trees surveyed within Vale of Glamorgan's rural area.

Species composition by origin

73% of the trees that were surveyed were native species. Of the remaining trees surveyed, 9% are considered naturalised and 18% non-native. These non-natives included Sitka spruce (4.7%), Japanese larch (3.9%) and Leyland cypress (<0.1%) to name a few.

Diversity index

Increased tree species diversity is generally focussed on urban areas, but there is still a need to ensure a range of trees are being

Figure 20a. Top 10 species recorded within the Vale of Glamorgan's rural areas

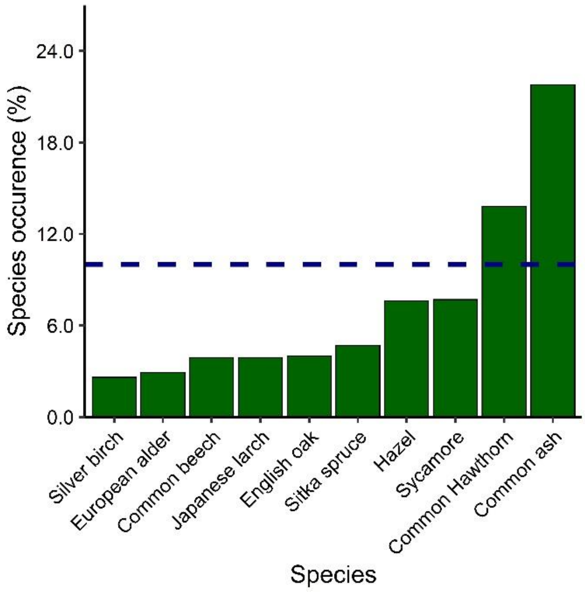
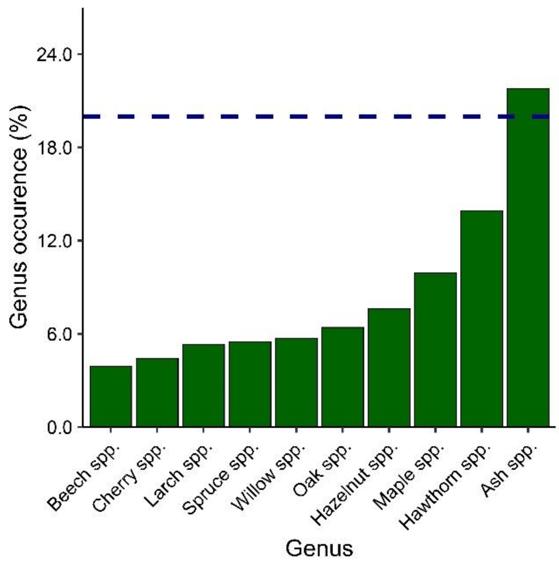


Figure 20b. Top 10 genera recorded within the Vale of Glamorgan's rural areas



planted and cared for in rural areas too. Diverse woodlands made up of different species and different structures can provide greater benefit for wildlife, and can offer much greater resilience to threats such as climate change and pests and diseases. **The diversity index score for the Vale's rural areas is 2.8.**

Table 15. Shannon-Wiener diversity index scores for tree species found on different land use types in the Vale of Glamorgan's rural areas

Land Use	Shannon-Wiener Diversity Index Score
Agricultural	2.6
Vacant	2.4
Residential	2.3
Park	2.1
Golf course	2.1
Transportation	1.8
Commercial/industrial	1.6
Institutional	1.1
Utility	0.6
Overall score	**2.8**

Size class distribution

The greatest proportion of the Vale of Glamorgan's rural tree population falls within the smallest DBH range of 7-20cm (Figure 21), making up 44% of the total rural tree population. When examining the split between those trees that are small stature and those that are large stature (Figures 22a and 22b), it seems that there is a fairly substantial number of young trees in the Vale's population, with 40% of large stature trees falling within this DBH band.

Figure 21. Proportion of the total rural tree population that falls into each DBH class

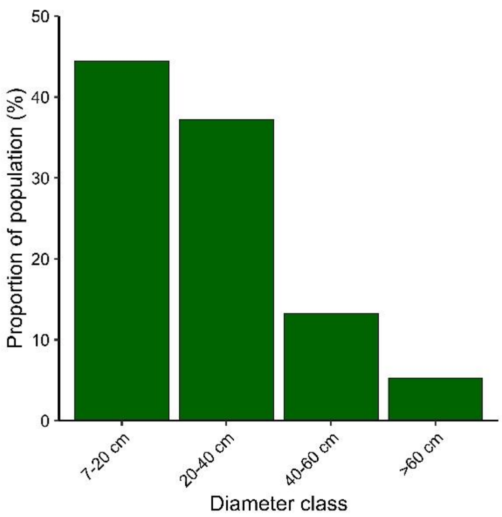


Figure 22a. Proportion of rural trees of large stature that fall into each DBH class

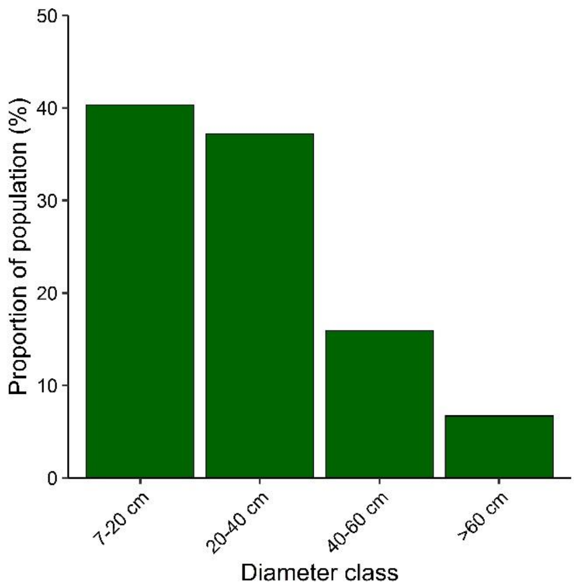
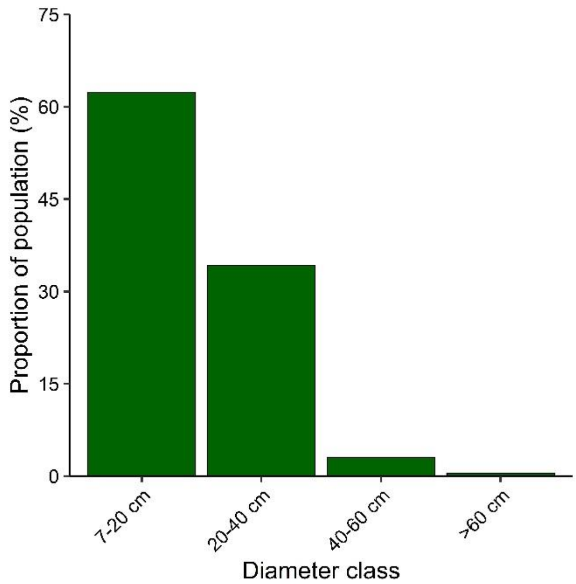
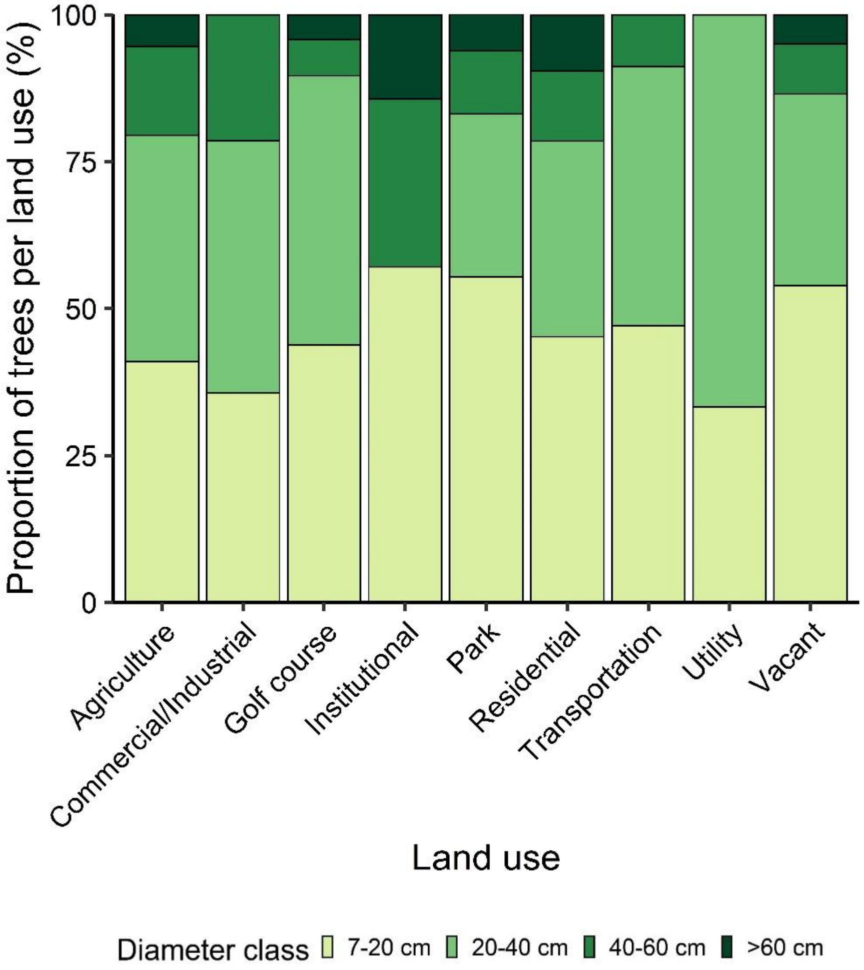


Figure 22b. Proportion of rural trees of small stature that fall into each DBH class



There is a very small proportion of trees that have a DBH greater than 60cm (5.3%). However, it is clear from databases such as the Ancient Tree Inventory (Woodland Trust, 2022) that within this category are some important trees which are likely to yield significant benefits for people and wildlife. Opportunities to protect and enhance such trees would be helpful in maintaining a balanced population structure and would be particularly beneficial for wildlife that might rely on some of the characteristics of mature, veteran or ancient trees for habitat or food. It is expected that a good proportion of the rural tree population will be grown as a commercial crop. As such, a sustainable tree population in rural Vale of Glamorgan will need to consider substantial tree replacement where losses incur (e.g. as a result of ash dieback), and a greater amount of planting where harvesting is not the end goal to maintain continuity of trees that reach the later life stages (i.e. ancient trees).

Figure 23. Land use types and their associated proportions of trees that fall within the different DBH size classes



Institutional land (e.g. schools, colleges, hospitals) hold the greatest proportion of larger trees per land use (Figure 23), but lack some intermediately sized trees (DBH 20-40cm). The proportion of young and/or small-stature trees (DBH 7-20cm) was relatively similar across the different land uses.

Rural Tree Health

Condition

Of the Vale of Glamorgan's rural trees 25.8% were in excellent condition, 17.1% in good and 17.6% in fair condition. A further 39.5% were estimated as being of poor or critical condition or were dying or dead. The land use type with trees in poorest condition was agriculture, with more than two fifths of trees recorded (41.6%) in critical or poor condition, or dying or dead (Figure 24).

Figure 24. The proportion of total trees that fall into different land use categories and their condition

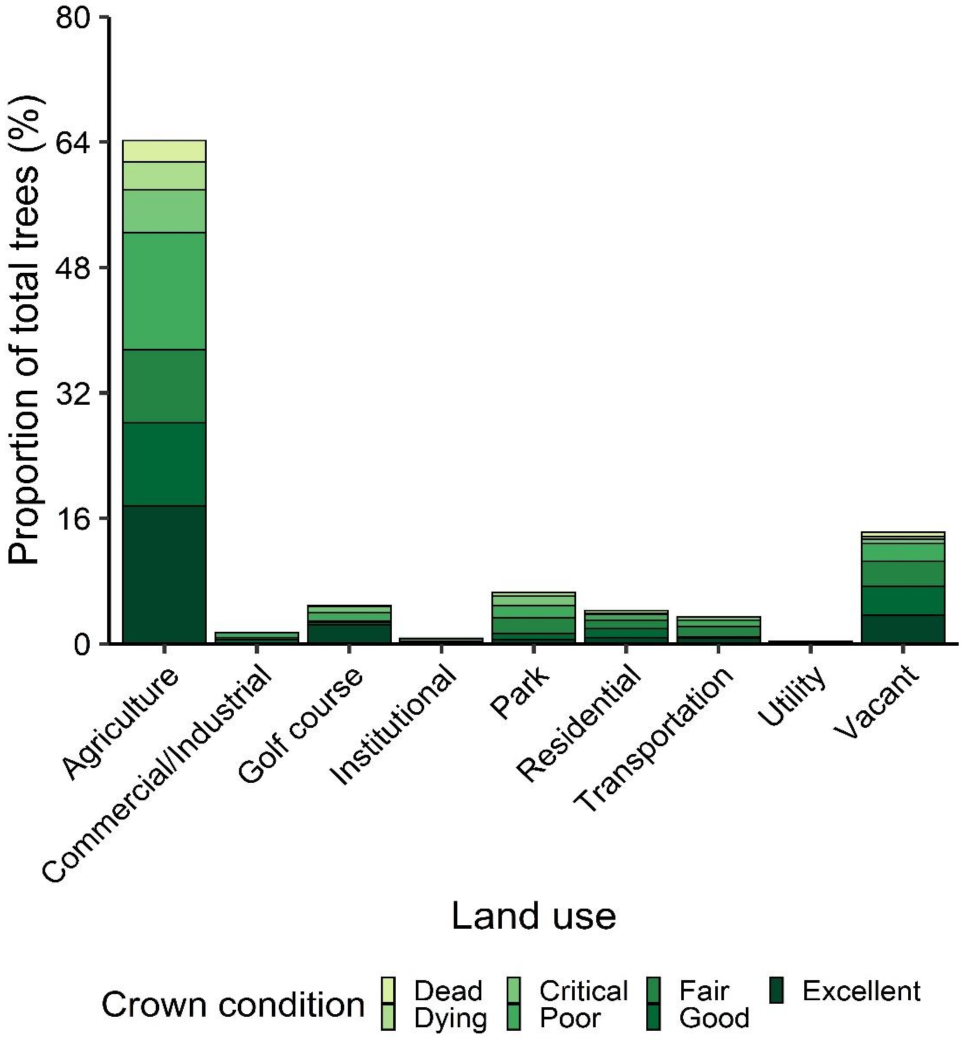
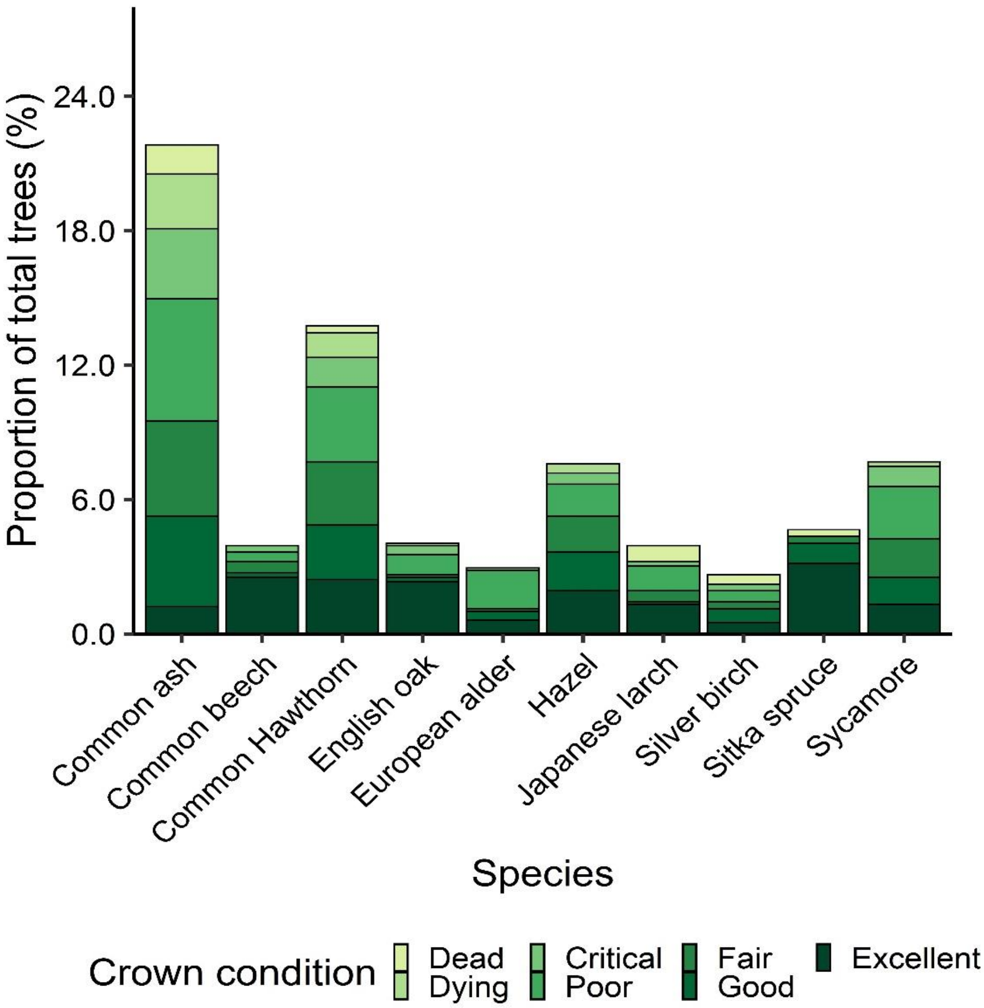


Figure 25. The condition of the top 10 tree species recorded in the Vale of Glamorgan's rural areas



Common ash had the greatest proportion of trees recorded in poorer condition (poor, critical, dying or dead), accounting for more than half (56.5%) of all the ash recorded. This could be a result of ash dieback infection. Contrarily, tree species that were recorded as proportionally in much better condition included Common beech, English oak and Sitka spruce. Notably 17.9% of Japanese larch recorded were dead, possibly as a result of infection from *Phytophthora ramorum*.

Pests and diseases

Understanding the impact of pests and diseases is particularly important where trees are grown on a commercial basis and in woodland planting. Outbreaks of pathogens can have a significant economic cost, with a direct impact on the local economy and further implications for the wider forestry sector.

The probability risk matrices (Tables 11 and 12) have been employed again for assessing the likelihood of the establishment of some pests and diseases that are not currently present in the Vale of Glamorgan, and for determining the potential level of impact of some pests and disease that are currently present in the area.

Table 16. Risk matrix used for the probability of a pest or disease becoming prevalent in the Vale of Glamorgan's urban forest on a single genus (one or more species).

Prevalence	**% Population**		
	0-5	6-10	>10
Not in UK			
Present in UK			
Present in South Wales			

Table 17. Risk matrix used for the probability of a pest or disease becoming prevalent in the Vale of Glamorgan's urban forest on multiple genera

Prevalence	**% Population**		
	0-25	26-50	>50
Not in UK			
Present in UK			
Present in South Wales			

Table 18 gives an overview of some of the established and emerging pests and diseases that could have a significant impact on the Vale of Glamorgan's rural tree population, focussing on the assessment of pests and diseases that are more likely to lead to a severe decline in tree health or mortality. Further details on individual pests and disease are provided in the appendices.

Table 18. Selection of pests and diseases and their potential impact on the Vale's rural trees

Pest/Disease	Tree species affected	Prevalence in the UK	Prevalence in Wales	Risk of spreading to the Vale of Glamorgan	Rural tree population at risk
Acute oak decline	*Quercus robur, Q. petraea, Q. cerris, Q. Fabri*	Mostly central and southern England, with a higher density of cases in the east.	Identified in at least one site in Wales	Medium – High	**4.3%**
Asian longhorn beetle	Many broadleaf species (see appendices)	Not known to be present. One outbreak in Kent (2012) was eradicated quickly	None	Medium – climate may be suitable	**63.6%**
Bronze birch borer	All *Betula* spp.	None	None	Medium	**2.7%**
Chalara dieback of ash	*Fraxinus excelsior, F. angustifolia*	Throughout the UK	Widespread infection throughout Wales	Already present	**21.8%**
Emerald ash borer	*F. excelsior, F. angustifolia*	None	None	Medium	**21.8%**
Large eight-toothed bark beetle	Most *Picea* spp., also reported on some *Abies* spp., *Pinus* spp., *Larix* spp.	Limited outbreaks in SE England	None	Medium-High	**12%**
Neonectria neomacrospora	*Abies* spp. Also reported on *Picea abies* and *Tsuga heterophylla*	Observed on some fir species in England and Wales since 2015	Present	High	**0.8%**
Oak processionary moth	*Quercus* spp.	Established in Greater London and locally in home counties	None (previous successful eradication efforts)	Medium-High	**6.3%**
Phytophthora pluvialis	*Pinus radiata, Pinus patula, Pinus strobus, Tsuga heterophylla, Pseudotsuga menziesii, Notholithocarpus densiflorus*	Multiple outbreaks across England, Wales and Scotland since its discovery in Cornwall (Sep 2021)	Some outbreaks present	High	**0.3%**

Table 18. (Cont.) Selection of pests and diseases and their potential impact on the Vale's rural trees

Pest/disease	Tree species affected	Prevalence in the UK	Prevalence in Wales	Risk of spreading to the Vale of Glamorgan	Rural tree population at risk
Phythophthora ramorum	Mainly *Larix spp.* but other tree species susceptible (for a full list, see appendices)	Widely present, mostly in the West	Cases reported throughout Wales	Already present	**5.2%**
Xylella fastidiosa subsp. *multiplex**	*Quercus robur, Ulmus glabra, Platanus occidentalis, Q. rubra, Acer pseudoplatanus, Prunus cerasifera*	None (one previous interception in the UK)	None	Medium – climate may be suitable	**14%**

Conclusions and Recommendations

The Vale of Glamorgan's total tree population is estimated to contain over **1.7 million trees**. A total of 59 species were recorded in the Vale's towns, and 40 species were surveyed in the county's rural areas. The three most common species throughout the entire study area were Common ash (*Fraxinus excelsior*), Sycamore (*Acer pseudoplatanus*) and Common hawthorn (*Crataegus monogyna*).

Urban trees in the Vale of Glamorgan provide benefits valued at **£2.05 million per year**. This value represents only a handful of ecosystem services, namely carbon sequestration, air pollution removal and avoided surface water runoff. Therefore, this is a conservative estimate of the services that urban trees in the Vale of Glamorgan are capable of providing, such as health benefits, social and cultural values and provisioning for wildlife. Investment in green infrastructure such as trees, is vital for continual benefit provision and its contribution to quality of life for the Vale of Glamorgan's residents.

Canopy cover across the Vale's urban and rural areas is broadly similar, at **13%** and **14%** respectively. There is a considerable difference in the canopy cover values between towns, ranging from 5.5% in Rhoose, to 21.2% in Penarth. Whilst some of the Vale's urban areas exceed recommended targets of 20% (or 15% for coastal towns and cities), Rhoose, Barry, Llanwit major and St. Athan all have very low canopy cover, and as such these areas should be prioritised for new tree planting schemes. Further work may be needed to identify potential planting sites, which may entail a combination of desktop mapping exercises, consultation with the local community and site visits. In rural areas, canopy cover is low, and engagement with a wide range of stakeholders is likely necessary to drive forward new woodland creation.

Both urban and rural areas lack enough mature large trees. 11.6% of the Vale of Glamorgan's urban forest comprised of large stature trees with a DBH of over 60cm, and in rural areas, this figure was 6.7%. Large stature trees are capable of providing a greater amount of ecosystem services and are integral to the landscape character and sense of place, bridging the gap between the present and the past and acting as 'living history'. Across Wales, there has been a general decline in large trees (NRW, 2016), highlighting the need to look after this particular age class of the tree population, and ensure younger trees are able to reach maturity.

Tree condition was variable across the Vale, with trees in rural areas in much poorer condition than those in towns. Almost 40% of trees in rural Vale of Glamorgan were in poor or worse condition, highlighting a possible need to further assess the state of current rural tree cover and the challenges of managing this resource. Whilst the i-Tree Eco survey did not include the identification of pests and diseases, it is highly likely that some of the tree population is being impacted by such, for example, ash dieback. Pests and diseases not currently present in the UK could also have a huge impact on tree health should they become established. Asian Longhorn Beetle could impact as many as 1.1 million trees, which equates to almost 70% of the Vale's total tree resource. This therefore highlights an overreliance on key tree species to make up the overall tree population, and a more diverse species mix will be necessary for future planting schemes to enhance overall resilience of the tree resource. This is true of both urban and rural areas.

Where trees were present, they most commonly occurred on agricultural land in rural areas, and residential land in urban areas. However, less than a quarter of all agricultural plots surveyed contained trees, which demonstrates that there is potential for incorporating further tree planting on this land. It is important to recognise the value of farming to the Vale of Glamorgan, but also to recognise that it is possible to integrate tree planting with agriculture to further enhance farming practice. In the Vale of Glamorgan's urban areas, residents are a key stakeholder in managing urban trees, and are the custodians of the most species-rich sector of the Vale's urban forest (45 species recorded in residential areas). Engagement, outreach and education is therefore critical, and could be encompassed in a strategy for engagement, the development of (or further development of) a dedicated tree warden network across the county, and the provision of resources and information on tree care for residents and landowners.

Recommended next steps:

- For both rural and urban areas, **setting canopy cover targets** to increase overall tree cover can be an effective means of engaging a wide range of stakeholders including decision-makers, landowners and the general public. Adopting a localised approach to canopy cover targets (i.e., per town) will support a more even spread of tree cover and facilitate more equal access opportunities to green infrastructure for the Vale's residents. Canopy cover targets need to be realistic and attainable, taking into consideration current tree cover and what opportunities exist for further tree planting. Mechanisms for **monitoring change in the tree population**, including canopy cover, the structure and composition of the tree stock (species diversity, age and size structure) and regular review of the threats and challenges to the Vale's trees (e.g., pests and disease, climate change, new development) will need to be included for consideration when setting targets. A repeat i-Tree Eco survey in 10 years could be a means of doing so.
- In addition to setting canopy cover targets for different locations, **identifying priorities for tree planting** will help to determine where to focus tree planting efforts (i.e., at the within-town level for urban areas). One such approach could be to undertake a GIS-based assessment of the Vale's towns, which incorporates a multi-criteria decision analysis (MCDA) to highlight potential areas for planting based upon planting priorities which are weighted or ranked.

Planting priorities for example, may include reducing air pollution, improving the quality of existing greenspaces or focussing on areas with higher levels of deprivation. A MCDA approach has been used for an analysis of opportunities for increased ecological connectivity through tree planting in the Vale of Glamorgan's rural areas, which can be found in the document 'Guiding future tree planting in the Vale of Glamorgan'.

- As there is a significant amount of future development in the Vale of Glamorgan, **incorporating canopy cover targets into relevant planning policy and documents** may help to protect existing trees and encourage longevity of newly planted trees in new developments (for example, Wycombe Council). Promoting and instilling the importance of long-term care of trees so that they are retained and able to reach maturity is a key aspect of managing a sustainable tree population. As such, **removing reference to tree planting numbers and focussing instead on tree establishment targets**, is anticipated to yield much better results with regard to long-term tree planting success.
- Whilst tree planting is essential to increase and maintain canopy cover where losses are incurred, **protecting the existing tree resource** is equally important. Regularly reviewing Tree Preservation Orders to ensure all trees worthy of preservation are protected (including administering more TPOs where necessary) and following up on required actions is just one means of helping to protect the Vale's trees. Expanding on current understanding of the tree population through monitoring and surveys, collating data, such as street tree inventories, and utilising resources such as Treezilla (www.trezilla.org) can help to keep track of changes over time and may also help to unpick reasons for trends. Furthermore, **raising public awareness about the value and importance of trees and creating opportunities for community engagement**, will likely lead to greater success with ongoing tree protection and management, and new tree planting.

- Maintaining and growing the sense of place of the Vale’s towns and countryside by **ensuring that trees are viewed as an integral component of landscape character** through creating quality greenspaces and implementing considered and distinctive planting schemes. By maintaining and creating characterful and attractive places in which to live and work, there may be positive effects on the local economy, tourism and wellbeing. Incorporating trees into the Local Plan or Neighbourhood Plan may help to reinforce the importance of trees in contributing to local character, and their role in delivering a multitude of benefits to people and the environment.

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Glossary of Terms

Biomass - the amount of living matter in a given habitat, expressed either as the weight of organisms per unit area or as the volume of organisms per unit volume of habitat.

Broadleaf species – for example, alder, ash, beech, birch, cherry, elm, hornbeam, oak, poplar, chestnut and sycamore.

Canopy / **Tree-canopy** - the upper most level of foliage/branches in vegetation/a tree; for example as formed by the crowns of the trees in a forest.

Carbon storage - the amount of carbon bound up in the above-ground and below-ground parts of woody vegetation.

Carbon sequestration - the removal of carbon dioxide from the air by plants through photosynthesis.

Champion trees – individual trees which are exceptional examples of their species because of their enormous size, great age, rarity or historical significance.

Council-owned trees – Trees owned and managed by the Vale of Glamorgan Council.

Crown – the part of a plant that is the totality of the plant's above-ground parts, including stems, leaves, and reproductive structures.

Deposition velocities - dry deposition: the quotient of the flux of a particular species to the surface (in units of concentration per unit area per unit time) and the concentration of the species at a specified reference height, typically 1m.

Diameter at Breast Height (DBH) – the outside bark diameter at breast height. In arboriculture and urban forestry, breast height is defined as 1.5m above the floor, on the uphill side of the tree.

Dieback – where a plant’s stems die, beginning at the tips, for a part of their length. Various causes.

Ecosystem services - benefits people obtain from ecosystems.

Height to crown base - the height on the main stem or trunk of a tree representing the bottom of the live crown, with the bottom of the live crown defined in various ways.

Leaf area index - the ratio of total upper leaf surface of vegetation divided by the surface area of the land on which the vegetation grows.

Meteorological - phenomena of the atmosphere or weather.

Particulate matter - a mixture of solid particles and liquid droplets suspended in the air. These particles originate from a variety of sources, such as power plants, industrial processes and diesel trucks. They are formed in the atmosphere by transformation of gaseous emissions.

Pathogen - any organism or substance, especially a microorganism, capable of causing disease, such as bacteria, viruses, protozoa or fungi.

Phenology - the scientific study of periodic biological phenomena, such as flowering, breeding, and migration, in relation to climatic conditions.

Public trees – Trees found on land-uses which are typically publicly-owned (but not necessarily by the local council) namely parks, cemeteries and transport land-uses.

Re-suspension - the remixing of sediment particles and pollutants back into the air, or into water by wind, currents, organisms, and human activities.

Structural values - value based on the physical resource itself (e.g. the cost of having to replace a tree with a similar tree).

Trans-boundary pollution - air pollution that travels from one jurisdiction to another, often crossing state or international boundaries.

Transpiration - the evaporation of water from aerial parts of plants, especially leaves but also stems, flowers and fruits.

Tree dry-weight – tree material dried to remove all the water.

Volatile organic compounds (VOCs) - one of several organic compounds which are released to the atmosphere by plants or through vaporization of oil products, and which are chemically reactive and are involved in the chemistry of tropospheric ozone production.Appendices

Appendices

Appendix I - Detailed Methodology

i-Tree Eco Models and Field Measurements

i-Tree Eco is designed to use standardised field data from randomly located plots along with local hourly air pollution and meteorological data to quantify:

- Tree resource structure (e.g. species composition, tree health, leaf area).
- Amount of water intercepted by vegetation
- Amount of pollution removed hourly by the urban forest and its associated per cent air quality improvement throughout a year. Pollution removal is calculated for ozone, sulphur dioxide, nitrogen dioxide, carbon monoxide and particulate matter (<2.5 microns; $PM_{2.5}$).
- Total carbon stored and net carbon annually sequestered.
- Replacement cost of the forest, in addition to the value of air pollutant removal, rainfall interception and carbon storage and sequestration.
- Potential impact of possible pests and diseases outbreaks (Nowak et al., 2008)

All field data were collected during the leaf-on season to properly assess tree canopies. Within each plot in urban areas, data collected included land use, ground and tree cover and individual tree attributes, including species, stem diameter, height, crown width, canopy missing and dieback. For rural plots, data collected included land use, tree cover, species, stem diameter and crown dieback.

Table A1. Land use definitions (adapted from the i-Tree Eco v6 manual)

Land-use	Definition
Residential	Freestanding structures serving one to four families each. (Family/person domestic dwelling. Detached, semi-detached houses, bungalows, terraced housing)
Multi-family residential	Structures containing more than four residential units. (Flats, apartment blocks)
Commercial/Industrial	Standard commercial and industrial land uses, including outdoor storage/staging areas, car parks not connected with an institutional or residential use. (Retail, manufacturing, business premises)
Park	Parks, includes unmaintained as well as maintained areas. (Recreational open space, formal and informal)
Cemetery	Includes any area used predominantly for interring and/or cremating, including unmaintained areas within cemetery grounds
Golf Course	Used predominately for golf as a sport
Agriculture	Cropland, pasture, orchards, vineyards, nurseries, farmsteads and related buildings, feed lots, rangeland, woodland. (Plantations that show evidence of management activity for a specific crop or tree production are included)
Vacant	Derelict, brownfield or current development site. (Includes land with no clear intended use. Abandoned buildings and vacant structures should be classified based on their original intended use)
Institutional	Schools, hospitals/medical complexes, colleges, religious buildings, government buildings,
Utility	Power-generating facilities, sewage treatment facilities, covered and uncovered reservoirs, and empty stormwater runoff retention areas, flood control channels, conduits
Water/wetland	Streams, rivers, lakes, and other water bodies (natural or man-made). Small pools and fountains should be classified based on the adjacent land use.
Transportation	Includes limited access roadways and related greenspaces (such as interstate highways with on and off ramps, sometimes fenced); railroad stations, tracks and yards; shipyards; airports. If plot falls on other type of road, classify according to nearest adjacent land use.
Other	Land uses that do not fall into one of the categories listed above. This designation should be used very sparingly as it provides very little useful information for the model.

[NOTE: For mixed-use buildings land use is based on the dominant use, i.e. the use that receives the majority of the foot traffic whether or not it occupies the majority of space.

Calculating the volume of stormwater intercepted by vegetation:

During precipitation events, a portion of the precipitation is intercepted by vegetation (trees and shrubs) while the other portion reaches the ground. The portion of the precipitation that reaches the ground and does not infiltrate into the soil becomes surface runoff. In urban areas, large extents of impervious surfaces can lead to highs amounts of surface runoff and to [localised] flooding during periods of high rainfall.

i-Tree Eco calculates the volume of precipitation intercepted by trees in order to enable valuation based upon, for example, flood alleviation or cost of treating surface water runoff avoided. To calculate the volume of surface runoff avoided calculations consider both precipitation interception by vegetation and runoff from previous and impervious surfaces. This requires field observation data, collected during the field campaign.

To calculate the volume of precipitation intercepted by vegetation an even distribution of rain is assumed within i-Tree Eco. The calculation considers the volume of water intercepted by vegetation, the volume of water dripping from the saturated canopy minus water evaporation from the canopy during the rainfall event, and the volume of water evaporated from the canopy after the rainfall event. This same process is applied to water reaching impervious ground, with saturation of the holding capacity of the ground causing surface runoff. Pervious cover is treated similarly, but with a higher storage capacity over time. The volume of avoided runoff is then summated. Processes such as the effect tree roots have on drainage through soil are not calculated as part of this model. See Hirabayashi (2013) for full methods.

The Standard volumetric rate – Surface water rebated per cubic metre value of £1.7318 set by Welsh Water (2021/22) was used as a representative value of the avoided cost of treating surface water runoff across the whole survey area.

Calculating current carbon storage

Biomass for each tree was calculated using equations from literature and measured tree data. Open-grown, maintained trees tend to have less biomass than predicted by forest-derived biomass equations (Nowak, 1995). To adjust for this difference, biomass results for open-grown urban trees were multiplied by 0.8. No adjustment was made for trees found in natural stand conditions. Tree dry-weight biomass was converted to stored carbon by multiplying by 0.5.

To estimate the gross amount of carbon sequestered annually, average diameter growth from the appropriate genera and diameter class and tree condition was added to the existing tree diameter (year *x*) to estimate tree diameter and carbon storage in year *x+1*.

Calculating air pollution removal

Estimates are derived from calculated hourly tree-canopy resistances for ozone and sulphur and nitrogen dioxides based on a hybrid of big-leaf and multi-layer canopy deposition models (Baldocchi, 1988; Baldocchi et al., 1987). As the removal of carbon monoxide and particulate matter by vegetation is not directly related to transpiration, removal rates (deposition velocities) for these pollutants were based on average measured values from the literature (Bidwell & Fraser, 1972; Lovett, 1994) that were adjusted depending on leaf phenology and leaf area. Particulate removal incorporated a 50% re-suspension rate of particles (Zinke, 1967).

Replacement costs

These are based on valuation procedures of the US CTLA approach (CTLA, 1992), which uses tree species, diameter, condition and location information. In this case, values are calculated using standard i-Tree inputs such as per cent canopy missing.

This dieback does not include normal, natural branch dieback, i.e., self-pruning due to crown competition or shading in the lower portion of the crown. However, branch dieback on side(s) and top of crown area due to shading from a building or another tree would be included.

US Externality and UK Social Damage Costs

The i-Tree Eco model provides figures using US externality and abatement costs. These figures reflect the cost of what it would take a technology (or machine) to carry out the same function that the trees are performing, such as removing air pollution or sequestering carbon.

Official pollution values for the UK, however, are based upon three different appraisal methods, including the impact pathways approach (IPA), damage costs and activity costs. The damage costs approach was used for this project, the impact values for which are derived from the IPA, which is a more detailed approach to air quality appraisal. Values were taken from Defra (2021). There are three levels of 'sensitivity' applied to the air pollution damage cost approach: 'High', 'Central' and 'Low'. This report uses the 'Central' scenario based on 2020 prices.

CAVAT Analysis

An amended version of the CAVAT "quick" method was chosen to assess the trees in this study. To reach a CAVAT valuation the following was obtained:

- the current unit value factor rating
- DBH
- the Community Tree Index rating (CTI), reflecting local population density
- an assessment of accessibility
- an assessment of overall functionality, (that is the health and completeness of the crown of the tree)
- an assessment of safe life expectancy (SLE).

The unit value factor, which was also used in CTLA analysis, is the cost of replacing trees, presented in £/cm^2 of trunk diameter. The unit value factor used was £16.25/cm^2

The CTI rating was constant across the Vale of Glamorgan at 100%. In actuality therefore, the survey concentrated on accessibility, functionality, appropriateness and SLE.

Accessibility was generally judged to be 100% for trees in parks, street trees and trees in other open areas. It was generally reduced to 80% for trees on institutional land, 40-60% on vacant plots, and 40% for trees in residential areas and on agricultural land.

Because CAVAT is a method for trained, professional arboriculturalists the functionality aspect was calculated directly from the amount of canopy missing, recorded in the field. For highway trees, local factors and choices could not be taken into account, nor could the particular nature of the local street tree make-up. However, the reality that street trees often have to be managed for safety and are frequently crown lifted or reduced (to a greater or lesser extent) and that they will have lost limbs through wind damage was acknowledged. Thus, as highway trees would not be as healthy as their more open-grown counterparts so tend to have a reduced functionality, their functionality factor was reduced to 50%. This is on the conservative side of the likely range.

For trees found in open spaces, trees were divided into those with 100% exposure to light and those that did not. On the basis that trees in open spaces are less intensively managed, an 80% functionality factor was applied to all individual open grown trees. For trees without 100% exposure to light the following factor was applied: 60% to those growing in small groups and 40% to those growing in large groups. This was assumed more realistic, rather than applying a blanket value to all non-highway trees, regardless of their situation to light and/or other trees.

SLE assessment was intended to be as realistic as possible and was based on existing circumstances. For full details of the method refer to www.ltoa.org.uk/resources/cavat.

Appendix II – Species List

The following list is of all species recorded during the study, and their associated population estimates for urban or rural areas.

Species	Strata	Number of trees recorded	Proportion of strata population (%)
apple spp (*Malus*)	Urban	1	0.34
Australian fan palm (*Livistona australis*)	Urban	1	0.34
Austrian pine (*Pinus nigra*)	Urban	2	0.68
Babylon weeping willow (*Salix babylonica*)	Urban	1	0.34
Bay laurel (*Laurus nobilis*)	Urban	3	1.02
birch spp (*Betula*)	Urban	2	0.68
Black poplar (*Populus nigra*)	Urban	2	0.68
Blackthorn (*Prunus spinosa*)	Urban	3	1.02
Cherry plum (*Prunus cerasifera*)	Urban	1	0.34
Chinese lilac (*Syringa x chinensis*)	Urban	1	0.34
Cider gum eucalyptus (*Eucalyptus gunnii*)	Urban	1	0.34
Common apple (*Malus domestica*)	Urban	9	3.05
Common lime (*Tilia x europaea*)	Urban	2	0.68
Common plum (*Prunus domestica*)	Urban	2	0.68
Copper beech (*Fagus sylvatica* 'Purpurea')	Urban	5	1.69
Cupressus x leylandii (*Cupressus x leylandii*)	Urban	23	7.80
Deodar cedar (*Cedrus deodara*)	Urban	1	0.34
Durmast oak (*Quercus petraea*)	Urban	1	0.34
English holly (*Ilex aquifolium*)	Urban	5	1.69
English oak (*Quercus robur*)	Urban	20	6.78
English yew (*Taxus baccata*)	Urban	2	0.68
European alder (*Alnus glutinosa*)	Urban	1	0.34
European ash (*Fraxinus excelsior*)	Urban	32	10.85

European beech (*Fagus sylvatica*)	Urban	4	1.36
European bird cherry (*Prunus padus*)	Urban	4	1.36
European black elderberry (*Sambucus nigra*)	Urban	1	0.34
European filbert (*Corylus avellana*)	Urban	9	3.05
European hornbeam (*Carpinus betulus*)	Urban	2	0.68
European mountain ash (*Sorbus aucuparia*)	Urban	4	1.36
European white birch (*Betula pendula*)	Urban	16	5.42
Giant dracaena (*Cordyline australis*)	Urban	6	2.03
Golden-chain tree (*Laburnum anagyroides*)	Urban	1	0.34
Grey alder (*Alnus incana*)	Urban	1	0.34
hawthorn spp (*Crataegus*)	Urban	1	0.34
Hedge maple (*Acer campestre*)	Urban	5	1.69
Horse chestnut (*Aesculus hippocastanum*)	Urban	7	2.37
Indian paper birch (*Betula utilis*)	Urban	2	0.68
Japanese flower crabapple (*Malus floribunda*)	Urban	1	0.34
Japanese flowering cherry (*Prunus serrulata*)	Urban	5	1.69
Japanese maple (*Acer palmatum*)	Urban	2	0.68
Juneberry (*Amelanchier x lamarckii*)	Urban	1	0.34
juniper spp (*Juniperus*)	Urban	1	0.34
Kanzan cherry (*Prunus Kanzan*)	Urban	1	0.34
Kapuka (*Griselinia littoralis*)	Urban	1	0.34
Large gray willow (*Salix cinerea*)	Urban	1	0.34
lilac spp (*Syringa*)	Urban	1	0.34
Littleleaf linden (*Tilia cordata*)	Urban	4	1.36
Lombardy poplar (*Populus nigra* v. italica)	Urban	3	1.02

magnolia spp (*Magnolia*)	Urban	1	0.34
maple spp (*Acer*)	Urban	1	0.34
Monterey cypress (*Cupressus macrocarpa*)	Urban	2	0.68
Oneseed hawthorn (*Crataegus monogyna*)	Urban	24	8.14
Orange cotoneaster (*Cotoneaster franchetii*)	Urban	2	0.68
Orange eye butterflybush (*Buddleja davidii*)	Urban	2	0.68
plum spp (*Prunus*)	Urban	1	0.34
Port orford cedar (*Chamaecyparis lawsoniana*)	Urban	4	1.36
Purpleleaf plum (*Prunus pissardii*)	Urban	1	0.34
Scots pine (*Pinus sylvestris*)	Urban	1	0.34
Southern catalpa (*Catalpa bignonioides*)	Urban	1	0.34
Southern magnolia (*Magnolia grandiflora*)	Urban	3	1.02
Swedish Whitebeam (*Sorbus intermedia*)	Urban	1	0.34
Sweet cherry (*Prunus avium*)	Urban	9	3.05
Sweet chestnut (*Castanea sativa*)	Urban	1	0.34
Sycamore maple (*Acer pseudoplatanus*)	Urban	28	9.49
Tree of heaven (*Ailanthus altissima*)	Urban	1	0.34
Turkish hazelnut (*Corylus colurna*)	Urban	1	0.34
Whitebeam (*Sorbus aria*)	Urban	2	0.68
willow spp (*Salix*)	Urban	4	1.36
Nordmann fir (*Abies nordmanniana*)	Rural	5	0.5
Hedge maple (*Acer campestre*)	Rural	19	1.9
Norway maple (*Acer platanoides*)	Rural	3	0.3
Sycamore maple (*Acer pseudoplatanus*)	Rural	76	7.7

Horse chestnut (*Aesculus hippocastanum*)	Rural	2	0.2
European alder (*Alnus glutinosa*)	Rural	29	2.9
European white birch (*Betula pendula*)	Rural	26	2.6
birch spp (*Betula*)	Rural	1	0.1
butterflybush spp (*Buddleja*)	Rural	1	0.1
Bloodtwig dogwood (*Cornus sanguinea*)	Rural	2	0.2
European filbert (*Corylus avellana*)	Rural	75	7.6
Oneseed hawthorn (*Crataegus monogyna*)	Rural	136	13.8
hawthorn spp (*Crataegus*)	Rural	1	0.1
Leyland cypress (x *Cuprocyapris leylandii*)	Rural	2	0.2
Blue gum eucalyptus (*Eucalyptus globulus*)	Rural	1	0.1
European beech (*Fagus sylvatica*)	Rural	39	3.9
European ash (*Fraxinus excelsior*)	Rural	216	21.8
English holly (*Ilex aquifolium*)	Rural	9	0.9
European larch (*Larix decidua*)		13	1.3
Japanese larch (*Larix kaempferi*)	Rural	39	3.9
magnolia spp (*Magnolia*)	Rural	2	0.2
European crabapple (*Malus sylvestris*)	Rural	1	0.1
apple spp (*Malus*)	Rural	3	0.3
Sitka spruce (*Picea sitchensis*)	Rural	46	4.7
spruce spp (*Picea*)	Rural	8	0.8
Scots pine (*Pinus sylvestris*)	Rural	8	0.8
White poplar (*Populus alba*)	Rural	4	0.4
Sweet cherry (*Prunus avium*)	Rural	21	2.1
Cherry laurel (*Prunus laurocerasus*)	Rural	4	0.4
European bird cherry (*Prunus padus*)	Rural	1	0.1

Blackthorn (*Prunus spinosa*)	Rural	17	1.7
plum spp (*Prunus*)	Rural	1	0.1
European turkey oak (*Quercus cerris*)	Rural	2	0.2
Durmast oak (*Quercus petraea*)	Rural	1	0.1
English oak (*Quercus robur*)	Rural	40	4
oak spp (*Quercus*)	Rural	20	2
Black locust (*Robinia pseudoacacia*)	Rural	2	0.2
Goat willow (*Salix caprea*)	Rural	24	2.4
Large gray willow (*Salix cinerea*)	Rural	2	0.2
Basket willow (*Salix viminalis*)	Rural	15	1.5
willow spp (*Salix*)	Rural	15	1.5
European black elderberry (*Sambucus nigra*)	Rural	11	1.1
European mountain ash (*Sorbus aucuparia*)	Rural	4	0.4
English yew (*Taxus baccata*)	Rural	1	0.1
Bigleaf linden (*Tilia platyphyllos)*	Rural	2	0.2
Western hemlock (*Tsuga heterophylla*)	Rural	3	0.3
elm spp (*Ulmus*)	Rural	2	0.2
Wych elm (*Ulmus glabra*)	Rural	23	2.3
Dutch elm (*Ulmus x hollandica*)	Rural	9	0.9
Field elm (*Ulmus minor*)	Rural	1	0.1
English elm (*Ulmus procera*)	Rural	1	0.1

Appendix III. Pests and Diseases

Acute Oak Decline

Acute oak decline (AOD) mainly affects mature trees (>50 years) of both native oak species (Quercus robur and Q. petraea) and a variety of other oak species including:

- *Q. ilex*
- *Q. aliena var. accuserrata*
- *Q. palustris*
- *Q. pyrenaica*
- *Q. rubra*
- *Q. coccinea*
- *Q. cerris*
- *Q. nigra*
- *Q. fabri*

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 bigatatus*, indicating potential AOD infection, have been increasing. The latest distribution map (Figure A1) shows a spread in cases westward and to the midlands. Figure A2 shows a medium to low probability that the Vale of Glamorgan's oak trees would be affected by AOD (based on modelling of predisposition factors including temperature, rainfall, and levels of atmospheric nitrogen pollution).

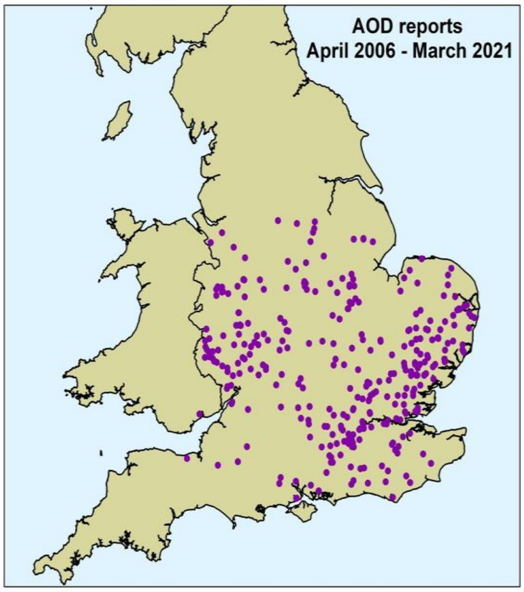

Figure A1. Locations where AOD has occurred between 2006-March 2021 (Forest Research, 2021)

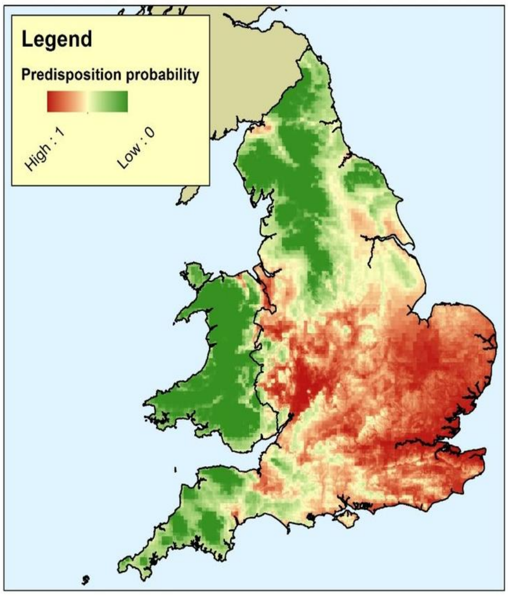

Figure A2. Probability of where AOD might occur based on modelling of predisposition factors (Forest Research, 2022)

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 have been outbreaks in Europe too. 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. The Forestry Commission and Fera removed more than 2,000 trees from the area to contain the outbreak. No further outbreaks have been reported in the UK.

The known host tree and shrub species include:

- *Acer spp.* (maples and sycamores)
- *Aesculus spp.* (horse chestnut)
- *Albizia julibrissin* (Mimosa silk tree)

- *Alnus spp.* (alder)
- *Betula spp.* (birch)
- *Carpinus spp.* (hornbeam)
- *Cercidiphyllum japonicum* (Katsura tree)
- *Corylus spp.* (hazel)
- *Fagus spp.* (beech)
- *Fraxinus spp.* (ash)
- *Koelreuteria paniculata* (Golden rain tree)
- *Malus spp.* (apple)
- *Platanus spp.* (plane)
- *Populus spp.* (poplar)
- *Prunus spp.* (cherry, plum)
- *Pyrus spp.* (pear)
- *Robinia pseudoacacia* (false acacia/black locust)
- *Salix spp.* (willow, sallow)
- *Sorbus spp.* (rowan, whitebeam etc)
- *Styphnolobium japonicum* (Japanese pagoda tree)
- *Quercus palustris* (American pin oak)
- *Quercus rubra* (North American red oak)
- *Ulmus spp.* (elm)

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. Here, the 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 Dieback of Ash

Ash dieback, caused by the fungus *Hymenoscyphus fraxineus*, is a highly destructive disease of ash trees, including *Fraxinus excelsior, F. excelsior* 'Pendula' and *F. angustifolia*. Young trees are particularly susceptible and can be killed within one growing season of symptoms becoming visible. Older trees can take longer to succumb, but can die from the infection or secondary pathogens (e.g. Armillaria) after several seasons. *H. fraxineus* was first recorded in the UK in 2012 in Buckinghamshire and is now widespread across the UK, including in urban areas. It is in these urban areas, along transport routes and rights of way/footpaths, that the dieback of the tree's woody components as a result of infection presents a significant health and safety risk.

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.

Larger eight-toothed spruce bark beetle

The larger eight-toothed spruce bark beetle (*Ips typographus*) is a pest of conifers, including those of the spruce genus (*Picea* spp.), fir trees (*Abies* spp.), pines (*Pinus* spp.) and larch trees (*Larix* spp.). The beetles tend to favour stressed trees, such as those that have been windblown or recently felled. However, they can also move to nearby live trees and cause significant damage by carving out galleries so that they can lay their eggs. *Ips typographus* can also spread pathogenic fungi between trees, such as the blue-stain fungus (*Endoconidiophora polonica*), which can weaken trees further.

Neonectria neomacrospora

A fungus that causes severe cankers of fir trees (*Abies* spp.) and can result in lesions, crown dieback and eventually even tree death. It has been reported on a variety of fir species in Europe and the UK including:

- *Abies alba*
- *A. amabilis*
- *A. balasmea*
- *A. cephalonica*
- *A. concolor*
- *A. durangensis*
- *A. fargesii*
- *A. fraseri*
- *A. grandis*
- *A. kawakamii*
- *A. koreana*
- *A. lasiocarpa*
- *A. magnifica*
- *A. nebrodensis*
- *A. procera*
- *A. nordmanniana*
- *A. pinsapo*
- *A. sibirica*
- *A. vejarii*

N. neomacrospora has been found in England and Wales and is of particular significance to Christmas tree plantations and forestry plantations, where large numbers of dead firs could present a heightened fire risk during periods of hot, dry weather.

Oak Processionary Moth

Oak processionary moth (OPM) was first accidentally introduced to Britain in 2005 and now there are established OPM populations in most of Greater London and in some surrounding counties. It is thought that OPM has been spread through imported nursery trees and it has been estimated that OPM could survive and breed in much of England and Wales. 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 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 pluvialis

A water mould (fungus-like pathogen) that was first discovered in the UK in a Cornish woodland in 2021. Since then, it has also been identified in multiple sites in England, Scotland and Wales. Affected sites have been given Demarcated Area Notices which means that there are movement restrictions on materials that could spread the disease further. It has been found affecting Western hemlock (*Tsuga heterophylla*), Douglas fir (*Pseudotsuga menziesii*), Tanoak (*Notholithocarpus densiflorus*) and some pines (*Pinus radiata, Pinus patula* and *Pinus strobus*).

Phytophthora ramorum

A water mould that has caused dieback of a significant scale (mainly of the UK's larch trees) since it was first reported in the UK in 2002. *P. ramorum* affects a wide range of plant species but has especially severely affected larch (*Larix* spp.), resulting in large losses of the species either through succumbing to the pathogen or through removing and killing affected trees as required. It has also been found on Sweet chestnut (*Castanea sativa*) on a few sites in the South of England. *P. ramorum* has been reported throughout most of the UK, but its distribution is generally more concentrated to the west of the UK, where conditions are wetter.

Xylella fastidiosa

Xylella fastidiosa is a bacterium that has the potential to cause significant damage to a range of broadleaf trees and commercially grown plants. The bacterium has been found in Italy, France, Spain, the Americas and Taiwan, and can be spread through the movement of infected plant material and through insects from the Cicadellidae and Ceropidae families. There are four known sub-species: *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 *Platanus occidentalis*.

For further information on the pests and diseases listed above, as well as other pathogens that pose a threat to the UK's trees, please visit https://www.forestresearch.gov.uk/tools-and-resources/pest-and-disease-resources.

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