University of Dundee Botanic Garden
Tree Asset Valuation Report

An i-Tree Eco and CAVAT assessment

Dundee Botanic Garden
University of Dundee

Treeconomics

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This assessment was carried out by Treeconomics

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Contents

Executive Summary

This report highlights the findings of a study to record the structure and composition of the trees within the University of Dundee's public facing landscapes to calculate some of the benefits, public goods, or ecosystem services they provide. This report examines two areas: the Botanic Garden, and the Campus. The report highlights the tree resources on each site, and their contribution to mitigating some of the environmental impact while adding significant value to the University urban estate beyond its perceived amenity.

- **1,378 trees** over 7cm DBH were recorded in the University of Dundee Botanic Garden and main campus grounds.
- Their potential is to remove over **60.3 kg** of air pollution annually at a current value of **£4,400**. These pollutants include Sulphur dioxide (SO_2), particulate matter (PM2.5) and nitrogen dioxide (NO_2).
- These trees reduce water runoff by **1,600 m³** per year, preventing it from entering the combined water drainage system, worth an estimated **£2,600** in avoided surface runoff water treatment costs. A highlighted priority in the 'Local flood risk management plan', due to the risk of being overwhelmed during extreme rainfall events.
- In total, the trees store over **633 tonnes** of carbon and sequester a further **15.7 tonnes** of carbon annually - with associated values of around **£624,000** and **£15,400** respectively.
- Trees also confer many other benefits as part of functional urban ecosystems, including habitat provision, soil conservation and noise reduction which currently cannot be valued. These should be considered when shaping policy or strategy documents. Reported values herein are a conservative estimate of overall benefits.
- **243 species** of tree are recorded within the University's tree inventory, with a relatively even spread that shows little reliance on a single species dominance. The most common tree species are *Pinus sylvestris* (Scots pine) with **153 trees**, *Betula pendula* (silver birch) with **114 trees**, and *Eucalyptus gunnii (cider gum)* with **93 trees.** Note: this is likely to be an underestimation of tree diversity, reflecting multiple surveyors and identification ability, that will be improved with subsequent surveys.
- The tree population includes a wide variety of species, which is a good indication that the sites will be more resilient to pests, diseases, and climate change than a less diverse treescape. The most prominent threats in this regard are **Dothistroma needle blight**, a**cute oak decline**, and o**ak lace bug**.
- The amenity value of the campus and garden trees were calculated to be **£38.1 million**, as determined using a CAVAT valuation approach. The replacement cost of these trees was an estimated **£1.48 million.**

Headline Figure

Data processed using i-Tree Eco version 6.0.32

Structure and Composition	
Number of Trees	1,378
Number of Species	243
Most Common Tree Species	*Pinus sylvestris, Betula pendula, Eucalyptus gunnii*
Replacement Cost (CTLA)	£1.48 million
Amenity Valuation (CAVAT)	£38.1 million

Combined Botanic Garden & Campus Ecosystem Services		
Annual Carbon Storage	633 tonnes	£624,000
Annual Carbon Sequestration	15.7 tonnes	£15,400
Annual Pollution Removal	60.3 kg	£4,400
Annual Avoided Runoff	1,600 m³	£2,600
Total Annual Benefits	**£22,400**	

Individual Level Ecosystem Services			
Annual Carbon Storage	Botanic Garden	498 tonnes	£491,000
	Campus	135 tonnes	£133,000
Annual Carbon Sequestration	Botanic Garden	11.8 tonnes	£11,600
	Campus	3.9 tonnes	£3,800
Annual Pollution Removal	Botanic Garden	45.6 kg	£3,300
	Campus	14.7 kg	£1,100
Annual Avoided Runoff	Botanic Garden	1,200 m³	£2,000
	Campus	400 m³	£600
Total Annual Benefits		**£22,400**	

Number of Trees: 1,378 records were used in this analysis. Exclusions detailed in Appendix II.

Replacement cost: Council of Tree and Landscape Appraisers Methodology from the Royal Institute of Chartered Surveyors. *Hollis, 2007

Amenity valuation (CAVAT): Capital Asset Valuation for Amenity Trees (CAVAT) is a method developed in the UK to provide a value for the public amenity trees provide. *Doick, 2018

Carbon storage and carbon sequestration values: These are calculated based on figures jointly published by the Department for Energy Security and Net Zero, and the Department for Business, Energy & Industrial Strategy, at a sum of £269 per metric tonne of CO_2e. *Gov.uk, 2012

Pollution removal: This value is calculated based on the UK social damage costs; £23,314 per tonne (nitrogen dioxide), £17,118 per tonne (sulphur dioxide), £172,816 per tonne (particulate matter less than 2.5 microns). *DEFRA, 2023

Avoided runoff: The value is based on an average volumetric charge of £1.676 per cubic metre from Scottish Water. *Scottish Water, 2024

Acknowledgements

This report represents the combined work and effort of many people, without whose efforts the report would not have been possible.

The project was conceived in lockdown, and began with a pilot project at the botanic garden, undertaken by master's student Victoria Potts, that was completed in 2020 as her unpublished thesis project. The momentum from this work led to further support from botanic garden staff and volunteers including Steven Douglas and Kate Frediani, to help progress the data capture before Kieth Vernon of TLC Environmental was employed to undertake a tree hazard assessment survey of both sites that helped collect much of the outstanding data. The final thanks for data collection and checking goes to Kate and Steven who helped upload the data from the botanic garden various sheets and collated into two separate spreadsheets that could be shared with Treeconomics before processing and initial analysis by Kenton Rogers and Katie Screech.

Kevin Frediani, helped analyse and interpret data while contributing to the authorship of this report which was co authored together with Kenton and Katie. The report has been edited and reviewed by the authors and checked by Catherine Vaughan-Johncey and Rosalea Kenmore, however, any errors or omissions remain those of the primary authors.

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15th May 2024

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Frediani, K., Rogers, K., and Screech, K. (2024) University of Dundee Botanic Garden Tree Asset Valuation Report: An i-Tree Eco and CAVAT assessment. University of Dundee. Dundee, Scotland.

Figure 1: University of Dundee Botanic Garden site with single mature sycamore circa 1969 © University of Dundee archives.

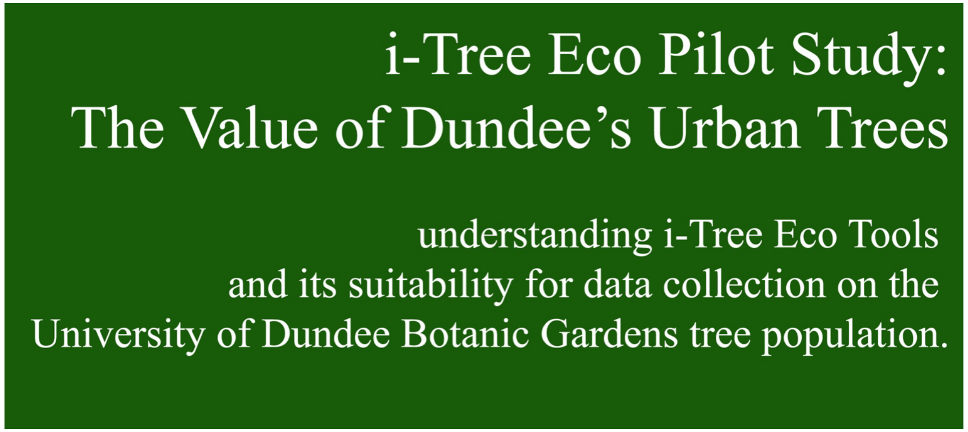


Figure 2: Unpublished master's thesis by Victoria Potts (2020)

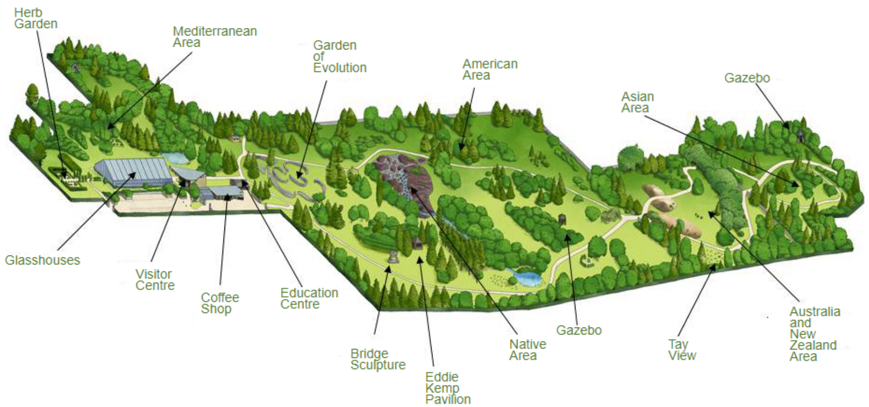
Introduction to the University of Dundee, its Grounds and Botanic Garden

On the 1 August 1967, the royal charter was granted, formally establishing the University of Dundee. Originating in 1881 as University College Dundee, a constituent college of the University of St Andrews, the university now occupies an urban campus in the city's west end. Since gaining independence, it has expanded from just four converted buildings to over 50 at present.

Most notable buildings are the Geddes Quadrangle (1907), University Tower (1957), Belmont Hall (1963), Fulton Building (1964), Bonar Hall (1975) and Duncan of Jordanstone College (1937 and 1974) adopting a local vernacular of sandstone. Recent additions, like the Library (1986 and 1995) and the Wellcome Trust Building (1997), mark the rise of modernist architecture, while buildings such as the Life Sciences building, the Dalhousie building and the School of Computing building, have kept the architectural vitality of the area alive. Historic lanes, paths, and courtyards between the buildings inform the character of the area, providing a soft connection through the diversity of hard structure by a ribbon of trees, shrubby mass and grass.

This report is the first attempt to baseline some of the significant ecosystem service benefits that are afforded by the main campus landscape, using i-Tree eco. It uses data collected in the field along with local hourly air pollution and meteorological data 'to quantify the structure, environmental effects, and value of the main campus urban forest'. We also assessed the benefits of the living collection at the university's botanic garden, which we will introduce next.

Shortly after its independence, the university founded a 9.5 hectare botanic garden, about 1.5 kilometres from the main campus in the west end of the city. A gently south facing slope overlooking the River Tay, on deep sandy loam soils, it was selected as the ideal site to realise a garden for teaching plant ecology and botany. The early plantings reflected the main habitat types to be found in the Tayside region, including upland oak, and Caledonian woodland habitats using phytosociological principles of classifying plant communities. This approach informed the subsequent collections accessioned from temperate regions of the world deemed climatically compatible with Dundee. A collection plan was then developed for an ecological botanic garden, that was never intended to be informed by traditional taxonomic curatorial norms[2].



The underlying principles that the gardens follows are those commonly shared with other botanic gardens internationally, which include research, education and conservation. However, from the outset, the aim has always been to showcase the collection through analogous plant communities that can be displayed in Dundee. This also includes cultivating plants of interest, especially under the protection of glass, that help to raise awareness of economic, social and environmental knowledge aligned to plants displaced from their communities and their human associated stories of exploitation and enterprise. Applying such principles helps to ensure that wider community interests beyond the university itself are served, aligning the garden's living collections to the university's implied mission, to think globally while acting locally. The garden acts as a green bridge, fostering an outreach network for collaboration rather than competition across the city. It works within the green and blue spaces between the university and the residents of this part of Scotland, encompassing the Tayside bioregion[3]. Unlike many political and administrative borders that are imposed in our world today, the bioregional boundaries are not an abstraction given to a place. Rather they are real, physical features which can be seen, felt, measured, and tested. These areas hold significant cultural and environmental importance, particularly in the context of global change[4].

[2] "The tradition of using the botanic garden to illustrate the taxonomic or evolutionary relationships of plants has never formed part of the policy of this garden"… Hugh Ingram & Alasdair Hood (2003) A guide to the garden and its purpose. University of Dundee.

[3] Bioregions are the natural countries of the planet, containing within them many nations, inhabitants, watersheds and ecosystems.

[4] https://bioregioningtayside.scot/

Core functions in the garden over its first 50 years have included cultivating themed plant communities based on geography and climate, and supplying materials for teaching and research to organisations in need. In the early years, these users significantly influenced the selection of plants and their current display groupings. Today, new collections and garden projects are influenced by awareness of climate change and the impacts of land use and land cover changes since agricultural improvements and industrial revolutions[5]. This not only influences the focus on the selection of new plants in the living collation, but it also informs new land art and creative exhibits[6]. At a time when the survival of many plant species is threatened, conservation is a necessary further aim[7]. This is increasingly important as objectives go beyond the encouragement of visits by schools and colleges, but to promote the use of the collections for biology classes, environmental education and instruction in fine arts.

Just over 50 years later, the garden now cultivates over 2,500 taxa, with over 70% sourced from wild collections of conservation importance nationally and internationally. Attracting over 65,000 annual visitors, it serves as a significant regional tourist attraction. Recently redefined as a living laboratory, it aligns with the University's triple-intensive aspirations of research, teaching, and outreach. This shift raises awareness of the challenges associated with climate change, population growth, and unsustainable resource use, that leads to unprecedented biodiversity loss and ecosystem degradation[8].

The Botanic Garden and University Grounds Strategy Since 2021

The strategy is based upon five interconnected work streams, each framed within the four nested levels of organisation. This organisational framework provides focus while ensuring resource use efficiency through prototyping projects and gaining evidence through the experience of sharing with the visitors. Evidence and experience gained at the botanic garden level then is fed into realising the potential of the university grounds. The outer layers are partnership and coproduced projects with communities of shared interest at the city and national (international) level as time and resource allows.

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[5] Frediani, K., & Rennie, F. (2021. 300 years of land use and land cover change in Angus. University of the Highlands and Islands.

[6] https://www.placeinternational.co.uk/post/cyclogenesis-a-new-earthwork-by-adrien-segal

[7] Antonelli, et al. (2023). State of the World’s Plants and Fungi 2023. Royal Botanic Gardens, Kew. DOI: https://doi.org/10.34885/wnwn-6s63

[8] https://www.dundee.ac.uk/corporate-information/botanic-garden-and-grounds-strategy

"…to transform lives, locally and globally through the creation, sharing and application of knowledge"

- University of Dundee - Mission

Strategy

The University of Dundee landscapes provide multiple services that are not yet all formally documented or known. As a steward of land, and a partner to Dundee's development, it is no longer expedient to maintain landscapes to provide amenity. Increasingly, there is a need to plan and enable local solutions that provide resilient landscapes for the future and help address growing global challenges. Landscapes include vegetation, soil and moving or contained water (aka: green and blue infrastructure). Climate change requires new landscapes to be planned, designed, and implemented to inform sustainable urban

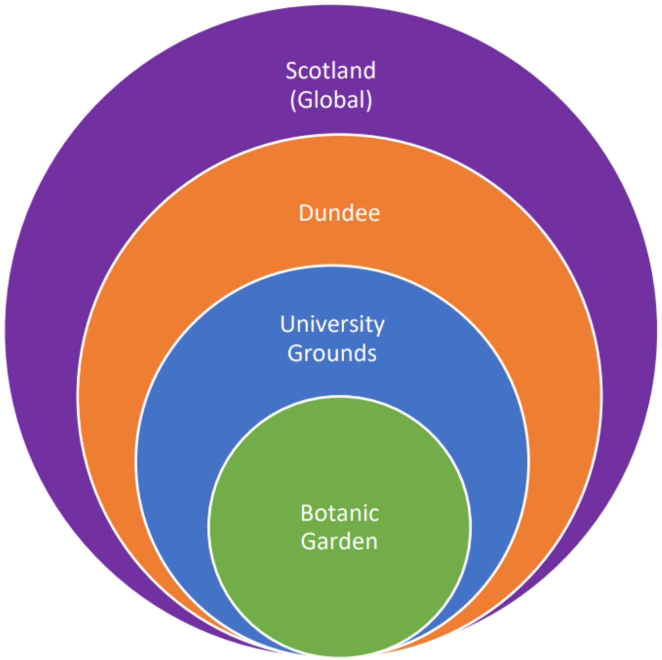

Figure 3: The nested relationship between research and development work programmes that will help achieve the University of Dundee mission.

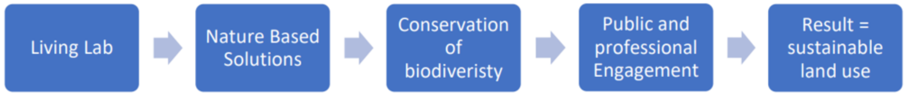

Figure 4: The five interconnected Botanic Garden and Grounds workstreams that are described in the strategic plan (Frediani, 2021).

landscapes while conservation requires opportunity for plants to thrive in landscapes that will serve people's needs today, while benefiting the diversity as it grows. To achieve this, new landscape requires novel research while providing opportunities to collaborate in local placemaking. The aim is to reduce risk through enabling a safe place to prototype land use interventions and grow an informed evidence base to help inform change in Dundee and elsewhere. This is the Garden and Grounds equivalent of the university mission: "Transforming lives, locally and globally through the creation, sharing and application of knowledge". As a public visitor attraction and a local centre of applied research and education, each University of Dundee landscape provides different opportunities as follows:

University of Dundee Spaces: Land Use Aims and Main Objectives

Botanic Garden - as a leading visitor attraction and centre. Provided through the provision of space for research and education, investment in the site's amenity for recreation and enjoyment through immersive and engaging place-based experiences. A university asset where Nature-based Solutions (NbS), Conservation of Biodiversity and Human Wellbeing are being explored using STEAM (STEM together with Art), gaining the evidence base for external interventions within the "Living Lab".

City Campus - an urban landscape of modern and historical built environment, where a landscape has evolved rather than been planned. The potential to unify the landscape through informed design of the interstitial spaces (between the buildings), while optimising ecosystem services and student and staff wellbeing through the application of appropriate NbS. The local vision of a wellbeing campus is the aim that inspires, attracts, and retains to support the academic community

Other sites with potential for future inclusion:

Riverside Sports Ground – This space has yet to be audited but provides a transition space between River Tay and Urban Dundee. A landscape of high inputs that provides a robust and durable grass sports surface to support student and staff wellbeing and health. While also providing a green corridor linking Riverside Nature Reserve to the waterfront development where connectivity and design can enhance the main transport route into the city with four seasons of interest.

Westpark Conference Centre and events space – Another space yet to be audited that comprises residential houses, urban apartment and land banks - multiple sites across the central and west end of the city. From University House to student apartments, with research facilities and land blocks all being maintained to provide local benefit. Although diverse origin and outwith any planned development process currently, they provide opportunities to extend the benefits of NbS across the city contributing to the wider community, while offsetting some of the carbon used by the University in conducting its business.

Figure 5: The importance of diversifying green spaces in the city is a new area of focus recently introduced by the gardens, engaging primary school children to codesign a Wee Forest and outdoor learning space in the Maryfield ward.

The New Focus of the Botanic Garden, as a 'Living Lab'!

Climate change is leading to ever worsening social and economic shocks[9]. The 2022 summer heatwave resulted in over 60,000 deaths in Europe, with the UK breaking its record for heat-related mortality (c. 3,500 deaths)[10]. Severe flooding because of higher intensity storms currently costs the UK c. £1.3 billion per year, with devastating effects on communities, businesses, and individuals[11]. The legacy of traditional urban grey infrastructure leaves our cities ill-prepared for heat and extreme weather impacts in our changing climate.

NbS offer a route through this crisis. The International Union for the Conservation of Nature suggests that NbS 'address societal challenges through the protection, sustainable management and restoration of both natural and modified ecosystems, benefiting both biodiversity and human well-being.' Urban green infrastructure (such as rain gardens, other Sustainable Urban Drainage (SUDs) systems, as well as green roofs, living walls and street trees) work with nature to meet the same human needs as the grey infrastructure they replace while also bringing biodiversity benefits. But early adoption shows that they require expertise in design, implementation, and maintenance to succeed.

Government and society increasingly look to botanic gardens, to advise on how to successfully achieve NbS. However, there is currently a void in how best to provide this advice nationally or regionally. This requires organisation and gardens to work complimentarily not competitively. In Scotland, the University of Dundee Botanic Garden is working closely with the Royal Botanic Garden Edinburgh, St. Andrews Botanic Garden and Cruikshank Botanic Garden at national level. It is also working regionally with delivery partners, including the Eden Project Dundee, Bioregioning Tayside, The Dundee Naturalists Trust, Bonnie Dundee and the Community gardens network plus the NHS Trust and RSPB, to ensure local projects deliver local benefit for people and planet. This has led to the University of Dundee Botanic Garden prototyping a range of NbS - including delivering four of the NatureScot pilot Wee Forests in the city of Dundee. It has applied ecological thinking to its own site, incorporating several interventions to educate the public on 'Rewild Dundee.' These include a green roof art gallery focusing on art and nature, the prototype urban wildflower meadows in the garden and developing a deadwood habitat trail, which are accompanied by a suite of ongoing scientific research and public engagement. These case studies should be considered as the starting point for a longer-term strategic programme of NbS action research and demonstration, with the necessary permeability between university researchers, botanic garden horticulture, on site education and public engagement programmes.

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[9] https://royalsociety.org/news-resources/projects/climate-change-evidence-causes/?gad_source=1&gclid=EAIaIQobChMIma2N4NeKhgMV4IxoCR0Qvw7TEAAYASAAEgKv8vD_BwE

[10] Ballester, J., Quijal-Zamorano, M., Méndez Turrubiates, R.F. et al. Heat-related mortality in Europe during the summer of 2022.

[11] Black (2022) Flood risk and the UK. Energy and Climate Intelligence Unit Briefing Report. [Online]: https://eciu.net/analysis

The Collections

The stated principle upon which most botanic gardens are established is the acquisition of plant materials for teaching, research, and public amenity[12]. Conservation has become a significant focus in recent years, shaping the evolving scope of The University of Dundee Botanic Garden curation in its recent past[13]. In the 1970s and 80s, university teaching and research primarily focused on cultivating plants to study their morphological and physiological adaptations to various habitats and ecosystems. This involved showcasing plants that illustrated diverse survival strategies, ecological roles, symbiotic relationships, and familial connections. Since then, the garden has been redefining its role in response to a decline in ecological and botanical education at university's, shifting focus towards life sciences and exploring the molecular potential of biology. This change has allowed for aesthetic development around the main entrance and cafe, enhancing its appeal as a visitor amenity.

However, as each new curator is reminded when taking up the post at Dundee, it is the words of John Lindley, who uttered in 1830 when he was invited to examine the role of the Botanic Gardens at Kew that are always kept in mind when selecting plants for this botanic garden:

> *"It is little better than a waste of time and money to maintain it in its present form if it fulfils no intelligible purpose except that of sheltering a large quantity of rare and valuable plants."*

In short, the ideal that the University of Dundee's curators are guided towards, is that each plant grown can be justified by its contribution to the garden's wider aims and objectives.

Native Plant Communities

One of the most important features of the garden is the Native Plant Communities Unit. A series of plant associations have been established to represent British vegetation types. Sited in a layout running north to south are representatives of the mountain and uplands areas, dwarf scrub, pine and birch forest, ash wood, oak and beech forest and, at the lowest point, a nutrient-rich pool. These are linked by a burn, which is fed from a spring in the north west corner of the garden. The woody plant elements are now mature enough to introduce the associated field layers beneath the trees, and the exhibited habitats are already proving a valuable teaching resource for students, school pupils, and the general public. Unlike a taxonomic layout, where plants are assembled in un-natural groupings that show supposed evolutionary relationships, the layout of the botanic garden respects the real nature of vegetation, thereby promoting familiarity with native plants from all over the British Isles, as well as providing a useful guide to their ecology. This is proving vital for school assisted visits where the curriculum is already crowded. Furthermore, it has proved cost-effective for growing environmentally demanding plants, since landscape gardeners and environmentalists responsible for countryside rehabilitation have found the methods of establishment and management of this Unit to be of great interest and utility.

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12 https://www.bgci.org/about/botanic-gardens-and-plant-conservation
#:~:text=Botanic%20gardens%20are%20institutions%20holding,conservation%2C%20display%2C%20and%20education.

13 Hood, A., & Reaney, C. (2013). Native Plant Project at the University of Dundee Botanic Garden. Sibbaldia: The International Journal of Botanic Garden Horticulture, (11), 175–185. https://doi.org/10.24823/Sibbaldia.2013.59

Diversity in Plantings

The remainder of the garden is given over to layouts of exotic plants with a similar ecological and geographical basis. Already there are noteworthy collections of conifers, Australasian, Asian, North American and Mediterranean plants, primitive flowering plants, and aquatics. The garden's favourable climate can be judged by the successful cultivation of plants which would normally be considered too tender to survive in the east of Scotland. *Regnellidium diphyllum*, a floating aquatic fern from Rio del Sul in Brazil, is an example of an unusual plant which thrives in the garden. Normally very difficult to grow, it seems to luxuriate not only in the temperate and tropical glasshouses but also in one of the necklace ponds which feed Loch Machar – the exotic plant pool near the Visitors' Centre, built with funds provided by Alex Machar, a former Curator of main campus grounds in the University, who was the first to realise the potential of the site. Other collections include examples of physiological adaptations to wet, dry, tropical and temperate zones, and of the strategies that plants have evolved to overcome hostile conditions.

Maintenance

Growth in the garden is rapid, due in large measure to the situation and climate, although the methods used to establish and maintain the collection are also beneficial. Although there is only a small number of staff (there are three gardeners in addition to the Curator and secretary) the garden is managed according to ecological principles with no pesticides to treat weeds. The methods that have been adopted to keep weed free areas include mulching and current exploration of ground cover plantings to create natural guilds in the planting that cover bear earth. The ongoing exploration of methods is shared with our volunteers and the public, with the core principle that they have to be simple and not labour intensive. Repetitive manual tasks are kept to a minimum; very little leaf raking is carried out and while hoeing or digging of borders is practiced, it is reduced through mulching and ground cover planting after the initial structural plantings are established. The activities of the worm population thus encouraged have also resulted in a parallel improvements below ground, to the soil structure, leaving space for water to be drained away from the surface and stored in the soil. Reducing soil water runoff and reducing soil erosion and flooding.

University of Dundee Botanic Garden and Grounds

Vision: to research, conserve and utilise plant biodiversity to inspire lifelong learning, enable sustainable land use, and provide enriching landscapes for the enjoyment and benefit of our students, staff, visitors, and local communities.

Mission: to advocate for the diversity and beauty of plants, through collaboration to achieve the sustainable development and design of its landscapes that inform, entertain, and enrich staff, students and visitors while serving to inspire and benefit our wider community.

Why i-Tree eco study of the Botanic Garden and Grounds?

i-Tree Eco is a software suite developed by the USDA Forest Service that helps assess and quantify the ecosystem services provided by urban trees. It's designed to evaluate the structure, function, and value of trees in urban environments. For a university estate and its botanic garden, i-Tree Eco could be incredibly beneficial in several ways:

- Education: It can serve as an educational tool to teach students about urban forestry, biodiversity, and ecosystem services. Through hands-on data collection and analysis, students can learn about tree species, their ecological roles, and how they contribute to the environment.
- Research: The software provides valuable data on tree health, canopy cover, air quality, carbon storage, and other ecosystem services. This data can support research projects within the university, such as studying urbanisation's impact on biodiversity, assessing green infrastructure's effectiveness in mitigating climate change, or examining the correlation between green spaces and mental health.
- Conservation: i-Tree Eco helps identify areas where conservation efforts are needed. By understanding the ecological value of the existing tree canopy, the university can develop conservation plans to protect and preserve biodiversity within its estate and botanic garden.
- Improving Site: By assessing the current state of the tree canopy, the university can identify areas for improvement and implement strategic tree planting initiatives. This could include planting native species, increasing tree diversity, and enhancing green spaces. Improving the site's green infrastructure not only enhances its aesthetic appeal but also provides numerous benefits for staff, visitors, and students.
- Health and Wellbeing: Trees provide a multitude of benefits for human health and wellbeing, including reducing stress, improving air quality, and providing opportunities for recreation and relaxation. By enhancing the tree canopy on the university estate and botanic garden, i-Tree Eco can contribute to creating a healthier and more pleasant environment for everyone on campus.

Overall, i-Tree Eco offers a comprehensive approach to managing urban forests, greatly enhancing the educational, research, conservation, and wellbeing efforts of a university estate and its botanic garden.

Urban ReLeaf is a new four-year cross-cultural EU project, started in January 2023 that aims to co-create citizen-powered data ecosystems to support climate change adaptation, green infrastructure, and urban design planning. The Horizon Europe-funded project builds on design-led research into citizen observatories being led by researchers at the University of Dundee that is aligned to the emerging work of the botanic garden. Urban ReLeaf is a collaboration between 15 academic and private sector partners as well as the cities of Athens (Greece), Cascais (Portugal) Dundee (UK), Mannheim (Germany), Riga (Latvia) and Utrecht (Netherlands).

Locally the University team will collaborate with Dundee City Council to deliver a two-year citizen sensing pilot monitoring a range of environmental issues that relate to Dundee's green transitions for the built environment. Their research will also support a range of pop up, co-design and insights labs across six cities; the leadership of a community of practice; and storytelling activities. Thousands of members of the public will be asked to install sensors and use mobile phone apps to capture data on the local environment. By gathering evidence and raising awareness of the problems they face, citizens can organise an effective grassroots, community, or local government response. Dundee is one of six cities across Europe to have joined forces to enable people to participate in citizen science for public sector innovation through the implementation of NbS to decrease issues such as air pollution and improve mental health, among other benefits. This will feed into and from the garden's living collection.

1. i-Tree Eco findings: Structure

1.1 Tree Population

Within the university estate, the University of Dundee Botanic Garden stands out for its diverse species distribution, with little dependance on a single species. The garden collections are laid out ecologically, emphasising Tayside regional plantings. Within the inventory, 11.1% of the trees are native *Pinus sylvestris*, followed by *Betula pendula* at 8.3%, which are both found among community plantings and native habitat areas.

Eucalyptus gunnii accounts for 6.7% of the recorded species, where native plantings are endemic to Tasmania. It should be noted that some survey errors are present; as multiple-stemmed trees without labels have been given a default species name. Future surveys will verify and correct the species names assigned to the unique identification numbers, although this reporting does not significantly impact the reported benefits.

Overall, the 10 most common species within the inventory account for 49.7% of the total population in the University of Dundee, with a total of 243 species identified in the survey.

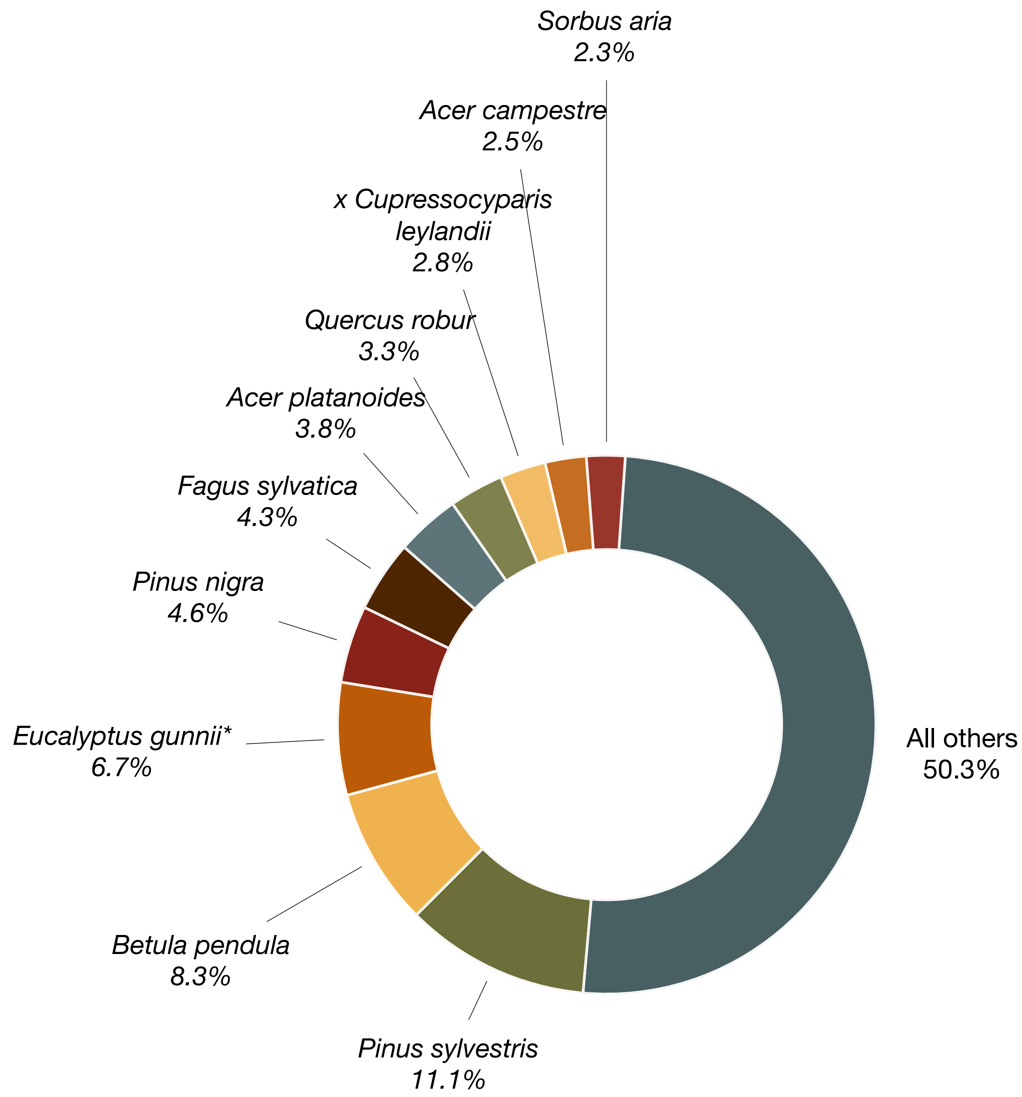

Figure 1. Most common species* within University of Dundee Botanic Garden's population

*Only named species are included in the top 10. Any trees identified only to genus level are included in 'Other' to avoid mixing metrics.

'By leaves we live'

'How many people think twice about a leaf? Yet the leaf is the chief product and phenomenon of Life: this is a green world, with animals comparatively few and small, and all dependent upon the leaves.'

- Patrick Geddes, 1st Professor of Botany, Dundee

Dundee Botanic Garden
University of Dundee

Treeconomics

1.2 Population by Strata

Botanic gardens collect, care for, distribute and display plant specimens and their derived artifacts. As cultural collections, they help further research, conservation, and education, while their living collections provide tangible and intangible amenity. Curation is an integral consideration of this melee, informing content and conferring value, through framing the visitor experience and progressing the host organisations mission (Frediani, 2024a).

For the purpose of this report, the tree inventory has been separated into two distinct areas for reporting that reflect their distinct origins and management: the Botanic Garden, and the Main Campus.

The Botanic Garden consists of 972 trees, constituting 70.5% of the total inventory, while the Campus hosts 406 trees, representing 29.5% of the overall tree count.

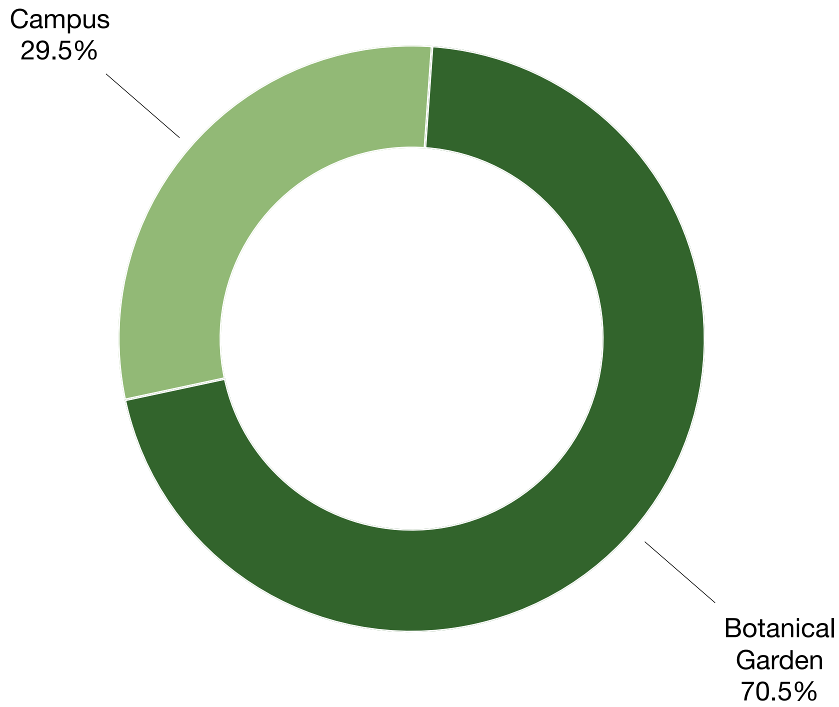

Figure 2. Population distribution of trees across University of Dundee Botanic Garden

1.3 Tree Diversity

Diversity is critical to a healthy and resilient tree population. This means assessing if the population relies heavily on a few species, or if each species represents an even proportion of the population.

Diversity indices, like the Shannon – Wiener index used in this study, consider factors such as species count, population, and dominance. Additionally, Santamour's 10-20-30 rule offers a practical guideline for tree planting to prevent over-reliance on specific species and genera.

The University's combined trees exhibit a good breadth of species diversity. *Pinus* is the most dominant genus, with a 19% share of the population. The *Pinaceae* (Pine) family, including *Pinus* (Pine), *Abies* (Fir) and *Picea* (Spruce), makes up 27% of all trees and accounts for the highest share of leaf area - a metric closely aligned with ecosystem service benefits. Accepting this, the breadth of species range across the University of Dundee will enable a better resilience against pest and diseases and the effects of climate change.

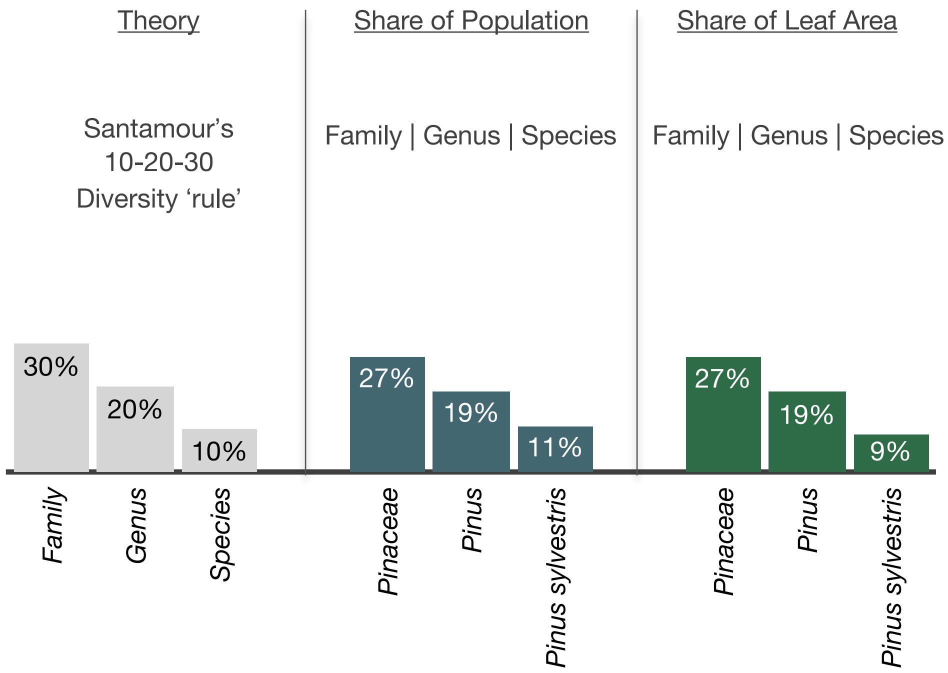

Figure 3. Santamour's tree diversity rule of thumb, comparing tree numbers with leaf area

Shannon - Wiener Diversity Index

A single number that takes account of two key concepts in diversity:

- Richness - number of species.
- Evenness - how equally they are distributed.

The higher the number, the greater the diversity.

Dundee Botanic Garden	3.08*
London	3.92

Note: * this is lower due to community planting bias, lack of key species verification mentioned above and the comparative scales of garden and London.

Santamour's 10-20-30 rule of thumb*

This suggests upper limits for a tree population as follows:

- Single species - 10%
- Single genus - 20%
- Single family - 30%

Many old city park and urban tree populations do not adhere to this 'rule' due to historic plantings, but it can help inform future plantings.

*Santamour 10-20-30 rule, included in this report for context, is typically used as a rule of thumb for urban forests and therefore may not be directly applicable to a Botanic Garden setting.

1.4 Origin of Tree Species

The vast bulk of the combined tree species of the University of Dundee Botanic Garden and main campus are native to Europe & Asia (figure 4). This combined distribution is beneficial going forward, as the UK's climate becomes more amenable to species typically found in warmer climates. Many native species are not able to thrive in the artificial environments of our urban landscaped areas, and the effects of climate change will exacerbate the situation (Frediani, 2024b). Maintaining a careful balance of native and non-native species within the population will ensure that habitats are protected whilst providing protection to our every-changing climate.

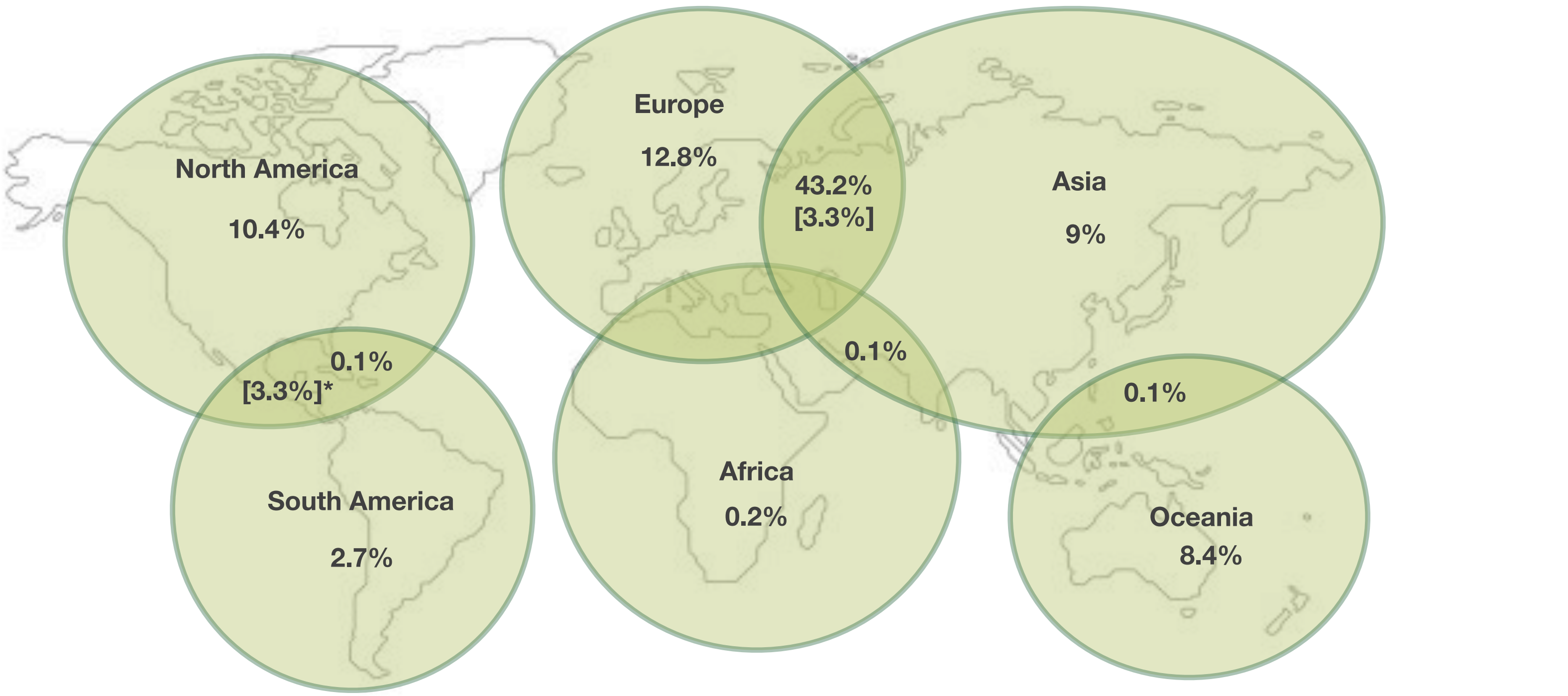

Figure 4. Origin of Tree Species; the share of trees native to different geographical regions. Overlaps indicate origins merge across continents.

Values with [ ] indicate species which originate from that continent plus another with which there is no intersection.

** Species origin is unknown, and it is unclear which region they originate from, or they are hybrids and therefore from multiple regions.

1.5 Size Distribution

Size class distribution is an important aspect to consider in managing a sustainable and diverse tree population, as this helps ensure that there are enough young trees to replace older specimens that are eventually lost through old age or disease. Diameter at breast height (DBH) can be considered a proxy for age, bearing in mind species and potential ultimate size and form. It is also relevant in terms of benefit delivery, as generally larger trees deliver greater benefits. The age of the botanic garden has skewed the data given its oldest plantings are only 50 years old, while older trees are to be found in older areas of development on the main campus or on its inherited periphery.

Figure 6 shows the share of tree population within each DBH class. Where the goal is to continually maintain tree cover within a landscape, a guiding principle is an inverse J-curve of age going from many young to few mature trees.

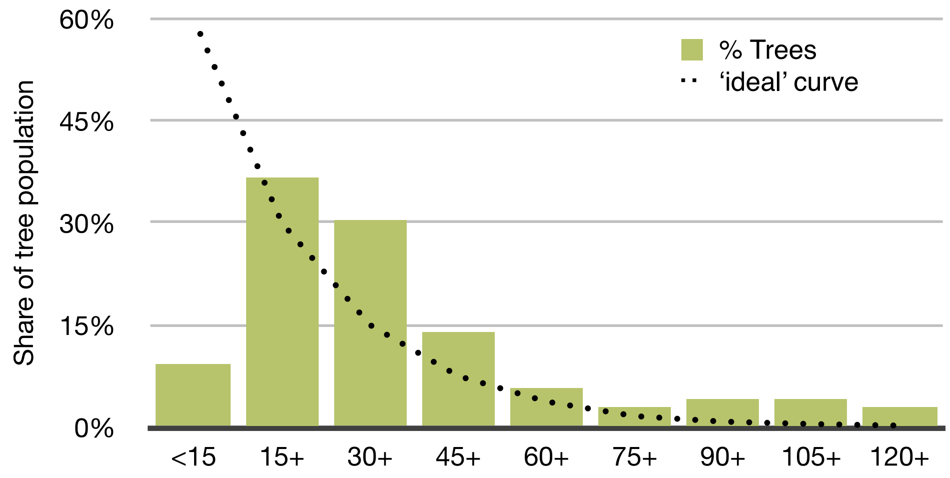

Figure 5. Tree population by DBH class (cm)

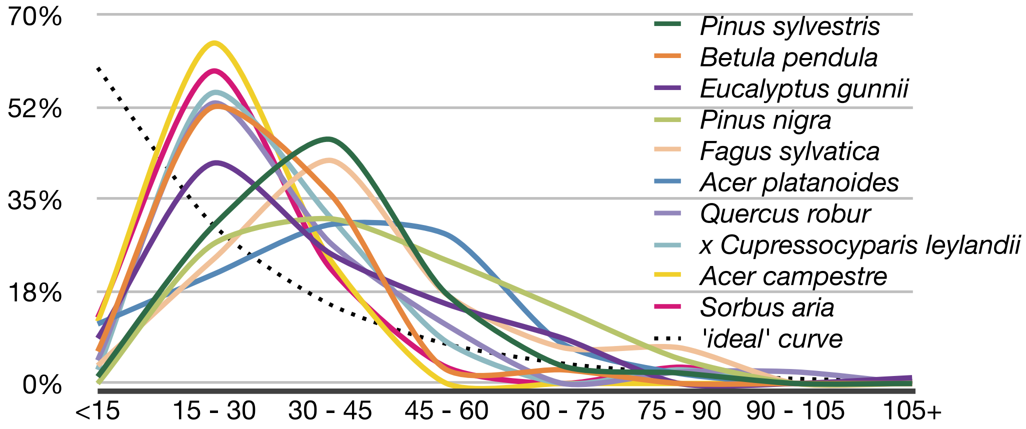

Figure 6. Spread of size classes amongst the top ten species

Despite its age, the size class distribution of trees within Dundee's Botanic Garden is well balanced (figure 5), largely following the J-curve that might be expected in a natural context[14]. However, increasing the proportion of smaller and young stature trees, as the provenance of new planting material for climate adaptation is identified, should help to sustain structural diversity and the overall resilience of the tree stock.

Most towns in England only have 10-20% of trees with a DBH that is greater than 30cm*, but in the University of Dundee Botanic Garden, it is 54%

*Trees in Towns II

[14] Kimmins, 2004

1.6 Leaf Area and Dominance

Leaf area is an important metric because the total photosynthetic area of a tree's canopy is directly related to the number of benefits provided. The larger the canopy and its surface area, the greater the volume of air pollution or stormwater which can be captured in the canopy of the tree.

The Dominance Value is calculated by considering the leaf area and relative abundance of the species. A high dominance value shows which species are currently delivering the most benefits based on their population and leaf area. These species currently dominate the urban forest structure and are therefore the most important in delivering current benefits that should be maintained and enhanced into the future for as long as possible.The most dominant species in terms of leaf area is *Pinus sylvestris*, with 8.9% of the total leaf area for all trees. Interestingly, *Acer pseudoplatanus* displays over twice the percentage of leaf area relative to its share of the tree population, suggesting the prevalence of larger crowns in these trees, which includes a significant 150+ year old tree, known as one of the only mature trees at the time of founding the university botanic garden.

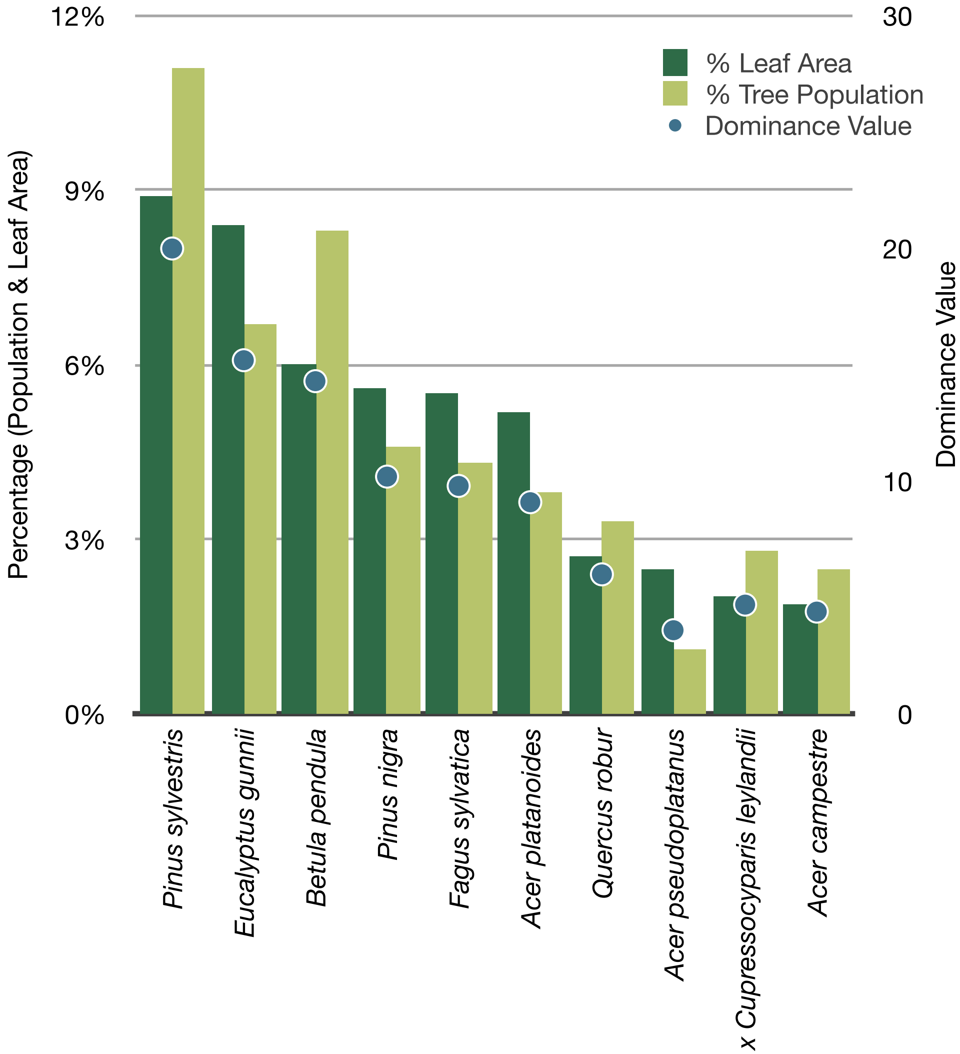

Figure 7. Dominance value and share of leaf area vs share of population for the top ten taxa.

The total leaf area, or amount of green leaf mass in the canopy, of all of the trees is estimated to cover the equivalent of 43.7* H.

As expected, the Botanic Garden comprises the highest leaf area, attributed to its dominant population size, accounting for 75.6% of the total leaf area, equaling 33 Ha. The Campus, accounting for 24.4% of the total leaf area, covers an area equivalent to approximately 10.7 Ha - highlighting the displacement that an intensively developed urban campus results in against its potential as a footprint for Nature-based Solutions to future urban improvement.

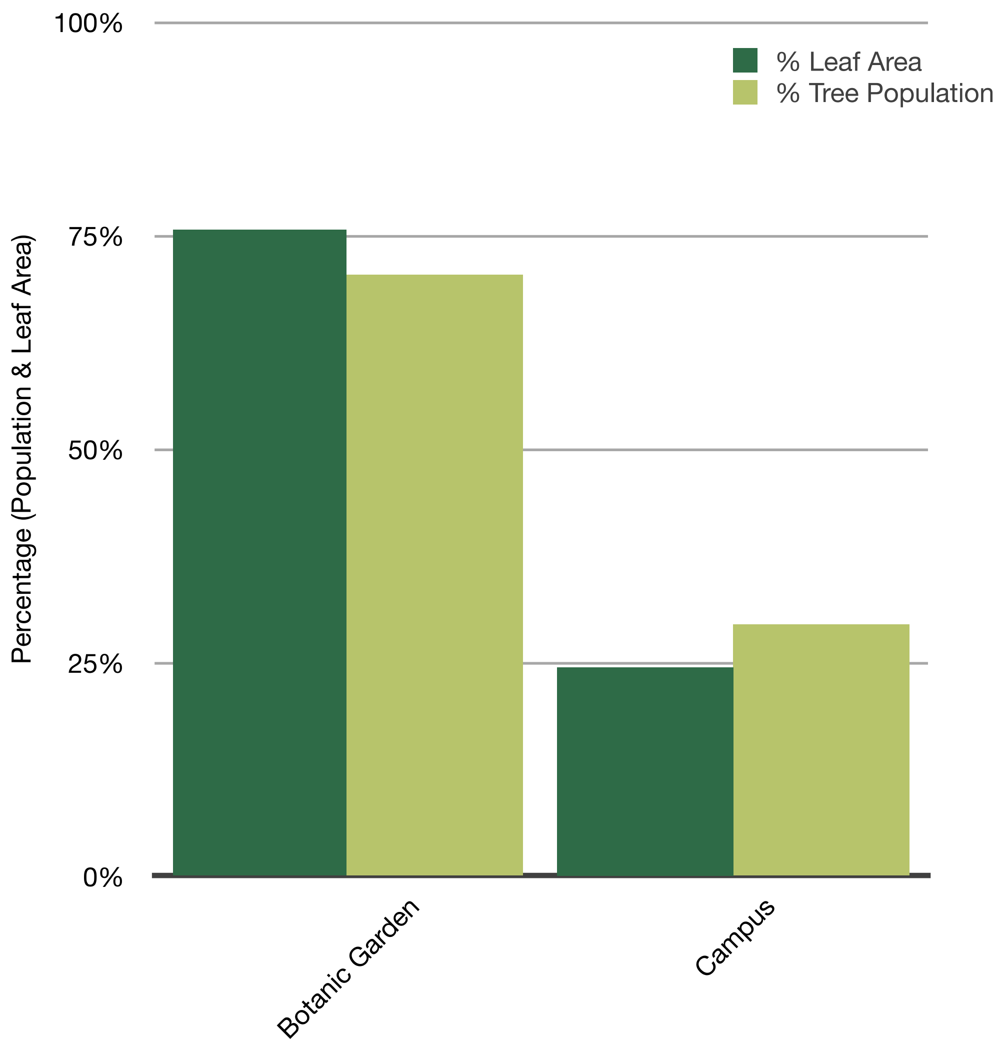

Figure 8. Dominance value, and share of leaf area vs share of population for the top ten genera.

* When calculating the total leaf area within tree canopies, the leaves are layered or stacked. Therefore when they are considered as if laid out side by side, their combined area can exceed the total size of the garden

2. The Value of Ecosystem Services

2.1 Carbon Storage

Trees take in carbon dioxide during photosynthesis; the carbon is then stored within the plants above and below ground parts, whilst the oxygen is released as a byproduct of splitting water to harvest hydrogen during the first phase of photosynthesis. In the reactions of the second stage, hydrogen is combined with carbon dioxide to make glucose (a carbon rich molecule and building block of plant cells). As trees grow, they accumulate more carbon in their tissue, but upon decomposition, much of this carbon is released back into the atmosphere. Carbon is stored not only in the biomass of the trees themselves - around 48% of carbon is stored in the leaf litter and soil of the forest, highlighting the significant carbon storage capacity of healthy forest ecosystems as a whole[16].

Approximately 50% of wood by dry weight is comprised of carbon. Tree stems and roots can store carbon for decades or centuries as woody matter while the tree is alive. If converted into soil carbon, this storage can last for millennia, and under extreme pressure and longer periods, it can even transform into coal. Trees are therefore seen to be an excellent natural way to reduce the amount of carbon dioxide in the atmosphere, and positively influence climate change. Maintaining a healthy, growing tree population will ensure that more carbon is stored than released.

The total carbon storage by trees in the University of Dundee is estimated to be 633 tonnes, with a value of £624,000 annually. Many factors influence storage capacity, such as the age, size, and species of a tree, and therefore it can be assumed from Figure 9 that this is what causes the *Eucalyptus gunnii* species dominance regarding Carbon storage.

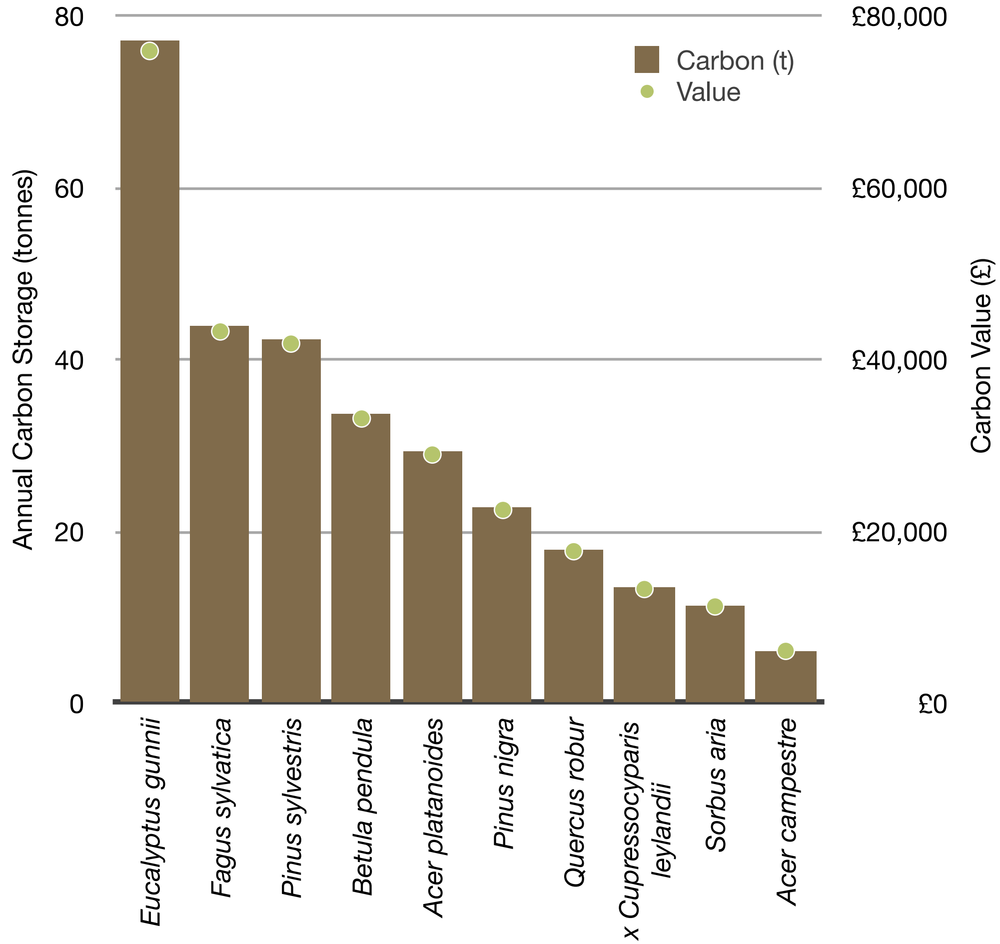

Figure 9. Amount and value of carbon stored by the ten most significant tree taxa for carbon storage

[16] Liu, X., Trogisch, S., He, J. S., Niklaus, P. A., Bruelheide, H., Tang, Z., ... & Ma, K. (2018). Tree species richness increases ecosystem carbon storage in subtropical forests. Proceedings of the Royal Society B, 285(1885), 20181240.

With a smaller footprint in size, but with its dominant share of the tree population, and much less development over the past 50 years, the Botanic Garden is the strata with the highest carbon storage, at 498 tonnes of carbon stored annually with an estimated value of £491,000 in 9.5 Ha of land. It is a reminder of how much impact we can have in a lifetime, if we encourage the planting of trees and help them grow through to maturity.

Overall, the Botanic Garden represents 79% of the total carbon storage of the University of Dundee, and the Campus represents 21%, equating to 135 tonnes with an estimated value of £133,000 per year.

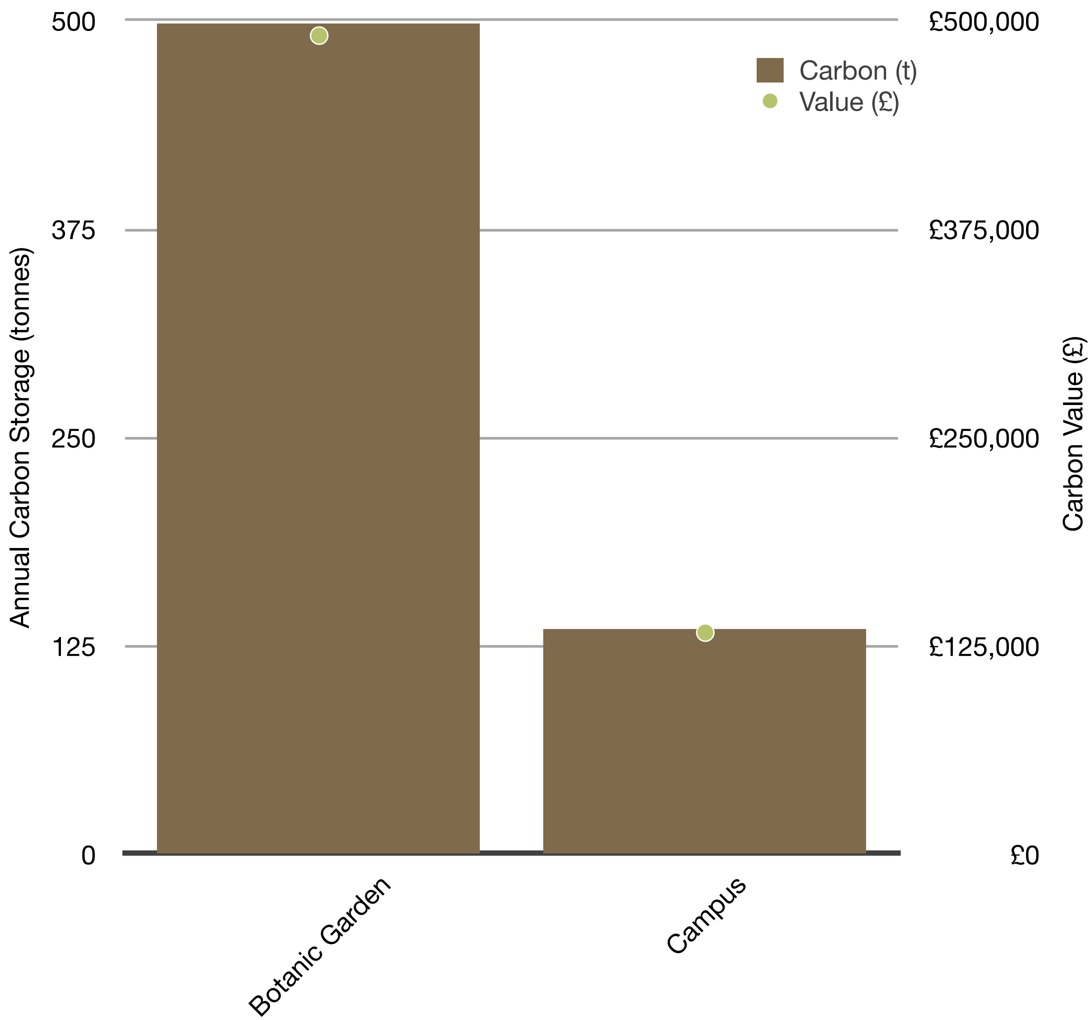

Figure 10. Amount and value of carbon stored annually by strata.

2.2 Annual Carbon Sequestration

Burning fossil fuels, cutting down forests and farming livestock are increasingly influencing the climate and the earth's temperature. This adds enormous amounts of greenhouse gases to those naturally occurring in the atmosphere, increasing the greenhouse effect and global warming. One of the main driving forces behind climate change is the concentration of carbon dioxide (CO_2) in the atmosphere. Trees can help mitigate climate change by sequestering atmospheric carbon (C) as part of the carbon cycle.

Carbon sequestration is the creation of glucose in a plant through the process of photosynthesis. It is an annual metric that can be calculated from tree measurements, climatic data, and predicted growth rates. It is measured (and reported here) as tonnes of carbon (C), which is converted to the equivalent amount of carbon dioxide (CO_2e), which is then valued using government published figures.

Trees at the University of Dundee sequester nearly 15.7 tonnes of carbon annually, with a value of £15,400. Figure 11 shows the ten tree genera that sequester the most carbon per year and the value of the benefit derived. Of all trees inventoried, *Eucalyptus gunnii* sequesters the most carbon, adding 2.8 tonnes every year to the current *Eucalyptus* carbon storage of 82 tonnes.

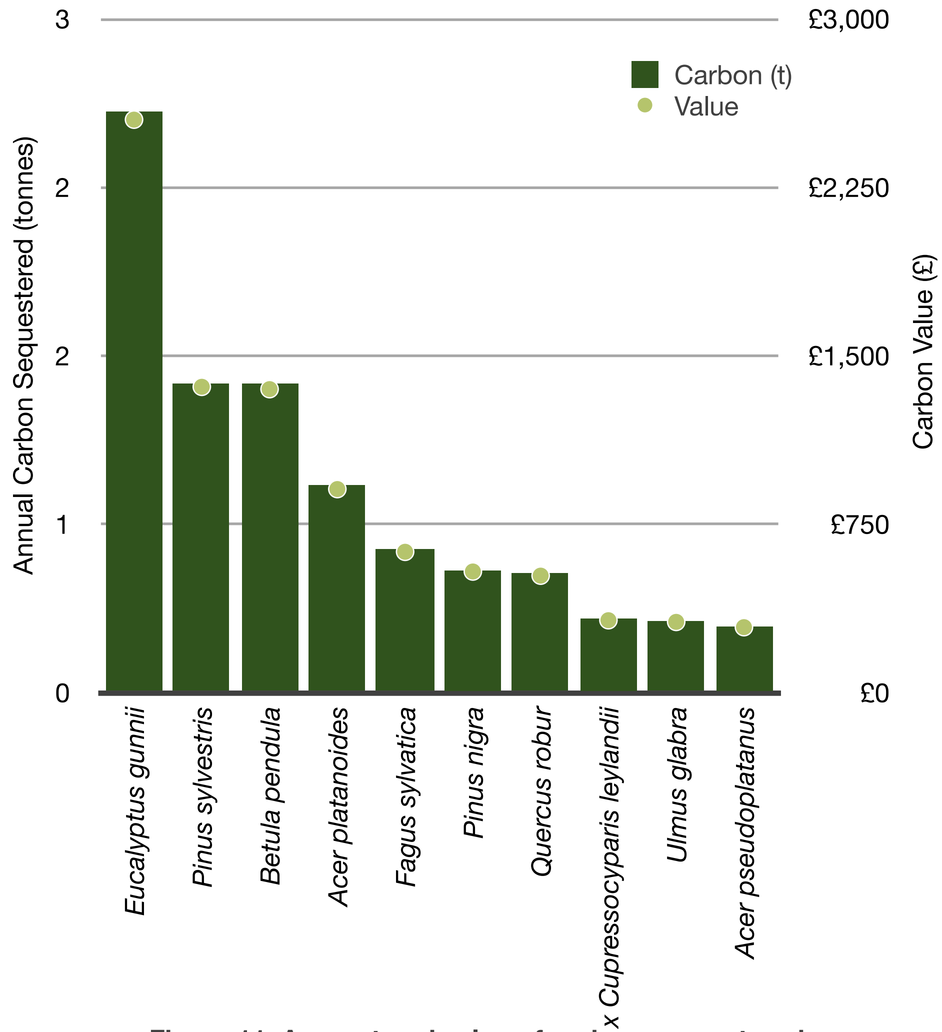

Figure 11. Amount and value of carbon sequestered annually by the ten most significant tree species for carbon sequestration.

The strata with the highest carbon sequestration is the Botanic Garden, which currently sequesters 11.8 tonnes of carbon per year, with an estimated value of £11,600 (Figure 12).

In total, the Campus contributes to 25% of the University of Dundee's total carbon sequestration, amounting to 3.9 tonnes annually, with an estimated value of £3,800 per year.

Compared to other plants, trees are ideal for carbon sequestration because of their large size. The practice of urban forest management is also well established and can help enhance carbon sequestration by strategically increasing the amount of tree growth within a population of trees. Trees that grow rapidly (e.g., young trees, pine species) are often preferred, because they take up more carbon dioxide at a faster rate.

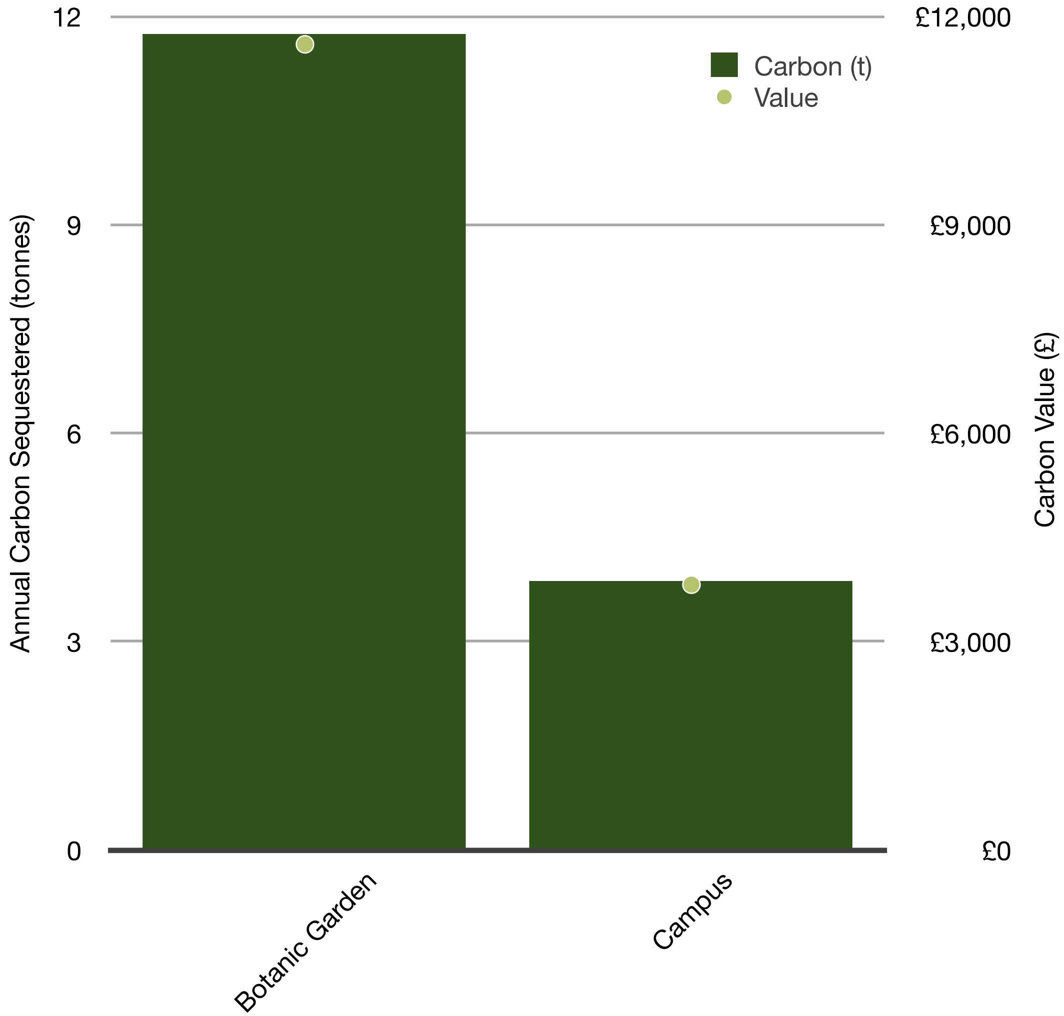

Figure 12. Amount and value of carbon sequestered annually by strata

2.3 Air Pollution Removal

Poor air quality is a particular problem in many urban areas and along road networks. The problems caused by poor air quality are well known, ranging from human health impacts to building damage. The annual cost to society due to particulate pollution in the UK has been estimated at £16 billion (COMEAP, 2010). As befits such significant externality, all local authorities in the UK are under a statutory duty to undertake an air quality assessment within their area and determine whether they are likely to meet the air quality objectives for several pollutants, as established by the Environment Act 1995 Part IV. Highly urbanised areas like the university's main campus and botanic garden, have higher concentrations of pollution than rural locations. Putting burdens on their resident and visiting population and potentially impacting human health through outdoor air pollution which is known to causes across a wide range of conditions. A challenge for the university and all city stakeholders is to help mitigate and try to avoid, as climate change has the potential to exacerbate poor air quality and increase associated health problems for urban populations[17].

Trees significantly contribute to improving air quality by directly removing pollutants from the air[18], absorbing them through the leaf surfaces[19], by intercepting particulate matter (e.g.: smoke, pollen, aerosols created in the atmosphere, and dusts), and by reducing air temperature. By removing pollution from the atmosphere, trees reduce the risks of respiratory disease and asthma, thereby contributing to reduced health care costs and improving human wellbeing.

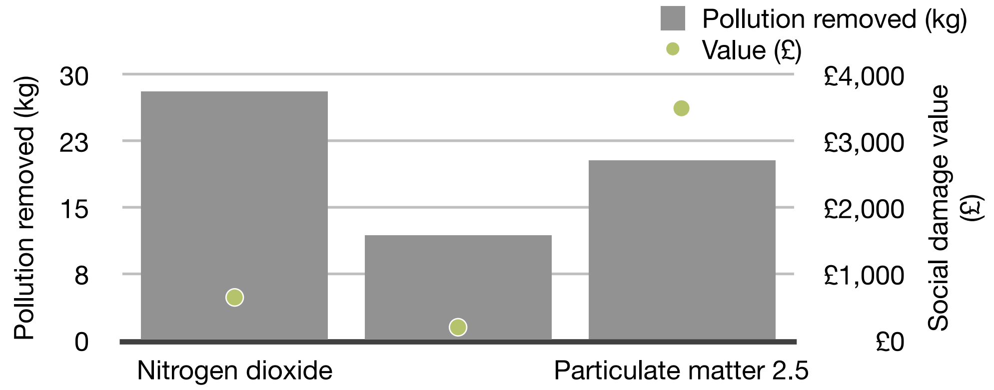

Figure 13. Combined amount and value of air pollution removed annually

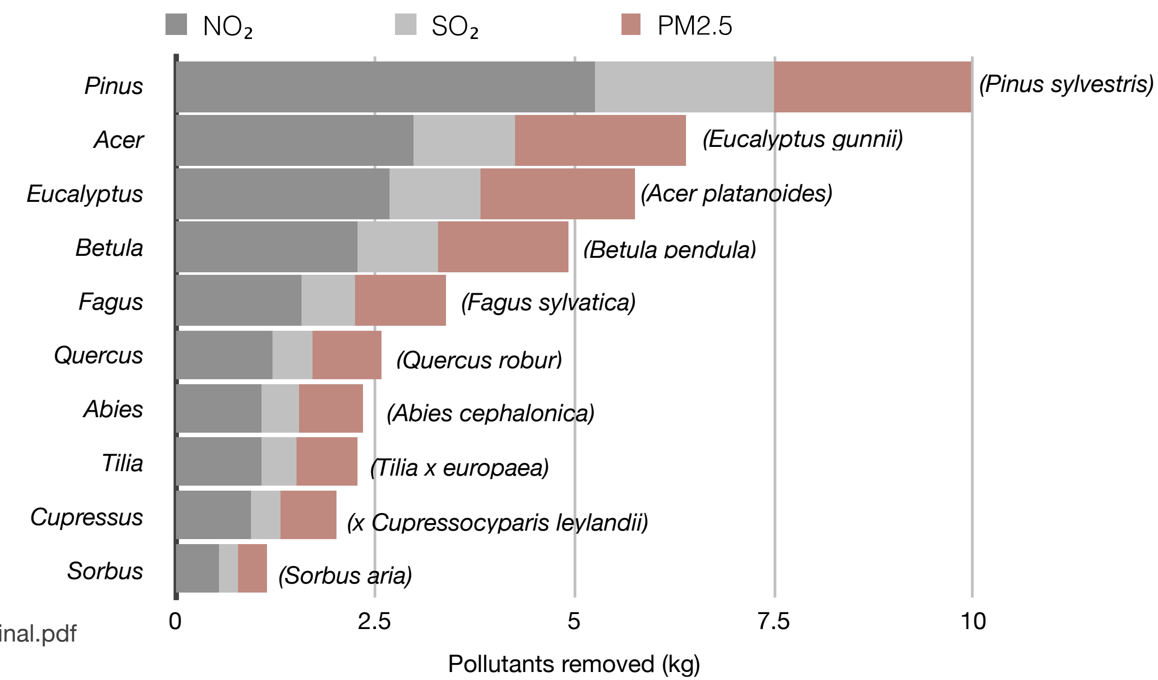

Figure 14: Pollution removed by top ten species

[17] https://www.dundeecity.gov.uk/sites/default/files/publications/dcc_apr2023_nov23_final.pdf

[18] Tiwary et al., 2009

[19] Nowak et al., 2000

Greater tree cover, the concentration of air pollution locally together with the leaf area are the main factors influencing pollution filtration and increasing tree planting has been shown to make further improvements in air quality.[20] As filtering capacity is closely linked to leaf area it is generally the trees with larger canopy potential that provide the most benefits.

Figure 14 shows the breakdown for the top ten pollution removing tree genera in the University of Dundee, with the species contributing the most noted in brackets. As different species can capture different sizes of particulate matter, a broad range of species should be considered.

The strata that removed the highest amount of combined pollution is the Botanic Garden, removing 45.6 kg annually, with an estimated value of £3,300 (Figure 15). Within this total, nitrogen dioxide comprises 21.2 kg, sulphur dioxide 9.1 kg, and particulate matter 2.5 amounts to 15.3 kg.

The Campus, accounting for 24.4% of the total pollution removed by the University's trees, removes 14.7 kg of pollution annually with an estimated value of £1,100. Among these, nitrogen dioxide constitutes 6.8 kg, sulphur dioxide 2.9 kg, and particulate matter 2.5 4.9 kg.

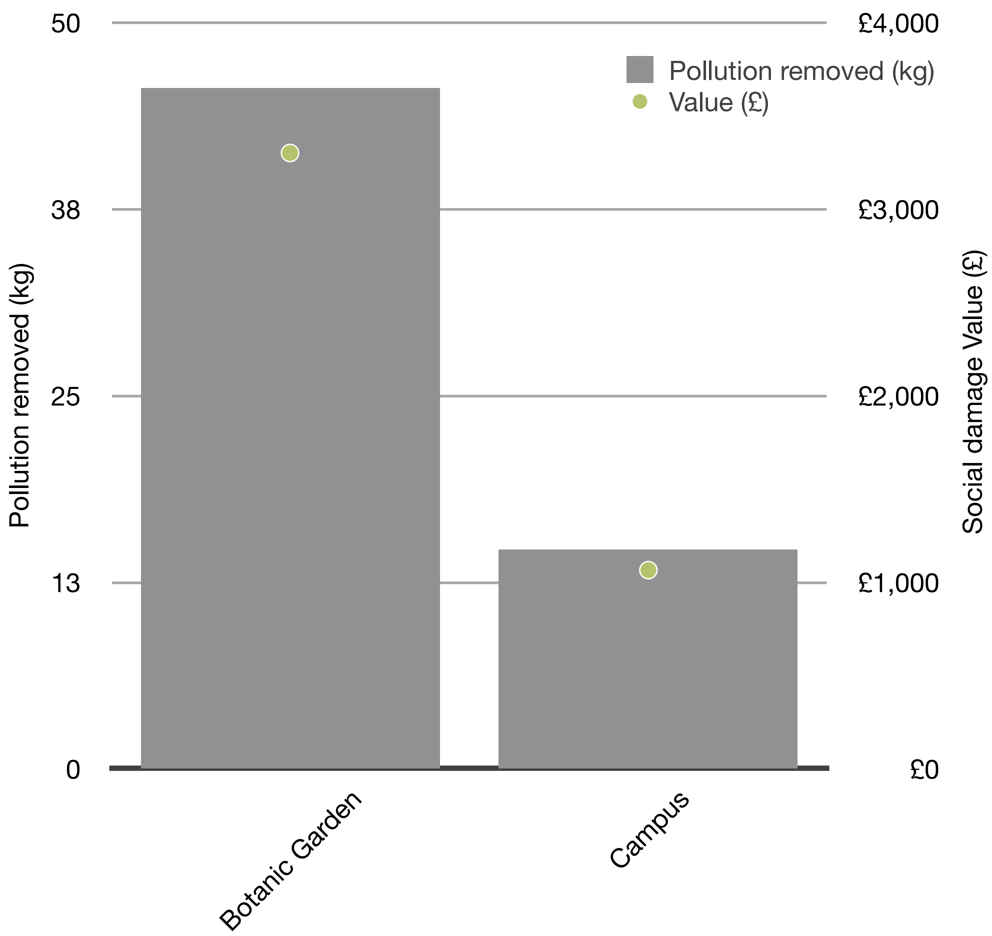

Figure 15. Pollution removal and value by strata

[20] Escobedo and Nowak, 2009

* As well as reducing ozone levels, some tree species also emit the volatile organic compounds (VOCs) that lead to ozone production in the atmosphere. The i-Tree Eco software accounts for both reduction and production of VOCs within its algorithms, and the overall effect of the trees is to reduce ozone through evaporative cooling, however this is not valued in this report as there is no UK Social Damage Cost for this pollutant.

2.4 Avoided Surface Runoff

Surface run-off can be a cause for concern in many areas as it threatens people, transport, property, and can contribute to pollution in streams, wetlands, rivers, lakes, and oceans. During precipitation events, a portion of the precipitation will be intercepted by vegetation; precipitation that reaches the ground and does not infiltrate into the soil becomes surface run-off.[22]

Within an urban area, the large extent of impervious surfaces increases the amount of run-off, however, trees are effective at reducing this. Trees intercept precipitation, whilst their root systems promote infiltration and water storage in the soil. Interception slows down rainwater reaching the ground, and some water will evaporate off the tree surfaces without ever touching the ground.

On its own landholding, the university is responsible for surface water drainage systems associated with the adopted road and footway networks, and for carrying out clearance and repair works to a relevant body of water where they would substantially reduce the risk of flooding. The Flood Risk Management (Scotland) Act 2009 requires the relevant responsible authorities to work together to produce a co-ordinated "Local Flood Risk Management Plan" to reduce the overall risk of flooding from whatever source. The current plan highlights the need for reducing the amount of surface water flowing into combined foul and surface water drains as a priority to reduce the impact of episodic flooding resulting from severe weather events[23].

Total avoided runoff by trees in the University of Dundee is estimated to be 1,600 m³ of water per year, with a value of £2,600 annually. *Pinus sylvestris* intercept the most water, removing roughly 140 m³ of water per year, a service worth £230. These trees have a greater surface area due to their needles that allow them to intercept rainfall. They are also in leaf all year and represent a high proportion of trees within the University of Dundee.

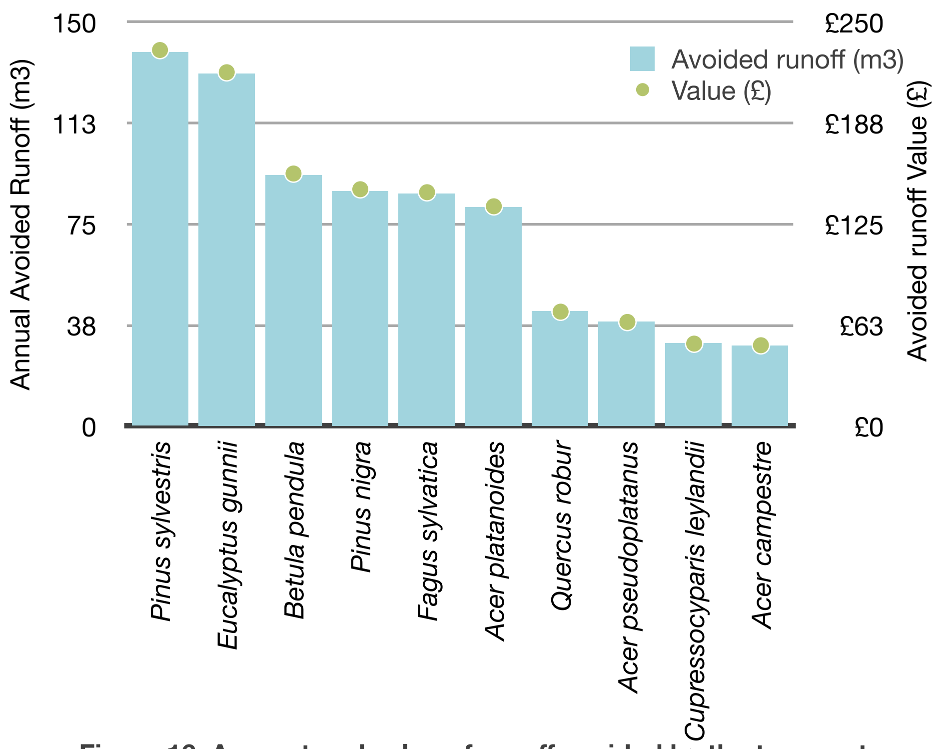

Figure 16. Amount and value of runoff avoided by the ten most significant tree taxa for interception.

[22] Hirabayashi, 2012

[23] https://www.dundeecity.gov.uk/sites/default/files/publications/20221102_dundee_city_council_flooding_advisory_note_-_final_a.pdf

The inventoried trees within the Botanic Garden account for 75.6% of the total avoided runoff, totaling 1,200 m^3 of water with an estimated value of £2,000 per year. The Campus, accounting for 24.4% of the total, intercepts 400 m^3 of water, valued at approximately £600 per year.

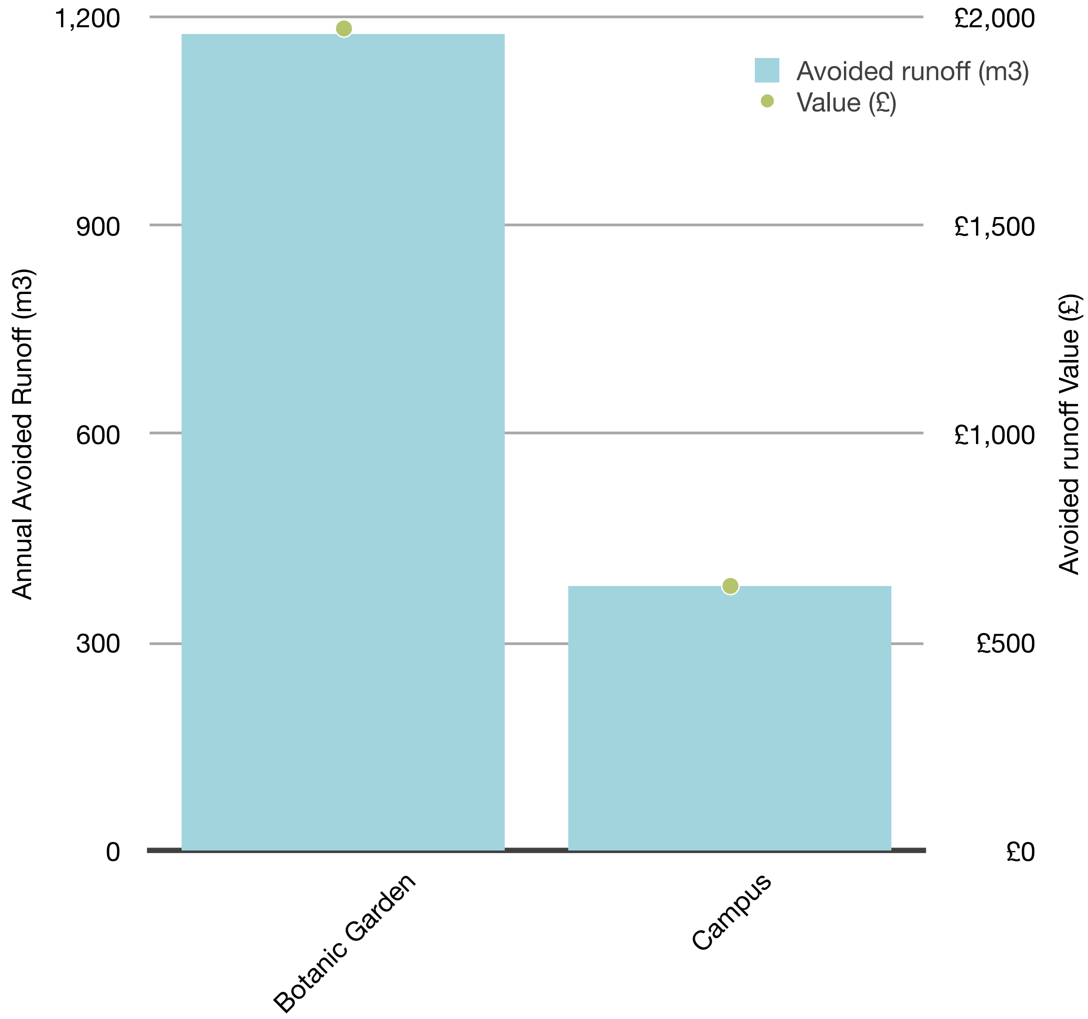

Figure 17. Amount and value of avoided surface water runoff by strata

3. Asset Value

3.1 Replacement Cost and CAVAT Amenity Value

In addition to estimating the environmental benefits provided by trees, i-Tree also provides a structural valuation. In the UK this is termed the 'Replacement Cost'. It is a depreciated replacement cost, based on the Council of Tree and Landscape Appraisers (CTLA) formula[24] intended to quantify what it might cost to replace any or all the trees (taking account of species suitability, depreciation and other economic considerations) should they become damaged or diseased for instance.

In contrast, CAVAT (Capital Asset Valuation for Amenity Trees) attempts to place a value of trees to the local population, accounting for the level of public access and population density, thus establishing a value for the public amenity that trees provide and is in use by many local authorities across the country.[25]

Replacement cost is relatively constant irrespective of location, whereas a CAVAT valuation is highly dependent upon trees' proximity to people. In the University, *Pinus sylvestris* are considered the most valuable in terms of both replacement cost and amenity value, given their dominance within the population.

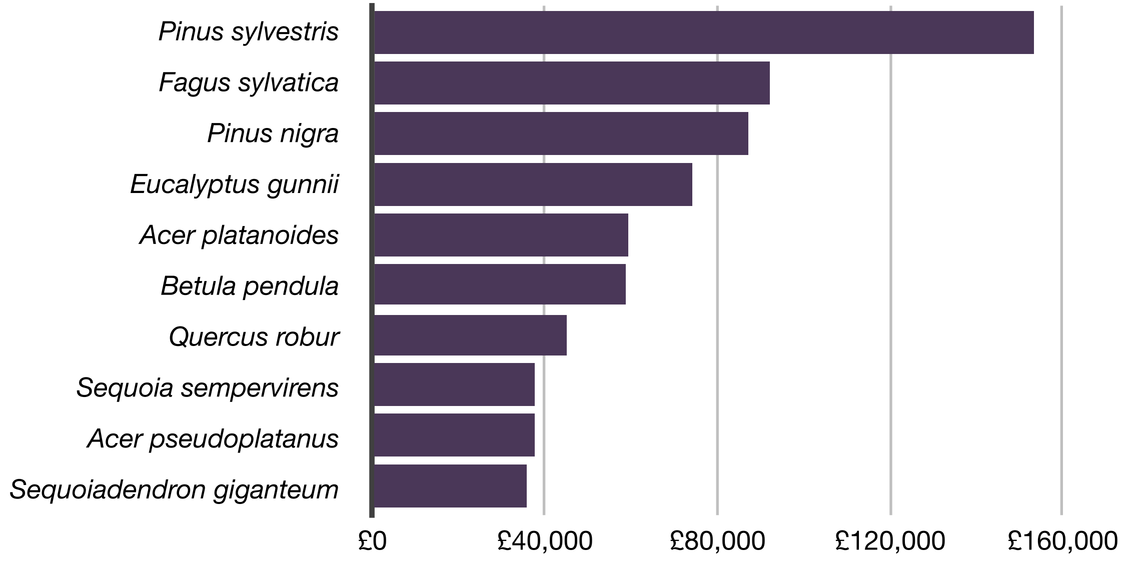

Figure 18. Replacement cost of the ten most significant tree taxa in the University Botanic Garden

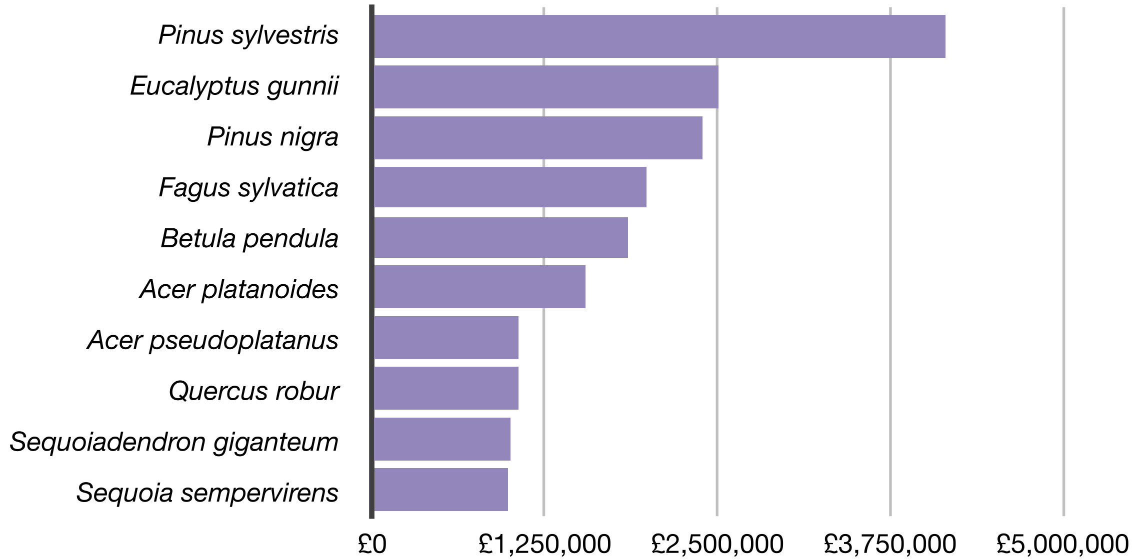

Figure 19. Amenity value (CAVAT) of the ten most significant tree taxa in the University Botanic Garden

[24] Hollis, 2007

[25] Doick *et al.*, 2018

The trees within the Botanic Garden are estimated to have a replacement value of around £1.18 million and a CAVAT valuation of £30.5 million. Meanwhile, the Campus trees contribute a replacement value of £300,000 and a CAVAT value of £7.64 million.

It should be noted that local factors do have some influence. Equally, due to the nature of street trees and the CAVAT method, management choices could not be considered as part of this study. The value should reflect the reality that public trees have to be managed for safety. They are often crown lifted, and especially those close to the roadways, are generally growing in conditions of greater stress than their open grown counterparts. As a result, they may have a significantly reduced functionality under the CAVAT system.

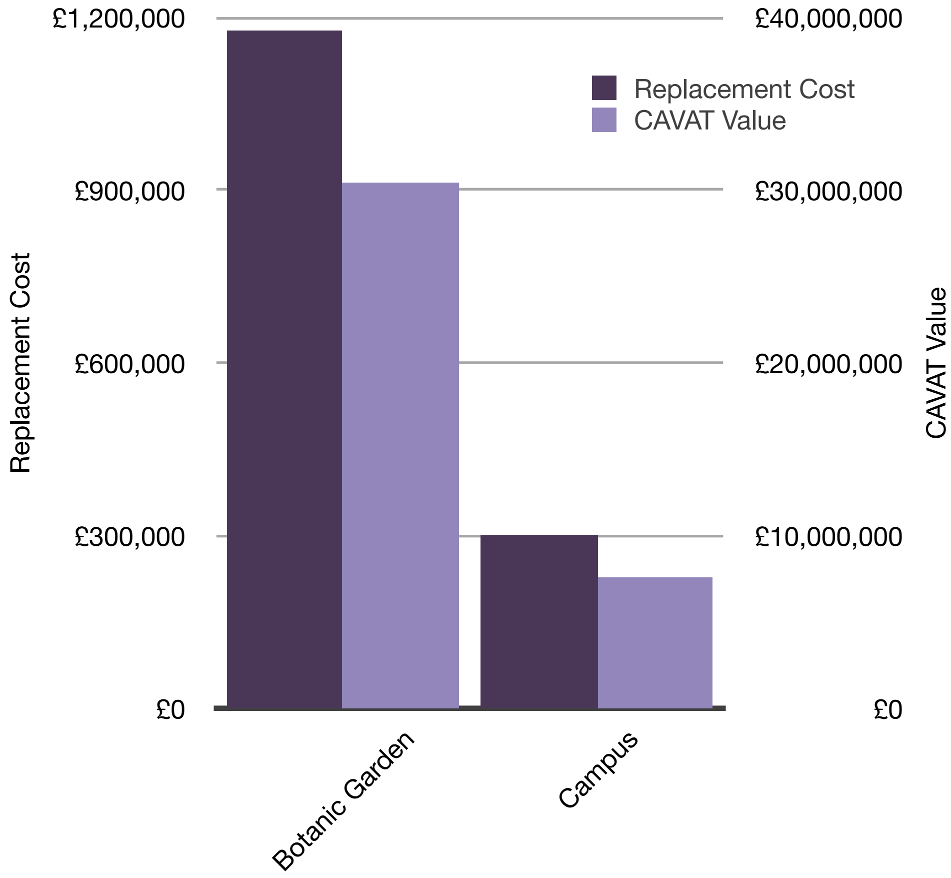

Figure 20. Replacement Cost and CAVAT value of the tree population in each stratum of University of Dundee landscape.

4. Pests and Disease Risk

Animal pests and microbial pathogens are a serious threat to urban forests and society, causing direct economic costs from damage, and impacting on ecosystem service provision[26], and it is likely that climate change will result in the introduction of pests and diseases not yet present in the UK.[27] The changing climate of the UK is predicted to increase growth and spore release of root pathogens, and make trees more susceptible to infection.[28] Temperature changes are likely to affect the geographical range, development rate and seasonal timing of life-cycle events of insects, and will have an impact on their host plants and predators.

Figure 21 shows the proportion of trees at risk for each of the most critical invasive pests and diseases of concern to the UK according to Observatree, led by Forest Research.[29] Potential impact varies based on climate and weather, tree health, local tree management, and individual young tree procurement policies. The figure shows that the threats which could have the largest impact are Asian longhorn beetle, despite not currently being present in the UK. Acute oak decline, which is present in the uk, poses the largest risk, due to the likelihood of the pathogen reaching Dundee's population, and the proportion of the trees which could be affected.

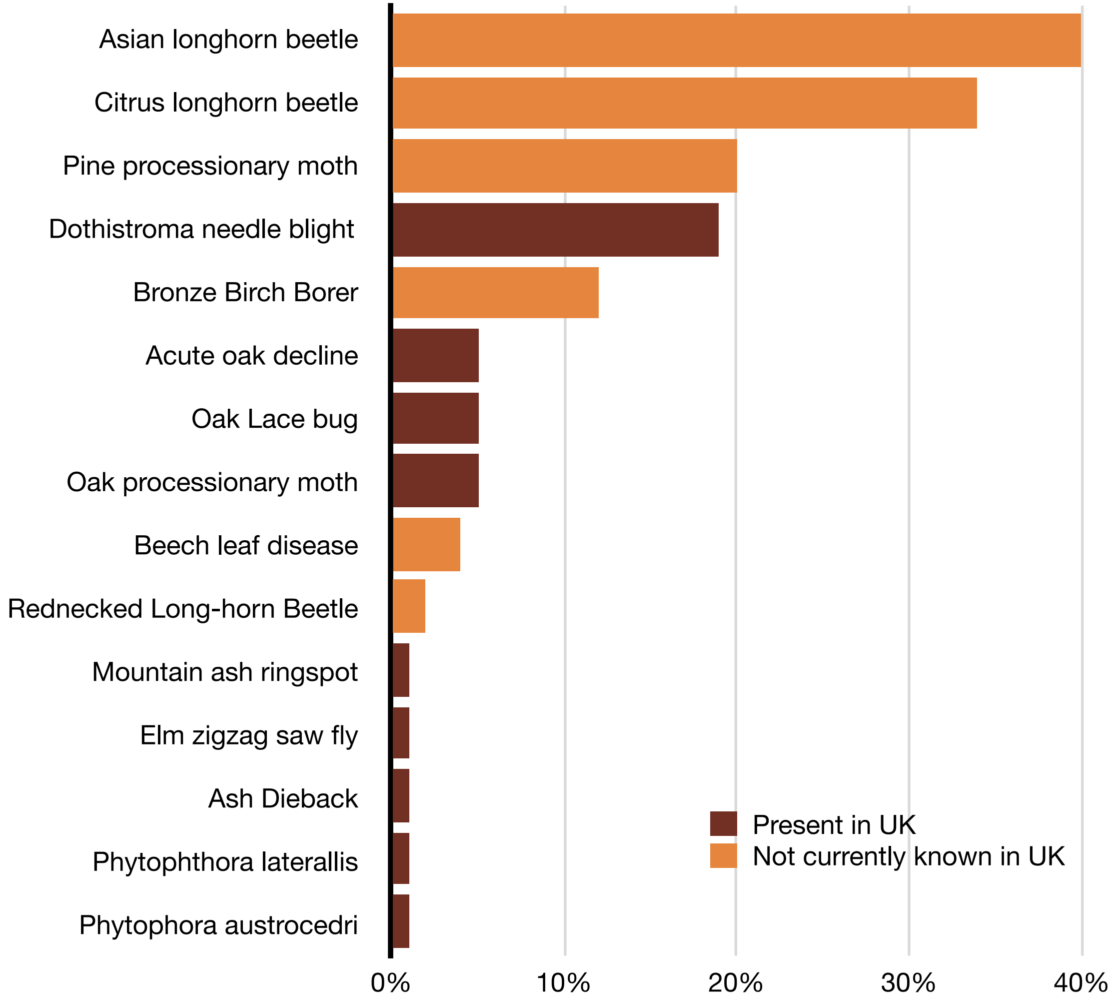

Figure 21. Share of tree population under threat from different named pests of highest concern at time of publication (Observatree, 2024)

[26] Antonelli, A., et al. (2023). See references.

[27] Wainhouse and Inward, 2016

[28] Federickson-Matika and Riddell, 2021

[29] Observatree, 2024

5. Global Warming and Species Choice

The management and maintenance of plants in amenity landscapes are traditionally informed by experience and previous observations. The climate crisis will bring temperatures and conditions that our living landscapes have never experienced, and this will become the new normal and require new modes of working.

Tools such as the Botanic Garden Conservation Climate Assessment Tool (CAT)[30] provides guidance on the likely suitability of taxa to the predicted future climate scenarios of a selected location. It achieves this by taking datasets of current known occurrences of taxa – such as those observed in the wild, in botanic gardens, and in general cultivation – and comparing the current climate of these known occurrences to the predicted climate. By comparing the two climates a suitability score can be generated.

It is through such predictive modelling that informed decision-making on selection or evaluating plants for our living plant collections and landscapes can take place. This work in the living laboratory in turn provides local knowledge that is evidence based and verified for local scaling, which in turn helps to adapt to and mitigate the worst impacts of climate change.

[30] Climate Change Alliance of Botanic Gardens. 2024. Climate Assessment Tool v1. Botanic Gardens Conservation International. Richmond, U.K. Available at https://cat.bgci.org. Accessed on 18/04/2024.

6. Recommendations

The results and data from previous i-Tree Eco studies have been used in a variety of ways to improve the management of trees and inform decision making in a diversity of urban and rural landscapes. The information in this report highlights the current structure, composition and value of the University of Dundee's tree inventory. It can be used to make more informed decisions on how these trees can be managed to provide long-term benefits to its stakeholders. A key outcome of undertaking a project such as this but one that can in turn be used to improve, enhance, and reduce risks associated with poor decisions based upon previous norms of management and design of the urban campus and botanic garden.

1. Pro-actively manage species diversity

The report highlights the need to continue to introduce a wide variety of species based upon previous work in the botanic garden. Utilising the botanic garden nursery to ensure local acclimation of soil and environmental conditions but significantly also reducing the risk associated with poor supply chain biosecurity through bought in tree stock. Botanic gardens traditionally grow unusual or untried species that can help add locally high levels of diversity. The university should continue to make the most of opportunities to increase the proportion of smaller and young stature trees, of seed origin or with high diversity within and between species, genera, and families, to sustain structural diversity and the overall resilience of the tree stock. Paying particular attention to those species which are predicted to be least adaptable to climate change, as forecast for Dundee's latitude and longitude (Frediani, 2024a).

The climate in Scotland has already changed[31], with further changes projected. There will be further increases in mean temperatures in all regions of Scotland, and in all seasons, including milder winters with fewer days of ground frost and lying snow. Rainfall patterns will also change, with drier summers and wetter autumns and winters. An increase in the frequency and intensity of extreme events, such as high winds, storms, flooding, heat waves and droughts is also likely.

In addition to the BGCI Climate assessment tool, there are a number of additional tools and published resources available to help support the identification and evaluation of suitable biogeographical material for future treescapes, including Hirons, et. al.; (2021), Watkins, et. al., 2021, Volk et. al., 2023 and tools highlighted by Forest Research and the forestry commission listed below:

- Climate matching tool: https://www.forestresearch.gov.uk/tools-and-resources/fthr/climate-matching-tool/
- Decision support tools: https://www.forestresearch.gov.uk/climate-change/resources/decision-support-tools/
- Forestry and climate change partnership: https://forestryclimatechange.uk/resources
- Trees and Design Action Group guides: https://www.tdag.org.uk/our-guides.html Including the Tree Species Selection for Green Infrastructure (Hirons and Sjoman, 2019)
- Sjoman and Anderson, (2023) The Essential Tree Selection Guide.

[31] https://www.forestresearch.gov.uk/climate-change/advice/official-country-guidance/scotland/

2. Plant forest-size trees where possible

Size and space matter. Identify trees that can grow to full maturity and reach their optimal canopy size and contribute the most benefits to the surrounding urban communities. Such an approach must consider site-specific restrictions and diversity-management requirements. Recent research on the growth rates of isolated, urban trees confirm that they vary as a function of simple and interactive effects of traits and size. These findings are useful for optimizing reforestation efforts in temperate cities, and therefore the botanic garden campus and grounds, where the curator, together with external green and blue space planners as part of projects with the university land managers can select species for rapid growth and Carbon sequestration using freely available data for the 'effect' traits that have been identified, including wood anatomy and density, leaf Nitrogen, and LDMC (Simovic, et, al., 2024).

3. Engage the public

Use the report's content to inform and advise local communities about the trees in their streets and the measurable benefits they provide. Public engagement has been shown to improve tree establishment as residents are more willing to contribute personal time and effort to looking after them.

4. Cost benefit analysis

Use the data for cost benefit analysis to inform decision making, e.g. securing water supplies through tree pits linked to SuDS are recovered as benefits accrue. This approach will be researched in the project under development as part of the Tay Cities funded innovation hub at the University of Dundee where a experimental rain garden has been specified and designed by the curator and external landscape architect for realization later in 2024[32].

5. Understand climate impact on species choice

Research and evaluate the living collection through further study and evaluative analysis to help inform long term tree and parkland strategies, particularly with regards to species choice. Recruit undergraduate, graduate and post graduate projects on the living collection, while collaborating in wide Botanic Garden Networks to help identify and source new plant material to trial in the botanic garden and then scale to improve and enhance the main campus site.

6. Include trees within wider decision making

Ensure that policy makers and practitioners take full account of Dundee University's trees in planning the development and maintenance of the main campus by sharing this report and making it known to decision making authorities. Not only raising awareness that the existing treesare a very valuable functional component of our existing landscape, but highlighting that they also make a significant contribution to peoples' quality of life and future potential requires their integration into site master planning now to ensure the optimal benefits in the future.

[32] https://www.dundee.ac.uk/innovation-hub

7. Appendix I - Tree Values by Genus and Species

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
Botanic Garden								
Pinus	*Pinus*	9	3.2	0.06	0.33	8.5	£11,274	£292,890
	Pinus armandii	1	0.0	0.00	0.01	0.3	£205	£8,124
	Pinus attenuata	1	0.4	0.01	0.02	0.4	£1,427	£38,981
	Pinus banksiana	1	0.2	0.01	0.04	1	£584	£17,703
	Pinus cembra	1	0.1	0.00	0.01	0.3	£303	£10,611
	Pinus contorta	2	0.4	0.02	0.09	2.2	£1,560	£45,281
	Pinus coulteri	1	1.1	0.01	0.07	1.8	£3,770	£98,170
	Pinus flexilis	2	0.3	0.01	0.04	1.2	£1,200	£36,936
	Pinus greggii	1	0.3	0.00	0.05	1.4	£1,295	£35,665
	Pinus jeffreyi	1	0.2	0.01	0.01	0.3	£1,360	£37,304
	Pinus muricata	1	1.6	0.03	0.08	2	£5,128	£136,248
	Pinus nigra	61	22.0	0.53	3.30	85.5	£83,640	£2,302,278
	Pinus peuce	3	1.9	0.03	0.18	4.6	£6,892	£182,911
	Pinus pinaster	10	4.5	0.13	0.61	15.6	£18,272	£494,039
	Pinus pinea	4	1.2	0.03	0.11	2.8	£4,374	£116,887
	Pinus ponderosa	2	0.8	0.03	0.21	5.5	£3,943	£105,465

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
	Pinus radiata	1	2.6	0.02	0.29	7.4	£8,684	£274,192
	Pinus sylvestris	149	40.9	1.34	5.19	133.7	£148,122	£4,057,738
	Pinus thunbergii	1	0.2	0.00	0.03	0.9	£630	£18,864
	Pinus uncinata	1	0.2	0.00	0.02	0.6	£727	£21,296
	Pinus wallichiana	3	1.7	0.04	0.25	6.5	£7,500	£198,257
	Pinus yunnanensis	1	0.4	0.01	0.05	1.4	£1,564	£42,444
Pinus Total		**257**	**84.0**	**2.31**	**11.00**	**283.9**	**£312,454**	**£8,572,284**
Eucalyptus	Eucalyptus coccifera	1	0.2	0.01	0.05	1.2	£227	£8,916
	Eucalyptus dalrympleana	1	0.5	0.01	0.05	1.2	£628	£21,296
	Eucalyptus delegatensis	2	0.8	0.03	0.11	2.9	£1,128	£38,649
	Eucalyptus glaucescens	1	0.8	0.02	0.05	1.3	£846	£28,020
	Eucalyptus globulus	1	0.3	0.01	0.03	0.8	£342	£12,453
	Eucalyptus gunnii	92	76.1	2.54	4.92	126.7	£73,108	£2,470,672
	Eucalyptus morrisbyi	1	0.2	0.01	0.02	0.6	£201	£8,124
	Eucalyptus nitens	1	1.3	0.03	0.08	2.1	£1,743	£55,726
	Eucalyptus pauciflora	2	0.5	0.02	0.10	2.5	£538	£20,430
	Eucalyptus perriniana	1	0.4	0.02	0.03	0.8	£549	£18,864
	Eucalyptus tenuiramis	1	0.1	0.01	0.01	0.4	£82	£6,650

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
	Eucalyptus urnigera	1	0.4	0.01	0.13	3.3	£342	£12,453
Eucalyptus Total		**105**	**81.6**	**2.73**	**5.59**	**143.8**	**£79,734**	**£2,702,254**
Betula	*Betula*	6	1.0	0.04	0.21	5.3	£1,778	£59,521
	Betula albosinensis	2	0.7	0.02	0.11	2.9	£1,270	£39,662
	Betula costata	1	0.3	0.01	0.02	0.5	£557	£17,703
	Betula ermanii	1	0.3	0.01	0.05	1.2	£599	£18,864
	Betula lenta	2	0.1	0.01	0.06	1.4	£260	£10,758
	Betula papyrifera	3	1.1	0.06	0.11	3	£1,879	£57,587
	Betula pendula	63	22.6	0.87	2.49	64.1	£39,835	£1,255,398
	Betula schmidtii	1	0.1	0.01	0.03	0.9	£233	£8,916
	Betula utilis	5	2.8	0.08	0.28	7.2	£4,307	£129,211
Betula Total		**84**	**29.0**	**1.10**	**3.36**	**86.5**	**£50,717**	**£1,597,621**
Quercus	*Quercus*	1	0.9	0.03	0.08	2	£2,775	£55,726
	Quercus cerris	1	1.2	0.04	0.09	2.3	£3,389	£73,117
	Quercus glauca	1	0.3	0.01	0.03	0.9	£553	£14,443
	Quercus ilex	7	2.4	0.08	0.29	7.4	£5,514	£118,158
	Quercus ilicifolia	1	0.2	0.01	0.03	0.7	£212	£8,124
	Quercus kelloggii	1	0.3	0.01	0.04	1	£791	£18,864

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
	Quercus palustris	2	0.8	0.03	0.11	2.7	£2,102	£47,344
	Quercus petraea	1	0.5	0.01	0.05	1.4	£1,401	£30,967
	Quercus robur	32	16.1	0.42	1.46	37.7	£41,665	£955,950
	Quercus suber	1	0.5	0.01	0.03	0.6	£1,207	£26,601
	Quercus x turneri	1	0.2	0.01	0.05	1.4	£395	£11,514
Quercus Total		**49**	**23.4**	**0.66**	**2.25**	**58.1**	**£60,004**	**£1,360,808**
Abies	*Abies*	20	6.1	0.15	0.83	21.6	£23,702	£609,876
	Abies alba	1	0.7	0.01	0.07	1.7	£2,702	£66,319
	Abies bracteata	1	0.7	0.01	0.10	2.6	£2,608	£64,127
	Abies cephalonica	2	1.9	0.01	0.35	9	£6,806	£167,713
	Abies cilicica	1	0.1	0.01	0.05	1.2	£569	£16,580
	Abies concolor	3	1.7	0.02	0.11	2.8	£7,373	£184,256
	Abies grandis	2	1.8	0.03	0.17	4.5	£8,261	£199,270
	Abies lasiocarpa	1	0.3	0.01	0.05	1.3	£1,530	£38,981
	Abies magnifica	1	0.3	0.01	0.01	0.1	£1,530	£38,981
	Abies nordmanniana	1	0.2	0.00	0.01	0.3	£719	£20,061
	Abies numidica	1	0.2	0.01	0.03	0.8	£667	£18,864
	Abies pinsapo	9	3.1	0.05	0.25	6.3	£10,451	£223,863

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
	Abies procera	6	3.0	0.07	0.34	8.7	£12,053	£302,175
Abies Total		**49**	**20.1**	**0.38**	**2.36**	**60.9**	**£78,970**	**£1,951,064**
Fagus	*Fagus orientalis*	1	0.2	0.01	0.04	1.1	£343	£10,611
	Fagus sylvatica	47	34.7	0.51	2.78	71.9	£72,530	£1,567,612
Fagus Total		**48**	**34.9**	**0.52**	**2.83**	**73**	**£72,873**	**£1,578,223**
Cupressus	*x Cupressocyparis leylandii*	31	11.2	0.26	1.01	26	£21,859	£623,784
	Cupressus arizonica	2	0.3	0.02	0.05	1.2	£428	£17,980
	Cupressus goveniana	3	1.7	0.03	0.11	2.8	£3,549	£94,762
	Cupressus sempervirens	5	2.0	0.03	0.14	3.6	£4,574	£125,140
Cupressus Total		**41**	**15.2**	**0.35**	**1.30**	**33.6**	**£30,411**	**£861,666**
Sorbus	*Sorbus*	3	0.8	0.01	0.07	1.9	£2,519	£50,292
	Sorbus alnifolia	1	0.2	0.01	0.03	0.7	£492	£12,453
	Sorbus americana	1	0.3	0.01	0.01	0.1	£685	£15,493
	Sorbus aria	20	9.6	0.14	0.47	12.1	£22,656	£398,316
	Sorbus aucuparia	3	0.8	0.05	0.06	1.4	£2,130	£34,965
	Sorbus commixta	2	0.3	0.02	0.04	0.9	£836	£22,567
	Sorbus domestica	2	1.3	0.03	0.11	2.8	£3,168	£55,947
	Sorbus latifolia	1	1.1	0.00	0.03	0.7	£2,805	£5,969

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
	Sorbus mougeotii	1	0.1	0.01	0.02	0.5	£129	£5,324
	Sorbus torminalis	3	1.1	0.03	0.10	2.5	£3,098	£62,874
Sorbus Total		**37**	**15.5**	**0.29**	**0.92**	**23.6**	**£38,519**	**£664,200**
Nothofagus	*Nothofagus*	8	4.7	0.10	0.47	12.1	£9,915	£262,144
	Nothofagus alpina	5	4.9	0.11	0.26	6.8	£10,513	£266,786
	Nothofagus antarctica	8	6.9	0.03	0.66	16.8	£14,197	£365,196
	Nothofagus dombeyi	3	7.6	0.13	0.55	14.3	£14,025	£352,301
	Nothofagus fusca	1	0.9	0.00	0.10	2.5	£1,645	£42,444
	Nothofagus obliqua	3	2.7	0.08	0.53	13.6	£5,462	£139,896
	Nothofagus pumilio	1	0.1	0.01	0.03	0.8	£239	£8,916
Nothofagus Total		**29**	**27.8**	**0.46**	**2.60**	**66.9**	**£55,996**	**£1,437,682**
Acer	*Acer*	1	0.1	0.00	0.03	0.8	£95	£5,969
	Acer campestre	5	1.8	0.03	0.21	5.4	£3,681	£101,892
	Acer capillipes	1	0.1	0.00	0.03	0.8	£66	£4,145
	Acer cappadocicum	3	0.6	0.03	0.10	2.6	£1,205	£38,520
	Acer davidii	2	0.1	0.01	0.04	1.1	£201	£12,619
	Acer griseum	1	0.1	0.00	0.02	0.5	£85	£5,324
	Acer platanoides	9	6.6	0.14	0.72	18.7	£12,967	£347,492

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
	Acer pseudoplatanus	2	7.3	0.06	0.28	7.3	£13,218	£402,813
	Acer rubrum	1	0.1	0.01	0.04	1	£106	£6,650
	Acer saccharum	1	0.1	0.00	0.03	0.7	£85	£5,324
Acer Total		**26**	**16.8**	**0.29**	**1.50**	**38.9**	**£31,709**	**£930,748**
Tsuga	*Tsuga*	2	0.3	0.01	0.07	1.7	£1,467	£40,455
	Tsuga diversifolia	1	0.0	0.00	0.03	0.6	£110	£6,650
	Tsuga heterophylla	18	3.2	0.06	0.74	19.1	£18,308	£482,157
	Tsuga mertensiana	1	0.0	0.00	0.01	0.1	£208	£6,650
Tsuga Total		**22**	**3.6**	**0.07**	**0.83**	**21.5**	**£20,093**	**£535,912**
Picea	*Picea*	2	1.3	0.04	0.18	4.8	£4,978	£112,834
	Picea abies	**2**	**0.9**	**0.01**	**0.08**	**2**	**£2,363**	**£59,429**
	Picea jezoensis	1	0.1	0.00	0.06	1.6	£133	£7,369
	Picea likiangensis	1	0.2	0.01	0.03	0.7	£716	£18,864
	Picea omorika	5	1.4	0.04	0.13	3.5	£4,385	£109,758
	Picea pungens	2	0.4	0.01	0.05	1.3	£1,189	£32,570
	Picea sitchensis	6	4.5	0.09	0.45	11.5	£15,660	£340,418
	Picea spinulosa	1	0.5	0.01	0.04	0.9	£1,587	£37,304
Picea Total		**20**	**9.5**	**0.20**	**1.02**	**26.3**	**£31,012**	**£718,546**

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
Zelkova	*Zelkova*	10	1.8	0.06	0.37	9.6	£6,419	£165,779
	Zelkova serrata	1	0.1	0.00	0.05	1.3	£517	£14,443
Zelkova Total		**11**	**1.9**	**0.06**	**0.42**	**10.9**	**£6,935**	**£180,222**
Ilex	*Ilex*	1	0.2	0.01	0.02	0.6	£375	£10,611
	Ilex aquifolium	10	3.7	0.03	0.17	4.4	£10,541	£139,528
Ilex Total		**11**	**3.9**	**0.04**	**0.20**	**5**	**£10,917**	**£150,139**
Ulmus	*Ulmus glabra*	8	5.5	0.20	0.60	15.5	£12,797	£343,753
	Ulmus procera	1	0.1	0.01	0.02	0.6	£237	£8,916
	Ulmus pumila	1	1.1	0.03	0.07	1.8	£2,360	£61,971
Ulmus Total		**10**	**6.6**	**0.24**	**0.70**	**17.9**	**£15,394**	**£414,640**
Fraxinus	*Fraxinus*	5	1.0	0.04	0.13	3.2	£2,311	£73,430
	Fraxinus americana	1	0.4	0.01	0.05	1.2	£732	£21,296
	Fraxinus excelsior	2	0.7	0.03	0.09	2.3	£1,488	£43,181
	Fraxinus ornus	1	0.3	0.00	0.03	0.8	£889	£25,220
	Fraxinus profunda	1	0.2	0.01	0.03	0.9	£732	£21,296
Fraxinus Total		**10**	**2.6**	**0.09**	**0.33**	**8.4**	**£6,154**	**£184,422**
Sequoia	*Sequoia sempervirens*	8	10.4	0.14	0.88	22.7	£37,723	£990,214
Sequoia Total	***Sequoia Total***	**8**	**10.4**	**0.14**	**0.88**	**22.7**	**£37,723**	**£990,214**
Tilia	Tilia *cordata*	4	2.5	0.07	0.42	10.9	£8,777	£186,669

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
	Tilia platyphyllos	1	0.1	0.00	0.04	1.1	£179	£7,369
	Tilia x europaea	2	0.7	0.02	0.16	4.2	£2,688	£55,560
Tilia Total		**7**	**3.3**	**0.09**	**0.63**	**16.2**	**£11,644**	**£249,598**
Populus	*Populus alba*	1	0.9	0.02	0.11	2.9	£1,109	£57,771
	Populus balsamifera	2	2.4	0.04	0.29	7.5	£3,175	£169,850
	Populus lasiocarpa	2	0.1	0.02	0.02	0.4	£261	£15,069
	Populus nigra	1	0.2	0.02	0.00	0.1	£484	£23,875
	Populus tremula	1	0.4	0.01	0.05	1.4	£534	£26,601
Populus Total		**7**	**4.0**	**0.11**	**0.48**	**12.3**	**£5,563**	**£293,166**
Prunus	*Prunus avium*	2	1.3	0.01	0.09	2.3	£1,750	£60,516
	Prunus lusitanica	2	0.3	0.01	0.04	1	£408	£13,356
	Prunus occidentalis	1	2.9	0.06	0.03	0.7	£1,898	£57,771
	Prunus serotina	1	0.4	0.01	0.02	0.5	£652	£21,296
	Prunus serrulata	1	1.6	0.00	0.03	0.8	£1,829	£20,061
Prunus Total		**7**	**6.5**	**0.10**	**0.21**	**5.3**	**£6,537**	**£173,000**
Tetraclinis	*Tetraclinis*	5	2.6	0.11	0.10	2.6	£3,690	£94,983
Tetraclinis Total		**5**	**2.6**	**0.11**	**0.10**	**2.6**	**£3,690**	**£94,983**
Pseudotsuga	*Pseudotsuga menziesii*	5	1.4	0.03	0.36	9.2	£7,652	£192,767

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
Pseudotsuga Total		**5**	**1.4**	**0.03**	**0.36**	**9.2**	**£7,652**	**£192,767**
Cedrus	*Cedrus atlantica*	2	3.3	0.05	0.15	3.9	£9,430	£245,840
	Cedrus deodara	3	2.3	0.07	0.11	2.8	£6,909	£184,016
Cedrus Total		**5**	**5.6**	**0.13**	**0.26**	**6.7**	**£16,339**	**£429,857**
Araucaria	*Araucaria araucana*	5	1.4	0.05	0.15	3.9	£6,779	£130,224
Araucaria Total		**5**	**1.4**	**0.05**	**0.15**	**3.9**	**£6,779**	**£130,224**
Salix	*Salix*	1	0.5	0.02	0.02	0.6	£2,286	£40,694
	Salix alba	1	1.2	0.04	0.05	1.4	£6,460	£106,405
	Salix caprea	1	0.1	0.00	0.04	1	£320	£9,745
	Salix sitchensis	1	0.5	0.01	0.04	1	£1,668	£30,967
	Salix triandra	1	0.3	0.01	0.05	1.2	£1,271	£10,611
Salix Total		**5**	**2.6**	**0.08**	**0.20**	**5.2**	**£12,006**	**£198,422**
Cryptomeria	*Cryptomeria*	5	2.3	0.05	0.24	6.1	£9,103	£226,110
Cryptomeria Total		**5**	**2.3**	**0.05**	**0.24**	**6.1**	**£9,103**	**£226,110**
Alnus	*Alnus cordata*	1	0.4	0.01	0.07	1.7	£2,286	£40,694
	Alnus glutinosa	3	1.2	0.03	0.11	2.8	£6,226	£112,116
	Alnus rubra	1	0.4	0.01	0.11	2.8	£2,627	£46,055
Alnus Total		**5**	**2.0**	**0.05**	**0.28**	**7.3**	**£11,139**	**£198,864**
Larix	*Larix*	2	0.4	0.01	0.05	1.2	£812	£36,346

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
	Larix decidua	1	0.2	0.01	0.01	0.2	£471	£21,296
	Larix gmelinii	1	0.1	0.01	0.01	0.4	£350	£15,493
	Larix occidentalis	1	0.6	0.03	0.07	1.7	£1,193	£55,726
Larix Total		**5**	**1.3**	**0.05**	**0.14**	**3.5**	**£2,826**	**£128,861**
Pseudolarix	*Pseudolarix*	2	0.9	0.02	0.10	2.6	£3,496	£87,117
	Pseudolarix amabilis	2	0.2	0.01	0.04	1.2	£968	£28,978
Pseudolarix Total		**4**	**1.1**	**0.03**	**0.15**	**3.8**	**£4,464**	**£116,095**
Aesculus	*Aesculus*	1	0.2	0.01	0.06	1.6	£641	£16,580
	Aesculus hippocastanum	3	2.5	0.05	0.30	7.8	£4,113	£116,224
Aesculus Total		**4**	**2.7**	**0.06**	**0.36**	**9.4**	**£4,754**	**£132,804**
Magnolia	*Magnolia*	3	0.2	0.01	0.08	2.1	£307	£14,738
	Magnolia salicifolia	1	0.1	0.00	0.03	0.8	£98	£4,716
Magnolia Total		**4**	**0.2**	**0.02**	**0.11**	**2.9**	**£406**	**£19,454**
Sequoiadendron	*Sequoiadendron giganteum*	4	29.0	0.07	0.51	13	£35,708	£992,388
Sequoiadendron Total		**4**	**29.0**	**0.07**	**0.51**	**13**	**£35,708**	**£992,388**
Amelasorbus	*x Amelasorbus*	4	1.1	0.02	0.10	2.5	£2,441	£37,544
Amelasorbus Total		**4**	**1.1**	**0.02**	**0.10**	**2.5**	**£2,441**	**£37,544**
Pyrus	*Pyrus*	2	0.5	0.02	0.05	1.1	£1,309	£30,009
	Pyrus calleryana	1	0.2	0.02	0.02	0.4	£755	£16,580

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
Pyrus Total		**3**	**0.7**	**0.04**	**0.06**	**1.5**	**£2,063**	**£46,589**
Thuja	*Thuja plicata*	3	0.9	0.01	0.24	6.3	£6,160	£158,539
Thuja Total		**3**	**0.9**	**0.01**	**0.24**	**6.3**	**£6,160**	**£158,539**
Cercidiphyllum	*Cercidiphyllum japonicum*	3	0.9	0.02	0.14	3.5	£3,862	£88,223
Cercidiphyllum Total		**3**	**0.9**	**0.02**	**0.14**	**3.5**	**£3,862**	**£88,223**
Catalpa	*Catalpa bungei*	2	2.0	0.01	0.09	2.3	£5,960	£130,280
	Catalpa x erubescens	**1**	**0.5**	**0.02**	**0.06**	**1.5**	**£1,470**	**£34,062**
Catalpa Total		**3**	**2.5**	**0.02**	**0.15**	**3.8**	**£7,430**	**£164,342**
Calocedrus	*Calocedrus decurrens*	3	1.0	0.02	0.16	4.2	£3,529	£91,225
Calocedrus Total		**3**	**1.0**	**0.02**	**0.16**	**4.2**	**£3,529**	**£91,225**
Carpinus	*Carpinus betulus*	2	0.7	0.02	0.08	2	£1,894	£39,220
	Carpinus orientalis	1	0.3	0.01	0.13	3.3	£826	£17,703
Carpinus Total		**3**	**1.1**	**0.02**	**0.21**	**5.3**	**£2,720**	**£56,924**
Taxus	*Taxus baccata*	3	1.4	0.02	0.15	3.8	£5,304	£97,010
Taxus Total		**3**	**1.4**	**0.02**	**0.15**	**3.8**	**£5,304**	**£97,010**
Ginkgo	*Ginkgo biloba*	2	0.1	0.01	0.04	1.1	£978	£26,178
Ginkgo Total		**2**	**0.1**	**0.01**	**0.04**	**1.1**	**£978**	**£26,178**
Arbutus	*Arbutus menziesii*	2	1.8	0.05	0.11	2.9	£4,537	£80,835
Arbutus Total		**2**	**1.8**	**0.05**	**0.11**	**2.9**	**£4,537**	**£80,835**

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
Hemiptelea	*Hemiptelea davidii*	2	0.6	0.02	0.05	1.3	£1,366	£35,738
Hemiptelea Total		**2**	**0.6**	**0.02**	**0.05**	**1.3**	**£1,366**	**£35,738**
Hoheria	*Hoheria*	2	0.1	0.01	0.07	1.8	£108	£5,840
Hoheria Total		**2**	**0.1**	**0.01**	**0.07**	**1.8**	**£108**	**£5,840**
Robinia	*Robinia neomexicana*	1	0.0	0.01	0.01	0.3	£32	£3,113
	Robinia pseudoacacia	1	0.4	0.01	0.03	0.9	£584	£22,567
Robinia Total		**2**	**0.4**	**0.02**	**0.04**	**1.2**	**£615**	**£25,680**
Umbellularia	*Umbellularia californica*	2	3.8	0.11	0.25	6.3	£7,720	£118,582
Umbellularia Total		**2**	**3.8**	**0.11**	**0.25**	**6.3**	**£7,720**	**£118,582**
Sciadopitys	*Sciadopitys verticillata*	2	0.2	0.01	0.02	0.6	£188	£11,293
Sciadopitys Total		**2**	**0.2**	**0.01**	**0.02**	**0.6**	**£188**	**£11,293**
Corylus	*Corylus colurna*	2	0.5	0.02	0.04	0.9	£1,594	£34,504
Corylus Total		**2**	**0.5**	**0.02**	**0.04**	**0.9**	**£1,594**	**£34,504**
Clusia	*Clusia minor*	2	5.0	0.00	0.08	2.1	£7,300	£44,286
Clusia Total		**2**	**5.0**	**0.00**	**0.08**	**2.1**	**£7,300**	**£44,286**
Juglans	*Juglans nigra*	1	0.8	0.02	0.06	1.6	£1,673	£44,231
	Juglans regia	1	0.8	0.02	0.08	2	£1,400	£38,981
Juglans Total		**2**	**1.6**	**0.05**	**0.14**	**3.6**	**£3,074**	**£83,212**
Cunninghamia	*Cunninghamia*	2	0.1	0.01	0.05	1.2	£762	£20,725

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
Cunninghamia Total		**2**	**0.1**	**0.01**	**0.05**	**1.2**	**£762**	**£20,725**
Libocedrus	*Libocedrus bidwillii*	1	1.5	0.00	0.06	1.6	£2,366	£57,771
Libocedrus Total		**1**	**1.5**	**0.00**	**0.06**	**1.6**	**£2,366**	**£57,771**
Metasequoia	*Metasequoia glyptostroboides*	1	0.2	0.01	0.04	1	£1,201	£30,967
Metasequoia Total		**1**	**0.2**	**0.01**	**0.04**	**1**	**£1,201**	**£30,967**
Koelreuteria	*Koelreuteria paniculata*	1	0.1	0.00	0.03	0.7	£111	£5,969
Koelreuteria Total		**1**	**0.1**	**0.00**	**0.03**	**0.7**	**£111**	**£5,969**
Actinidia	*Actinidia*	1	0.6	0.02	0.03	0.8	£725	£8,124
Actinidia Total		**1**	**0.6**	**0.02**	**0.03**	**0.8**	**£725**	**£8,124**
Rhamnus	*Rhamnus cathartica*	1	0.0	0.01	0.02	0.5	£77	£4,145
Rhamnus Total		**1**	**0.0**	**0.01**	**0.02**	**0.5**	**£77**	**£4,145**
Genista	*Genista aetnensis*	1	0.2	0.01	0.03	0.8	£420	£12,453
Genista Total		**1**	**0.2**	**0.01**	**0.03**	**0.8**	**£420**	**£12,453**
Kalopanax	*Kalopanax septemlobus*	1	0.3	0.01	0.02	0.4	£1,107	£26,601
Kalopanax Total		**1**	**0.3**	**0.01**	**0.02**	**0.4**	**£1,107**	**£26,601**
Leucothrinax	*Leucothrinax morrisii*	1	0.0	0.00	0.01	0.2	£482	£7,369
Leucothrinax Total		**1**	**0.0**	**0.00**	**0.01**	**0.2**	**£482**	**£7,369**
Morus	*Morus nigra*	1	0.0	0.01	0.03	0.8	£58	£3,113

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
Morus Total		**1**	**0.0**	**0.01**	**0.03**	**0.8**	**£58**	**£3,113**
Wollemia	*Wollemia nobilis*	1	0.0	0.00	0.00	0.1	£52	£3,113
Wollemia Total		**1**	**0.0**	**0.00**	**0.00**	**0.1**	**£52**	**£3,113**
Juniperus	*Juniperus recurva*	1	0.1	0.00	0.05	1.4	£106	£6,650
Juniperus Total		**1**	**0.1**	**0.00**	**0.05**	**1.4**	**£106**	**£6,650**
Tetramolopium	*Tetramolopium humile*	1	0.3	0.02	0.02	0.4	£633	£4,145
Tetramolopium Total		**1**	**0.3**	**0.02**	**0.02**	**0.4**	**£633**	**£4,145**
Nageia	*Nageia nagi*	1	0.0	0.00	0.00	0	£33	£18
Nageia Total		**1**	**0.0**	**0.00**	**0.00**	**0**	**£33**	**£18**
Ailanthus	*Ailanthus altissima*	1	1.7	0.06	0.15	3.8	£3,833	£82,696
Ailanthus Total		**1**	**1.7**	**0.06**	**0.15**	**3.8**	**£3,833**	**£82,696**
Pongamia	*Pongamia*	1	1.4	0.03	0.02	0.5	£3,256	£70,814
Pongamia Total		**1**	**1.4**	**0.03**	**0.02**	**0.5**	**£3,256**	**£70,814**
Diospyros	*Diospyros samoensis*	1	0.2	0.01	0.04	1	£732	£18,864
Diospyros Total		**1**	**0.2**	**0.01**	**0.04**	**1**	**£732**	**£18,864**
Liriodendron	*Liriodendron tulipifera*	1	0.9	0.02	0.10	2.7	£2,523	£55,726
Liriodendron Total		**1**	**0.9**	**0.02**	**0.10**	**2.7**	**£2,523**	**£55,726**
Styrax	*Styrax japonicus*	1	0.2	0.01	0.04	0.9	£467	£13,430
Styrax Total		**1**	**0.2**	**0.01**	**0.04**	**0.9**	**£467**	**£13,430**

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
Styphnolobium	*Styphnolobium japonicum*	1	3.0	0.04	0.11	2.7	£4,077	£87,707
Styphnolobium Total		**1**	**3.0**	**0.04**	**0.11**	**2.7**	**£4,077**	**£87,707**
Crataegus	*Crataegus tanuphylla*	1	0.8	0.00	0.01	0.2	£1,877	£42,444
Crataegus Total		**1**	**0.8**	**0.00**	**0.01**	**0.2**	**£1,877**	**£42,444**
Tetradium	*Tetradium daniellii*	1	6.5	0.00	0.11	2.9	£5,705	£123,869
Tetradium Total		**1**	**6.5**	**0.00**	**0.11**	**2.9**	**£5,705**	**£123,869**
Liquidambar	*Liquidambar styraciflua*	1	0.0	0.00	0.01	0.2	£107	£5,969
Liquidambar Total		**1**	**0.0**	**0.00**	**0.01**	**0.2**	**£107**	**£5,969**
Castanopsis	*Castanopsis*	1	0.1	0.01	0.03	0.8	£288	£9,745
Castanopsis Total		**1**	**0.1**	**0.01**	**0.03**	**0.8**	**£288**	**£9,745**
Platanus	*Platanus x hybrida*	1	0.7	0.01	0.19	4.9	£3,241	£55,726
Platanus Total		**1**	**0.7**	**0.01**	**0.19**	**4.9**	**£3,241**	**£55,726**
Cornus	*Cornus controversa*	1	0.0	0.00	0.03	0.7	£50	£3,113
Cornus Total		**1**	**0.0**	**0.00**	**0.03**	**0.7**	**£50**	**£3,113**
Ouratea	*Ouratea litoralis*	1	1.2	0.00	0.02	0.6	£1,964	£44,231
Ouratea Total		**1**	**1.2**	**0.00**	**0.02**	**0.6**	**£1,964**	**£44,231**
Quillaja	*Quillaja saponaria*	1	0.1	0.00	0.02	0.5	£111	£5,969
Quillaja Total		**1**	**0.1**	**0.00**	**0.02**	**0.5**	**£111**	**£5,969**
Castanea	*Castanea sativa*	1	0.2	0.01	0.02	0.6	£755	£16,580

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
Castanea Total		**1**	**0.2**	**0.01**	**0.02**	**0.6**	**£755**	**£16,580**
Nyssa	*Nyssa sylvatica*	1	0.2	0.01	0.03	0.7	£621	£16,580
Nyssa Total		**1**	**0.2**	**0.01**	**0.03**	**0.7**	**£621**	**£16,580**
Eucryphia	*Eucryphia*	1	0.1	0.00	0.01	0.3	£77	£4,145
Eucryphia Total		**1**	**0.1**	**0.00**	**0.01**	**0.3**	**£77**	**£4,145**
Lithocarpus	*Lithocarpus*	1	0.2	0.01	0.05	1.3	£420	£12,453
Lithocarpus Total		**1**	**0.2**	**0.01**	**0.05**	**1.3**	**£420**	**£12,453**
Botanic Garden Total		**972**	**497.8**	**11.76**	**45.65**	**1177.2**	**£1,177,452**	**£30,475,008**

Campus								
Acer	*Acer campestre*	29	4.4	0.11	0.96	24.6	£7,967	£263,877
	Acer cappadocicum	2	0.5	0.01	0.05	1.2	£1,021	£28,169
	Acer davidii	1	0.1	0.00	0.02	0.5	£89	£3,200
	Acer griseum	1	0.1	0.00	0.01	0.4	£206	£8,124
	Acer negundo	1	0.9	0.02	0.06	1.6	£2,280	£57,771
	Acer platanoides	44	22.7	0.78	2.43	62.6	£46,539	£1,185,541
	Acer pseudoplatanus	13	13.5	0.23	1.21	31.3	£24,288	£664,038
	Acer saccharum	2	1.0	0.03	0.16	4	£2,168	£61,924

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
Acer Total		**93**	**43.2**	**1.20**	**4.89**	**126.2**	**£84,558**	**£2,272,645**
Betula	*Betula*	1	0.3	0.01	0.05	1.2	£556	£9,799
	Betula albosinensis	21	1.0	0.07	0.16	3.9	£1,392	£87,501
	Betula papyrifera	1	0.3	0.01	0.06	1.5	£475	£15,493
	Betula pendula	51	11.0	0.50	1.15	29.3	£18,957	£603,590
	Betula utilis	9	0.7	0.05	0.17	4.3	£773	£46,596
Betula Total		**83**	**13.2**	**0.65**	**1.58**	**40.2**	**£22,153**	**£762,978**
Tilia	*Tilia cordata*	15	0.8	0.04	0.20	5.2	£1,598	£50,712
	Tilia platyphyllos	4	3.1	0.07	0.51	13.2	£12,109	£208,499
	Tilia x europaea	11	7.1	0.17	0.97	25	£28,083	£536,870
Tilia Total		**30**	**11.0**	**0.28**	**1.67**	**43.4**	**£41,790**	**£796,081**
Sorbus	*Sorbus*	2	0.0	0.00	0.01	0.2	£112	£3,113
	Sorbus aria	12	1.8	0.07	0.14	3.4	£3,875	£88,831
	Sorbus aucuparia	12	1.1	0.07	0.10	2.6	£2,510	£62,964
	Sorbus hupehensis	1	0.0	0.00	0.00	0	£36	£288
Sorbus Total		**27**	**3.0**	**0.14**	**0.24**	**6.2**	**£6,533**	**£155,196**
Prunus	*Prunus*	7	1.0	0.05	0.10	2.6	£1,235	£43,525
	Prunus avium	13	5.1	0.08	0.34	8.7	£6,888	£255,102

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
	Prunus Kanzan	1	0.0	0.00	0.00	0.1	£26	£1,842
	Prunus lusitanica	1	0.2	0.01	0.02	0.5	£179	£7,369
	Prunus serrula	4	2.2	0.08	0.07	1.7	£1,467	£38,130
	Prunus subhirtella	1	0.1	0.01	0.01	0.4	£96	£7,369
Prunus Total		**27**	**8.7**	**0.22**	**0.54**	**14**	**£9,890**	**£353,337**
Quercus	*Quercus palustris*	2	0.9	0.04	0.16	4.2	£2,585	£56,371
	Quercus petraea	1	0.1	0.00	0.01	0.2	£106	£5,324
	Quercus robur	13	1.8	0.11	0.18	4.7	£3,244	£107,970
Quercus Total		**16**	**2.8**	**0.15**	**0.35**	**9.1**	**£5,935**	**£169,665**
Carpinus	*Carpinus betulus*	13	3.5	0.09	0.54	14	£9,084	£197,059
Carpinus Total		**13**	**3.5**	**0.09**	**0.54**	**14**	**£9,084**	**£197,059**
Fagus	*Fagus sylvatica*	12	9.2	0.13	0.57	14.6	£19,321	£414,144
Fagus Total		**12**	**9.2**	**0.13**	**0.57**	**14.6**	**£19,321**	**£414,144**
Cupressus	*x Cupressocyparis leylandii*	7	2.3	0.06	0.18	4.6	£4,298	£118,836
	Cupressus macrocarpa	2	4.5	0.00	0.52	13.5	£10,199	£258,275
Cupressus Total		**9**	**6.8**	**0.06**	**0.71**	**18.1**	**£14,497**	**£377,111**
Zelkova	*Zelkova carpinifolia*	9	0.8	0.03	0.13	3.2	£2,034	£55,424
Zelkova Total		**9**	**0.8**	**0.03**	**0.13**	**3.2**	**£2,034**	**£55,424**
Chamaecyparis	*Chamaecyparis*	1	0.3	0.01	0.04	0.9	£424	£7,199

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
	Chamaecyparis lawsoniana	4	1.7	0.02	0.11	2.8	£3,595	£60,781
	Chamaecyparis pisifera	3	0.4	0.01	0.03	0.9	£566	£17,676
Chamaecyparis Total		**8**	**2.3**	**0.04**	**0.18**	**4.6**	**£4,585**	**£85,656**
Pinus	*Pinus armandii*	1	0.1	0.00	0.03	0.7	£540	£16,580
	Pinus nigra	3	0.8	0.02	0.08	2.1	£3,364	£94,177
	Pinus sylvestris	4	1.5	0.04	0.20	5.3	£5,110	£96,048
Pinus Total		**8**	**2.5**	**0.06**	**0.31**	**8.1**	**£9,013**	**£206,805**
Ilex	Ilex aquifolium	4	0.4	0.01	0.02	0.6	£844	£30,449
	Ilex x altaclerensis	3	0.3	0.01	0.02	0.5	£856	£20,651
Ilex Total		**7**	**0.8**	**0.03**	**0.04**	**1.1**	**£1,700**	**£51,100**
Ulmus	Ulmus glabra	5	3.9	0.12	0.27	6.8	£8,424	£225,489
Ulmus Total		**5**	**3.9**	**0.12**	**0.27**	**6.8**	**£8,424**	**£225,489**
Alnus	Alnus glutinosa	4	1.5	0.04	0.30	7.7	£9,450	£167,437
	Alnus incana	1	0.2	0.01	0.04	1	£586	£13,932
Alnus Total		**5**	**1.7**	**0.05**	**0.34**	**8.7**	**£10,037**	**£181,368**
Pyrus	Pyrus	4	0.2	0.02	0.02	0.5	£455	£18,772
Pyrus Total		**4**	**0.2**	**0.02**	**0.02**	**0.5**	**£455**	**£18,772**
Griselinia	Griselinia littoralis	4	0.9	0.03	0.08	2.1	£1,596	£40,292
Griselinia Total		**4**	**0.9**	**0.03**	**0.08**	**2.1**	**£1,596**	**£40,292**

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
Salix	Salix caprea	2	0.1	0.01	0.03	0.8	£480	£13,356
	Salix fragilis	2	1.8	0.03	0.18	4.7	£6,200	£107,013
Salix Total		**4**	**1.9**	**0.04**	**0.21**	**5.5**	**£6,681**	**£120,369**
Malus	Malus	2	0.4	0.02	0.04	0.9	£962	£24,550
	Malus sylvestris	1	0.1	0.00	0.01	0.3	£121	£5,585
Malus Total		**3**	**0.5**	**0.02**	**0.05**	**1.2**	**£1,083**	**£30,135**
Rhus	Rhus typhina	3	2.1	0.01	0.59	15.1	£5,833	£130,382
Rhus Total		**3**	**2.1**	**0.01**	**0.59**	**15.1**	**£5,833**	**£130,382**
Liquidambar	*Liquidambar styraciflua*	3	2.3	0.08	0.32	8.3	£10,272	£229,313
Liquidambar Total		**3**	**2.3**	**0.08**	**0.32**	**8.3**	**£10,272**	**£229,313**
Nothofagus	*Nothofagus dombeyi*	1	0.1	0.01	0.02	0.5	£239	£8,916
	Nothofagus obliqua	2	2.7	0.09	0.15	3.7	£5,934	£151,741
Nothofagus Total		**3**	**2.8**	**0.09**	**0.17**	**4.2**	**£6,173**	**£160,657**
Fraxinus	*Fraxinus excelsior*	3	2.3	0.08	0.21	5.3	£5,789	£125,505
Fraxinus Total		**3**	**2.3**	**0.08**	**0.21**	**5.3**	**£5,789**	**£125,505**
Populus	*Populus nigra*	3	6.1	0.14	0.10	2.6	£6,206	£284,731
Populus Total		**3**	**6.1**	**0.14**	**0.10**	**2.6**	**£6,206**	**£284,731**
Cotoneaster	*Cotoneaster*	2	0.1	0.01	0.01	0.4	£90	£4,945
Cotoneaster Total		**2**	**0.1**	**0.01**	**0.01**	**0.4**	**£90**	**£4,945**

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
Metasequoia	*Metasequoia glyptostroboides*	2	0.2	0.01	0.06	1.5	£1,103	£27,566
Metasequoia Total		**2**	**0.2**	**0.01**	**0.06**	**1.5**	**£1,103**	**£27,566**
Corylus	*Corylus colurna*	2	0.0	0.00	0.02	0.6	£112	£3,832
Corylus Total		**2**	**0.0**	**0.00**	**0.02**	**0.6**	**£112**	**£3,832**
Trachycarpus	*Trachycarpus fortunei*	2	0.1	0.00	0.02	0.5	£444	£22,125
Trachycarpus Total		**2**	**0.1**	**0.00**	**0.02**	**0.5**	**£444**	**£22,125**
Pittosporum	*Pittosporum tenuifolium*	2	0.1	0.01	0.01	0.2	£144	£7,756
Pittosporum Total		**2**	**0.1**	**0.01**	**0.01**	**0.2**	**£144**	**£7,756**
Cercidiphyllum	*Cercidiphyllum japonicum*	2	0.1	0.00	0.04	1.2	£299	£13,766
Cercidiphyllum Total		**2**	**0.1**	**0.00**	**0.04**	**1.2**	**£299**	**£13,766**
Ginkgo	*Ginkgo biloba*	2	0.0	0.00	0.00	0.1	£173	£9,211
Ginkgo Total		**2**	**0.0**	**0.00**	**0.00**	**0.1**	**£173**	**£9,211**
Platanus	*Platanus x hybrida*	2	0.2	0.01	0.14	3.8	£1,210	£25,680
Platanus Total		**2**	**0.2**	**0.01**	**0.14**	**3.8**	**£1,210**	**£25,680**
Eucalyptus	*Eucalyptus gunnii*	1	0.8	0.05	0.16	4.1	£991	£32,496
Eucalyptus Total		**1**	**0.8**	**0.05**	**0.16**	**4.1**	**£991**	**£32,496**
Catalpa	*Catalpa bignonioides*	1	0.0	0.00	0.00	0	£39	£660
Catalpa Total		**1**	**0.0**	**0.00**	**0.00**	**0**	**£39**	**£660**

Taxa	Species	Trees	Carbon Storage (tonne/yr)	Carbon Sequestration (tonne/yr)	Pollution Removal (kg/yr)	Avoided Runoff (m3/yr)	Replacement Value (£)	CAVAT Value (£)
Ligustrum	*Ligustrum*	1	0.0	0.00	0.00	0.1	£24	£450
Ligustrum Total		**1**	**0.0**	**0.00**	**0.00**	**0.1**	**£24**	**£450**
Arbutus	*Arbutus unedo*	1	0.1	0.00	0.00	0.1	£76	£1,800
Arbutus Total		**1**	**0.1**	**0.00**	**0.00**	**0.1**	**£76**	**£1,800**
Picea	*Picea abies*	1	0.1	0.00	0.02	0.4	£127	£7,369
Picea Total		**1**	**0.1**	**0.00**	**0.02**	**0.4**	**£127**	**£7,369**
Liriodendron	*Liriodendron tulipifera*	1	0.3	0.02	0.10	2.7	£1,247	£29,475
Liriodendron Total		**1**	**0.3**	**0.02**	**0.10**	**2.7**	**£1,247**	**£29,475**
Garrya	*Garrya elliptica*	1	0.1	0.01	0.02	0.5	£77	£4,145
Garrya Total		**1**	**0.1**	**0.01**	**0.02**	**0.5**	**£77**	**£4,145**
Taxus	*Taxus baccata*	1	0.0	0.00	0.00	0	£54	£2,229
Taxus Total		**1**	**0.0**	**0.00**	**0.00**	**0**	**£54**	**£2,229**
Campus Total		**406**	**134.9**	**3.88**	**14.72**	**379.3**	**£299,855**	**£7,637,717**
Grand Total		**1,378**	**632.7**	**15.64**	**60.37**	**1,556.5**	**£1,477,307**	**£38,112,725**

Table 2. Tree values by species & genus

i-Tree Eco Software

i-Tree is a suite of computer software tools developed through a collaborative public/private partnership. These tools are designed to engage urban and rural populations in assessing and valuing their forest resource, understanding forest risk, and developing sustainable forest management plans to improve environmental quality and human health. The tools can assess individual trees and forests in both urban and rural areas.

Eco uses sample or inventory data collected in the field along with local hourly air pollution and meteorological data to assess forest structure, health, threats, and ecosystem services and values for a tree population. Information provided to the user includes number of trees, diameter distribution, species diversity, potential pest risk, invasive species, air pollution removal and health effects, carbon storage and sequestration, storm water runoff reduction, VOC emissions, and effects on buildings' energy use.

Structure is the basic information on the physical forest resource (e.g., number of trees, species composition, tree sizes and locations, leaf area, etc.). The attributes are directly measured by users or estimated (e.g., leaf area) by i-Tree based on direct measures of structure. From the structure data, along with local environmental data (e.g., weather data), various tree functions (e.g., gas exchange, tree growth) are estimated. These functions are then converted to various services (e.g., pollution removal) based on other local data (e.g., pollution concentrations). These services are then converted to benefits (e.g., cleaner air, impacts on human health) based on other data (e.g., local atmospheric conditions, human population data). Finally, the benefits are converted to values based on various economic procedures.

At a minimum, i-Tree Eco requires only tree species and DBH data, however additional data such as tree height, canopy spread, condition, etc., allow for more accurate assessments of structural and functional features.

Reason for Removal / Assumption	Number of records affected
Dead / Dying Tree	7
No DBH or Height	62
Where species not given, assumed based on top 10 most common species	163
DBH wrong unit factor	16
TOTAL RECORDS REMOVED	**69**
TOTAL RECORDS ASSUMED	**179**

Table 4. Inventory Records removed for use in Eco

Data Processing Assumptions

The raw inventory supplied to Treeconomics ltd contained 1,443 records, expanded to 1,447 individual trees. Given the requirements of i-Tree and the format of the data provided, some data manipulation was required. Assumptions are detailed below

CAVAT assumptions

Data used for the CAVAT assessment was the same processed inventory data used for the i-Tree analysis. CAVAT requires at a minimum DBH, condition, and life expectancy, though accessibility and special factors can be added for a more specific estimation.

The Unit Value Factor (UVF) represents the full cost of a newly planted tree on the basis of per unit of trunk cross-sectional area (i.e. £ per cm2). Specifically, the unit area cost is the average cost per square centimetre of stem area determined as the

cost, at trade prices, of the top 10 mostly commonly purchased species/varieties as 12–14 cm diameter standard containerised trees. The UVF used in this report was £24.69 for 2023. The Community Tree Index (CTI) is a multiplier used to account for the locations' population density. For Dundee, the CTI value used was 125%.

Other Notes

Values and costs are subject to change due to government guidance updates and annual inflation assumptions, and are not necessarily comparable from year to year between Treeconomics reports.

Data	Assumption
Accessibility	All trees are treated as having 100% accessibility in line with standard CAVAT assumptions for street trees and parks.
Safe Life Expectancy	Factor of 100% applied for all species classed in 'good condition' (years), 95% 'fair condition' (40-80 years), and 55% 'poor condition'.
Community Tree Index	Reference UVF level used £24.69 for 2023, applied to a CTI factor of 125%
Amenity Value (Species, Habitat, Setting, Heritage)	Assumed no uplift and no reduction on any parameter

Table 5: CAVAT Assumptions

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