STREET TREE COST BENEFIT ANALYSIS

BY GREENBLUE URBAN

Contents

Our Mission
To enable sustainable cities through green and blue infrastructure.

Company Vision
To be the best tree pit solution provider in the World!

Project Name
Kings Cross Station

Location
London, UK

Project Type
Public Realm

Introduction

Mature trees in our towns and cities contribute significantly to our health and well-being in a multitude of ways.[1] For example, a large tree with a trunk diameter of 75cm (30”) can intercept 10 times more air pollution, can store up to 90 times more carbon and contributes up to 100 times more leaf area to the tree canopy than a 15cm (6”) diameter tree[2].

However, recent studies indicate that there are a declining numbers of larger trees in our urban areas[3]. Older, larger tree species are routinely being replaced by trees which are much smaller in stature even when fully grown[4].

Lack of maintenance and poor planting can also mean that some trees seldom live long enough to reach maturity and provide meaningful ecosystem services.

What is the cost of not investing in healthy trees? Trees which are given the opportunity to reach their full growth potential and deliver maximum benefits.

In order to answer this question, we estimated the costs and the benefits of a typical London plane tree over 50 - 200 years (the age of many of the older existing planes trees, planted in the 1800’s). We looked at the difference between a tree planted using a ‘RootSpace system’ (RSS), which will provide uncompacted soil for root development and growth, and a typical street tree planted in a small tree pit, surrounded by compacted soil. A standard street tree will cost much less to plant but will usually be replaced every 8-15 years. This means that it will never reach the size at which it can deliver maximum benefit and provide a return on investment.

We also looked at the difference between trees which may only live to 50 years compared to those which, given the right space above and below ground, could easily live for 200 years.

Costs were calculated using extensive tree maintenance records from municipalities including Islington Borough Council, and benefit values were derived using i-Tree Eco, a software suite that provides values for urban forest benefits.

Tree measurements from over 1000 plane trees across London were used in the analysis.

A government economist reviewed the figures and also calculated the Net Present Value of both the costs and the benefits provided by these trees[5].

Many projects featured within this publication are using GreenBlue’s first ever soil cells; RootCell & StrataCell, dating back to 2001. **RootSpace** is the 3rd generation soil cell designed for maximum soil volume and high strength capacity.

1 Delivery of Ecosystem Services by Urban Forests - Forestry Commission Research Report, 2016
2 McPherson, E. G., Nowak, D. J., Rowntree, R. A., eds. 1994. Chicago’s Urban Forest Ecosystem: Results of the Chicago Urban Forest Climate Project. Gen. Tech. Rep. NE-186. Radnor, PA: U.S. Department of Agriculture, Forest Service, Northeastern Forest Experiment Station: 201 p.
3 Trees in Towns 2 - Britt and Johnston 2008
4 Rogers K, Jaluzot A, Neilan C. (2012) Green Benefits in. Victoria Business Improvement District.
5 Vladim Saraev (Forest Research)

Project Name
Selfridges Duke Street Project, Phase 2

Location
Selfridges, Duke Street, UK

Project Type
Public Realm

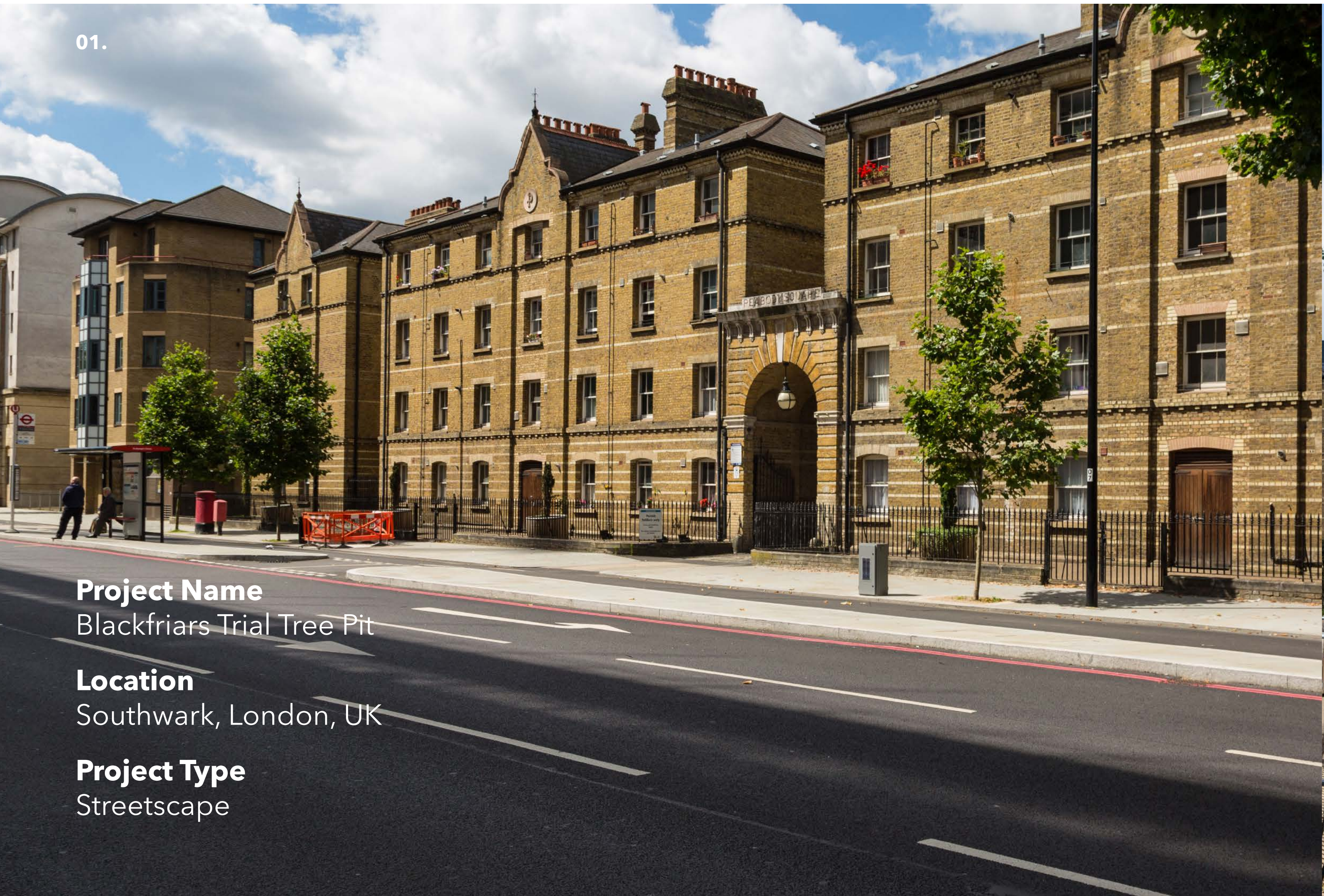
Headline Findings

01. Soil Cell Benefits

Benefits[5] provided by trees with a RSS are generally **greater** than those from street trees when compared like for like (based on diameter at breast height). This is because the leaf area of trees with **adequate rooting volume** are proportionally **larger** than for street trees with the same trunk diameter.

01. A side-by-side comparison.
Transport for London with partners GreenBlue Urban, Barcham Trees and the London Borough of Southwark boldly embarked on a real life tree pit trial in 2014 at a Central London high traffic site. Four identical trees (Platanus Hispanica) were planted in differing systems being used in London at the time. One was the standard street tree pit (approximately 600mm x 600mm x 600mm deep excavation, backfilled with excavated soil), one was a structural soil tree pit (size approximately 3000mm x 1500mm x 1000mm deep), a GreenBlue Urban Soil Cell system with sub-optimal volume (2500mm x 1000mm x 250mm deep) and finally, a larger GreenBlue Urban Soil Cell system (3500mm x 1200mm x 500mm deep). This was intended to be monitored for at least 10 years to establish empirical evidence as to the effectiveness of the different systems. The same maintenance regime was common to all trees.

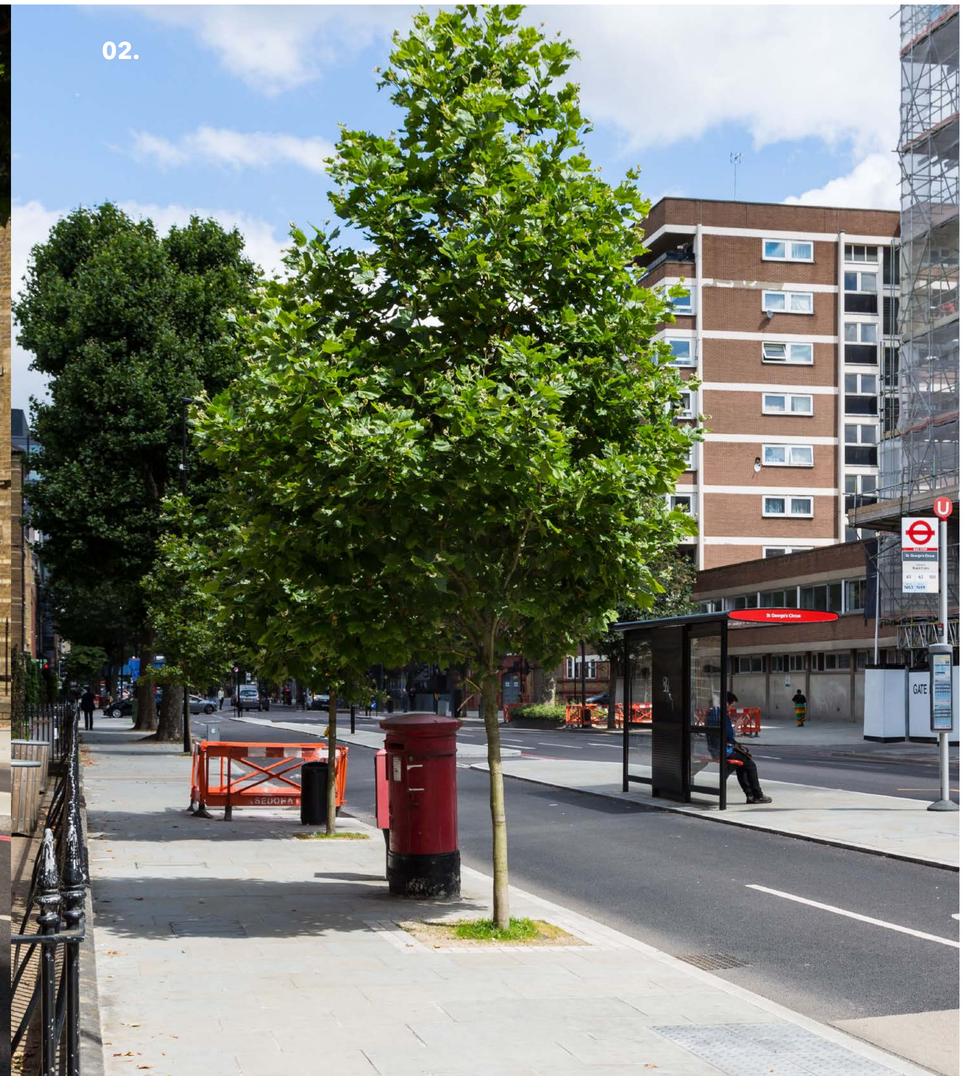
02. Suffering tree planted in hardscape without cells.
This tree is the one installed in a structural soil, an urban tree soil type. Within 2½ years, the tree is clearly suffering from both the lack of water availability in a tree sand type medium, (shown by the poor leaf colour) and the lack of nutrient availability shown by the significant reduction in canopy size and density.



Project Name
Blackfriars Trial Tree Pit

Location
Southwark, London, UK

Project Type
Streetscape



03. Healthy & thriving trees planted in hardscape.
The two nearest trees are the ones planted in GreenBlue Urban soil cell systems. Clearly doing well, with good shoot extensions every year, and no difference yet between them in size, as neither will have reached the limit of the soil cell systems. Expected to see growth rates slow in the sub-optimal volume tree pit within the next 5 years. These trees are already providing multiple benefits in this busy street.

Headline Findings

01. Soil Cell Benefits

Another comparison project in Cambridge, Canada planted trees in both soil cells and structural soil on the same block. The renovations to Main Street in downtown Cambridge, Ontario were aimed to boost street traffic in an attempt to keep more entrepreneurs in the business area.

The pedestrian-friendly and accessible street has done exactly that. The City of Cambridge knew that healthy trees would be a contributing factor for this, not only for Main Street but for future revitalization projects as well. In consultation with GreenBlue Urban, the City of Cambridge selected a block of the redevelopment to host an in-situ tree pit trial, the results of which has helped shape future street tree planting specifications for the city.

The installation took place in 2011, with four identical Linden trees planted on the same side of Main Street between Water Street and Ainslie Street – two planted in soil cells and two planted in structural soil. Each tree pit was 28 ft x 6.5 ft x 2 ft (8500mm x 2000mm x 500mm).

Due to the fact that structural soil is about 80% stone and 20% soil, that means the trees in structural soil received approximately 2.6 cubic meters (92 cubic feet) of soil volume.

Since an assembly of soil cells provides over 95% usable soil, the trees in soil cells obtained approximately 8.5 cubic meters (300 cubic feet) of soil volume per tree – even though they were planted in the same size tree pit. At time of planting, you wouldn't have known which of the systems each tree was planted in. Now, seven years later, the photos speak for themselves.

Pictured: One of two trees planted in GreenBlue Urban's soil cells.

Pictured: Two struggling trees in the distance planted in structural soil, whilst the nearest tree, planted in soil cells, continues to flourish.

Project Name
Cambridge Main Street Trial Tree Pits

Location
Cambridge, Ontario, Canada

Project Type
Streetscape

Headline Findings

02. Long Term Canopy

At 50 years the total cumulative benefits provided by both open grown and street trees are similar, at £1223 and £1060 ($1645 and $1430 USD) respectively.

01. St. Peters Square, Manchester, UK

This central public realm area in Manchester is a main gathering area in the city and a major transport interchange. To provide an atmosphere of tranquillity and rest in this busy zone required major investment in green infrastructure. The GreenBlue Urban soil cell system was specified to guarantee long term tree health whilst allowing heavy vehicular overrun, and the effects of these large trees (Paulownia tomentosa) are stunning. Not a very frost friendly tree, the heat island effect of the city centre has allowed these trees to thrive and provide a beautiful backdrop to the fine buildings around the square.

02. Wembley Stadium, London, UK

GreenBlue Urban were proud to have provided tree planting solutions for the 9 trees (Quercus palustris 'Pin Oak') planted on Wembley Park Boulevard opposite Arena Square using the first generation Soil Cell System along with root management and irrigation. Regular site inspection shows that over the last 13 years the 9 trees have flourished, a clear demonstration on how uncompacted soil in cells work! These trees have been valued at £16,000 per tree, recognising the enormous benefits that large trees bring.

03. Navy Pier, Chicago, Illinois

The Navy Pier is Chicago's most visited lakefront attraction, enjoyed by millions of tourists every year. The redevelopment plan incorporated the most advanced ecological design principles and environmental best practices, incorporating highly mature trees to create a tree grove promenade of healthy Marmo maples and American sycamores, results in a green oasis, inviting visitors to escape the hard edges of the downtown and enjoy unfettered views of the majestic waters of Lake Michigan in a more natural setting. With the high volume of traffic endured by the area each year, it was critical to ensure an engineered surface that would withstand the extremely heavy pedestrian movement and occasional vehicular traffic. To accomplish this structural stability and still provide a healthy growing condition for the many trees that would be creating the focal point of the pier, GreenBlue Urban soil cells were specified.

Headline Findings

03. Increasing Value

However, for trees within a GreenBlue Urban **RSS**, benefits are greatly increased due to the provision of stormwater treatment. By the end of the 50 year time horizon, over **£8,000 ($10,775 USD)** of benefit had been determined. Inversely, for standard street tree plantings, frequent replacement is required which lowers the 50 year accumulated benefits to only **£139 ($185 USD)**.

01. Utilising RootSpace for stormwater attenuation.

By using the new RootSpace tree system, large volumes of uncompacted soil could be provided, with a high strength air deck support allowing flood dispersion and air replenishment to the soil zone.

02. Calculating stormwater benefits.

In this project, the system has eight trees, and has a minimum combined stormwater capacity of 19,511 litres. That's a staggering 2438 litres of attenuation per tree. These figures do not include the ever-increasing attenuation being provided by the canopy interception storage, and the water drawn from the tree pit by the tree. A SuDS / LID system which becomes ever more efficient!

Project Name
Bletchely Town Centre

Location
Milton Keynes

Project Type
Streetscape

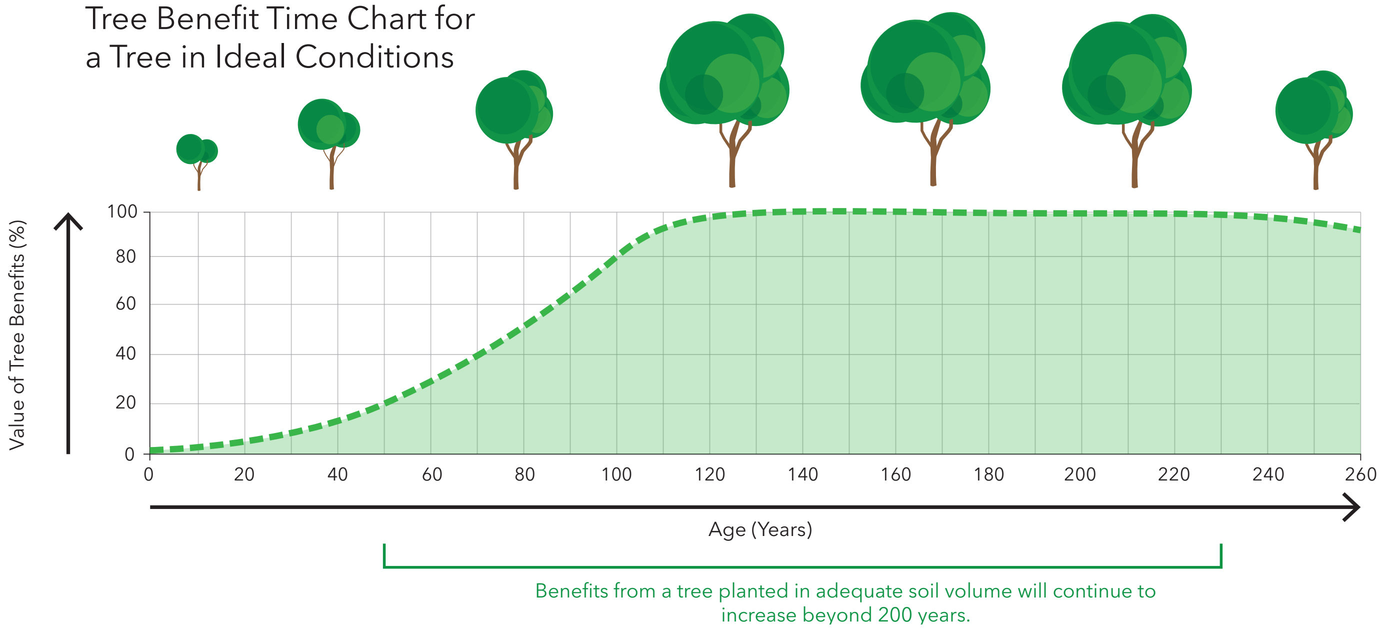
On this project **eight** trees provide a **minimum** combined stormwater capacity of **19,511 Litres (5200 Gallons)**.

Headline Findings

04. Cost Effectiveness

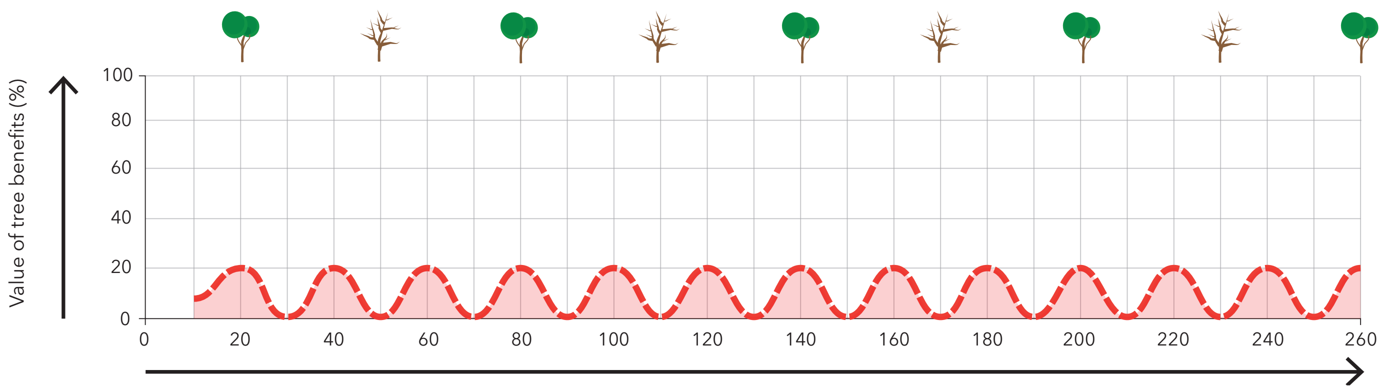
Standard street trees planted without an appropriate volume of uncompacted soil are **not cost-effective** despite initial installation costs being cheaper. This is because the breakeven point on cost vs benefits is never reached.

Tree Benefit Time Chart for a Tree in Ideal Conditions



01.

Trees are the largest, and longest living things on earth – when planted well, and maintained. Most street trees do not attain their species potential simply because the long term requirements are not calculated at planting stage. As you can see from the above graphic, originally formulated by Jeremy Barrell of Barrell Tree Consultancy, the real cost benefits start to increase after about 50 years, and continue to increase for another 150 years! Much of urban development does not look ahead more than 75 years, so well planted trees can shape our cities for decades and even centuries to come!



02.

This image shows how regular replanting of trees which fail before they have achieved 10 years of age is not only a total waste of resources, but never provide the multiple and needed benefits to our urban communities. Realistically, they will not give us more than 20% of their potential values – so better to plant one tree well, than 5 trees poorly!

Headline Findings

05. Increasing Return

After 50 years, the benefits provided start to rise exponentially, plateauing at around **200 years** for trees within a **RootSpace system**.[6]

01. Northumberland Avenue, UK.
In about 1876, Northumberland Avenue in London was opened and planted with London Plane (Platanus hispanica) trees, and much care was taken in the below ground preparation to ensure that the trees would survive. The immediate paving area surrounding the new trees was protected by an open grating (an early tree grille) and the whole paving area was supported on steel girders. This meant that the paving was suspended over what was a vast soil vault, leaving the trees able to exploit this large uncompacted soil volume. Nearly 150 years on, these trees are bringing massive benefits to humanity, being described as one of London's finest tree lined thoroughfares, providing an almost complete shaded canopy in high summer. Proof that uncompacted high quality soil provision works!

Suspended paving, or cantilevered sidewalks have been used quite extensively around the globe. In North America, a constructed system where the paving is resting on beams has been proved to be effective, but expensive to construct, and has a high carbon footprint. GreenBlue Urban Soil Cell Systems, manufactured from 100% recycled composite material are the most cost effective and low carbon impact way of providing this essential uncompacted soil provision for long term tree growth.

RootSpace – the latest generation soil support system was pioneered to replicate the methods adopted by the Victorians – uncompacted soil & load bearing capacity – therefore continuing to benefit our urban spaces for generations to come!

Northumberland Avenue, London, UK

Headline Findings

06. Cumulative Benefits

A hundred-year-old tree has around **4 times** the cumulative benefits of a 50-year-old tree. At **200 years** it will have achieved between 20 - 40 times the benefit of a 50-year-old tree.

01. 15 Blackheath Hill, Greenwich, London.

During 2000/2001 discussions were held with the Highways department of various London Boroughs, and the Greater London Authority and Transport for London as to how trees could be established in highly compacted and trafficked areas. A trial site was identified adjacent to the bus stop on the busy A2 in Greenwich, at the bottom of the Blackheath Hill. The tree pit was excavated, surrounded by compacted subsoil, with a clay strata running below the tree pit. In many ways, a more hostile position could not have been invented in which to plant a forest floor plant, the London Plane (Platanus Hispanica) tree. The tree pit size was very constrained, and provided only a sub-optimal volume of $5m^3$ (175 ft^3) of uncompacted soil within a GreenBlue Urban soil cell system, surrounded by a GreenBlue Urban ReRoot barrier to a depth of 600mm (24"). It was anticipated that the tree would grow for 5-10 years, and would then reach the maximum canopy size that this soil volume would support. However, to the surprise of many, the tree has grown reliably for the last 17 years!

02. Root Radar Results.

During summer 2014, the tree was examined and the leaves measured for chlorophyll fluorescence, giving us a reliable stress reading and confirming that the tree was thriving. The tree had grown massively, from a girth of 14-16cm (5"-6") at planting, to in excess of 60cm (24")!. A root radar test was commissioned, and in the image to the right, clearly shows how the tree had spread its roots throughout the soil cell volume to enable continual growth.

02.

01.

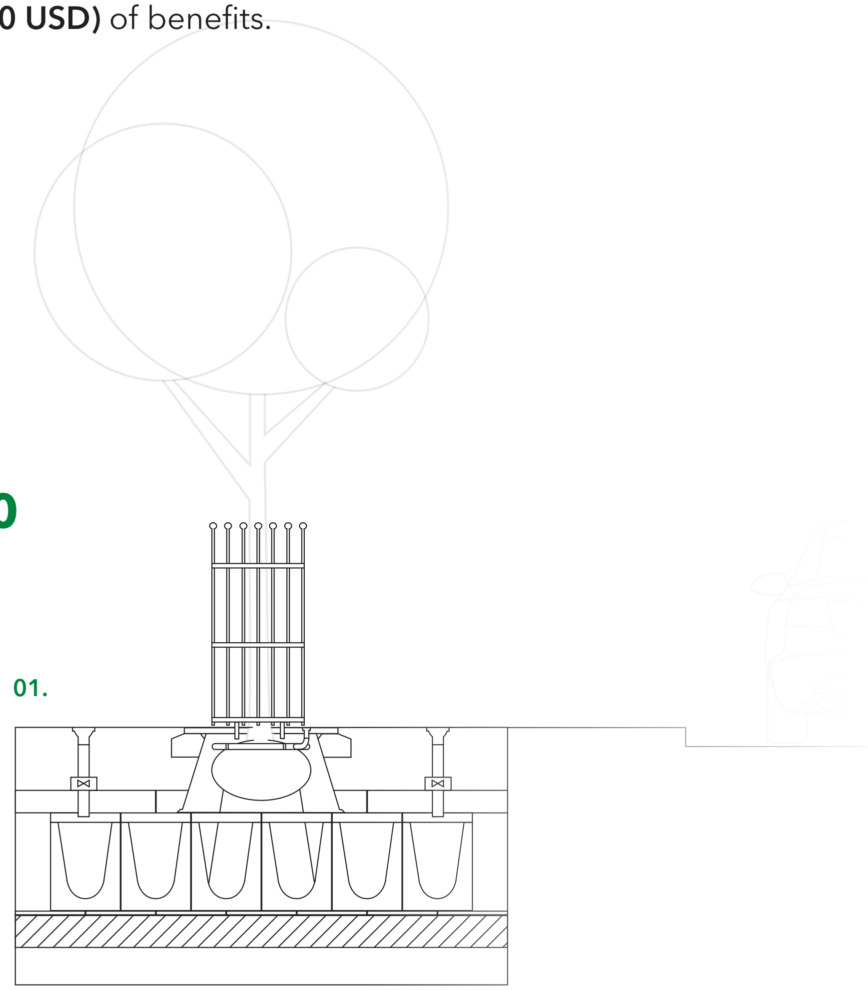
Headline Findings

07. RootSpace

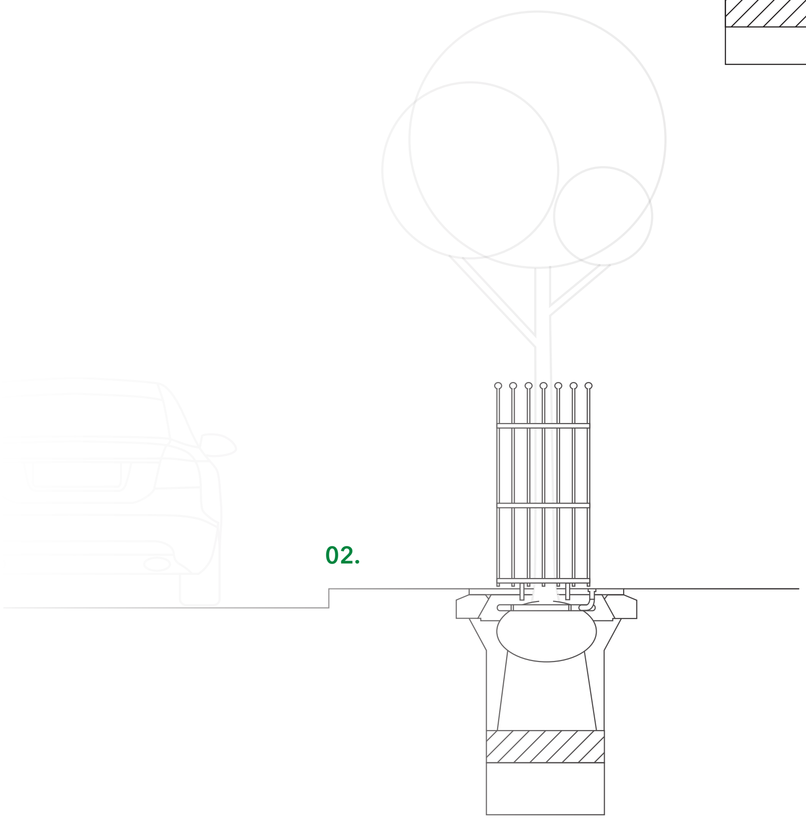
Over the **200 year** time horizon, a tree planted within a **RootSpace** system will have the potential to provide **£410,000 ($551,690 USD)** of benefits whilst a standard street tree will have only provided **£21,000 ($28,250 USD)** of benefits.

Over 200 years, a tree planted within a **RootSpace** system will have provided **£410,000 ($551, 690 USD)** of benefits.

01.



02.



Over 200 years, a standard street tree will have provided just **£21,000 ($28,250 USD)** of benefits.

01. Tree planted in RootSpace system.
A tree planted in a RootSpace system has sufficient access to below ground elements (nutrient water and air) to support long term growth. It has been proved that trees having free access to adequate uncompacted soil are less likely to suffer stress, and thus far less vulnerable to pest and disease. It does seem from current research, that certain species of tree that become established within a GreenBlue Urban soil cell system are empowered to exploit further volumes outside of the initial celled area. Thus a vigorous healthy tree can keep growing.

02. Standard street tree.
A tree planted in a standard 1m³ (35 ft³) tree pit surrounded by heavily compacted anaerobic ground is extremely unlikely to achieve independence within the landscape. Many of our towns and cities have numerous trees which were planted 7-10 years ago, and are still alive, but have not grown for the last few years. Finally, under the stresses of this difficult growing environment, both physical and drought stress, the trees are likely to succumb to pest or disease, without ever having had a chance to attain their potential.

Headline Findings

08. Retaining Existing Trees

Retaining an existing tree (provided it has adequate space for root and crown development) is five times more cost effective than periodic removal and replacement.[8]

01. Considering existing trees in new developments.
When considering development sites where trees are existing, GreenBlue Urban strongly advocates retention of large trees. Careful working practices, and close interaction with arboricultural supervision. This means that a new development can incorporate old trees, giving instant maturity and added value. Retaining existing green infrastructure can practically benefit developers too, and removal of trees can disturb the delicate balance of water tables, resulting in expensive below ground construction processes. Large trees also give tall buildings a better sense of scale, screening and shielding other nearby properties.

Bristol Waterfront, UK

Headline Findings

09. GBU Specification

GBU planting specification gives trees the required rooting volume to achieve their full open grown potential in size and age. This represents a significant saving over the replacement of smaller, shorter lived trees.

01. CAD Resource Centre.
GreenBlue Urban is at the forefront of using technology to simplify specifiers complex responsibilities: the earliest adopters of CAD details, now working in 3D CAD and BIM modelling; constantly updating the website with the very latest in tree planting developments. The Resource Centre includes PDF and CAD files of tree pit and SuDS / LID designs, product data sheets and NBS / CSI specifications, enabling all disciplines to easily access the relevant information. The GreenBlue Urban tree Pit Configurator is a handy tool to help understand what products are required to enable the chosen tree to establish in a number of environments.

02. Soil Volume Calculator.
Following extensive research with universities, colleges and academia throughout the world, GreenBlue Urban has produced the Soil Volume Calculator, available in print and online, giving a simple guide to the soil volumes required to get trees to chosen long term canopy diameters. Whilst not totally prescriptive – different tree species have differing nutrient requirements – is has been proved very useful by practitioners all over the world.

Headline Findings

10. Total Value

It is not yet possible to quantify or value all of the ecosystem services provided by trees in urban areas. However, all costs have been factored in to this analysis. Therefore the benefit figures should be considered as a conservative estimate. The reality is that in all probability the value of tree benefits is much higher than stated herein.

11. Sustainable Development

Trees make good design, and good design is key for sustainable development. Trees are indivisible from good planning, and should therefore be used to contribute positively to making places better for people to live and work. For this to happen, trees need the space above and below ground to reach maturity and beyond.

A **10%** increase in urban green space can postpone the onset of health problems by up to 5 years.

Students who have a green window view recover from mental fatigue faster and thus pay attention for longer.

Research has indicated that a **10%** increase in tree canopy was associated with roughly a **12%** decrease in crime.

Particulate levels on tree-lined streets can be up to **60%** lower than those without trees.

Many species of wildlife depend on trees for habitat. Trees provide food, protection, and homes for many birds and mammals.

A series of international third-party studies have shown that trees can increase property prices anywhere from **5%** to **18%**.

There is up to a **24%** reduction in particulate matter near a mature tree.

Trees can help reduce stormwater runoff. For every **5%** of tree cover, stormwater runoff is reduced by **2%**.

Project Name
5 Broadgate, Sun Street

Location
Broadgate, London

Project Type
Streetscape

References

5 Benefit values for air pollution filtration, carbon sequestration and stormwater attenuation were considered.

6 The oldest plane tree in the UK was planted in 1680 in Ely. At 338 years old it is still growing with good vigour.

7 In the 200 yr scenario periodic street tree replacement was omitted.

8 Based on retaining a 200 year old tree and replacing other trees every 50 years.

Specification for Example Trees

For the trees modelled in this study the following specifications were used.

For the 'standard' street tree, the supplied size of the tree was an 18-20cm (7-8") London Plane, planted in a 1m x 1m (3¼ ft x 3¼ ft) pit with soil rooting volume capped at 1m³ (35 ft³).

For the GreenBlue Urban RootSpace tree, the supplied size of the modelled tree was identical, but the available rooting volume was greatly enhanced by the RootSpace system to provide 25m³ (885 ft³) of available rooting space.

Full technical specifications are illustrated in fig 1 & 2.

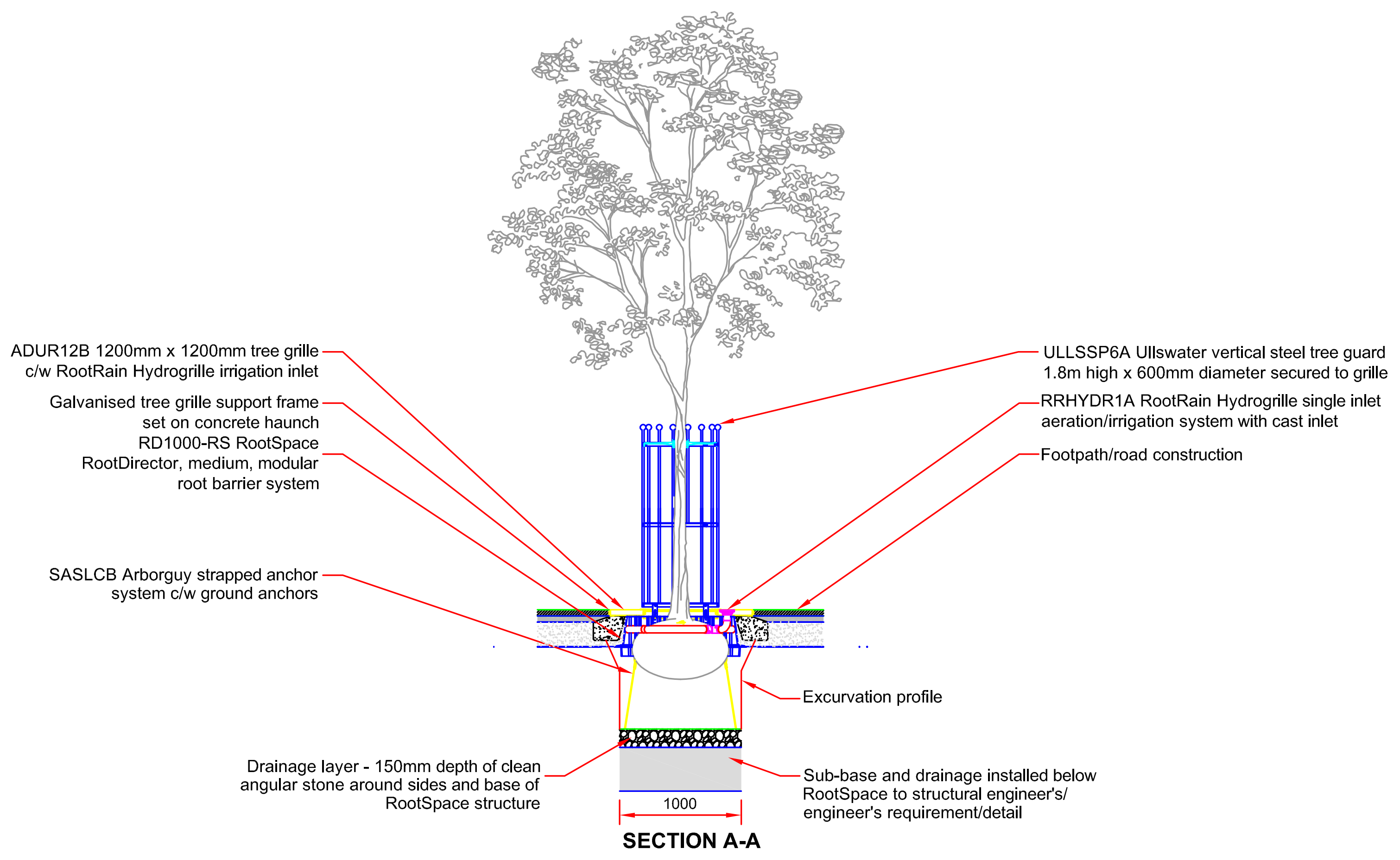


Fig 1: Standard Tree Pit Specification

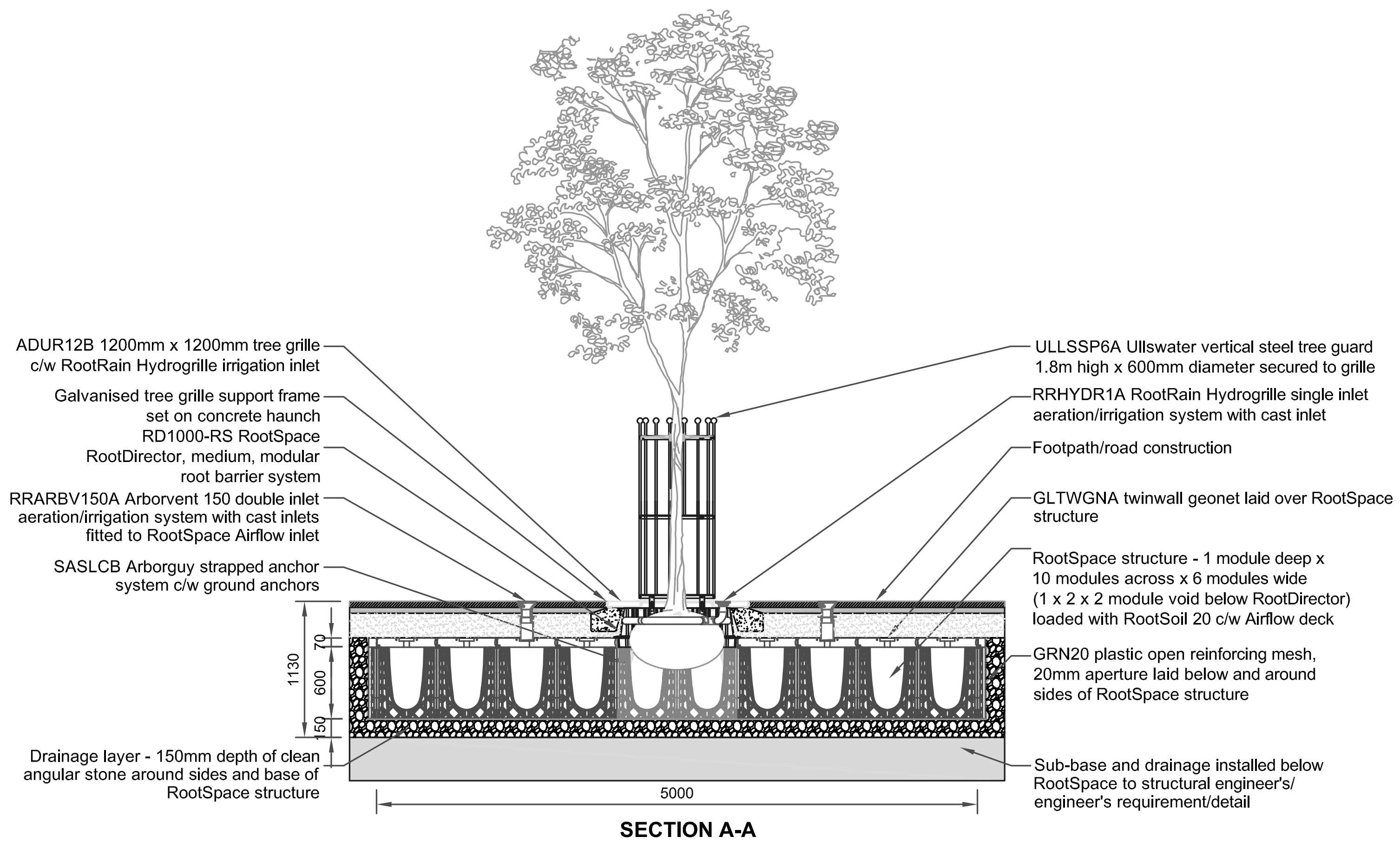


Fig 2: GreenBlue RootSpace System

50 Year Scenario

Cost Profile for Urban Trees

Table 1 (below) illustrates the total lifecycle cost and benefits for a tree over a 50 year time horizon. At the end of 50 years, a standard street tree will have cost £11,902 ($16,078 USD). However, a tree planted with a RSS will have generated a surplus benefit of £2,700 ($3,647 USD).

This represents a much more cost-effective, longer lasting and beneficial way to plant trees. However, the real cost of not planting trees properly is never having a tree with a mature crown that can deliver maximum benefits to society.

Table 1: Cost Profile

	01		02	
Item	**Street Tree - 50yrs**	**Notes**	**Tree with RSS - 50yrs**	**Notes**
Installation Costs	-£8,634.00 (-$11,665.75)	Tree replaced 4 times over the study period[1]	-£4,946.00 (-$6,679.99)	GBU planting spec[2]
Total Accumulated Benefits after 50yr period	£139.50 ($188.41)	Air pollution filtration, carbon sequestered and stormwater attenuated from the tree canopy	£8,123.00 ($10,970.80)	Air pollution filtration, carbon sequestered and stormwater attenuated from both the tree canopy and RSS
Total Maintenance	-£1,667.00 (-$2,252.17)	15% Failure Insurance (Yrs1-3), Inspection, leaf clearing and formative pruning	-£405.00 (-$547.17)	Inspection, leaf clearing, formative pruning
Removal Costs	-£1,740.00 (-$2,350.80)	End of life felling (3 times) and stump grinding	£0.00 ($0.00)	Still growing at 50 years
Net Life Cycle Cost	-£11,901.50 (-$16,078.99)		£2,772.00 ($3,743.63)	

01.
Costs include supply, delivery, installation, tree guard and tree grille, warranty, traffic management and watering. Materials such as tree grille and guard were considered reusable in subsequent tree replacement.

02.
Includes below-ground anchoring, sturdier metal guard, watering tube, aeration system, $25m^3$ (885 ft^3) load-bearing cellular system complete with soil, root director, twin walled load bearing geonet and a surface opening with tree grate or permeable rubber surround.

Breakeven Point

A common argument for not planting a tree with a RSS is that it costs more than for a tree in a traditional tree pit. If the costs for the initial year of installation are taken in isolation, then this is indeed true. However, this short-sighted approach will become a significant cost in a very short number of years, as table 1 illustrates.

Fig 1: Breakeven points for standard tree (GBP + USD)

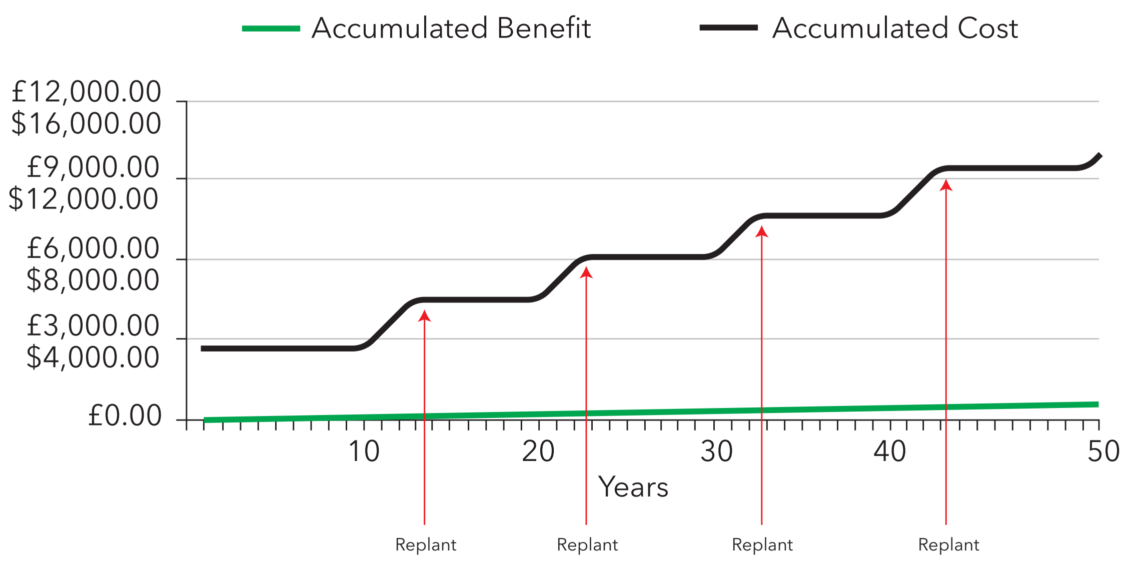
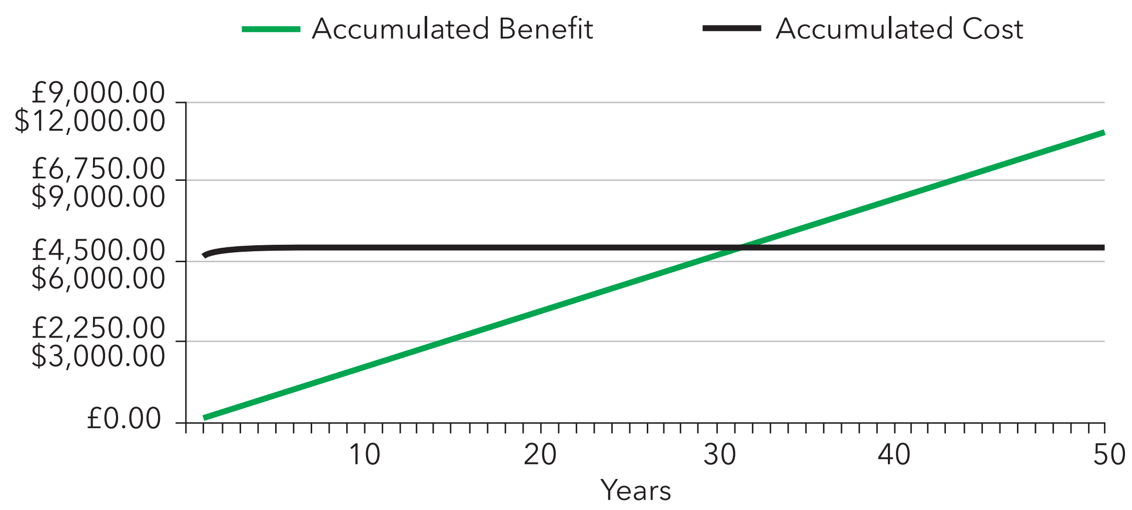


Fig 2: Breakeven points for a tree with RSS (GBP + USD)



Accumulated costs vs benefits are illustrated in fig 1 and 2 in order to find the point at which the benefits outweigh the costs, the 'breakeven' point.

The results are interesting. A standard street tree will never breakeven despite the lower initial establishment costs on account of the tree needing periodic replacement. However, the tree with a RSS will break even in year 32.

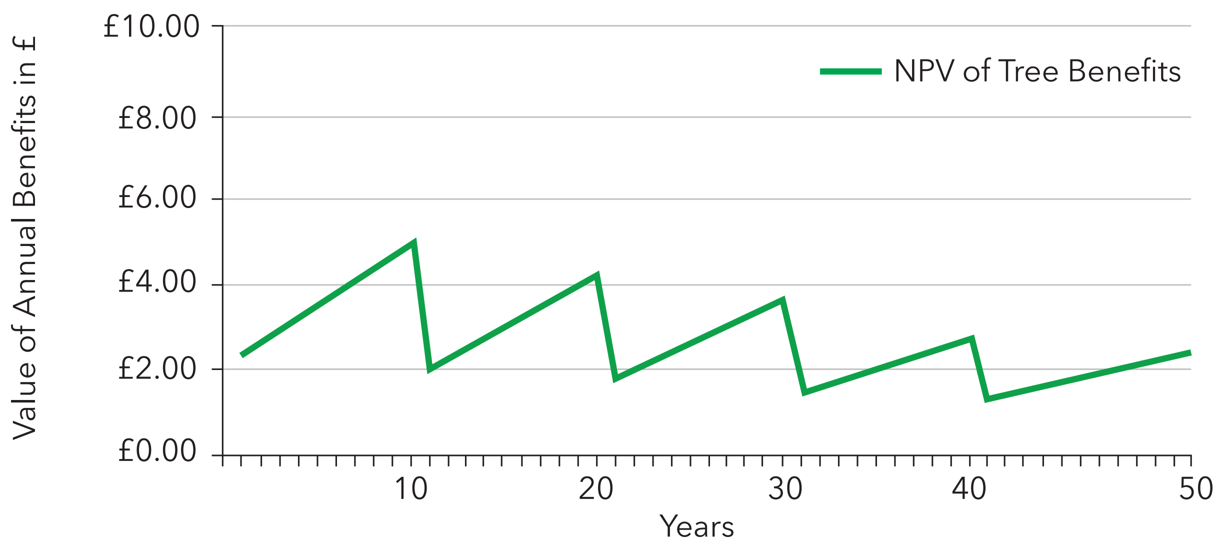
In reality the breakeven point could be much earlier but as yet it is not possible to quantify and value all the benefits from urban trees.

50 Year Scenario

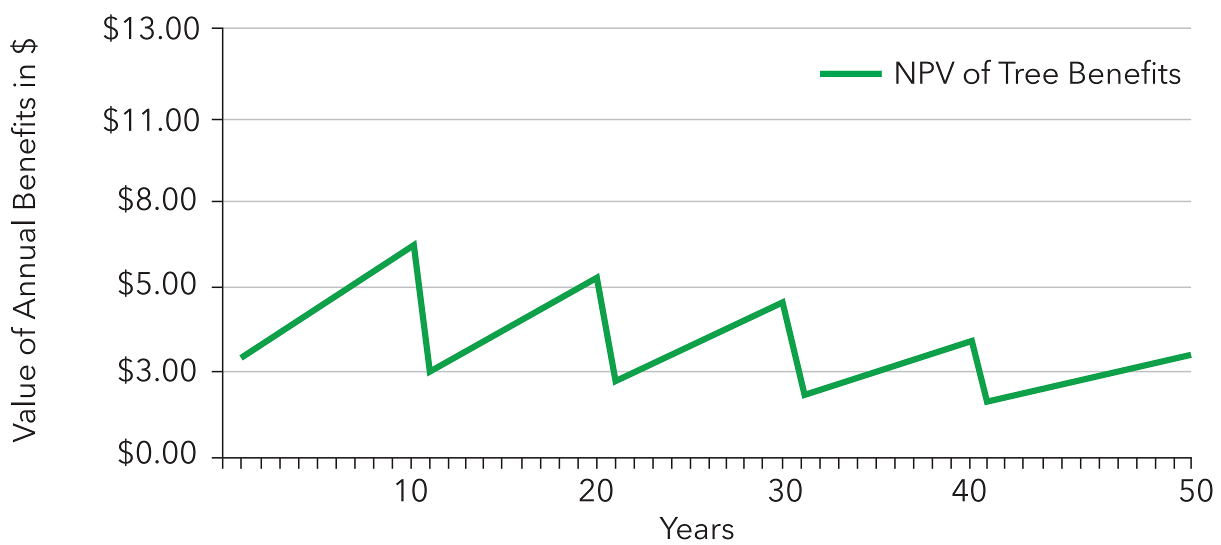
Annual Benefits of Urban Trees

Fig 3 below illustrates the simple fact that a tree which requires replacement every 10 years, provides no meaningful benefits over its lifespan as the tree never grows large enough to provide adequate leaf area (or crown size), the driving force behind tree benefits or ecosystem services.

Fig 3: Annual Benefits over 50 years - Street Tree (replaced every 10 years) (GBP)



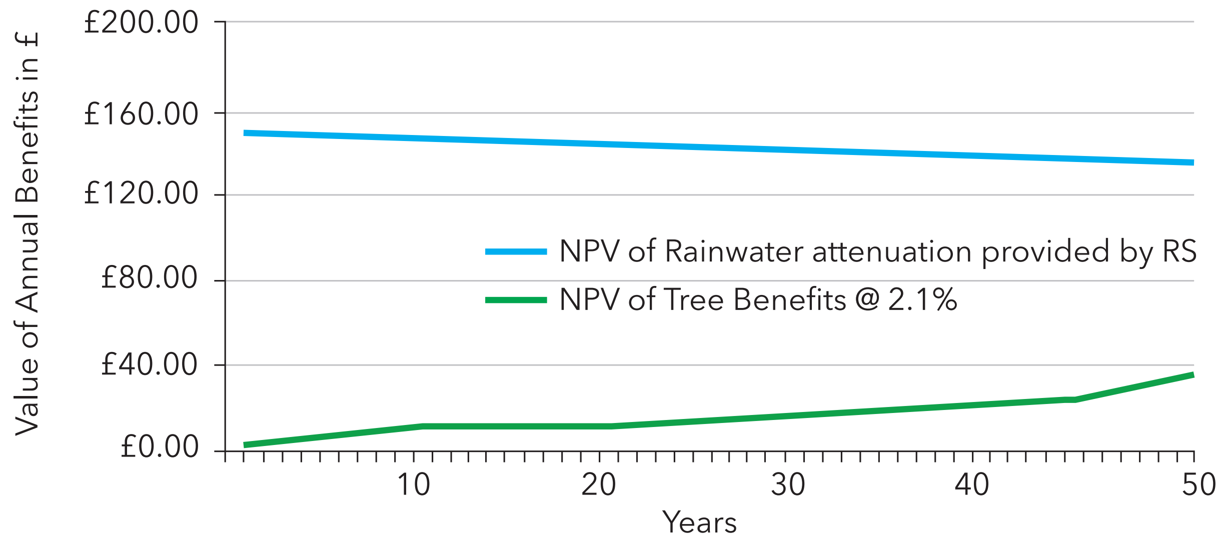
Annual Benefits over 50 years - Street Tree (replaced every 10 years) (USD)



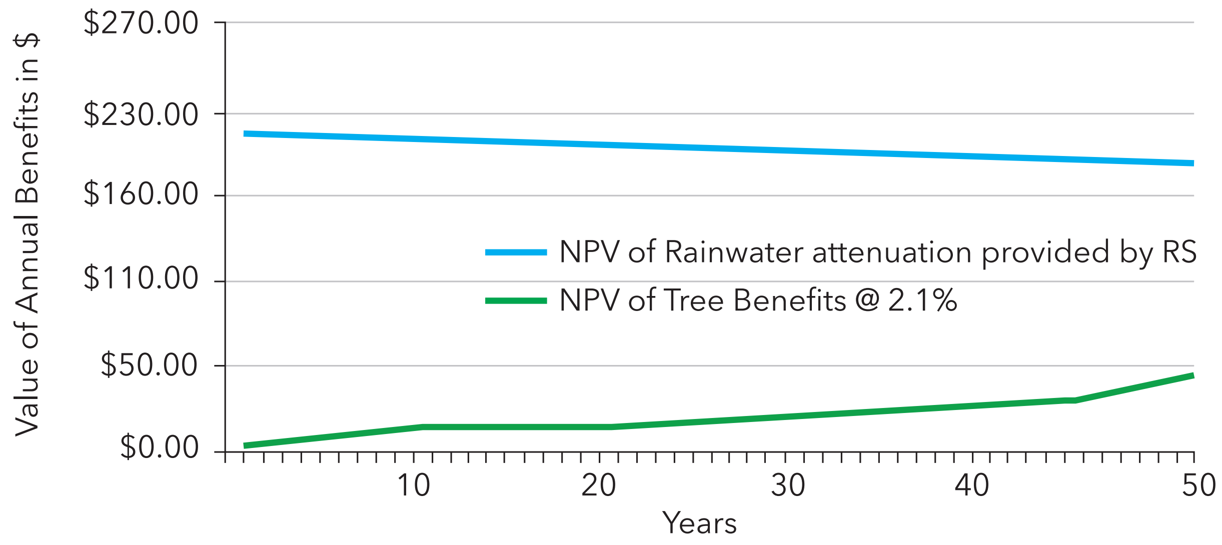
Increased Benefits Using RootSpace

In Fig 4, (below) the tree with a RSS, there is a steady increase in benefits over the same time period, even when the benefits are discounted to net present value (NPV). This is because as the tree grows, its leaf area increases to provide greater benefit. The slight decline in the value for rainwater retention over the study period is due to the economic practice of discounting, which provides the value of a future benefit, today. Discounting was also applied to the tree benefits, however, as trees grow, the amount of benefits they provide increases too, cancelling out the depreciation.

Fig 4: Annual Benefits over 50 years - Tree with RSS (GBP)



Annual Benefits over 50 years - Tree with RSS (USD)



Mature Trees in Santa Monica, California

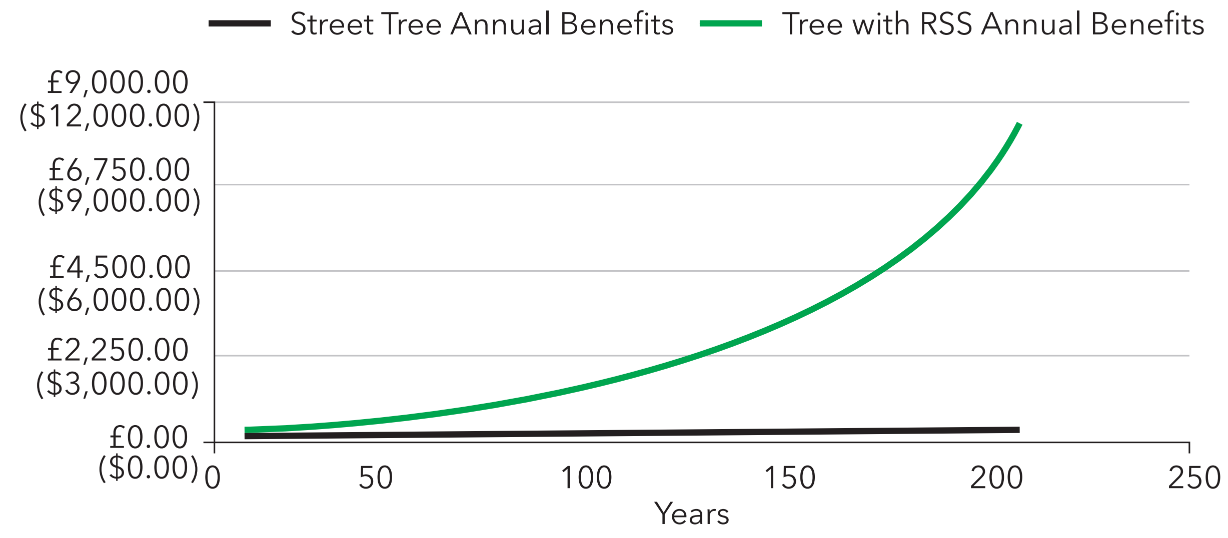
Full Lifecycle Benefits & Costs

If given adequate rooting volume, street trees will live well beyond 50 years. In cities like London for example, many of the older plane trees were planted prior to the exact engineering standards of today, and accessed uncompacted soil volumes allowing them to survive and enable growth beyond 200 years.

Unfortunately, urban design cycles are generally only 30 years (termed 'design' life) up to around 60 years (the 'whole' life). This means that at the time when trees really start to provide maximum benefits, the infrastructure around them may be in a process of (or due for) redevelopment.

In the example below (fig 5) tree benefits were calculated over the 200 year time horizon to demonstrate the importance of large mature trees with full crowns. These larger trees are providing much more in terms of the benefits. It is therefore important to try and retain trees beyond 50 years so that they can become large, mature specimens providing maximum benefit.

Fig 5: 200 year benefits (GBP + USD)



Project Name
The Old Bailey

Location
London

Project Type
Streetscape

Multiple Additional Benefits

Trees can be used to provide many many benefits, well beyond those already mentioned in this publication. These side effects of urban tree planting are often overlooked, or are discounted as being too difficult to evaluate. However, research carried out around the globe has enabled some of these benefits to be given a monetary value, and these can be staggering. The scheme below in London is calculated to bring **£1.762m** of health benefits annually – increasing activity leading to a decrease in health issues; reducing traffic speeds resulting in a reduction in road traffic accidents; reduction in summer peak temperatures leading to a reduction in heat related illnesses, and even skin cancer; absorption of air pollution reducing cases of respiratory diseases; reduction in crime levels is directly linked to increase in tree canopies; reduction of noise by buffering, enhances quality of life. Even the economic benefit of providing areas for pop up stalls cannot be discounted. Only trees can provide all of these diverse benefits – and live for hundreds of years.

This scheme is calculated to bring **£1.762m** of health benefit every year!

(Source: TFL Better Streets Delivered 2)

Project Name
Leonard Circus

Location
Hackney, London

Project Type
Shared Space

Valuing Our Urban Forests

Urban forests play a much greater role than just beautifying our cities. They represent an important investment in environmental impact, human health, and overall quality of life for those who visit, work, and live in a city. This increasing recognition of the importance of urban trees and the benefits they provide has resulted in Toronto's urban forest being viewed as an investment in the economic and environmental well-being of the city, and hence an urban forest worth $7 Billion (£5.3 Billion).

It's not by chance either. From the highest level of local government, urban trees are provided for and protected as valuable infrastructure. That's why the City of Toronto has put in place a mandatory minimum uncompacted soil volume of 30 cubic meters (1,000 cubic feet) per tree for any new tree planted in city right-of-way. This is an aggressive target that is making leaps and bounds in the progression and future establishment of Toronto's urban forest.

Planting new city trees for success by providing the elements they need when planted in urban environments (i.e. uncompacted soil volume) and maintaining the health of existing trees, is the best way to protect the value of our green infrastructure and the investment put into it. The cost-savings produced by urban forests make it clear that increasing and keeping the green on our streets, keeps the green in our wallets.

In short, investing in urban trees is investing in the well-being of an urban society.

A recent study estimated Toronto's urban forest to be worth **$7 Billion.**

Leaside Bridge, Toronto, Canada

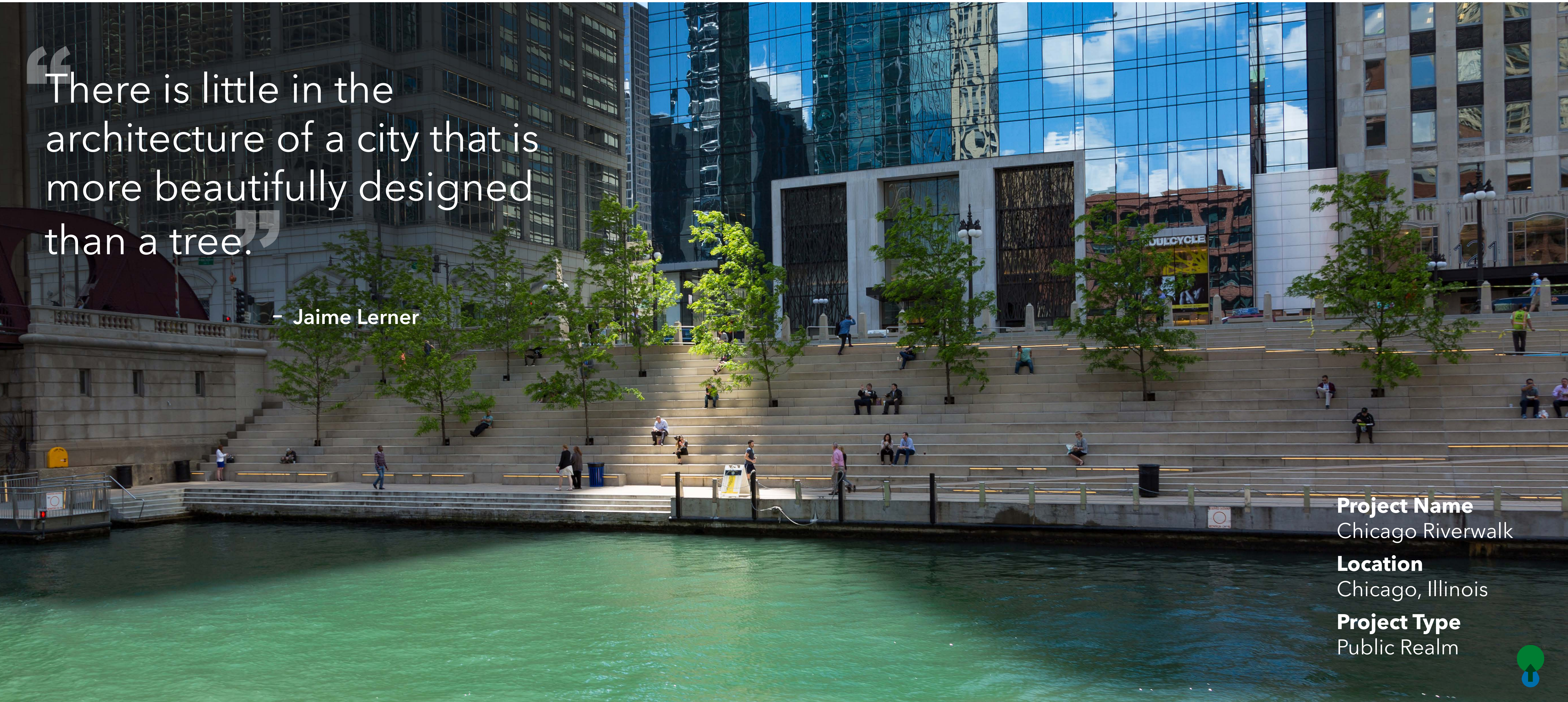
Conclusions

There is compelling research, industry support and political aspirations for a more balanced approach to managing trees, in order to account for their full value to society.

To provide this value, trees need adequate space above and below ground to be able to grow large enough to offer meaningful ecological services.

Providing space for trees, above and below ground, can seem costly in urban areas, but we are only just beginning to fully understand the long-term value of this investment. Unlike most infrastructure, long-living, mature street trees actually appreciate in value over time, providing tremendous ecological value and significant cost savings over shorter lived trees.

This cost analysis demonstrates that the investment into adequate uncompacted tree rooting volume can more than pay back for itself, as conservatively estimated benefits far outweigh estimated costs.



"There is little in the architecture of a city that is more beautifully designed than a tree."

– Jaime Lerner

Project Name
Chicago Riverwalk

Location
Chicago, Illinois

Project Type
Public Realm

Methodology Notes

Treeconomics

Treeconomics is a social enterprise, with a mission to highlight the benefits of trees and woodlands. Treeconomics develops projects with landowners, communities, academics and other stakeholders to quantify and value trees, green infrastructure and natural capital. Together, Treeconomics delivers sustainable urban forest management plans, projects and consultancy that aim to improve our environment. This report was compiled by working closely with Kenton Rogers, a chartered forestry consultant with over 20 years of experience and co-founder of Treeconomics.

Tel: 01392 249170 | www.treeconomics.co.uk

Tree Data

Data was collected from over 1000 London Planes which had previously been recorded as part of several i-Tree Eco studies across London. These trees were split into 2 data sets, those recorded as 'Street Trees' and those which were 'Open Grown' which were located in parks with unrestricted rooting volume.

The trees were assorted by DBH and an age was calculated using the formula proposed by Mitchell (1974).

Tree Benefits

Benefit values for air pollution removal, carbon sequestration and rainwater attenuation were calculated using i-Tree Eco, a peer-reviewed software suite from the USDA Forest Service[9].

Discount Rate

The Treasury Green Book assumes a marginal utility of consumption as 1.03% and uses a growth rate of 2.0% to derive the social time preference rate of 3.5%. Hence, the Green Book recommended that 3.5% is used as a discount rate to convert all future costs and benefits to present values.

However, there are reasoned arguments that whilst grey infrastructure depreciates, trees appreciate in both size and value. Other studies have therefore used lower discount rates (ranging from 0.1% to 3%) based on the argument for intergenerational equity. For this study a 2.1% discount rate was deemed reasonable, appropriate and defendable.

Stormwater Method

1 tree within a 25m³ (885 ft³) of GreenBlue Urban RootSpace system (RSS) has 22% of that volume available for stormwater attenuation. This is equivalent to 5,500 ltrs (1,453 US Gallons) of storage space, or 5.5m³ (195 ft³), with a 48hr recharge rate. This is enough to capture 10mm (almost ½") of rain from 550m² (5,920 ft²) of impervious surface (Nisbett 2005)[10].

Treating the 10mm (½") rain event treats about 26% of the annual rainfall in London[11]. Annual rainfall is 671mm (26") in London, and 26% of this is 176mm (7").

Treating 176mm (7") per year from 550m² (5,920 ft²) amounts to 96.8 m³ (3,418 ft³) per year.

Multiplying this by the standard volumetric charge[12] for having to treat the water – £1.516 ($2.05 USD) p/m³ gives a total of £146.75 ($198.30 USD) per annum.

This sum will be increased by RPI every year and will then be discounted to NPV.

9 A description of how trees provide these benefits can be found in the i-Tree Streets User's Manual (available at http://www.itreetools.org/resources/manuals/i-Tree%20Streets%20Users%20Manual.pdf)
10 Rainfall and evaporation are usually expressed as an equivalent depth of water in mm across the land surface. The addition or loss of 1 mm of water to/from an area of 1 m2 of ground is equivalent to a total volume of 1 litre. Similarly, 1 mm of rainfall or evaporation to/from 1 ha is equivalent to 10 m3 or 10 000 litres of water.
11 Average 10mm events per year in London equal 17.6 days. Average annual rainfall = 671mm. Data Source: Analysis of 2008-2012 rainfall in Ofcom regions - https://www.ofcom.org.uk/__data/assets/pdf_file/0025/74356/mo_ofcom_report.pdf Met Office Exeter

Limitations

Whilst all costs can be accounted for, it was not possible to account for all the benefits which trees can provide. This is because robust methods to quantify and then monetise these benefits do not yet exist.

Therefore, the benefit values presented within this report should be viewed as a conservative estimate as not all benefits have been accounted for.

For example, the following benefits could not be quantified:
Increased economic growth and prosperity (Rolls and Sunderland, 2014)[13], including increased consumer spending[14] and greater ground rents in leafier areas[15], increased productivity (Kaplan, 1993; Wolf, 1998)[16], house prices[17] and a reduction in crime[18,19].

Trees also improve journey quality (Davies et al., 2014)[20] and can encourage use of alternative transport corridors such as pavements/sidewalks and cycleways[21]. Additionally, trees near road networks reduce noise [22] and lower traffic speeds[23].

There is a growing body of research that shows people are happier and healthier in leafier environments: hospital recovery times[24] and stress[25] are reduced and birth weights are increased[26], meaning fewer health issues later in life[27].

Trees are also key to enhancing biodiversity by providing habitat and places of recreation.

Trees help reduce peak summer temperatures in both the urban and wider environment by several degrees[28], thereby 'reducing vulnerability and providing resilience to the impacts of climate change, and supporting the delivery of renewable and low carbon energy and associated infrastructure.

12 Rogers, Jaluzot and Nielan (2012)
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