Forest Research

Treeconomics




Valuing Newport's Urban Trees

The Research Agency of the Forestry Commission

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

A project for:

Newport City Council **Welsh Government**

NEWPORT CITY COUNCIL
CYNGOR DINAS CASNEWYDD

Ariennir gan Lywodraeth Cymru
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Copies of this report and of its two-page summary can be downloaded from:

http://www.newport.gov.uk/en/Planning-Housing/Trees/Trees.aspx

and:

https://www.forestresearch.gov.uk/research/i-tree-eco/

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 66-67.

Executive Summary

Urban trees form a resource that provides a range of benefits to human populations living in and around cities. Termed ecosystem services, the benefits provided by urban trees help to offset many of the problems associated with increased urban development. For example, trees can improve local air quality, capture and store carbon, reduce flooding and cool urban environments. They provide a home for animals, a space for people to relax and exercise, and they can improve social cohesion in communities. These benefits are directly influenced by their management.

All the trees in the urban realm are collectively termed the 'urban forest'. Management and maintenance across each of the owners of the trees in our towns and cities impact the overall structure, composition and vitality of the urban forest resource.

A well-known tool for assessing and evaluating urban forests – i-Tree Eco – was used to gain a better understanding of the make-up of Newport's urban forest and a range of the benefits it provides. **This information can act as a baseline from which to understand threats, set goals and monitor progress towards optimising Newport's urban forest**. Through i-Tree Eco not only can some of the benefits provided by urban forests be determined, but they can also be valued. Valuing these services can allow Newport City Council to increase the profile of its urban forest, and thereby help to ensure its value is maintained and improved upon.

The data presented in this report provides detailed information on the structure of Newport's urban forest, its composition, condition and public amenity value. It demonstrates that residents of and visitors to Newport benefit significantly from urban trees.

In terms of avoided water runoff, carbon sequestration and the removal of three types of air pollution, Newport's urban forest **provides ecosystem services worth £2.2 million per year**. This value, whilst astonishing, is an **underestimate** as it excludes many ecosystem services that i-Tree Eco cannot currently assess, including cooling local air temperatures and reducing noise pollution.

This study captures a snapshot-in-time. It does not consider how the urban forest has or might change over time, or the reasons for this change. However, it does provide a means to make informed decisions on how the structure and composition of Newport's urban forest should change in the future, and how to ensure that it is resilient to the effects of a changing climate.

The study was funded by Welsh Government and carried out by Forest Research and Treeconomics. Field work was conducted by Forest Research's Technical Services Unit (TSU).

Headline Facts and Figures

Structure and Composition of Newport's Urban Forest in 2019		
Total number of trees (estimate)	259,900	Pg 18
Average tree density (estimate) (trees per ha)	54	
Total tree canopy cover (estimate)	12%	
Number of tree species surveyed	59	Pg 20-21
Top three most common species surveyed	Leyland cypress (14%) Birch (Hybrid) (8%) Hawthorn (8%)	
Land uses where a greater percentage of surveyed trees were found	Residential (36%) Parkland (16%) Vacant land (13%)	
Proportion of surveyed trees of different sizes (by dbh)	7-20 cm (49%) 20-40 cm (31%) 40-60 cm (14%) 60+ cm (6%)	Pg 25
Proportion of trees in good or excellent condition	80%	Pg 28
Top pest and disease threat	Asian Longhorn Beetle	Pg 51

Estimated ecosystem service provision amount and value in 2019			
Avoided runoff	**87,900 m^3** of water (per annum)	**£143,000** (per annum)	Pg 33
Pollution removal	**76 tonnes** (per annum)	**£1,587,000** (per annum in terms of NO_2, SO_2 and PM)	Pg 36
Carbon storage	**75,700 tonnes** to date	**£17.2 million**	Pg 39
Net carbon sequestration	**2,114 tonnes** (per annum)	**£481,000** (per annum)	
Replacement cost	Amenity value of all trees: **£2.1 billion** (CAVAT) Structural value of all trees: **£210 million** (CTLA)		Pg 46
Total annual benefit, and Benefit: Cost ratio	**£2.2 million** (air pollutant removal, net carbon sequestration, avoided runoff) equivalent to **£456/ha**, or **£15.17/capita** The **benefit: cost ratio** of Newport's Urban Forest is **7:1**		Pg 52
The value of these annual benefits over the next 100 years is projected at £80.5 million (discounted Present Value)			Pg 52

Report scope and use

This report provides baseline information on the structure and composition of Newport's urban forest and the benefits it delivers. Understanding Newport's urban forest structure and composition can help to inform future decision-making and strategy. By showcasing the value of benefits provided by Newport's trees, increased awareness can be used to encourage investment in the wider environment.

The assessment presented in this report provides the opportunity to explore several areas of interest including:

- Maintaining or improving current tree cover in Newport
- Identifying areas vulnerable to loss of tree cover (e.g. as a result of pests, diseases, or development) which would benefit from new planting or enhanced protection
- Identifying land classes within Newport where trees could further enhance direct local benefit.

This report can also be used by:

- those writing policy
- those involved in strategic planning to build resilience or planning the sustainable development and resilience of the city
- those who are interested in local trees for improving their own and others' health, wellbeing and enjoyment across the city
- those interested in the conservation of local nature.

This report's appendices are provided in a separate document to improve the use and readability of this document:

Buckland, A., Sparrow, K., Handley, P., Hill, D. and Doick, K.J. (2020). *Valuing Newport's Urban Trees – A Supplementary Report. A report to Newport City Council and Welsh Government.* Forest Research, Farnham. 14 pp.

Key Conclusions

- Newport's urban forest is one of the UK's most sustainable, however poor species diversity threatens overall resilience.
- With an urban tree canopy cover low of 12%, there is significant scope for improvement relative to the Welsh average of 26%.
- There is a shortage of large trees. Providing greatest benefit to society a strategy should be developed to increase their numbers.
- A significant proportion of Newport's tree population are privately owned. Community engagement is recommended to protect and expand this valuable resource.

Introduction

Urban forests are a vital component of urban ecosystems, as they provide a wide range of important benefits to society. These benefits, also known as ecosystem services, make urban areas more enjoyable places to live, support the physical and mental health of residents, and mitigate risks from flooding, climate change, high urban temperatures and air pollution. If the ecosystem services achieved through urban trees were not in place, urban areas would require substantial investment in engineered solutions to obtain equivalent results.

Newport City Council is committed to increasing its tree cover to meet the Welsh average of 26% tree canopy cover and to maximise the benefits that trees provide to the public, infrastructure, ecology, and landscape. In order to achieve this the city council plant two trees for every one removed. However, to be able to support and inform urban forest management and the continued provision of its ecosystem services, an understanding of the current structure, composition and function of the urban forest is necessary. i-Tree Eco is a fit-for-purpose tool for valuing UK green infrastructure (eftec, 2013) and was developed by the US i-Tree Cooperative[1] to assess the make-up of urban forests and estimate and value some of its benefits. It has been used successfully in over 30 areas in the UK, and in 100s of cities globally.

This report presents the findings of an i-Tree Eco survey and urban forest assessment, undertaken in Newport in 2019. The report aims to provide a 'baseline' understanding of Newport's urban forest, incorporating elements such as its species diversity and distribution amongst different land uses.

Most of the existing data available on Newport's urban forest concerns canopy cover. When averaged across all wards, it is estimated that Newport had 15.9% canopy cover in 2019[2]. Previously, NRW highlighted a loss in canopy cover between 2009 and 2013; reporting that canopy cover in Newport declined by 38ha (13ha of which was woodland; NRW, 2016b).

i-Tree Eco projects can provide further understanding of urban forests than the use of canopy assessments alone and, when used in conjunction, may help to shed light on the causes of identified trends or emphasize the meaning of lower canopy cover in areas such as Pillgwenlly, where urban tree canopy cover is 5%[2].

[1] i-Tree Co-operative: an initiative involving USDA Forest Service, Davey, Arbor Day Foundation, the Society of Municipal Arborists, International Society of Arboriculture and Casey Trees
[2] Forest Research's Urban Tree Canopy Cover mapping project: http://forestry.maps.arcgis.com/apps/webappviewer/index.html?id=d8c253ab17e1412586d9774d1a09fa07

Ecosystem Service Provision

This section presents an introduction to the concepts of natural capital and ecosystem service provision required to understand the i-Tree approach to urban forest assessment. This knowledge forms an important foundation to help the city council make informed decisions towards achieving their green infrastructure objectives. It also serves to improve the focus of efforts to invest in the urban forest through planned intervention to maximise benefit and avoid (potentially costly) loss, through protection and development.

The Millennium Ecosystem Assessment (2005) and the UK National Ecosystem Assessment (2014) provide frameworks to examine the goods and services that ecosystems deliver. They identify four categories: provisioning, regulating, supporting, and cultural services. The ecosystem services provided by an urban forest are presented in Tables 1 and 2; those valued by i-Tree Eco are shown in Table 1 along with the significance of the benefits of each service in Newport.

For a more detailed review of ecosystem service provision by urban trees and how this varies depending on the environment, tree structure and composition, and management, see "Delivery of Ecosystem Services by Urban Forests" (Davies et al., 2017).

Quantifying and assessing the value of the services provided by Newport's urban forest can help raise the profile of urban trees and inform decision making to improve human health and environmental quality; see box 'What difference can i-Tree Eco make?' on page 13.

Plate 1: Recently planted trees in a new residential development in Newport

Table 1. Review of the four ecosystem services measured in i-Tree Eco and their significance to Newport.

	Ecosystem service	What urban trees do	Relevance to Newport
Measured by i-Tree Eco	**Avoided surface water run-off**	Impermeable surfaces in urban areas can lead to high risk of surface flooding, which also increases costs for sewage treatment. Tree canopies can intercept rainfall, reducing the volume of water that forms surface run-off	Fluvial and tidal flooding are the most significant flooding risk to Newport, however there have been notable surface water flooding events in the city. Areas at greater risk to this type of flooding include Alway, Allt-yr-Yn, Bettws, Graig and Ringland (NCC, 2015); higher tree cover in these areas could help reduce this risk
	Air pollution removal	Tree canopies intercept air pollutants harmful to human health, such as nitrogen dioxide (NO_2) and so can help reduce overall exposure	Air pollution is estimated to be linked to 72 deaths in Newport each year (PHE, 2014). Newport has 11 air quality management areas (AQMAs) and an air quality management action plan is currently being developed (NCC, 2019a)
	Carbon storage and sequestration	Carbon dioxide (CO_2) can be removed from the atmosphere by trees and stored within their woody components, helping to mitigate climate change	Newport has the third highest CO_2 emissions per capita in the UK, at 7.08 tons (Centre for Cities, 2016). Vehicle emissions are believed to be the primary source of CO_2 emissions, with the number of road vehicles having increased by 20% over the last 15 years (NCC, 2019b)
	Habitat provision	Urban trees support animal, invertebrate and plant species by providing habitat and food, whilst also allowing people to engage with nature	There are a number of protected areas within Newport with national and local designations (e.g.11 SSSIs), where trees play an important role in supporting local wildlife, e.g. Ringland Wood (NCC, 2020). Newport's Biodiversity Duty Plan (NCC, 2019c) includes tree management and planting, with a proposed 100 standards and 2,000 whips planted over 2019-2020

Table 2. Review of ecosystem services provided by urban tree that are not measured in i-Tree Eco, plus their significance to Newport.

	Ecosystem service	What urban trees do	Relevance to Newport
Not measured by i-Tree Eco	**Cultural and historical value**	Trees help to create a sense of place and old trees can help create a link to local history and nature	Newport is home to a number of notable trees, including **Champion trees** found in Beechwood Park and Belle Vue Park, giving an insight to historical land use
	Educational value	Trees and woodlands are educational resources and create further learning opportunities for children and adults alike	Trees are an important component in forest school learning; there are many schools across Newport that run forest school programmes, and Newport City Council also have two qualified forest school leaders (NCC, 2020)
	Noise reduction	Trees can significantly reduce noise and apparent loudness, particularly when planted in wide, dense belts	Traffic is a significant concern in many cities and Newport is no exception - trees could help to reduce the negative impacts associated with traffic noise
	Temperature regulation	Temperatures in urban areas are often higher than those in rural areas. Trees can play an important role in reducing air temperatures; strategic tree placement can cool the air by 2-8°C (Forest Research, 2013)	In Wales, regional summer mean temperatures could increase by as much as 4.5°C by the 2050s (ASC, 2016)
	Landscape enhancement	Urban trees can make the local area a more attractive place to live, raise property values and increase footfall in commercial areas. Trees can have a restorative effect, improving mental well-being	Newport's Well Being Plan (One Newport, 2018) acknowledges the importance of accessing parks, green spaces and countryside for well-being. 75% of Newport's population live within 300m of an accessible natural greenspace (Welsh Government, 2012)
	Recreation	People are more likely to engage in physical activity in greener environments, improving resident's physical and mental health (Kondo et al., 2018)	22% of Wales' population frequently use the outdoors for informal recreation (NRW, 2016c)

Many of the ecosystem services provided by urban trees are not currently quantified or valued by i-Tree Eco (Table 2). **The value of Newport's urban forest presented in this report should therefore be recognised as a conservative estimate** of the value of the full range of benefits that this urban forest provides to the residents of and visitors to Newport.

It is also important to recognise 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 a city-wide 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).

What difference can i-Tree Eco make?

Since i-Tree Eco was first used in the UK, in Torbay in 2011, it has been applied in over 30 UK projects, including in London, Wrexham and Edinburgh. A review of the impacts from a number of these projects identified many of the outcomes that an i-Tree Eco project can provide (Hall et al., 2018; Hand & Doick, 2018), including:

- Improving understanding of urban forests and their ecosystem service value.
- Identifying susceptibility and level of resilience of urban forests to emerging threats, such as pest and disease outbreaks. This information has been used to inform local and regional reports on these threats, and strategies to improve the age, size and species structure of urban forests. The London Victoria BiD i-Tree Eco study in 2011, for example, showed a dependence on London Plane for ecosystem services; with the possible threat of diseases such as Plane Tree Wilt a more diverse population was suggested to be beneficial to increase resilience.
- Informing new tree and woodland strategies, such as in Edinburgh and Torbay.
- Justifying investment in the urban forest, such as securing two £25,000 budget increases in two years in Torbay, and an arboricultural officer post in Wrexham.
- Raising the profile of urban trees in the wider community (e.g. Community groups – Sidmouth Arboretum) and within local authorities. Increased interest in trees has sparked conversations between different local authority departments and since i-Tree Eco projects, trees have been cited in a range of local authority reports including climate change, open space strategies, landscape design and neighbourhood design strategies.
- In Cardiff, i-Tree has been an invaluable resource feeding into policy relating to the declared Climate Emergency and Cardiff's response to it through One Planet Cardiff. It has also helped with planning for Ash Dieback and has highlighted the importance of Cardiff's urban forest, particularly in the context of pressures such as development, land sales and infrastructure improvements.

Links

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 or 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 Canopy Cover web page on Forest Research's website (https://www.forestresearch.gov.uk/research/i-tree-eco/urbancanopycover/).

Plate 2: Trees can make valued additions to gardens, and a range of species can provide interest in different seasons.

Methodology

i-Tree Eco uses a plot-based method of sampling from which the recorded data is extrapolated to represent the whole study area. For this study, 203 plots were randomly selected across distributed throughout the City of Newport. Assessment was completed in 201 plots. The location of the plots is presented in Figure 1.

The study area encompassed 4,854 ha, resulting in one sample every 24 ha. This sample density was high compared to Cardiff, the most recent Welsh i-Tree Eco Study, though like those in other areas in Wales (see Table 3 on page 18).

The field data was entered into i-Tree Eco where it was combined with local climate, phenology (in this case leaf burst and leaf fall) and air pollution data to produce estimates of ecosystem service provision. Full details on the methodology are provided in the Supplemental Report.

i-Tree Eco data collection

i-Tree Eco uses a standardised field collection method outlined in the i-Tree Eco Manual v6 (i-Tree, 2018) and this was applied to each plot. Each plot covered 0.04 ha (circle with radius 11.4 m) and from each was recorded the following data:

- Land use type, e.g. park, residential
- Land cover, as a percentage, e.g. grass, tarmac
- Tree and shrub cover
- The percentage of the plot that could have trees planted in it
- Information on all trees present including:
    - number of trees and their species
    - size of the trees including height, canopy spread and diameter at breast height (DBH) of trunk (measured at 1.3 m above ground level)
    - whether it was a street tree or if it was in public land (public land included parks, streets and cemeteries)
    - condition of the trees including the fullness of the canopy
    - the amount of light exposure the canopy receives
    - amount of impermeable surface (e.g. tarmac) under the tree

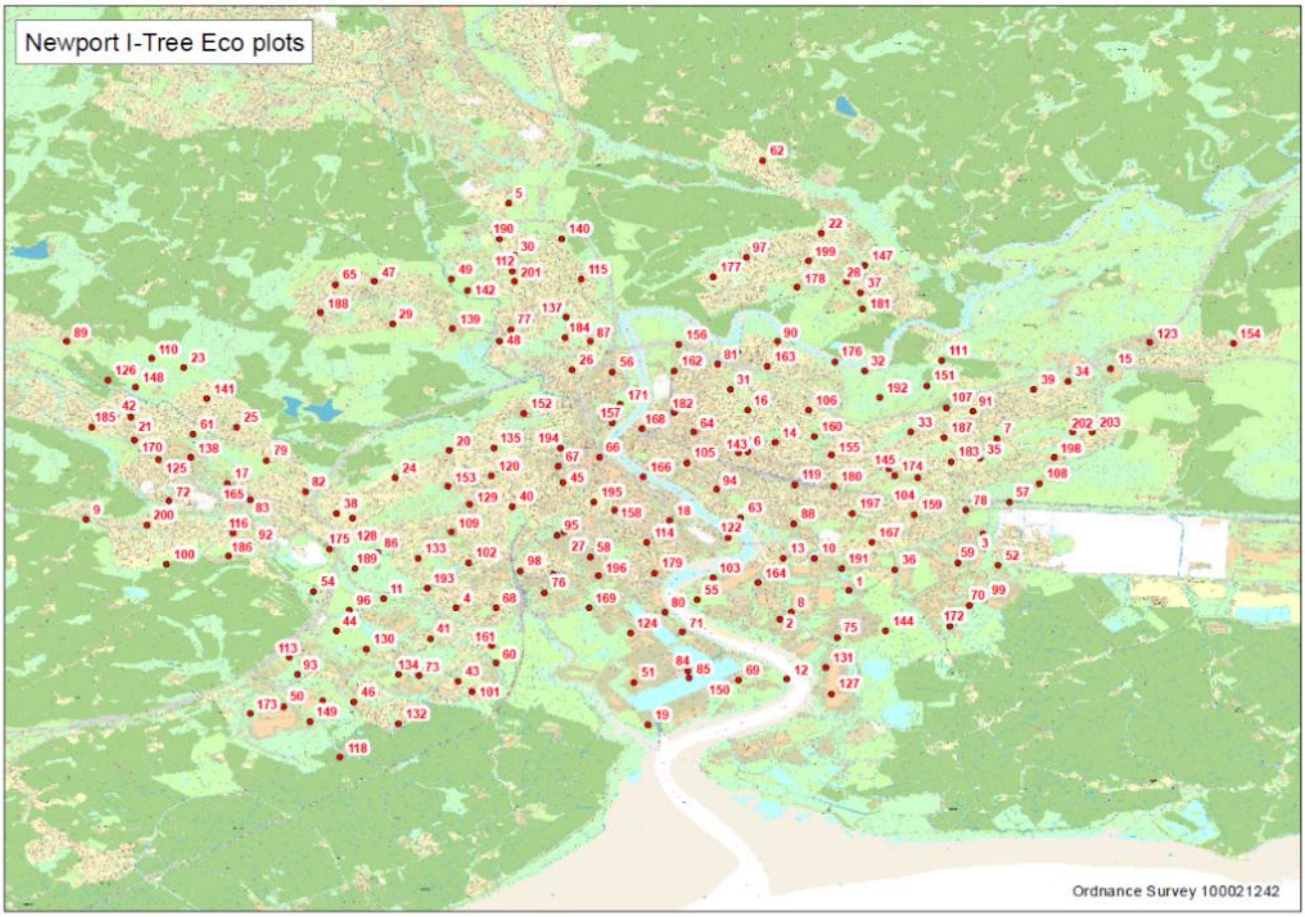


Figure 1. The Newport sample grid and randomised plots across the study area.

Replacement Cost and Amenity Value

i-Tree Eco provides replacement costs for trees based on the CTLA (1992) valuation method. An amended version of the Capital Asset Value for Amenity Trees (CAVAT) Quick method (Doick et al., 2018) was also used in this study. CAVAT has been developed in the UK and has been used by many councils to support planning decisions. CAVAT provides a value for trees in towns, based on tree size (trunk diameter) and depreciated for attributes that impact its contribution to amenity. This value relates to the replacement cost of amenity trees rather than their worth as property per se (as per the CTLA method). Particular differences to the CTLA trunk formula method include the addition of the Community Tree Index (CTI) factor which adjusts the CAVAT value to take account of greater amenity in areas of higher population density, using official population figures.

Pests and Diseases

Pest susceptibility was assessed using information on the number of trees within pathogen/pest target groups and their prevalence within Newport or the wider UK. A risk matrix, as used in previous Eco studies, was used to determine the potential impact of priority pests and diseases should they become established in Newport's urban tree population.

Habitat Provision

Trees and shrubs provide valuable habitats and food for many species, from non-vascular plants such as moss, to insects, birds and mammals. 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).

A short pollinator survey has also been conducted to highlight patterns in pollinator presence. This survey consisted of the surveyor watching the plot for pollinators for two minutes, and noting the presence or absence of bees, hoverflies or butterflies, along with a comment on the weather.

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 measurements within plots.
Identification	Most common species found, based on field observations.
Pollution removal value	Based on the UK social damage costs (UKSDC) where available: £13.2 per kg NO_x (nitrogen oxides - UKSDC), £6.27 per kg SO_x (sulphur oxides - UKSDC) and £250.22 per kg PM (particulate matter – UKSDC).
Stormwater alleviation value	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 (£1.63 per m^3) in 2019.
Carbon storage & sequestration values	The baseline year of 2018 and the respective value of £63 per metric ton (DECC, 2011).
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).

Italic entries denote non-standard i-Tree outputs conducted by the authors

Results and Discussion

This chapter presents the results of the i-Tree Eco survey of Newport. Throughout, comparisons of results are drawn from these previous UK i-Tree Eco study reports:

- Cardiff (Hand et al., 2019)
- London (Rogers et al., 2015)
- Edinburgh (Doick et al., 2017a)
- Bridgend (Doick et al., 2016b)
- Tawe Catchment (Doick et al., 2016c)

Table 3. Outputs from the Newport's i-Tree Eco survey compared to five other UK surveys.

	Newport	Cardiff	Bridgend	Tawe catchment	London	Edinburgh
Study area size (ha)	4,854	14,064	4,440	6,995	159,470	11,468
Number of trees ('000's)	259	1,410[1]	439	530	8,421	712
Plot density (one plot per […] ha)	24	71	22	28	221	57
Canopy cover (ha)	582	2,658[2]	533	1,119	22,326	1,950
% Tree canopy cover	12	19	12	16	14	17
Average number of trees per ha	54	100	99	76	53	62

1. This represents 1.78 trees per resident (based upon a Newport population of 145,736)
2. Approximately 222 times the size of Newport's 12 ha Beechwood Park (NCC, 2020)

Canopy Cover

The **tree canopy cover of Newport is estimated to be 12.0%**, which is lower than the canopy cover found in most other UK i-Tree Eco studies (Table 3). It is also lower than the 2013 reported average for Welsh urban areas: 16.3% (NRW, 2016a), though it should be noted that NRW's estimate is based on a boundary specific to built-up areas only. The estimate of 12.0% canopy cover ranks Newport at 211th out of 312 UK urban areas for published canopy cover estimates (www.urbantreecover.org). Many of these estimates were created using i-Tree Canopy, including those assessed in Doick et al. (2017a).

The urban forest of Newport has an estimated tree population of 259,900 trees. This is a density of 54 trees per hectare, less than estimated in any other Welsh i-Tree Eco study (Table 3). The electoral ward level canopy cover percentage for Newport, as assessed using i-Tree Canopy, can be viewed on the Canopy Cover Webmap[3]. According to this survey, the average canopy cover of Newport's wards is 15.9%. This webmap is a citizen science project to assess the canopy cover of all the urban wards in the UK, it is useful for comparing variability in canopy cover within a city, as well as making a comparison between cities.

Ground Cover

Ground cover in Newport consisted of 46% permeable materials, such as grass and soil; the remainder consisted of non-permeable surfaces such as tar (asphalt), concrete and cement, which contribute to heating of the urban environment and slow precipitation infiltration to soil. Greater presence of permeable surfaces in an urban environment can reduce the risk of flash flooding. Based on i-Tree Eco surveys, the percentage of permeable cover in Newport is lower than in Cardiff (59%) and Wrexham (52%), but similar to Bridgend (49%).

Land use

Figures 2 and 3 illustrate the proportional land use of plots measured, and the land uses of plots where trees were found. The charts also show the public and private split of land uses.

The percentage of trees on publicly-owned land (parks, cemeteries and streets) was estimated at 19%. This leaves the majority of Newport's trees in private ownership; this poses considerable risk with respect to the management of the urban forest. Educating Newport's residents on the significance of this important resource can be a way to mitigate this risk. Engagement in stewardship can appeal to those interested in working as a community of good practice, such as observed in Sidmouth where a civic arboretum has been formed through public action (Frediani, 2015). It would be beneficial for Newport City Council to undertake a detailed evaluation of local land use, enhancing this report's analysis of the proportional representation of trees on different land uses.

[3] https://www.forestresearch.gov.uk/research/i-tree-eco/urbancanopycover/

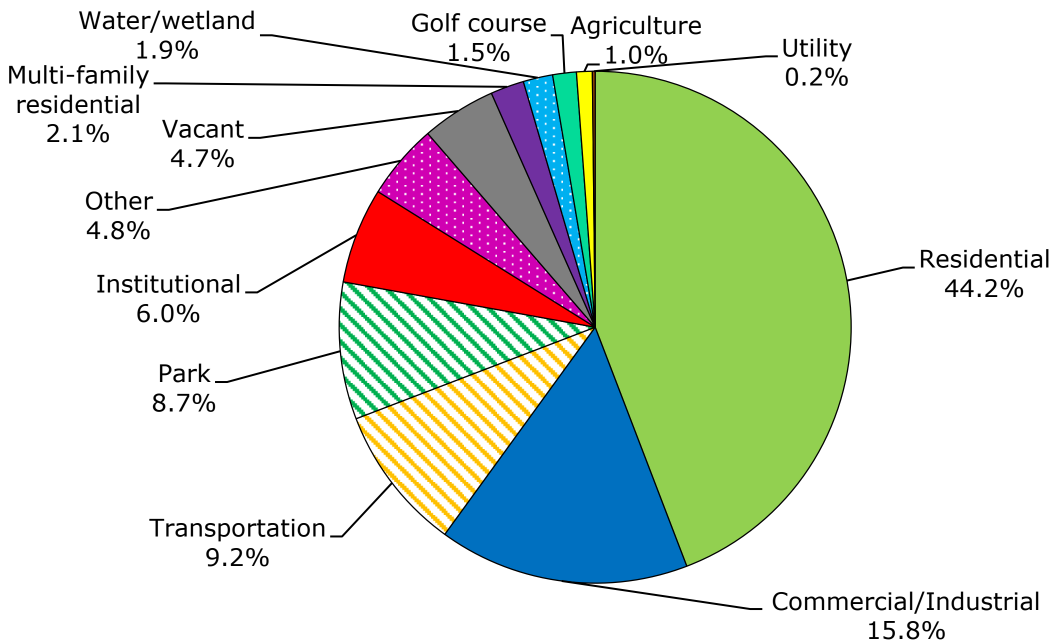


Figure 2. Proportion of plots falling into each of the different land uses by dominant land use in that plot. For a definition of land-uses see the Supplementary Report. Plots can contain more than one land use (e.g. where they straddle the boundary between a residential property and the street). The solid colour sectors represent private land use, the striped sectors represent public land use, and the spotted sectors represent other.

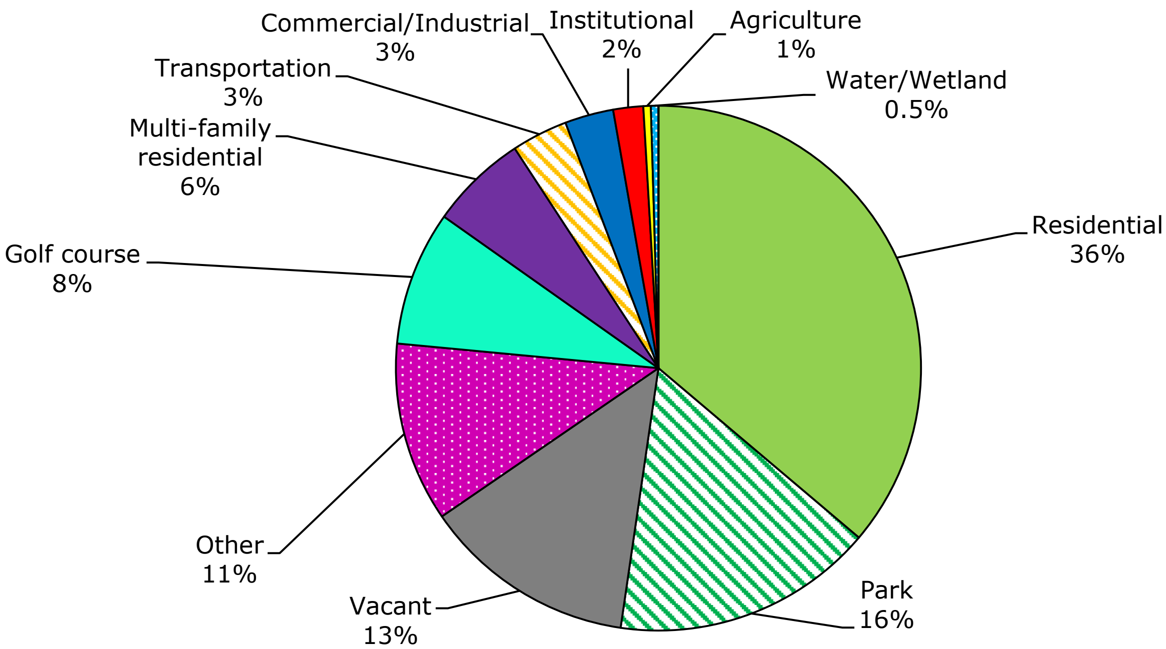


Figure 3. Land use types on which trees were present. The solid colour sectors represent private land use, the striped sectors represent public land use and the spotted sectors represent other.

Urban Forest Structure

Species Composition and Diversity

A total of **59 tree species** were recorded during the study (for a full list of tree species see the Supplemental Report). This is similar to the species diversity identified in Bridgend (60 species), but lower than recorded in the Cardiff (73 species) and Tawe catchment (88 species) i-Tree Eco studies.

The three most common species were **Leyland cypress**, **Birch (hybrid)**, and **Hawthorn**. The ten most common tree species accounted for **63%** of the trees surveyed (Figure 4).

68% of the trees were native species. 28% of all trees were evergreen and 72% deciduous. Large evergreen trees, such as Norway spruce and Scots pine, are important for year-round provision of ecosystem services, achieving a high level of resilience in the long term, and enhancing ecosystem service delivery via diversity of species and provision of a structurally diverse urban forest.

Where trees were present, they most commonly occurred on **residential land** (Figure 3, 36%; for definitions see Appendix I), parks (16%) and on vacant land (13%). Tables 4 and 5 provide a breakdown of species composition and canopy cover in the four most common land uses in Newport.

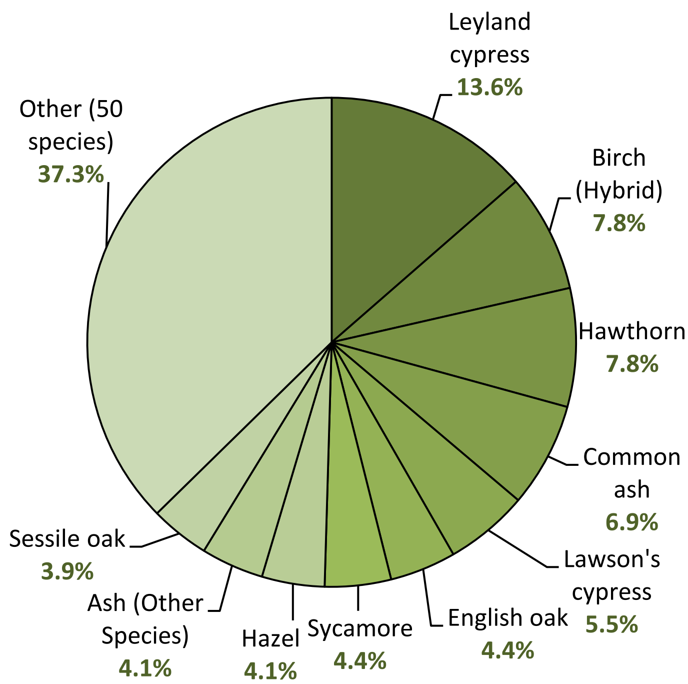


Figure 4. Breakdown of the percentages of the ten most common tree species found in the Newport survey

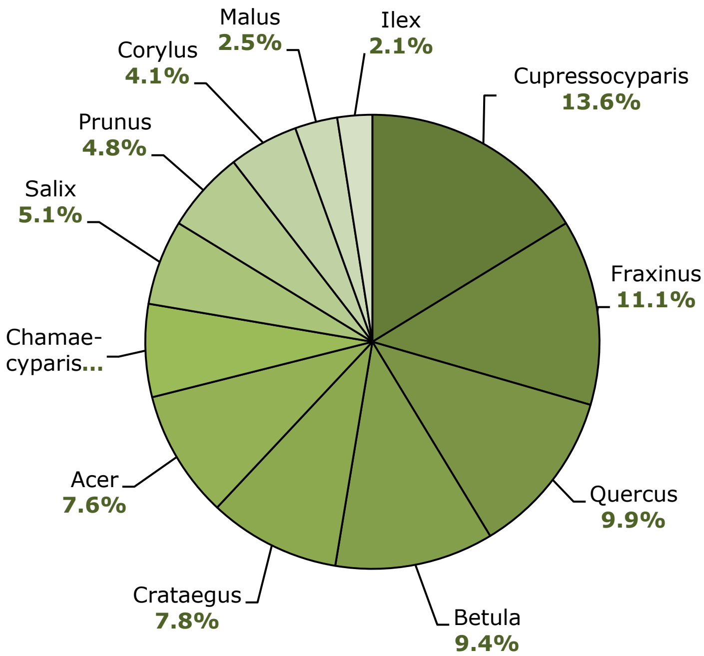


Figure 5. Breakdown of the percentages of the twelve most common tree genus found in the Newport survey

Table 4: Plot and tree information across the four most common land uses.

	Residential	Commercial	Transportation	Park
Percentage of all plots	44%	16%	9%	9%
Percentage of plots with trees present	48%	24%	8%	47%
Average canopy cover (%) of plot	7.9%	1.9%	9.2%	21.8%
Average plot plantable area (%)	24.1%	9.2%	13.4%	75.9%
Number of Trees Measured	157	13	15	70
Species richness	42	6	8	17

Table 5: A breakdown of the top ten species on the land uses with the most trees measured. Red cells indicate presence in excess of the recommended 10% threshold for any one species.

	Residential		Park	
Top 10 species breakdown (%)	Leyland cypress	36	Birch (hybrid)	44
	Apple spp.	4	English oak	14
	Common ash	4	Hawthorn	7
	Common holly	4	Silver birch	4
	Hawthorn	4	Sessile oak	4
	Lawson's cypress	3	Laurel spp.	4
	Sycamore	3	Hazel	4
	Ash (Other Species)	3	Common ash	3
	Cherry laurel	3	Cherry spp.	3
	Field maple	3	Sweet chestnut	1
Notes	There is a high proportion of Leyland Cypress within Residential areas in Newport, which are primarily used for hedging (see Plate 3). Other common species include apple (a common garden tree) and ash, which is vulnerable to ash dieback. The mix of large, medium and small stature trees is good, however this is primarily due to the Leyland cypress, a large stature tree but often pruned heavily.		There is a high proportion of birch species in park areas in Newport, however this result is strongly influenced by one plot with 31 hybrid birch specimens in a mixed birch and oak woodland. Newport could work to increase species richness in parks, and across all land uses. A large percentage of the measured trees are of large stature which is beneficial for the provision of ecosystem services[4].	

[4] Davies et al. 2017

Species Composition by Origin

Of those trees identified to species level in the Newport i-Tree Eco study, it is estimated that **68% are native to Wales**. The origin and provenance of tree species and cultivars can impact their vitality and tolerance to stresses and threats such as pests and diseases. Potential stresses such as flood events and prolonged exposure to drought are projected to increase due to climate change (Murphy et al., 2009). These factors are leading some councils to consider further use of underused non-native species. Such species may be more suited to future climates and, if biosecurity procedures are followed, can have fewer pests associated with them due to being removed from the native range of their specialist predators and diseases (Connor et al., 1980). Trees from warmer climates may also be able to better withstand the effects of climate change (RHS, 2018b). However, some exotic species can disrupt native ecosystems by changing the available niches for wildlife to fill (Townsend et al., 2008). They also support fewer native animals (Kennedy & Southwood, 1984), and can become invasive (Mitchell & Power, 2003). A balance of carefully selected native and non-native species may provide the most resilient solution.

Diversity Index

Increased diversity of tree species, i.e. the number of different species present in a population and their numbers, offers a higher level of resistance to pests and diseases (Johnston et al., 2011). To promote species diversity, Santamour (1990) recommends that no species should exceed 10% of the urban forest population, no genus 20% and no family 30%. In Newport, one species exceeded the 10% guideline (Leyland Cypress) across the total population. No genus exceeded 20% frequency and no family exceeded 30%.

The diversity of populations can be calculated using the Shannon-Wiener index. This is a measure of number of the different species and dominance by certain species. The diversity score of Newport's urban forest is 3.5 according to the Shannon-Wiener index. This is similar to Cardiff's score (3.3), Wrexham (3.1) and Bridgend (3.6). The highest diversity of trees was found in residential areas (2.9) and land categorised as 'other' (2.9) (Figure 6). There was very low diversity on agricultural land and wetland, where the main species were common ash, horse chestnut, hazel and alder.

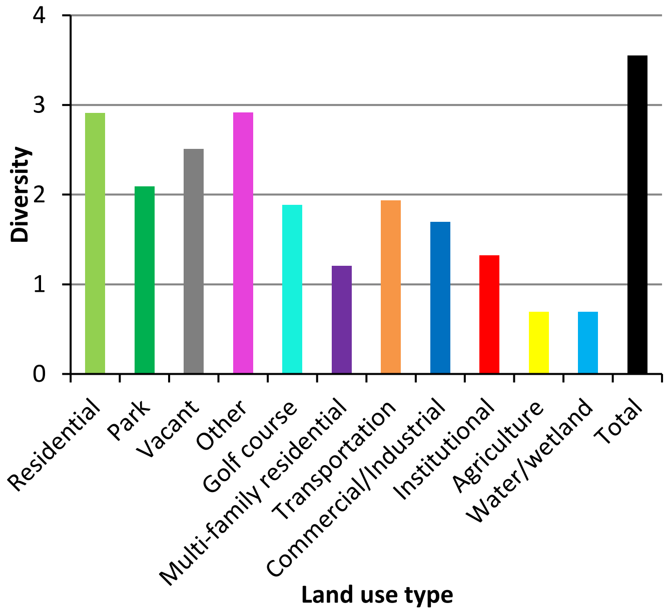


Figure 6. Shannon-wiener diversity index scores for trees on different land use types in Newport, in order of number of trees in that land use.

Targeting management for greater diversity

Understanding where species diversity could be improved can help to inform urban forest management at a local (e.g. ward) and city-wide scale. In Newport, Leyland Cypress currently makes up a higher proportion of species than deemed as suitable (13.6%, compared to the recommended maximum of 10% presence of any one species; Santamour, 1990). Over 95% of these Leyland Cypress were found in residential areas, most commonly used as hedges or screens. Encouraging and promoting the use of alternative or mixed species as hedging options could help to diversify some of the tree species found in private gardens.

Influencing the residential selection of trees can however be challenging; land designated as such is largely owned by private individuals, with different land use objectives. In many cases tree species are selected based on their aesthetic value or their ability to screen the property, as such, benefits for the wider community are less likely to feature as a priority. Whilst the planning system could influence tree species diversity on new residential developments, this is limited, thus there is also a need for education and outreach to developers and the residents of Newport so that trees are more widely appreciated and protected.

Selecting trees to broaden the variety of species and increase the diversity offer of Newport's urban forest is crucial for offering increased resilience to the impacts of a changing climate, while also increasing the public amenity value and providing greater support to biodiversity.

Plate 3: Leyland cypress used as hedging in a residential garden.

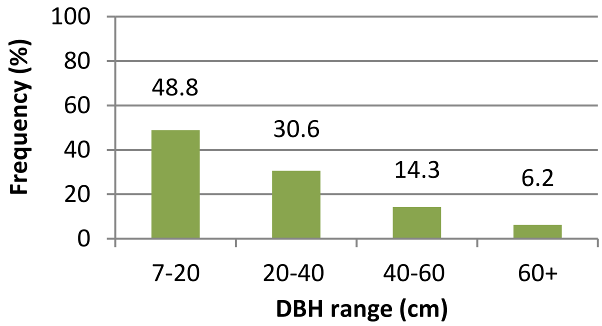
Size Class Distribution

The size distribution of trees is important for a resilient population. Large trees frequently provide more ecosystem services than small ones (Sunderland et al., 2012; Hand et al. 2018, a,b). Mature trees, whether of small or large stature, will provide greater levels of most ecosystem services than younger trees of the same species. Therefore, planting more large stature trees and supporting more trees to maturity will increase the ecosystem service delivery per tree of the urban forest. To maintain an on-going level of mature trees, young trees need to be planted in a surplus to allow for mortality.

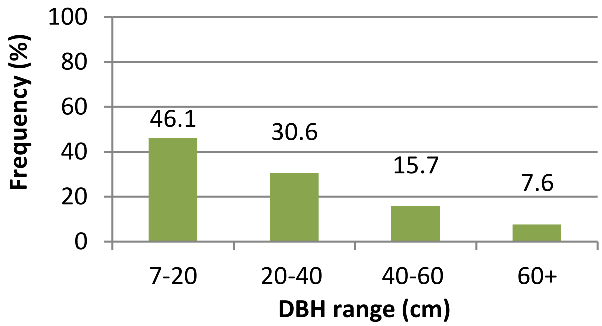
Richards (1983) suggested the ideal street tree distribution to ensure a healthy stock is 40% of trees with a DBH <20 cm, 30% of trees with DBH from 20 to 40 cm, 20% of trees with DBH from 40 to 60 cm and 10% of trees with DBH >60 cm.

It is estimated that trees with a DBH <20 cm constitute 48.8% of the total tree population in Newport (Figure 7a). The number of trees in each DBH class then declines successively. Trees with a DBH >60cm make up for 6.2% of the tree population, which is lower than the 10% value recommended by Richards (1983). However, Newport performs well in comparison to Bridgend and the Tawe Catchment which reported 4% or fewer trees were >60cm, and performs only slightly lower than Cardiff (reported 6.9%). Analysis of only the large stature trees[5] shows that trees with DBH >60 cm and trees with DBH 40-60 cm accounted for 7.6% and 15.7%, respectively (Figure 7b). There was a slight shortage of trees maturing into large diameter trees in the near future.

a) All Species



b) Large Stature Species



c) Small Stature Species

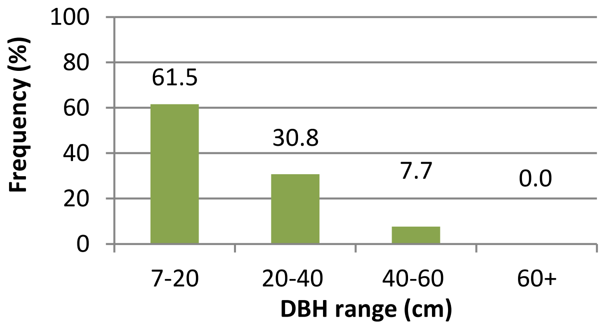


Figure 7. DBH ranges of (a) all measured trees, (b) large stature trees only, and (c) small stature trees only (data values are shown for clarity). Diamonds represent recommended frequencies for that DBH class by Richards (1983) i.e. 40, 30, 20, 10%.

[5] Large stature trees are defined as trees that attain a maximum height greater than 12 m.

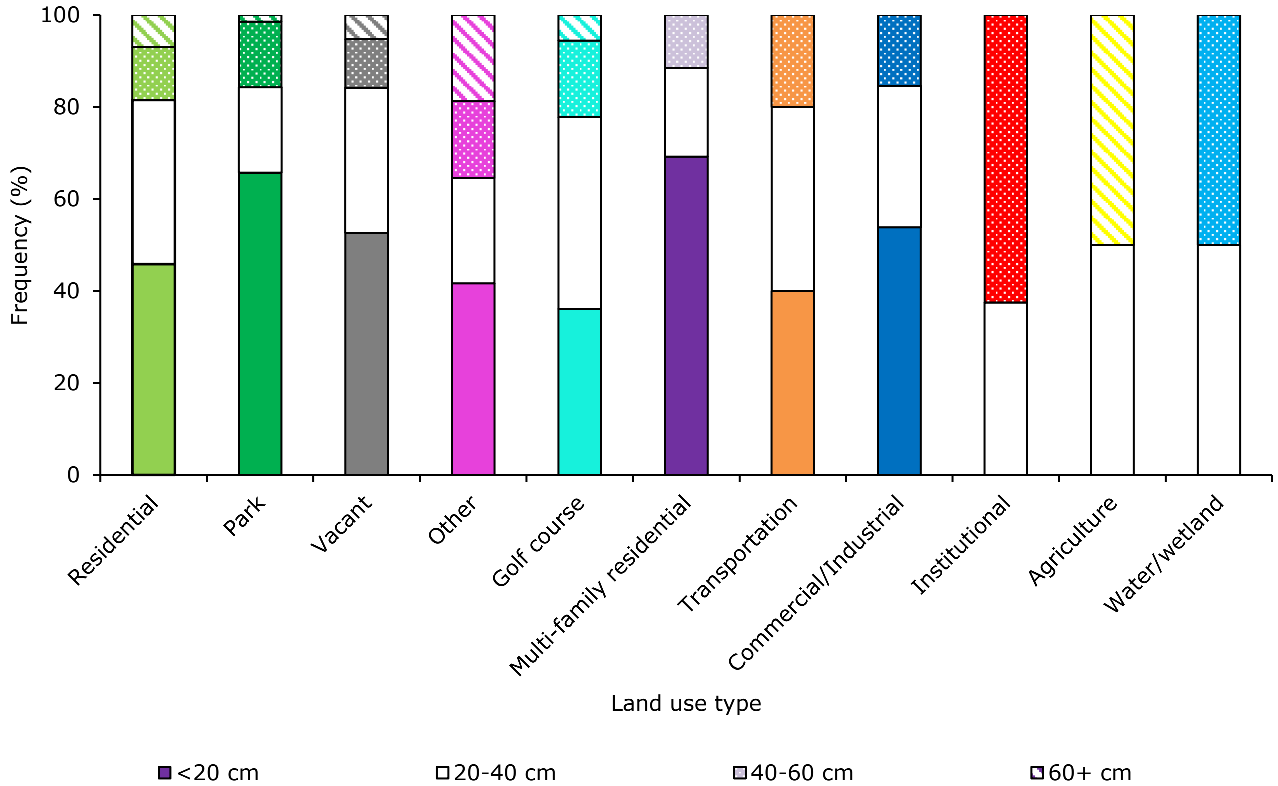


Figure 8. Proportion of diameter size classes per land use type, in order of number of trees in that land use.

There is generally a good distribution of diameter size classes across the land use types (Figure 8). The distribution tends to favour small (<20cm DBH) and intermediately sized trees (20-60cm DBH), and notably, there are no large trees (>60cm DBH) in Transportation or Commercial/industrial land uses. The proportion of large trees is particularly low in other land use categories, such as Parks, therefore it would be beneficial to focus on increasing the number of large DBH trees in these areas to ensure a sustainable DBH distribution.

Size matters

There is a high proportion of small and, in particular, medium sized trees in Newport, providing a reservoir that can be fostered, through careful management, to maturity. These would provide for future generations the benefits of a canopy cover with a higher proportion of large trees, through proportionally more carbon storage, air pollution removal and avoided surface water run-off. A programme of planting would also ensure an on-going presence of small, young trees. A tree planting strategy for Newport would be one way to address this.

Urban planners in Newport have an opportunity to explore these findings while seeking to continue to conserve and expand the range of tree size classes across all land-use types. Such a strategy could explore what can be done to improve mature trees safely growing alongside highways and in commercial areas where currently no trees were identified in this study.

To illustrate the different ecosystem service delivery of trees of different stature, two trees within this study were selected for comparison: a young ash tree (7 cm DBH), and a mature ash tree (80 cm DBH). The mature tree stores 200 times the carbon and has over thirty times the carbon sequestration rate. For avoided runoff services and pollution removal: both were approximately 65 times greater in the mature versus the young tree.

Tree Condition

The condition scores used to give a broad picture of tree health within i-Tree Eco are related to leaf loss and branch dieback in the crown. Reduction in leaf area and loss of woody components is damaging to the provision of ecosystem services. The condition assessment can be a useful indicator of potential pest or disease presence, trees planted in unsuitable site conditions, poor management, or need for further investigation. For example, follow-up surveys may be targeted at specific species or locations where a trend is observed.

55% of Newport's trees were in excellent condition, 25% in good and 14% of trees in fair condition[6]. A total of 6% of Newport's trees are estimated as being in 'poor', 'critical', 'dying' or 'dead' condition. The proportion of dead trees across Newport was low; whilst this is a positive indicator of general urban forest health, it is important to recognise the importance of dead trees due to their contribution to biodiversity. Across land uses types,

[6] Conditions: excellent = <1% dieback; good = 1-10% dieback; Fair = 11-25%; poor to dead rating = >25% dieback (Nowak et al 2008). For full definition see Appendix I.

wetland areas had no trees in excellent condition, and transport followed with the fewest trees in excellent condition. Dying trees or those in a critical condition were found in vacant and residential areas, including multi-family residential.

Tree condition across Newport was worse than that reported for Bridgend and Wrexham (87% and 58% in excellent condition, respectively), but not for Cardiff (49% excellent). However, Newport had a much lower proportion of trees in the poor to dead categories compared to Cardiff and Wrexham (both 13% in the poor to dead condition categories).

Figure 11 shows the condition of the top ten most commonly encountered trees across Newport and reveals that English oak had the lowest proportion of trees in 'excellent' condition, and Common ash had the highest proportion of trees that were dying or in a critical condition.

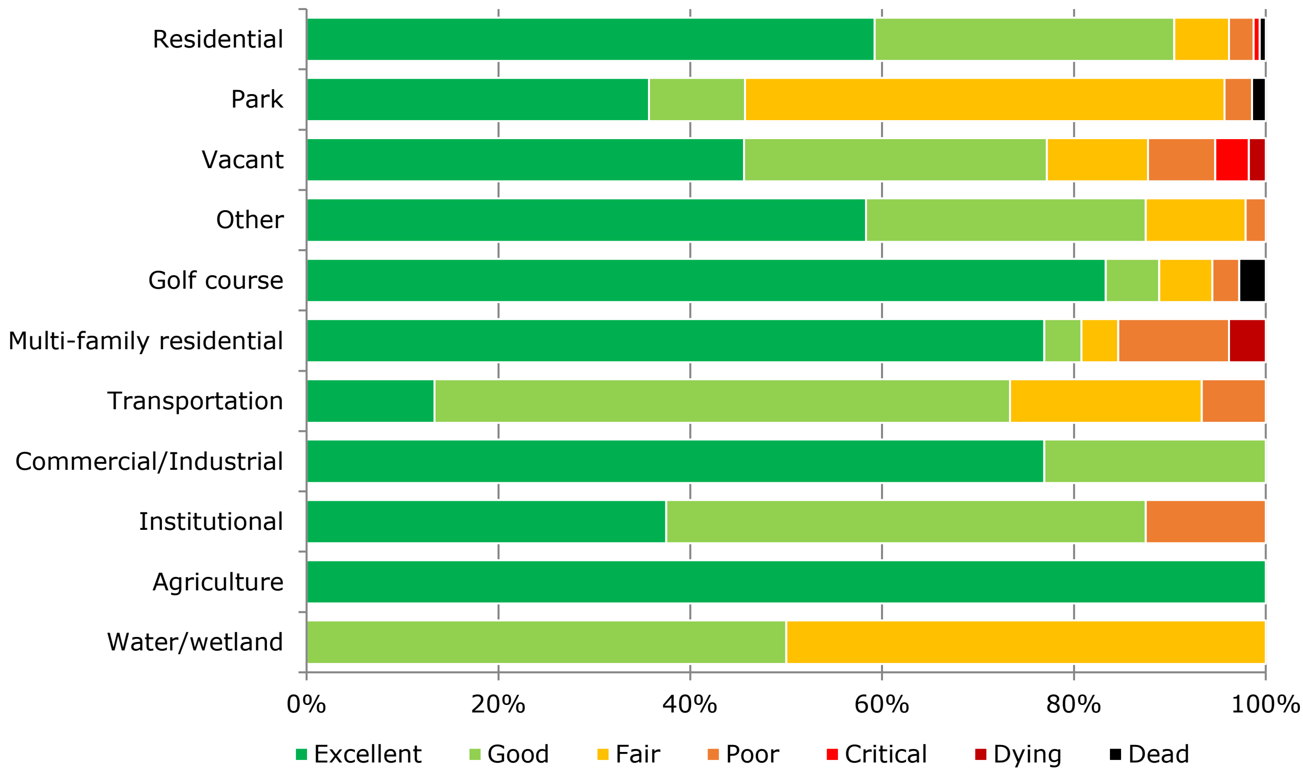


Figure 9. Condition of the total tree population surveyed and by land use, in order of number of trees in that land use.

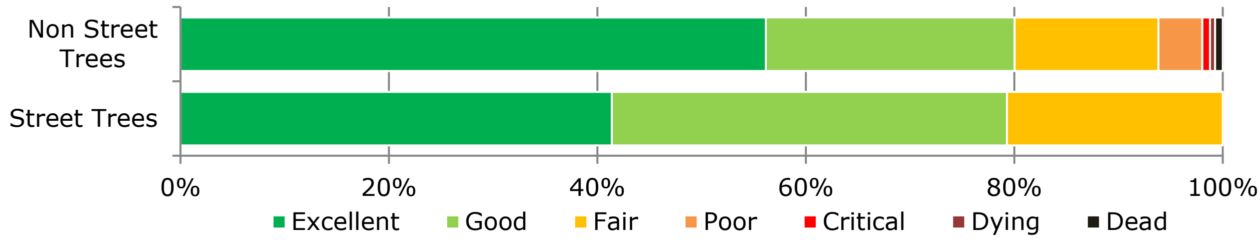


Figure 10: Condition of the total tree population surveyed by street tree/ non-street tree.

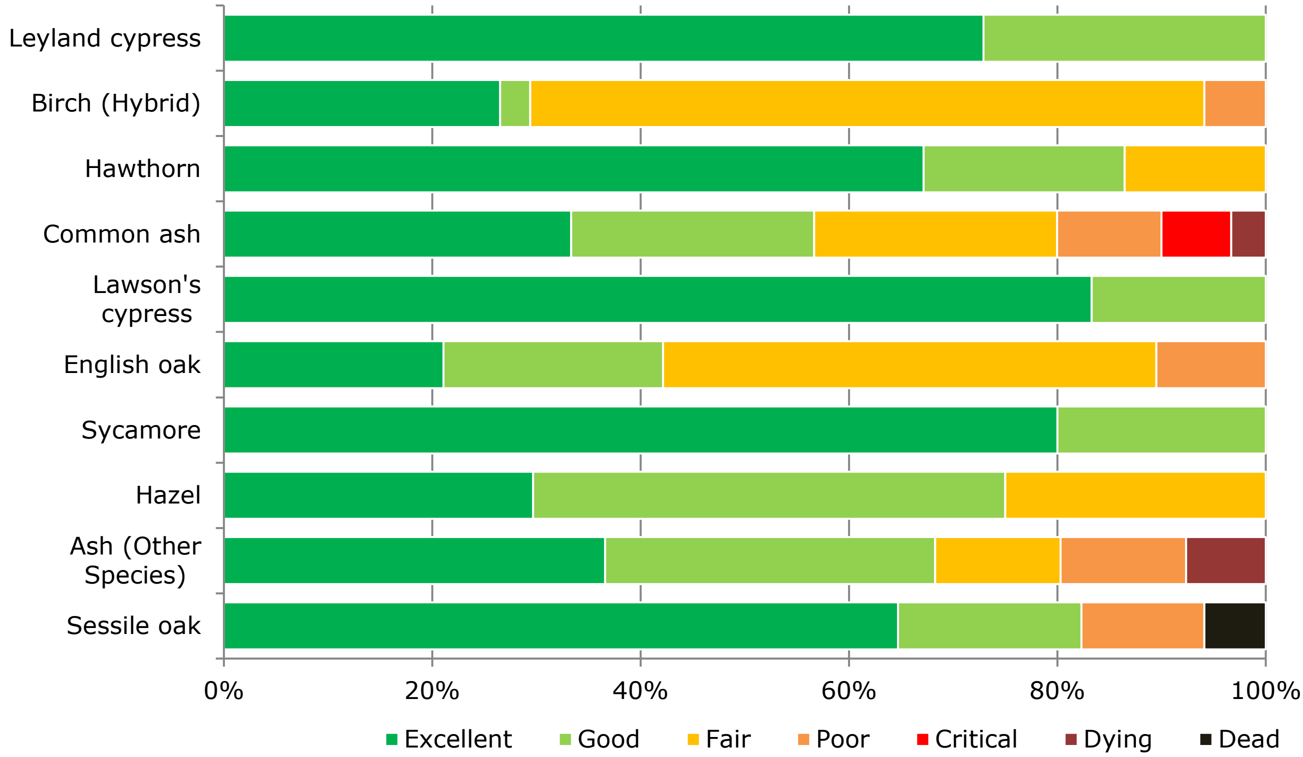


Figure 11. Condition of the top ten most commonly encountered trees across Newport.

The importance of condition

Tree condition is closely linked with the extent of ecosystem services provided, as a decline in tree condition is usually associated with dieback of functional parts, including leaves, woody components, roots and other tissues. In particular, the loss of leaves and accompanying reduction in leaf area can limit the capacity to intercept rainfall and absorb pollutants.

A decline in tree health and condition can often by attributed to pests, diseases, unsuitable management practice and unfavourable site conditions. For example, ash dieback was observed in plots around Newport, and approximately 20% of ash surveyed were either dying or in a poor or critical condition.

To ensure that ecosystem service provisioning is maximised where possible, understanding the effects on tree condition at a local level is important to help inform management of the urban forest. Regular surveys and monitoring can help identify declining trees, causal factors (where possible) and remediation. Current knowledge of the extent of pests and diseases, and specific local threats (e.g. flooding, vandalism) are also key.

Plate 4: Mature trees, including Common ash and Atlantic cedar in a residential setting in Newport

Leaf Area and 'Dominance Value'

The healthy leaf surface area of trees is an indicator of the extent to which trees can provide their benefits, including the removal of pollutants from the atmosphere (Nowak et al., 2006) and shade provision.

The **total leaf area provided by Newport's trees is 31.1 km²**. Sycamore, Sessile oak and Common ash provide the most leaf surface area (9.1%, 6.4% and 6.3% of the total leaf area of Newport's urban forest, respectively; Figure 12).

Dominance value is calculated in i-Tree Eco from leaf area and population size as an indication of which tree species within an urban forest are contributing most to ecosystem service provision. Thus, trees with dense canopies and/or large leaves tend to rank highly. The top tree species in the Newport study, by dominance value, were those which appeared in greater numbers, such as Leyland cypress and Common ash, and those with large leaves, such as Sycamore (Figure 12).

A list of the dominance values for all tree species encountered during the study is presented in the Supplemental Report.

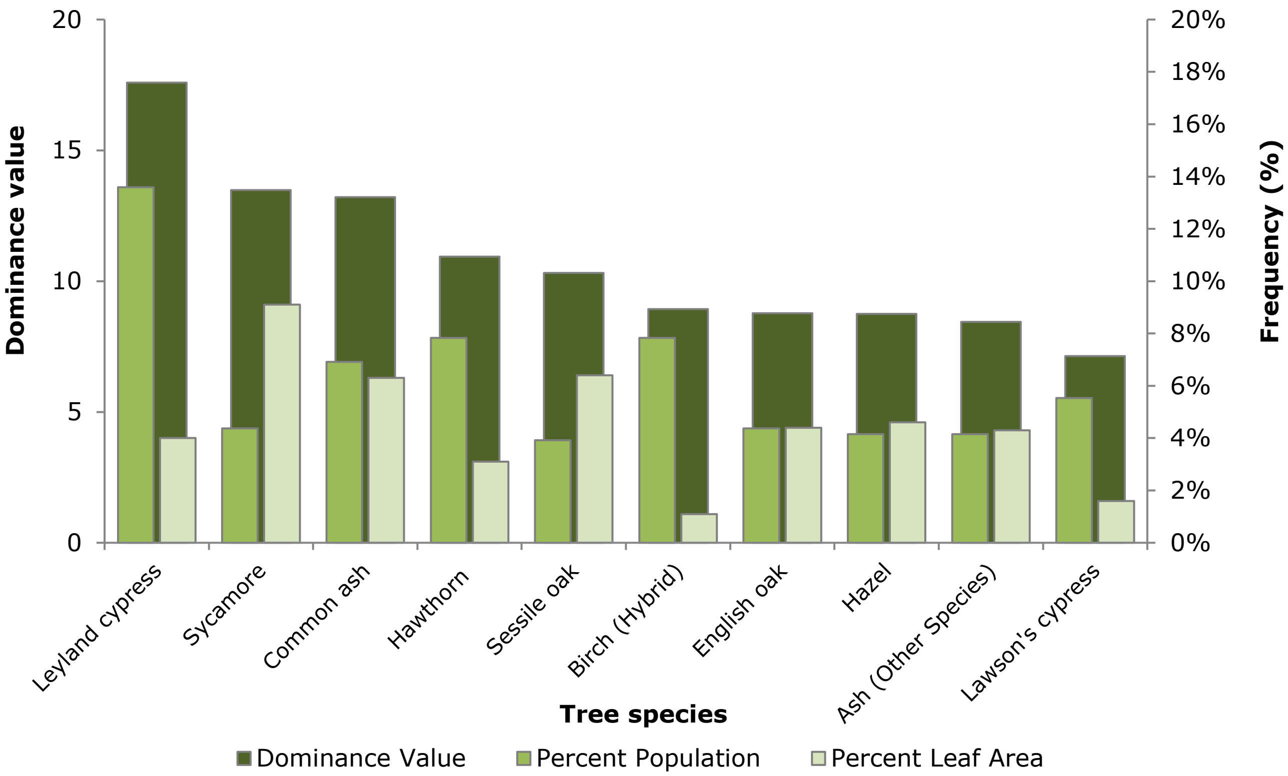


Figure 12. Dominance value of the ten most important tree species in Newport, along with their associated percentages of population and leaf area.

i-Tree Eco dominance value

The scientific models that underpin i-Tree Eco reveal a direct relationship between leaf area and the provision of ecosystem services. Thus, in i-Tree Eco, dominance 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 dominance.

Also known as the Tree Importance value, this relationship is more often termed the Tree Dominance Value to avoid assumptions that these are the tree species that should form the core of any future planting strategy. Rather, it shows which species are currently delivering the most benefits based in their population and leaf area.

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

Ecosystem Services

Avoided Surface Water Runoff

The issue

Flooding is a serious concern for many towns and cities in the UK, which can ultimately result in damage to property and a risk to life (e.g. Wheater, 2006). Urban areas can be particularly vulnerable to surface water flooding, where rainfall may be unable to drain away due to high coverage of impervious surfaces, such as tarmac or asphalt, or due to inadequate infrastructure.

How can trees help

Trees can reduce the risk of surface-water flooding by intercepting rainwater: by retaining it on their leaves and bark, and by absorbing it into their tissues. The roots of trees can also increase natural drainage; this is particularly relevant where there is a permeable surface around the trees, allowing the water to infiltrate into the soil instead of flowing into the drainage system (NB. root absorption is not calculated within i-Tree Eco).

Newport's trees

Trees in Newport intercept an estimated 87,900m^3 of rainfall per year. This equates to 35 times the total water volume capacity of an Olympic sized swimming pool. Based on the standard local rate charged for sewerage[7], this saves **£143,315 in avoided sewerage charges across Newport each year**. By individual tree species, sycamore intercepts the most water (7,340 m^3 per year), worth almost £13,000 in avoided sewerage charges (Figure 13). This is primarily due to the sycamore's large canopies.

Plate 5: Trees with large canopies can intercept rainfall, helping to reduce surface water on impermeable substrate.

[7] Based on Welsh Water's 2019/20 value for the household standard volumetric rate of sewerage charges: £1.63 per m^3 (Welsh Water, 2019).

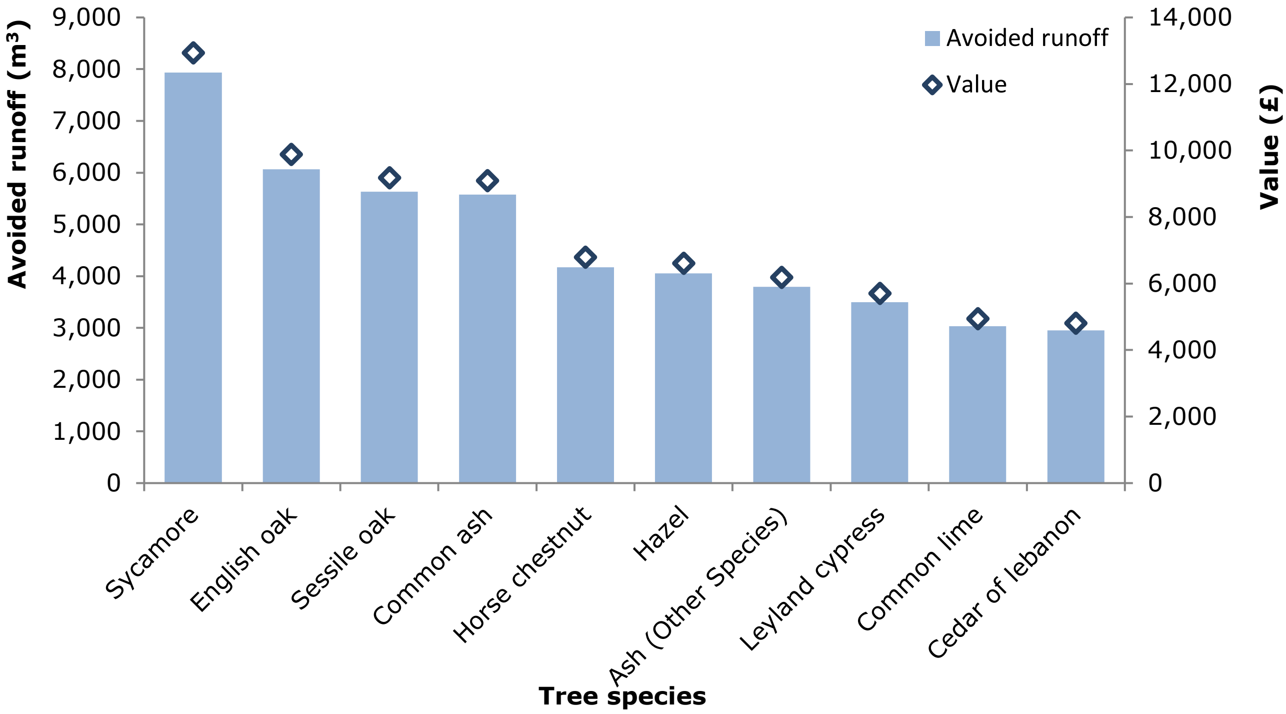


Figure 13. Avoided surface water runoff of the ten top performing species per year provided by urban trees in Newport (columns) and their associated value in avoided sewer costs (diamonds).

Reducing flooding in Newport

Trees with large canopies are particularly useful in rainfall interception and across Newport oak trees provide a valuable storm water interception service. With good design, the planting of large stature trees in areas prone to flooding can complement a planning authority's strategy against flooding. Planting should occur where there is appropriate space and species selection must be informed by preference to the local soil, climate and hydro-geological conditions. It should take account of tolerance to flooding (e.g. see TDAG, 2019).

Planting for interception can be complemented with planning for Sustainable Urban Drainage Systems (SUDS). SUDS are a sequence of management practices, control structures and strategies designed to efficiently and sustainably drain surface water, while minimising pollution and managing the impact on water quality of local water bodies (CIRIA, 2007). Trees can provide a positive contribution to a SUDS system. The selection criteria must include all three elements of the SUDS principles: quality, quantity, and amenity (including biodiversity) in addition to the usual tree selection considerations mentioned above.

Air Pollution Removal

The issue

Air pollution leads to a decline in human health, a reduction in the quality of ecosystems, and it can damage buildings (Table 6). Newport has been reported to suffer from some of the poorest air quality in Wales, second only in terms of fine particulate air pollution to Cardiff (PHE, 2014). To address this eleven air quality management areas (AQMAs) have been declared in Newport (DEFRA, 2020). Public Health England estimated that in Newport 72 deaths were attributable to fine particulate air pollution in 2010 (PHE, 2014).

How can trees help

Trees and shrubs can mitigate the impacts of air pollution by directly reducing concentrations of airborne pollutants. Plants absorb pollutants through their stomata, or simply intercept pollutants on their surfaces (Nowak et al., 2006). This leads to year-round benefits, with bark continuing to intercept pollutants throughout winter (Nowak et al., 2006). Plants also reduce local temperatures by providing shade and transpiring, reducing the rate at which some air pollutants, such as ozone (O_3), are formed (Jacob & Winner, 2009). However, trees can also contribute to ozone production by emitting volatile organic compounds (VOC's) that react with other pollutants such as NO_x emitted by vehicle exhaust fumes (Lee et al*.* 2006). i-Tree Eco reports biogenic emissions of monoterpene and isoprene, the most important naturally emitted VOC's (Stewart et al., 2002). i-Tree Eco takes the release of VOC's by trees into account to calculate the net difference in O_3 production and removal.

Table 6. Urban air pollutants: health effects and sources.

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 NO_2 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

Source: www.air-quality.org.uk; * PM: particulate matter

Newport's trees

It is estimated **that Newport's urban forest removes 76 tonnes of airborne pollutants** per year, including NO_2, O_3, SO_2, CO and PM. Ozone is removed in the greatest quantity. This demonstrates that although trees, as vegetation, can contribute to ground-level O_3 formation, they remove more than they produce.

NO_2 is the air pollutant of most concern in Newport, and PM is of national concern. Both pollutants are caused in part by transport. **It is estimated that Newport's trees remove approximately 1.1% of the NO_x** (oxides of nitrogen, collectively NO, N_2O and NO_2) **and 8.8% of PM emissions from transport in Newport**[8]. 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 Social Damage Costs (UKSDC) in the UK. The UK method does not cover all airborne pollutants (Table 7) 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 SDC has not yet been determined by the UK Government.

Using the UK system, the annual removal of these air borne pollutants by Newport's trees is valued at over **£1,587,000**[9] (Table 7; Figure 14). Using the US valuation system, pollution removal by urban trees in Newport is valued at £459,000 each year (Table 7; NB. this valuation system has not been tested for use in the UK and so should not be used, it is presented here purely for comparison purposes).

The removal of airborne pollutants varies seasonally, for example with higher volumes of O_3 removed during spring and summer (Figure 15). This is because O_3 is a product of the combination of VOCs and NO_x, which are also removed in greater volumes in summer. The production of O_3 is also more prevalent in warm temperatures (Sillman & Samson, 1995) and therefore there is more present to be removed by the trees. In addition, there is a diurnal pattern, with O_3 levels higher during the day than at night (Nowak et al., 2000).

[8] Calculated from the total transport emissions of Wales for 2013 (NO_x 22.35 kt, PM_{10} 1.377Kt, Welsh Government, 2018), where it is estimated 4.7% of these values are attributable to Newport based on the number of cars in Newport (72,900; Department for Transport, 2019) versus in Wales (1.6 million; Department for Transport, 2019).
[9] Using the central "domestic" emission source for NO_x, SO_X and PM_{10}

Table 7. Amount of each pollutant removed by Newport's urban forest and its associated value. USEC denotes United States Externality Cost and UKSDC denotes UK Social Damage Cost. n/a = not available.

Pollutant	Amount removed (tonnes)	US value (£/tonne)	US Value (£: USEC)	UK value (£/tonne)	UK Value (£: UKSDC)
CO	0.36	980	350	N/A	N/A
NO_2	11.46	270	3,074	13,200	151,300
O_3	55.84	1,800	100,424	N/A	N/A
$PM_{2.5}$	5.67	625,000	354,489	250,221	1,419,306
SO_2	2.67	100	261	6,273	16,773
TOTAL	76		**458,598**		**1,587,378**

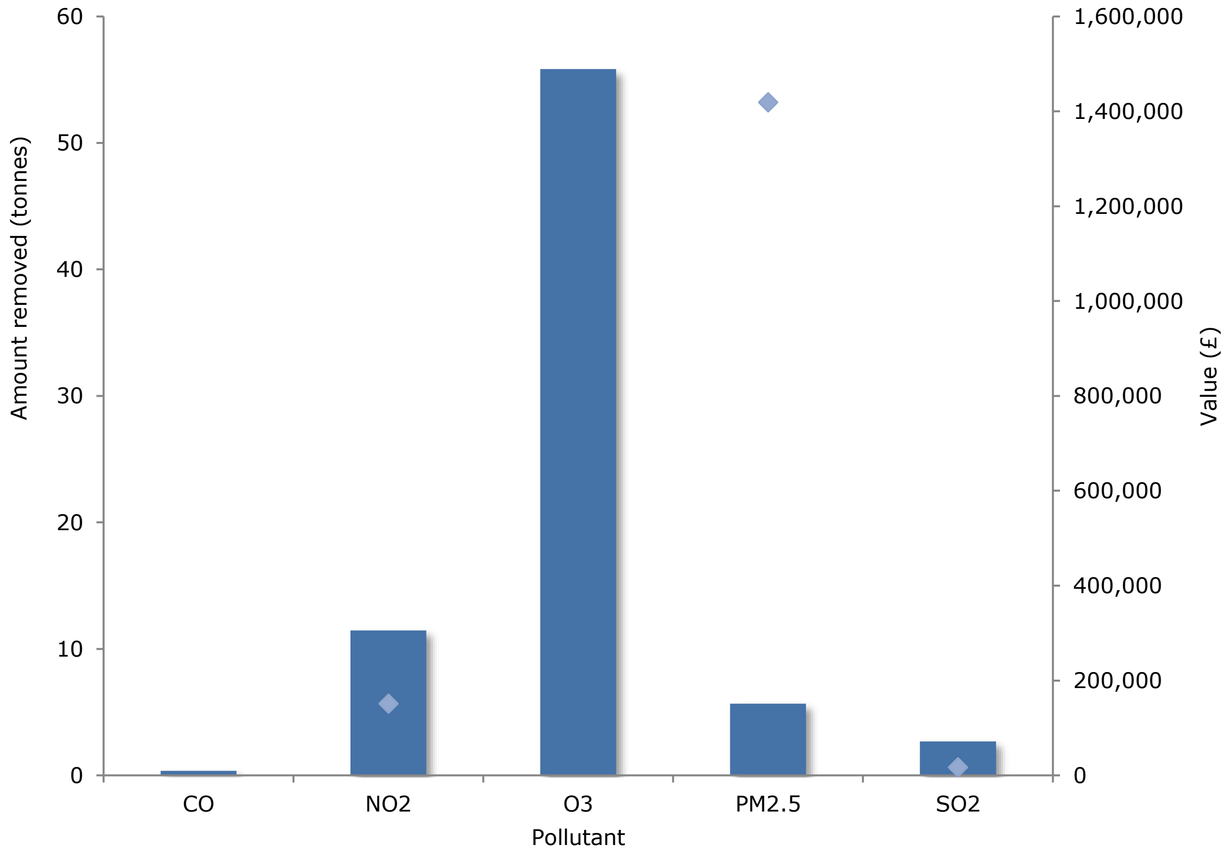


Figure 14. Mean quantity of pollutants removed by urban trees in Newport (columns) and the associated value for NO_2, O_3 and SO_2 (diamonds) according to the UKSDC valuation approach (NB. UKSDC values are not available for CO or O_3).

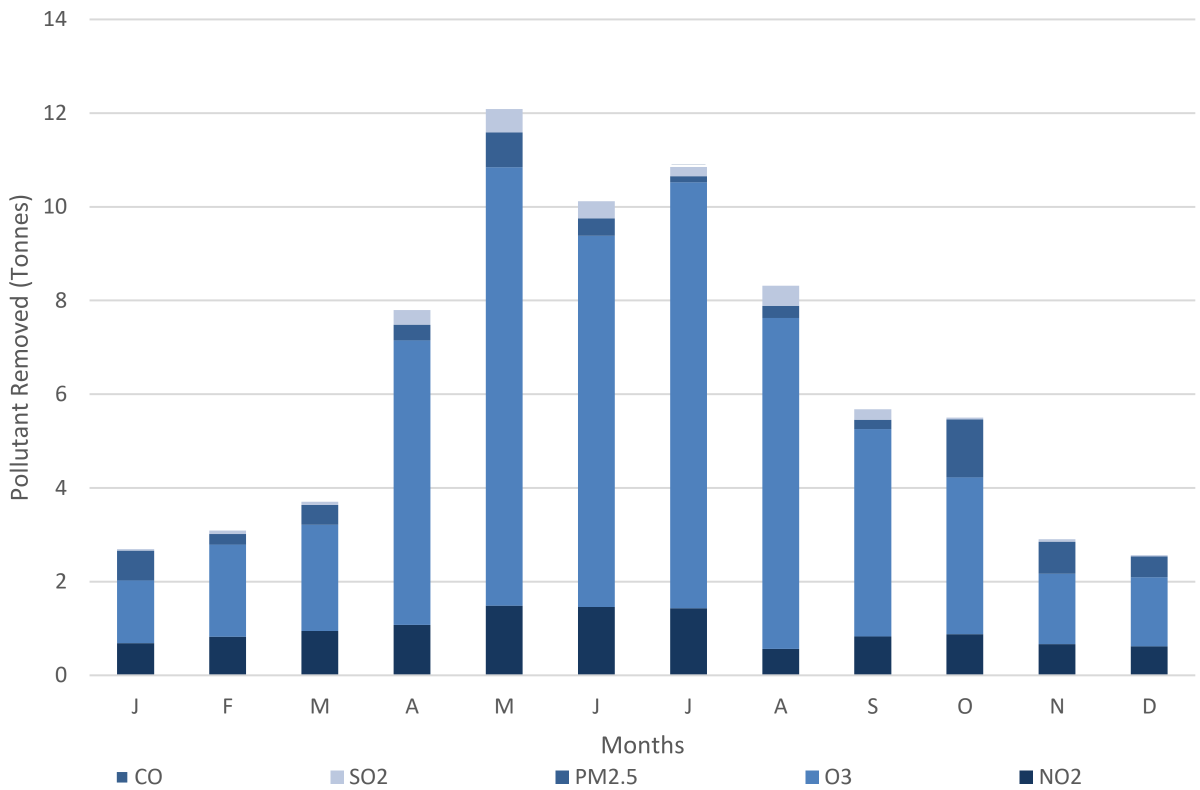


Figure 15. Amount of pollutants removed by Newport's urban trees on a monthly basis.

Air pollution removal by urban trees

Air pollution is recognised by the Welsh Government as a critical threat to the health and well-being of urban populations (Welsh Government, 2017). Newport has one of the poorest levels of air quality in Wales (CCC, 2017a). In particular, high levels of NO_2 have led to the designation of eleven Air Quality Management Areas in Newport.

In order to improve the air quality in Newport, action needs to be taken across the city as whole. Urban trees cannot prevent the root causes of poor air quality: primarily traffic emissions, but their role in contributing to improving air quality is recognised in Welsh Government guidance (Welsh Government, 2017). Trees can help to improve local air quality by intercepting pollutant particles in the air, by encouraging more active forms of travel, by creating a buffer between traffic emissions and pedestrians, and by having a calming effect on drivers leading to smoother driving (Welsh Government, 2017). Careful site selection, design, species selection, and integration with other air quality management strategies can help improve air quality. 'First Steps in Air Quality for Built Environment Practitioners' (TDAG, 2018) provides examples of how urban trees can help mitigate poor air quality.

Carbon Storage and Sequestration

The issue

Increasing levels of carbon dioxide in the atmosphere are a significant contributor to global climate change. In Wales, climate change is predicted to increase summer temperatures, the risk of coastal flooding events and winter rainfall. Reducing carbon emissions could help to mitigate the future extent of climate change. The Environment (Wales) Act 2016 outlined a commitment to reducing Wales' greenhouse gas emissions (including carbon dioxide) by at least 80% by 2050.

How can trees help

The urban forest is an important repository for carbon, both with respect to the total amount of carbon stored as well as the annual sequestration rate. By absorbing carbon dioxide from the atmosphere trees help to combat a key driver of climate change. Large trees are particularly important carbon stores.

Newport's trees

It is estimated that **Newport's trees store a total of 75,700 tonnes of carbon in their wood.** This is equivalent to the annual carbon emissions produced by **15,141** households, around 4 times the number of households in Newport[10]. As with other ecosystem services, carbon storage depends not only on the number of trees present, but also their characteristics. In this case, timber density and quality are important. Larger trees can store more carbon, mostly within their woody components. For example, the estimated 4,190 horse chestnut trees that make up 1.6% of the population store approximately 10% of the total carbon (Figure 16), whereas hawthorn stores only 4% of the total carbon while constituting 7.8% of the population.

The net carbon sequestered by the urban forest in Newport each year is estimated at **2,114 metric tonnes per year**. The carbon in trees can be valued within the framework of the UK government's carbon valuation method (DECC, 2011). 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 2018[11], **it is estimated that the carbon in the current tree stock is worth £17.2 million.**

[10] Based on an average UK household emission of 5 tonnes of CO_2 per year in 2010 (Palmer & Cooper, 2011) and 63,445 households estimated in Newport in 2011 (ONS, 2011)
[11] The 2018 value for 1 tonne of carbon is £227, based on the non-traded value of 1 tonne of CO_2 equivalent as £62 (DECC, 2011).

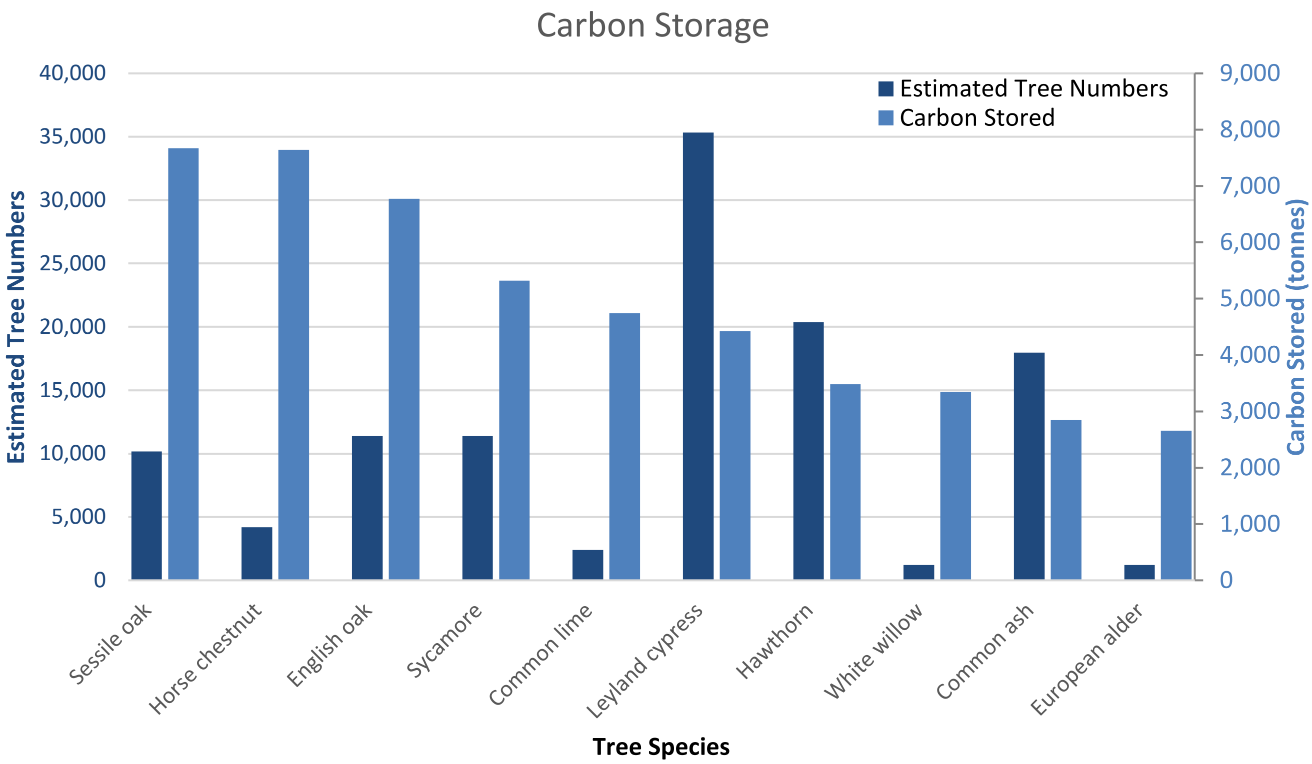


Figure 16. Amount of carbon stored in the ten species with the highest storage rates and the frequencies estimated by i-Tree Eco.

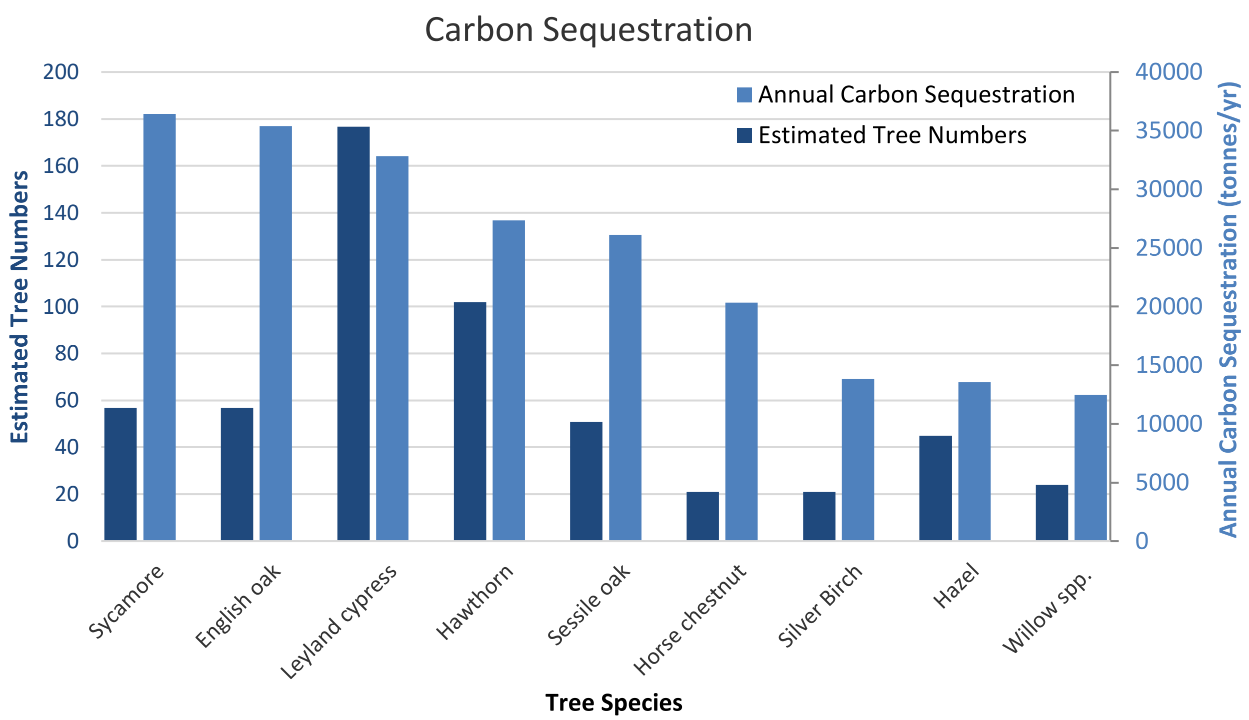


Figure 17. Carbon sequestered per year by the ten trees with highest rates, along with the species frequencies estimated by i-Tree Eco.

Carbon storage and sequestration

Carbon has a significant role in climate change. This is due to the absorption of heat by carbon dioxide (CO_2) in the atmosphere, preventing heat from being lost to space, and re-emitting some of this thermal energy back to Earth. As a result, increasing levels of carbon contribute to global warming.

The urban forest is an important repository for carbon, and thus helps to combat a key driver of our changing climate. This i-Tree Eco study shows that for Newport's urban forest, oaks (Sessile and English) make a significant contribution to carbon storage and sequestration, in addition to other large stature trees, including sycamore and horse chestnut. There is a significantly high storage and sequestration capacity to tree number ratio for these trees, emphasising the importance of large stature trees in providing ecosystem services. However, species diversity must be carefully considered to ensure resilience and prevent over reliance on certain tree species. For future planting, pioneer species or other fast-growing trees may offer a quicker solution to increased carbon storage capacity, such as birch, willow, pine, spruce and some ornamental choices such as dogwoods and Liquidambars.

Habitat Provision

The issue

The UK is suffering from a net loss of biodiversity and in Wales a third of the assessed priority species are in decline (Hayhow et al., 2016). Supporting nature in cities helps to conserve wildlife species and retain opportunities for people to view and interact with nature. This connection to nature is linked to improved health and wellbeing (Sandifer et al., 2015) and understanding of the natural world (Miller, 2005).

How trees can help

Trees create habitats which other flora and fauna use (Smith et al., 2006; Nielsen et al., 2014). Native trees have been thought to be more important in supporting native biodiversity (Kendle & Rose, 2000), but non-natives can also be beneficial for nature, particularly in urban areas where native trees may not always be suitable (Sjöman et al., 2016). In particular, non-native species can be important food sources for pollinators (Baldock et al., 2015). Recent research has shown that exotic plants can extend the flowering season and provide additional resources to pollinators when the abundance of flowers on native and near-native plants was low. In addition, interactions between an exotic plant and some pollinators suggest that exotic plant species can be especially valuable to some insect species. Therefore, selecting trees from one region of origin may not be the optimal strategy for providing resources for pollinating insects in urban landscapes. It seems that the best advice is to encourage the planting of a variety of trees in Newport with a balance between native and non-native species suitable for current and future climates which may help to extend the flowering season and hence food provision for some groups, for example solitary bees (Salisbury et. al., 2015). Larger and older trees have been found to harbour greater biodiversity (Nielsen et al., 2014; Carr et al., 2018). Overall, a diversity of trees is most important, with a range of tree species, ages and sizes offering the greatest range of possible habitats (Nielsen et al., 2014).

Newport's trees

Newport's urban forest contains a large number of tree species, 68% of which are native trees. This includes scarcer native species: black poplar and elms (Cottrell, 2004; Tomlinson & Potter, 2010). Newport contains three woodland SSSIs, further highlighting the importance of Newport's trees.

The biodiversity value of Newport's 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 Newport. 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 Newport's urban tree population is assessed by reviewing the biodiversity value of the tree species and their population size in Newport. 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 (BRC, 2018). 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 18-20). The figures illustrate the values of different species, but generally show that many of Newport's larger tree populations provide high levels of biodiversity value. It also identifies potential species for future planting which could be considered to provide biodiversity value.

Figure 18 shows that **Newport's significant populations of birches, willows and oaks support the greatest species richness of foliage invertebrates.** Non-native species tend to support fewer associations with foliage invertebrates than native species. However, some non-natives can perform well and be important surrogate species when natives go into decline, such as sycamore and horse-chestnut when elms were lost to Dutch elm disease (Key 1995; Alexander et al., 2006).

In terms of pollen and nectar provision native species of cherries, birches and oaks are ranked highest, though many non-native species also perform well (Figure 19). Trees can be important sources of food for pollinating invertebrates (Alexander et al., 2006), which are themselves in decline (Baldock et al., 2015). Diversity in trees which produce pollen and nectar are also important – trees come into flower at varying times of year from spring to autumn, having a constant source of pollen and nectar available helps to support pollinator species. Table 8 provides a review of tree species and their flowering times. In terms of fruit and seed provision, the native species Holly and Hawthorn perform best (Figure 20).

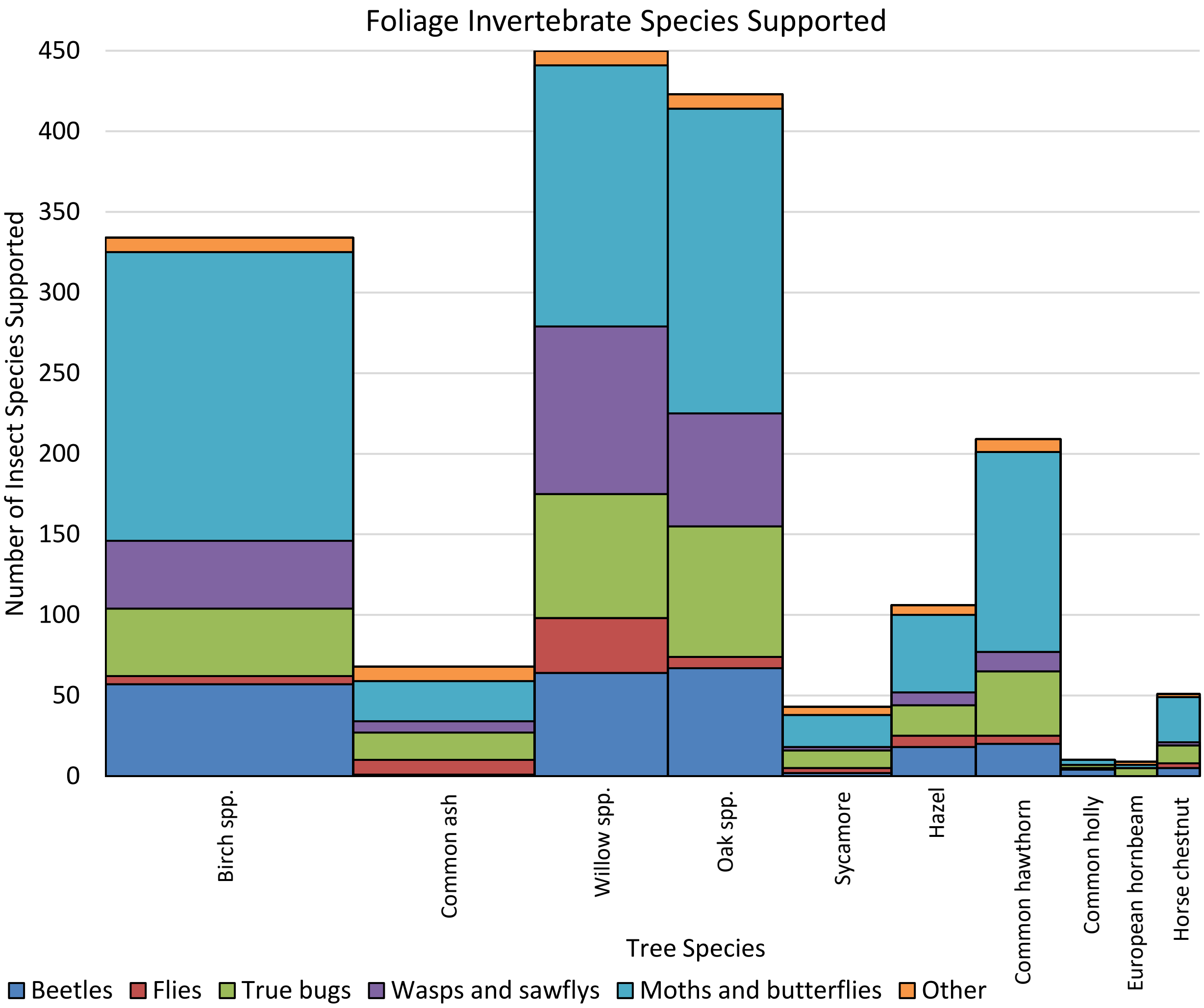


Figure 18: The top ten most populous tree species (of those assessed by Southwood (1961), Kennedy and Southwood (1981), supplemented with additional species from the BRC (BRC, 2018)). The height of the columns represents the number of insect species supported by the tree species, and the width of the columns represents the size of the population in Newport. See Appendix IV for a breakdown of the numbers of foliage invertebrate supported by each species.

Pollinators in Newport

Trees provide valuable habitat and food for many animal and plant species. Data availability on the role of each tree in supporting biodiversity in the urban environment is far from comprehensive.

As an addition to the i-Tree Survey undertaken in Newport, the surveyors performed a simple presence/absence survey of pollinators at some plots over the course of two minutes, and the weather was also noted. In total, 67 plots were surveyed, and in 14 of these pollinators were found. Conclusions are difficult to draw and must be treated with caution because of the limited sample size, however interesting observations can be made. Of the 14 plots where pollinators were observed, 10 had trees present, and of these, over half had more than 5 trees. The species most commonly found on 'Pollinator Friendly' plots included: hazel, Leyland cypress, hawthorn, crack willow, and common ash. All these species are in the top 15 most common tree species in Newport, so this is not unexpected. Table 8 shows in orange the trees that are beneficial to pollinators and found on plots where pollinators were present.

Table 8. Tree species encountered in Newport that are beneficial to pollinators, highlighted in orange are those found in plots where pollinators were marked present

Species	Season
Field maple	Spring
Norway maple	Spring
Sycamore	Spring
Hawthorn	Summer
Common holly	Summer, Spring
Holly spp	Summer, Spring
Laurel spp	Summer
Bay laurel	Summer
Sweet cherry	Spring
Common plum	Spring
Cherry laurel	Spring
Blackthorn	Spring
Goat willow	Spring
Rowan	Summer
Small-leaved lime	Summer
Common lime	Summer

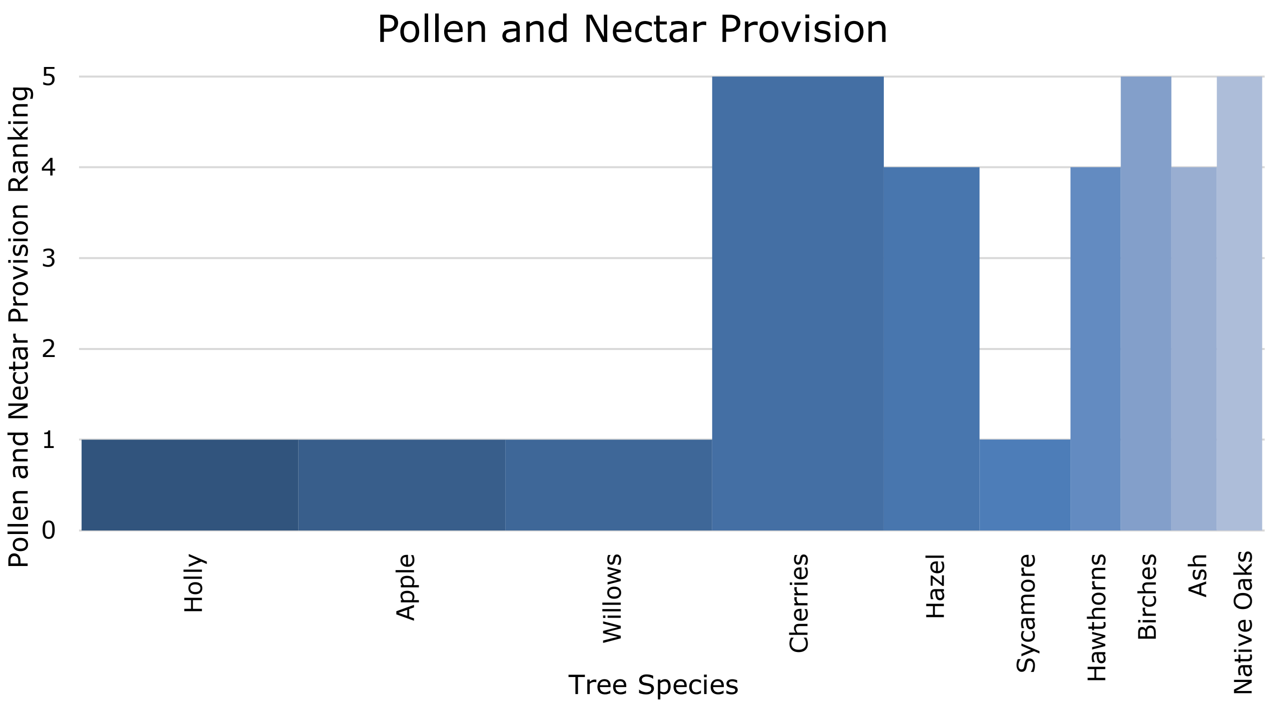


Figure 19: Tree species ranked from 0 to 5 for their provision of pollen and nectar. The width of the columns represents the population size of the tree species.

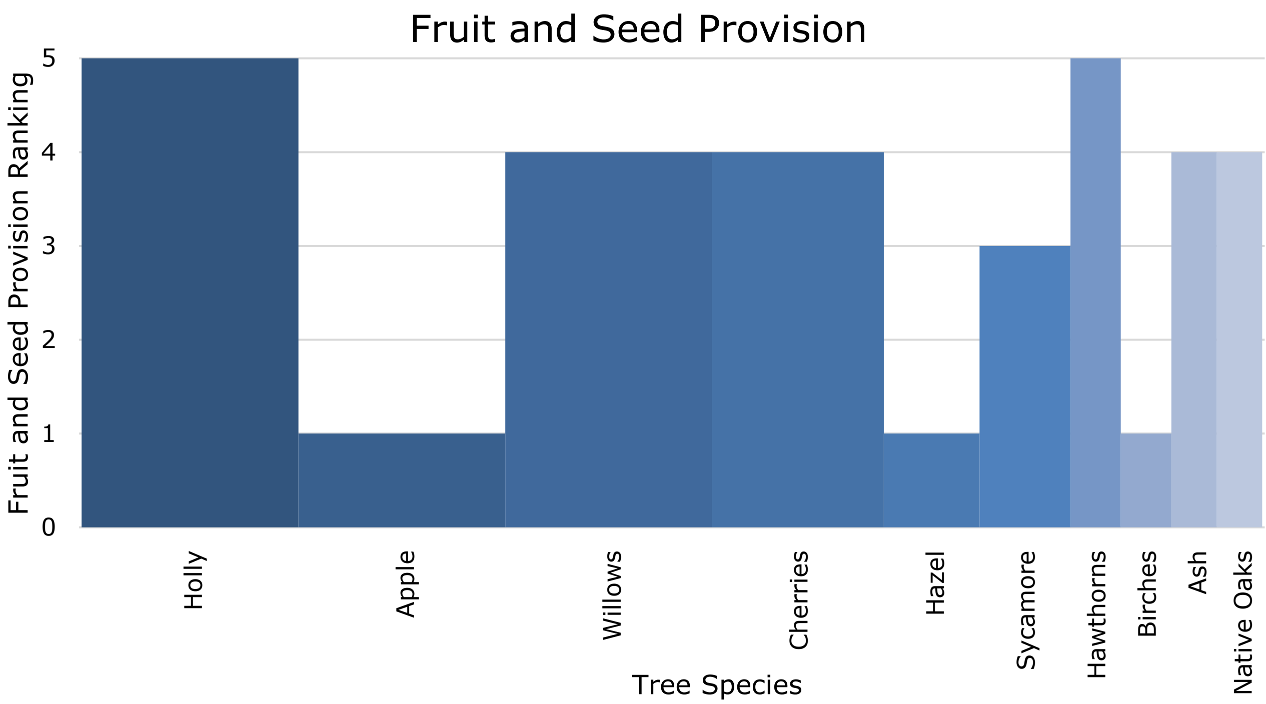


Figure 20: Tree species ranked for the provision of fruits and seeds, which can support a range of invertebrates, birds and mammals. The width of the columns represents the population size of the tree species.

Replacement Cost and Amenity Value

CTLA valuation

The urban forest of Newport has an estimated **replacement (structural) value of £210 million** according to the CTLA Appraisers (1992) valuation method. This is the cost of replacing the urban forest of Newport should it be lost; this valuation method does not take into account the health or amenity value of trees, only the trunk area as a proxy for tree size.

CAVAT valuation

Newport's urban forest has an estimated **public amenity asset value of £2.1 billion** determined 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. The oak trees in Newport had the highest overall value (Table 9, Figure 21), representing 15% of the total public amenity value of all of trees in Newport's urban forest. This is because most oaks were mature ones. Large, healthy long lived trees provide the greatest structural and functional value, which translates into the higher amenity values. The **single most valuable tree was a common lime, with an estimated CAVAT QM asset value of £272,309**.

The land use type containing the highest CAVAT value of trees is Residential, with 31% of the total value of the trees and estimated value of approximately £1.1 million. This equates to greater than £6.7 billion when extrapolated for the whole of Newport. Vacant land and parks were also important contributors for the CAVAT value (Figure 22). In i-Tree Eco studies and pan-city CAVAT valuation studies, trees on these land-use types typically return a high contribution to total public amenity.

Table 9. CAVAT value for the main genera.

Genus	Total value across Newport (£)	Value across Newport (%)
Quercus	325,100,000	15.2%
Cupressocyparis	230,300,000	10.8%
Acer	213,700,000	10.0%
Tilia	186,200,000	8.7%
Salix	127,300,000	6.0%
Aesculus	115,900,000	5.4%
Crataegus	98,310,000	4.6%
Alnus	86,990,000	4.1%
Fraxinus	82,520,000	3.9%
Pinus	70,850,000	3.3%

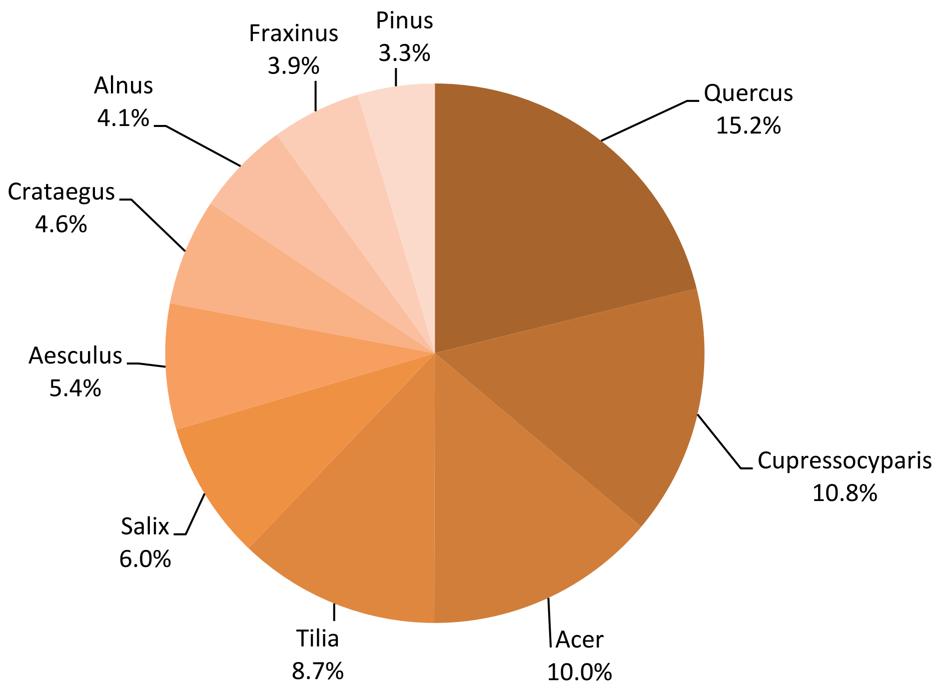


Figure 21. Ranking of the top-ten tree species according to their CAVAT valuation.

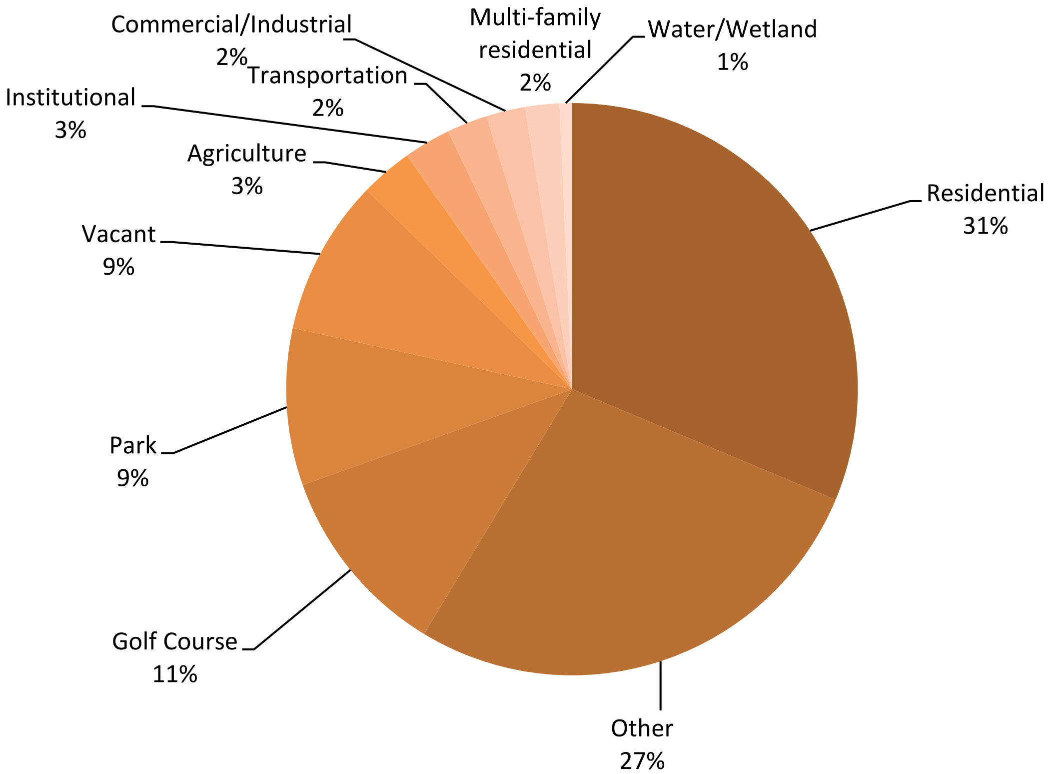


Figure 22. Percentage of the public amenity value held by trees in Newport according to land use.

Valuing amenity trees

CAVAT provides a method for managing trees as public assets rather than liabilities. It is designed not only to be a strategic tool and aid to decision-making in relation to the tree stock as a whole, but also to be applicable to individual cases where the value of a single tree needs to be expressed in monetary terms. Trees that have high CAVAT values are those of large size that are highly visible to the public, which are healthy and are well suited to the location, both in terms of their ability to grow there as well as their specific contribution to the character of the place.

In this evaluation the CAVAT Quick Method (amended) was used. Residential, Other and Golf courses were the land use types in Newport with the greatest CAVAT value. By conserving maturing large stature trees in publicly accessible places such as parks will help to ensure that the urban forest has high public amenity into the future. Selection should always be guided by local policy, diversity in planting for resilience, suitability to the soil type and it should be mindful of suitability to the location long term.

Plate 6: The large poplar in this residential area in Newport provides significant visual amenity value for nearby residents and other members of the public.

Risks of Pests and Disease

The Problem

Pests and diseases are a serious threat to urban forests. Historical outbreaks have had significant impacts, such as Dutch Elm Disease, which has killed approximately 30 million trees in the UK since the 1960s (Webber, 2010). Climate change is predicted to increase the threat associated with pests and diseases (Forestry Commission, 2014), particularly through the introduction of species not yet present in the UK and through altered life cycles and natural ranges of new and existing species.

As a result, assessing the risk posed by pests and diseases to urban forests is vital. In Newport, assessment of these risks has included developing risk matrices for determining the probability of establishment of some pests and diseases not currently present in the city (Tables 10 and 11). It has also included determining the potential level of impact of some pests and diseases that are currently present.

Pests and diseases in Newport

There are a number of pests and diseases already present in Newport. Ash dieback or 'chalara dieback of ash' (*Hymenoscyphus fraxineus*) has been noted by surveyors in the city, with some trees showing severe symptoms. *Phytophthora ramorum* is highly prevalent in South Wales, with many infected larch trees identified in nearby areas such as Wentwood. Decay fungi such as *Armillaria spp*. and *Meripilus giganteus*, whilst not actively identified within this survey, are highly likely to affect the urban tree population, and may reduce tree health in isolation, or in combination with other pests and diseases.

Management to reduce this risk

Increasing the resilience of the urban forest as a whole by increasing tree species diversity may reduce the impact associated with some pests and diseases. Some pests and diseases that are not currently present in the UK, such as Asian longhorn beetle and *Xylella fastidiosa*, pose a threat to many species and could devastate a diverse range of urban trees. Monitoring overseen by the FC Tree Health team at Newport docks is particularly important – whilst timber imports are limited, pallets and dunnage associated with the importation of other products can pose a significant biosecurity risk. In order to protect urban forests from all pests and diseases vigilance is key. Monitoring urban trees for signs of pests and diseases helps trigger a fast response to eradicate them before they are a problem, as well as informing research targeted at combating diseases in the long term.

Table 10. Risk matrix used for the probability of a pest or disease becoming prevalent in Newport’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 11. Risk matrix used for the probability of a pest or disease becoming prevalent in Newport’s urban forest on multiple genera.

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

Healthy trees

In 2019, cases of oak processionary moth (OPM) increased significantly, with over 70 intercepted cases across Wales, England and Scotland. At least one case of OPM has been noted in South Wales, found on recently imported oak. This highlights the necessity of biosecurity procedures, but also vigilance and regular monitoring, particularly of newly planted stock. To limit the risk of widespread loss of urban trees caused by pests and disease, planting a diverse range of species can help increase resilience. Advice is available on suitable species for diversification and in consideration of projected climate change from www.righttrees4cc.org.uk and http://www.tdag.org.uk/species-selection-for-green-infrastructure.html.

Table 12 gives an overview of the some of the established and emerging pests and diseases that could have a significant impact on Newport’s urban forest, focusing on pests and diseases that lead to tree death or pose a significant human health risk; further details on individual pests and diseases are provided in the Supplemental Report. The table presents an estimate of the population of Newport’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 Newport’s urban forest, Table 12 does give an indication of their potential impact to Newport’s trees. The information contained in the table could 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 12. The significance of a range of existing and emerging pests and diseases to Newport's urban forest.

Pest/Pathogen	Species affected	Prevalence in the UK	Prevalence in South Wales	Risk of spreading to South Wales	Population at risk (%)	CAVAT value of trees (£)
Acute oak decline	*Quercus robur, Q. petraea, Q. cerris, Q. Fabri*	Central and SE England	Confirmed case in the Newport area in 2015	High – already present	**8.3%**	279 million
Asian longhorn beetle	Many broadleaf species (see Supplemental report)	None (previous outbreaks contained)	None	Medium risk – climate may be suitable	**50.5%**	969 million
Bronze Birch Borer	All *Betula spp.*	None	None	Medium risk	**9.5%**	59 million
Chalara dieback of ash	*Fraxinus excelsior, F. angustifolia*	Throughout England and Wales, SE Scotland and N. Ireland	Widespread infection throughout Wales	Already present	**11.1%**	82 million
Emerald ash borer	*F. excelsior, F. angustifolia*	None	None	Medium risk (imported wood)	**11.1%**	82 million
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 risk – climate may be suitable	**9.7%**	122 million
Oak processionary moth	*Quercus* spp.	Established in Greater London	Not prevalent, but one interception in Glamorgan in 2019	Medium, small colonies are containable	**9.9%**	325 million

*Note this is one of four subspecies of *Xylella fastidiosa* - there is the potential to affect a more extensive range of ornamental plant species when taking the other subspecies into consideration

Net Present Value

The 100yr Present Value (PV) calculated for Newport's urban forest is £89.4 million, based upon the small proportion of the total value of the ecosystem services that i-Tree Eco can value for an urban forest (Table 13). This value is estimated from only three of the many ecosystem system services urban forests can provide. This value also assumes no change in the urban forest over the next 100 years, which may be unrealistic given the trends suggesting a decline in urban forest cover (NRW, 2016a) and continued development pressure in South Wales. The future benefit provision in Newport will depend both on the demand for services from those who live, work and visit Newport, but also by how the urban forest will change in the next 100 years.

Considering management costs, borne by City of Newport Council, of £300,000 annually for maintenance, surveys and replanting, the NPV of Newport's urban forest is £80.4 million. These costs maintain an asset worth £2.1 billion (CAVAT value) providing services of over £1.9 million annually (net value) (Table 13).

Table 13. The total annual value of ecosystem service provision by services Newport's urban forest and the 100 year Present Value (PV) of these services. The Net Present Value (NPV) is the discounted value of benefits over the next 100 years minus the discounted costs over the next 100 years.

Annual costs*	£300,000
Annual benefits (avoided runoff, air pollution removal, carbon sequestration)	£2.2 million
Annual net value (benefits minus costs)	£1.9 million
Benefit:Cost ratio	7:1
100 yr Present Value (PV) (avoided runoff, air pollution removal and carbon sequestration, discounted)	£89.4 million
100 yr Net Present Value (NPV) (avoided runoff & air pollution removal minus costs, discounted)	£80.5 million

*This value represents the maintenance, surveys and replanting budget for the Newport City Council arboricultural team.

The growing population of Newport is likely to increase the number of individuals benefiting from existing and future urban trees; benefits such as reduced air pollution, more attractive areas for recreation, socialising and relaxation. Additionally, the value of carbon storage in Newport is likely to increase with growth of the forest and the increasing value of carbon (DECC, 2011). However, it is worth remembering that many services were not able to be valued and included in this calculation. This includes the numerous cultural services which ecosystem services provide, such as health benefits, education and learning opportunities, and noise mitigation (Davies et al., 2017).

How the urban forest is managed, both now and in the future, will affect whether current rates of annual benefit provision can be maintained or increased in future years. Ecosystem service delivery depends not only on tree planting and removal, but also which species are planted and where, and whether they are maintained in a healthy condition and able to reach maturity. It is also important to recognise that in order to maintain the carbon sequestration values included in this report, substantial levels of tree planting are needed to expand the total carbon storage capacity of the urban forest. If further planting is not undertaken the carbon sequestration rate will slow as the trees reach maturity.

Urban Forest Sustainability

Newport's urban forest performs well in four of the five urban forest sustainability indicators proposed by Monterio et al. (2019; Table 14). Newport performs well in canopy cover, as it is over 75% of the target as suggested by Doick et al., (2017). Newport also displays a size distribution close to that recommended by Richards (1983), and over 75% of the trees surveyed had less than 10% dieback. Newport also consists largely of trees that are suitable for the current climate, according to the USDA hardiness zones.

The only area Newport falls down on is taxonomic diversity and this is only due to Leyland cypress making up 13.6% of the population. For a 'good' urban forest sustainability rating, the urban forest should have no one species making up more than 5%, no one genus making up more than 10%, and no one family making up 15% of the urban forest. Overall, **Newport's urban forest sustainability is shown to be** equal to Cardiff's, which is **one of the best in the UK (Table 14)**.

Table 14: Urban forest sustainability rating for Newport compared to other cities in the UK (assessed using the framework of Monterio et al., 2019)**.**

Region	City/Town	1. Canopy cover	2. Size diversity	3. Taxonomic diversity	4. Tree condition	5. Cold hardiness suitability
Scotland	Edinburgh					
	Glasgow					
Wales	Bridgend					
	Cardiff					
	Swansea					
	Wrexham					
	Newport					
England	Burton					
	London					
	Oldham					
	Petersfield					
	Southampton					
	Torbay					

Conclusions

Newport's tree population is estimated to contain over **250 thousand trees**. A total of 59 species were identified in the survey. The three most common species are Leyland cypress *(Cupressocyparis leylandii*), Birch (*Betula*) and Hawthorn (*Crataegus*). Leyland cypress is considered to be the most dominant species, with the greatest combined leaf area and frequency.

Newport's urban forest provides services valued at **£2.2 million per annum**. This valuation only considers ecosystem services of carbon sequestration, air pollution removal, and avoided stormwater runoff and does not include, for example, benefits to health, social and cultural values, amenity value, and wildlife value. These services can help Newport towards its goals of reducing greenhouse gas emissions and improving the health of its residents, by improving air quality and mitigating the risk of damage from flooding from stormwater runoff.

Newport's canopy cover was estimated at 12%. This is lower than the other cities in the UK which have been assessed using i-Tree Eco. Out of the 312 towns and cities on the Urban Tree Cover website[12], Newport would be placed 211th out of the 312 locations. However, this assessment may underestimate Newport's Canopy Cover as two other assessments estimate Newport's canopy cover at 16.3% and 15.9% (NRW, 2016a, and Canopy Cover webmap[13] respectively). These differences may also be due to different boundary use for each canopy cover assessment.

In 2016, NRW estimated that over 1,430 ha across Newport was potentially available for tree planting (NRW, 2016a). Not all of this space could necessarily be planted, but this does indicate that opportunities for planting in urban areas are present. Potential development areas could see a decline in canopy cover if urban expansion is not managed and mitigated with respect to canopy cover.

Newport's urban forest is under-populated with respect to large trees. 6.2% of Newport's trees are estimated to be over 60 cm in trunk diameter. Large trees provide the greatest ecosystem service value and can form iconic heritage features in urban areas. A report by NRW (2016b) found a declining trend in large stature trees in Wales generally. This study also found a significant bias towards young, smaller trees, with 79.4% of trees inventoried with a stem diameter less than 40 cm.

55% of the urban forest of Newport surveyed was in excellent condition. A further 25% of trees are in good condition and 14% in fair condition. This percentage of healthy trees is promising for the future of the urban forest and its ability to provide ecosystem

[12] www.urbantreecover.org
[13] https://www.forestresearch.gov.uk/research/i-tree-eco/urbancanopycover/

services in the future. Of the top ten most common tree species, ash species had the highest proportion of trees in dead, dying, critical and poor condition.

Where trees were present, they most commonly occurred on residential land. In total, 47 species were found on residential land, compared to only 18 species in parks. Overall, Newport shows a good species mix, including 59 species in total, however a significant proportion of the population is Leyland cypress. Leyland cypress is a common hedging tree and appears often in residential areas. High proportions of single species can be a vulnerability in an urban forest, as decline in any one of these species represents a significant loss of canopy cover and ecosystem service delivery. For example, the replacement value of common ash based on its amenity value is £82 million, therefore the potential impact of chalara ash dieback and pests such as emerald ash borer could have a significant impact on the amenity value of Newport's urban forest.

Increasing species diversity could increase resilience to pest and diseases, improve ability of the urban forest to adapt to climate change, and provide a range of habitats for wildlife. The habitat analysis indicated a number of native smaller tree species (cherries, hawthorns, hazel) which could be used to support pollinators and, due to their stature, are likely to be suitable for an urban area.

The present value (PV) of Newport's urban trees was calculated at £89.4 million. This value represents the discounted value of only the avoided stormwater runoff, air pollution removal and carbon sequestration services provided by Newport's urban forest, projected over the next 100 years. It assumes no change in the urban forest. However, recent analyses indicate a decline in canopy cover (NRW, 2016a), suggesting that some loss in the value of the urban forest could occur if this trend continues.

Recommendations

This section provides information on opportunities for Newport City Council to improve its urban forest for increased benefit provision to those who live and work in Newport.

Where to focus tree planting efforts: Undertake GIS based planting assessment, involving Multi Criteria Decision Analysis (MCDA) to identify where there are opportunities to expand the tree and woodland resource in the Newport area. This can draw upon the NRW (2016a) assessment of Ward level canopy cover (and is currently under review by the Welsh Government), or Newport City Council may seek to undertake their own update. The MCDA could involve the incorporation of indicator statistics from the Office for National Statistics (ONS), in-particular the Index of Multiple Deprivation (IMD). Combining IMD score with building density and canopy cover, weighted using a relative score within a GIS software program, could identify where there is greatest opportunity to improve benefit delivery through increased canopy cover in the areas of greatest need. The referenced loss of woodland canopy cover (*ibid*) indicates a need to also work to reverse this decline.

What trees to plant and where: Develop a tree planting strategy for Newport that will incorporate tree species selection which will be suited to Newport's current and future climate. When commissioning or considering a tree planting scheme as part of any new (or re-) development, a variety of species appropriate to the specific setting should be considered. For trees planted in the harshest of urban settings, challenges such as reduced moisture regime or compaction mean that the focus should be on selecting species with the ability to cope in these environments, e.g. higher drought tolerance. For trees having to cope with less challenging settings, for example in parks and greenspaces, species choice will be from a broader palette, as specific traits may be less critical to tree growth. Caring adequately for newly planted trees, wherever they may be, is of paramount importance to survival and independence in the landscape.

Protect the existing resource: The local authority Tree Preservation Orders can be subjected to regular review with the aim of making sure that all trees worthy of preservation are protected (making new preservation orders where necessary) and that re-planting has been carried out where specified. Creating and updating photographic records of all protected trees is recommended to ensure some measure of tree condition over time can be ascertained – such an opportunity could be undertaken within the Treezilla (www.treezilla.org). By identifying risks to the current tree population, the urban forest can be protected more effectively. Furthermore, raising public awareness about the value and importance of trees will lead to greater protection through civic engagement.

Masterplan the urban forest's future: Newport City Council could commission a fully costed and multi-faceted urban forest masterplan, with a vision to 2100, that sets targets and priorities to ensure the identified actions are properly implemented and audited. Objectives may include:

- Describe the nature and extent of the urban forest of Newport and provide a vision for the future, together with an action plan for delivery and monitoring;
- Set individual canopy cover targets for key land uses and/or geographic areas as Key Performance Indicators, integral to the delivery of the Local Plan;
- Set ambitious targets for cooperative development of the urban forest together with, for example, communities, local business and utility companies;
- Monitor canopy cover as a Key Performance Indicator;
- Identify and prioritise action through planting and management to ensure that tree cover is maintained, sustained and improved;
- Describe the role of trees within the landscape of Newport, for example through a Landscape Design Plan;
- Develop a set of principles, standards or policies relating to urban trees that can be used to guide the design, development, and deployment of services delivered by Newport's urban trees, whether public or privately owned.
- Manage Newport's Urban Forest as an asset, with appreciable return.

Commerce, tourism and industry: plan for and finance expansion of canopy cover to ensure that the central role of greenspace in shaping the character of the city is retained and enhanced.

Urban Forest masterplans should cover a variety of disciplines and be incorporated into and referenced by the Neighbourhood or Local Plan and can contain targets for canopy cover levels for new developments. For example: 'New development will provide a projected 20% canopy cover in 25 years' time'. The species and size combination and layout should be subject to discussion between developers and the local authority.

A previous canopy cover study for Wycombe in Buckinghamshire, showed that densities of 29-34 dwelling/ha could be designed to accommodate projected canopy cover of 26-32%. This projection allowed for the prevailing trend of predominantly low-rise, detached residential development. More attached housing and flatted development, for example, would allow for more communal space with increased canopy cover without sacrificing total dwelling footprint size.

Many factors will combine to influence the delivery of a desired level of future canopy cover in a development; and these include:

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

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

Monitor change: repeating the i-Tree Eco study process in 10 years (2030) will enable Newport to assess the impacts of this Eco study and changes to its urban forest, including:

1. changes in the canopy cover of Newport, including woodland canopy
2. changes in species and size diversity of Newport's tree stock
3. pest and disease outbreaks and their impact, including a refreshed risk analysis of the pests and diseases of greatest concern
4. Policy changes directed or informed by this Eco study

Education and community engagement: much of Newport's urban forest is on privately owned land. A community engagement programme could aim to educate members of the local community about their trees, the benefits they provide to society and the environment. Engagement could involve setting up tree planting projects and education around species selection and the importance of the right tree being in the right place. This could help to reduce Newport's reliance on species such as Leyland cypress.

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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 City of Newport 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. Breast height is defined as 4.5 feet (1.37m) above the forest floor on the uphill side of the tree. For the purposes of determining breast height, the forest floor includes the duff layer that may be present, but does not include unincorporated woody debris that may rise above the ground line.

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.