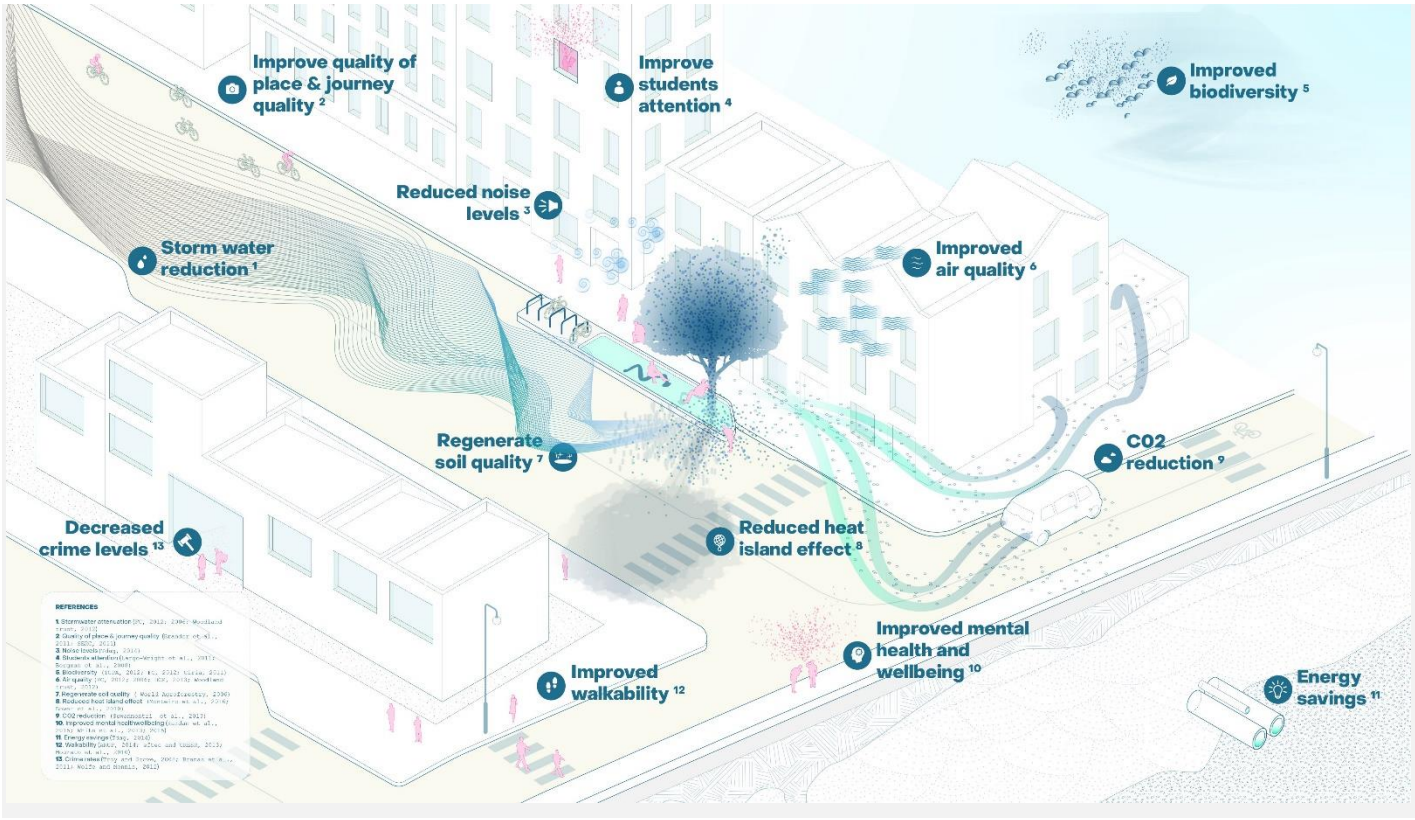


1 Social and ecosystem benefits associated with urban trees are widely supported by scientific research

Trees As Infrastructure

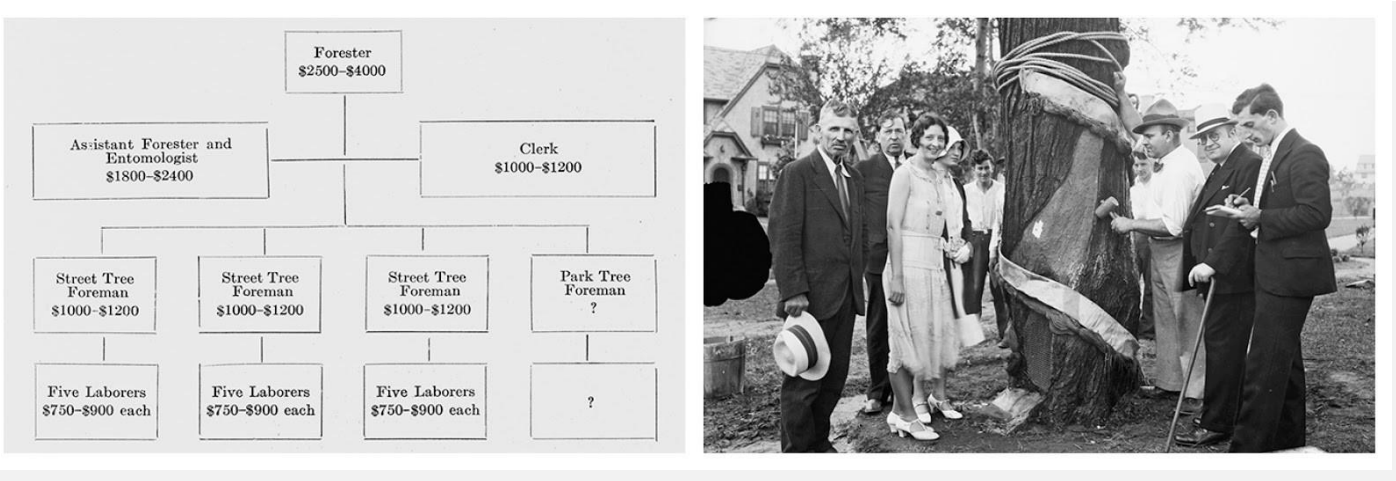
An open source model to support municipalities in transitioning toward resilient urban forest management practices

This is one of two related articles. In this first blog, we examine why municipalities are struggling to reach tree-planting targets. In the second blog, we will develop a proposition for supporting cities to transition towards green infrastructures. Source: https://provocations.darkmatterlabs.org/trees-as-infrastructure-1dd94e1cfedf

We are seeing a growing acknowledgement of the importance of trees to combat (and mitigate the impacts of) the climate crisis — including within our cities. However, a series of structural problems inherent in our urban forestry management processes are working against the more and more ambitious tree-planting targets that cities are announcing. By 2030, Prague has pledged to plant 1 million trees, Milan is aiming at 3 million trees and Sydney intends to add 5 million trees to the city's existing urban forest. But the authorities responsible for such greening efforts are failing to construct credible, practical implementation and maintenance strategies. In England, tree-planting is falling 71% short of the Government's target, US cities are losing 36 million trees a year due to natural disasters and disease, and Sheffield, Europe's greenest city, has lost 5,000 trees, chopped down by a private tree maintenance contractor despite furious local protests. Such manifest failures direct our attention to a series of deeper issues relating to budget allocations, accounting procedures and socio-political perceptions about trees in cities. It is these deep-rooted obstacles that we have to overcome in order to unlock the massive collective investment we need in trees as vital infrastructures for a resilient and thriving future.

A HISTORICAL TRANSITION FOR URBAN TREE SYSTEMS: THEN AND NOW

In 1896, Massachusetts in New England, passed the first ever tree warden law obligating the municipality to appoint wardens and deputies to be responsible for the care and protection of public trees. Wardens were empowered to appropriate funds for tree planting and regeneration, to remove trees and to give public notice of removal or pruning. The description of these early duties portrayed the tree as a single isolated unit, disassociating it from its connections to the soil, other trees and species and enforced an image of the 'proper' or model tree; one with guards to protect stems from collisions with automobiles, one whose branches do not pose a threat to pedestrians, one whose roots aren't a threat to buildings' foundations. More than a century later, our systems still persist in treating trees according to the highly partial and siloed mental image formed during those proto-modernist tree warden laws.



2 Twentieth century treatment of street trees: (left) early proposal for the organisation of the New York Bureau of City Forestry; (right) celebrating a tree surgeon's work in Queens

Most evidently, in 2016, Silvan Linden documented the extensive felling of fourteen large trees in Berlin by the Parks Department that insisted the trees were threatening the safety of pedestrians and traffic, stating they were wild trees of uncontrolled growth and not 'proper' street trees. We still plant and maintain trees as isolated units, although our scientific and social understanding of urban trees has greatly advanced.

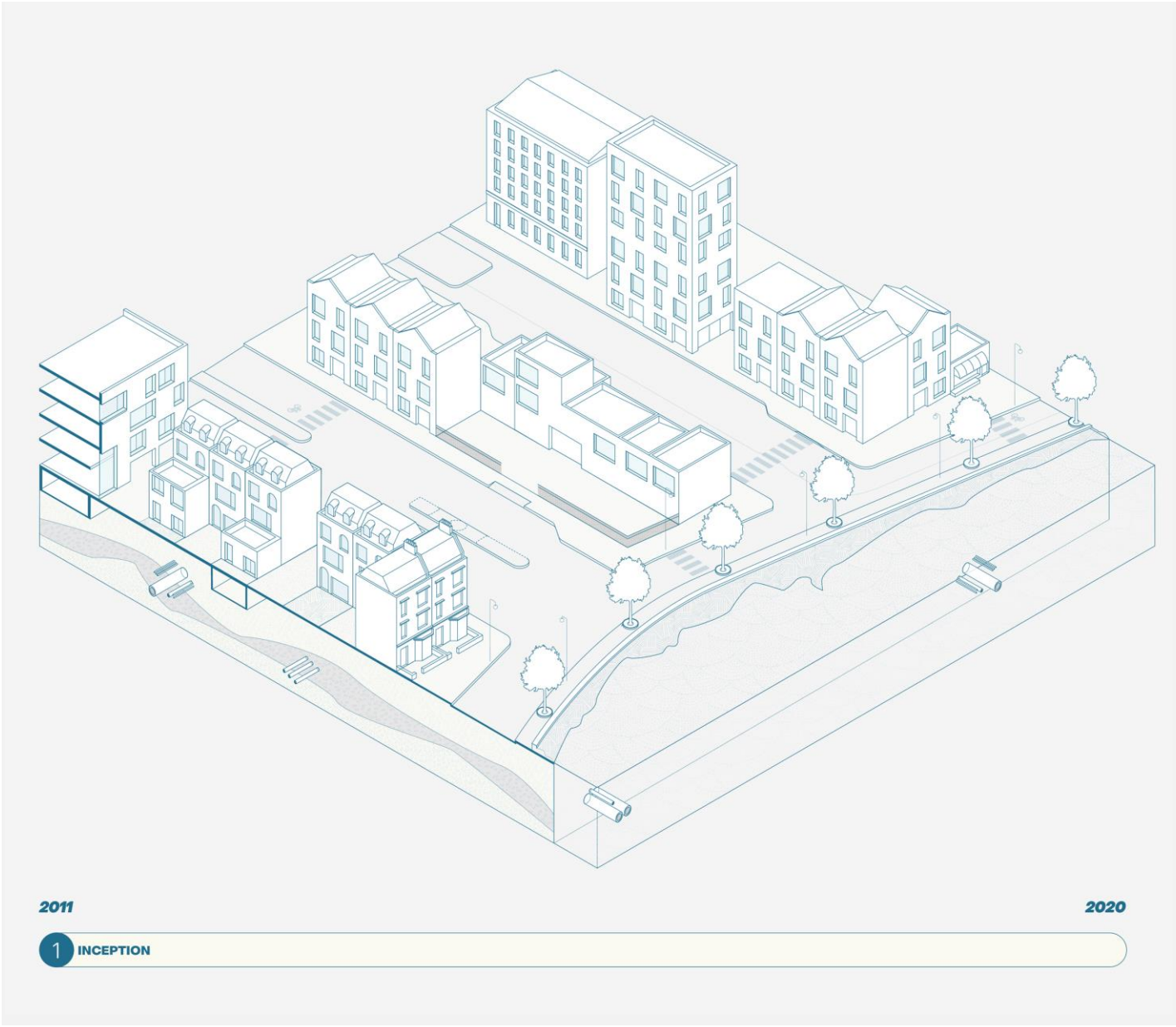
3 Twentieth century models of urban forest management persist in the twenty-first century: A survey map and photograph marking felled trees in the Mitte district, Berlin

We now understand that within cities, trees and humans are enmeshed in a rich network of agencies and dependencies sharing intimate relations and mutual obligations towards preserving a common, liveable place. Recognising urban trees beyond their aesthetic presence and treating them as city co-inhabitants might offer a better way to attend to our relations and establish a tangled web of links to support living processes. Urban trees can be companions, communities, providers, expert witnesses, economies, data stories or resourceful ancestors. They can regenerate soil quality, reduce heat island effects, offer food and shading, support urban biodiversity or mitigate energy usage. Our municipal urban forestry practices should work towards aligning the human species with these processes to live by and through trees.

A handful of cities are already innovating in the way they purposefully connect trees as green infrastructure with other urban systems to encourage an effective maintenance of forestries. Melbourne is pursuing an ambitious programme aiming to double the city's canopy cover from its current 22.5 percent to 40 percent by 2040 to manage and recycle surface water runoff and reduce urban temperatures by installing a series of infiltration trenches along sidewalks that direct water runoff to a structural soil system supporting city trees. Similarly, the Greater Lyon Authority

is capturing rainwater to enable green infrastructure-based cooling strategies; amongst other elements it is installing sensors on newly planted and existing trees to monitor and quantify the cooling effect of vegetation at different stages of maturity and under different irrigation regimes, providing controlled data for further green infrastructure development.

In 2018, the city of Cardiff Council, completed the Greener Grangetown project, partnering with Dŵr Cymru Welsh Water and Natural Resources Wales to invest £2.5 million in an innovative scheme to manage rainwater in the neighborhood by re-designing the urban realm with soft landscaping to catch, clean and divert rainwater directly into the river instead of pumping it over 8 miles to release into the sea, effectively using the capacity of SuDS (Sustainable Drainage Systems) for stormwater protection, and providing direct services to the Welsh water management company. Using rain gardens, kerbside trees and other green infrastructure systems, the combined sewer overflow was reduced as was the amount of energy used for pumping wastewater to treatment facilities. All this financially benefited Dŵr Cymru Welsh Water; at the same time the project, developed through an extensive public consultation process, unlocked further benefits such as pedestrian footways and a community orchard transforming the relationship of the neighborhood with its trees. A number of other stakeholders are now interested in exploring the scheme's other potential upsides, with universities participating e.g. in measurements to understand the ability of green infrastructures to remove microplastics.



4 The Greener Grangetown green infrastructure project in Cardiff developed an innovative scheme for rainwater management

WHY MUNICIPALITIES ARE STRUGGLING TO INCREASE URBAN FOREST GROWTH

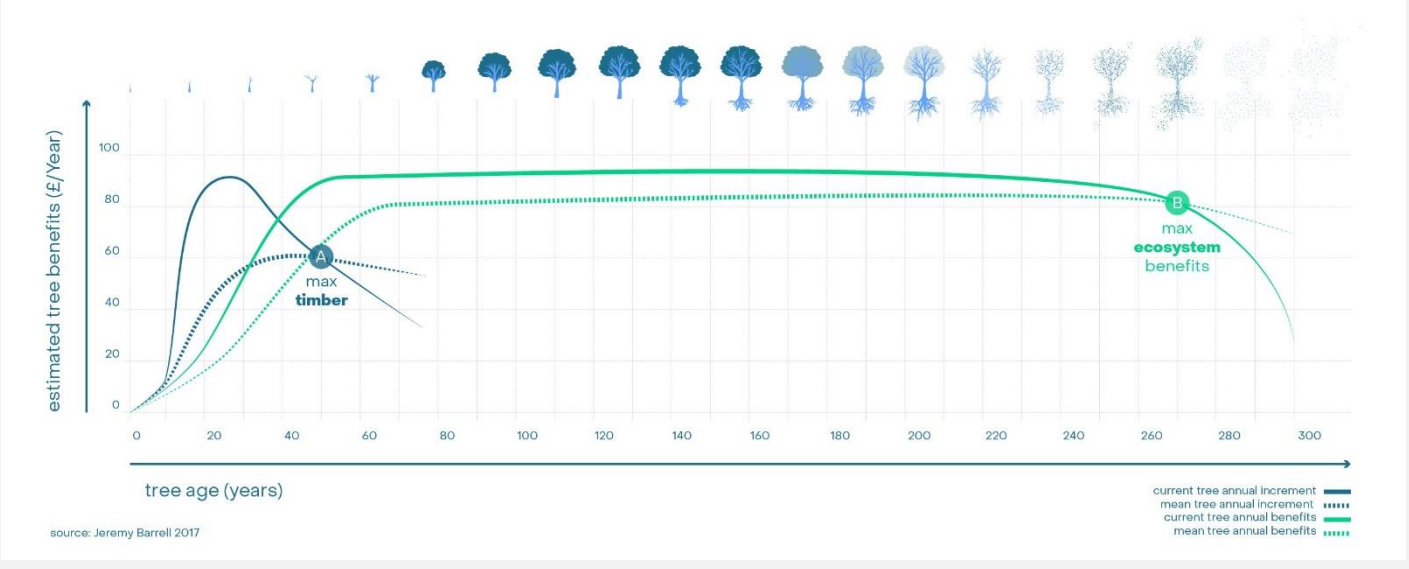
Our current persistent models, developed during the 19th and 20th centuries, have created a series of obstacles, relating to the **accounting, regulating, funding and managing of urban trees**, that we recognise are preventing municipalities from raising the necessary public capital and participation to increase the rate of urban forest growth.

1 / Urban trees are framed as costs rather than assets

Today within local authorities' balance sheets and accounting practices trees are registered as costs; amongst others, budgets need to be allocated for maintenance, insurance claims and felling. At the same time as austerity measures

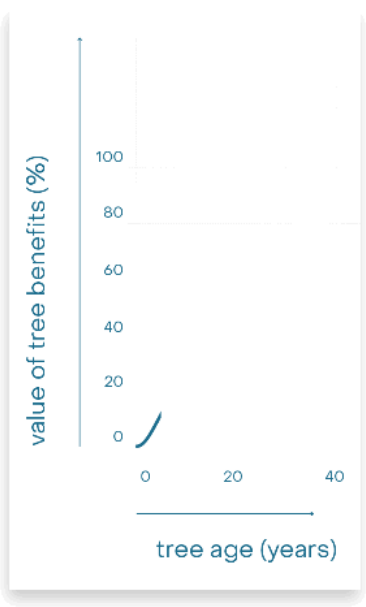
have dominated economics for the past three decades, cities have faced growing budget cuts, forcing municipal projects to opt for cost reductions even if they engender a lack of quality.

This incentivises the planting of small tree species, which results in a reduction in street tree canopy cover and ecosystem services. During procurement processes for hiring contractors to deliver and maintain urban trees, councils grant the project to the lowest bidder who has managed to make a compelling offer by minimising the demand for spending. For example, as trees get older they require increasing maintenance, hence the lowest bidder proposes to replace these with saplings frequently to reduce escalating costs. More worryingly, most professional tree officers accept these practices because they understand optimum timings to fell based on forest tree models that amplify timber production as there is very little guidance and research on street trees. As a result, our systems are unable to register, take advantage of, let alone foster the benefits derived from the ecological behaviours of urban forestries.



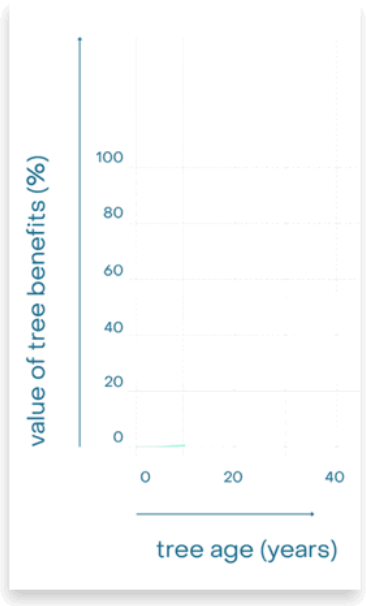
5 Two approaches to tree felling timescales: A. conventional forest management timescale where the optimal age to fell and replant trees is planned to optimise timber volume production; B. optimal timescale where the optimal age to fell and replant trees is planned to maximise social and ecosystem tree benefits

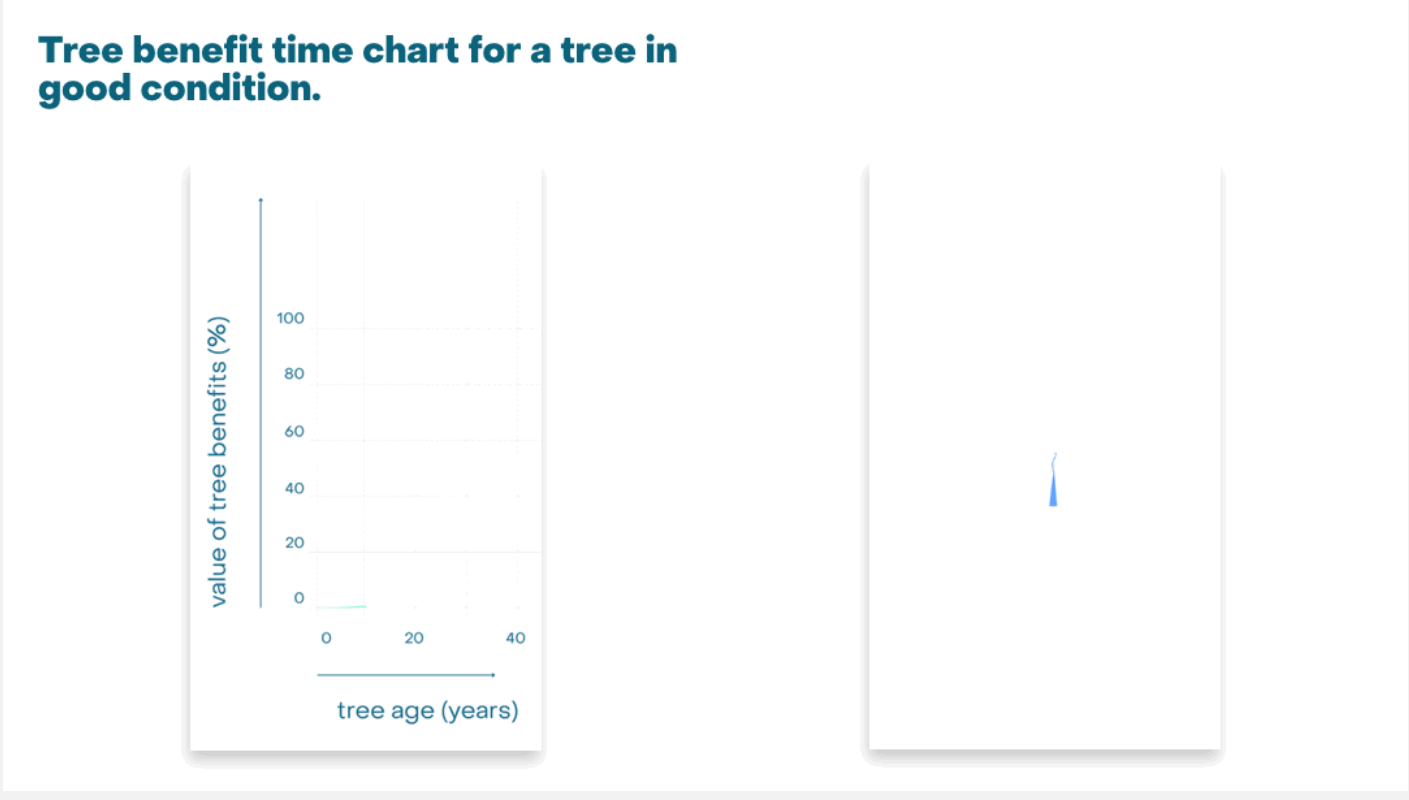
In the UK, tens of thousands of newly planted trees — replacing in many cases ancient woodlands affected by the new High Speed Rail link — died as HS2 claimed replacing dead saplings is more cost-effective than watering them. In Turkey, up to 90% of 11 million saplings planted as part of a record-breaking mass planting project may have died after just a few months. Due to our accounting models, 50% of urban trees don't make it to 10 years. This should be a growing concern to councils since the ecological benefits of trees substantially start after 50 years of existence; we are currently building a deficient urban forest. Shifting our view to perceive public trees as assets rather than liabilities is an important aspect of maintaining and enhancing the benefits that trees provide in an urban setting.



6. Tree benefits time chart for a tree in mainstream urban forestry practices

Tree benefit time chart for a tree in good condition.





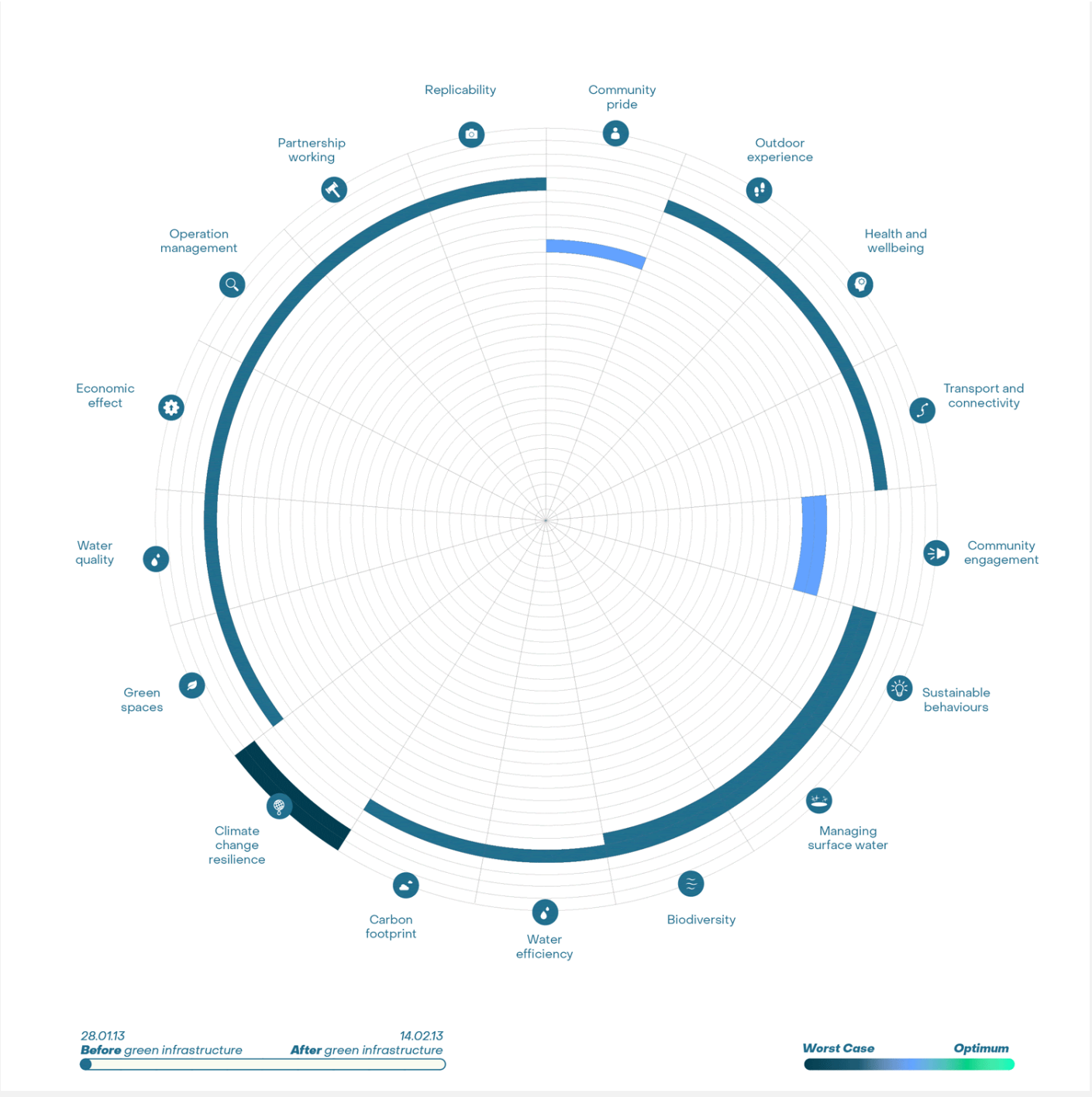
7. Tree benefits time chart for a tree planted and maintained in conditions to thrive

2 / Success metrics are focused on planting rather than maintaining

There is an intrinsic problem with our current targets, they fixate on the number of trees we need to plant to describe and define metrics of success. This numerical value is usually derived at a national level through political manifestos and does not reflect the contextual realities of neighborhoods.

In Hackney, Councillor Jon Burke, has insisted that 'while talking tree numbers is a good way of making manifesto pledges 'real' for the public, they don't begin to tell the story of nature-based carbon sequestration'. He suggests that we should start describing urban forest growth efforts differently, for example a '40% canopy cover on neighbourhoods can effect greatly energy demands for cooling and medical services'. Or what if we aimed at maintaining a constant stock of urban trees that are between 50 and 200 years of age to reap the most cost-effective benefits. Councils need to start understanding success beyond planting and consider a suite of different metrics that are more granular and greatly entwined with the science of climate.

In the innovative development of the Greener Grangetown project in Cardiff, no tree planting targets were set. Instead during the feasibility stage, a report describing the neighborhood's scope for improvement was developed. As a result the project targeted a variety of metrics and benefits including community pride, outdoor experience, water quality, health and wellbeing.



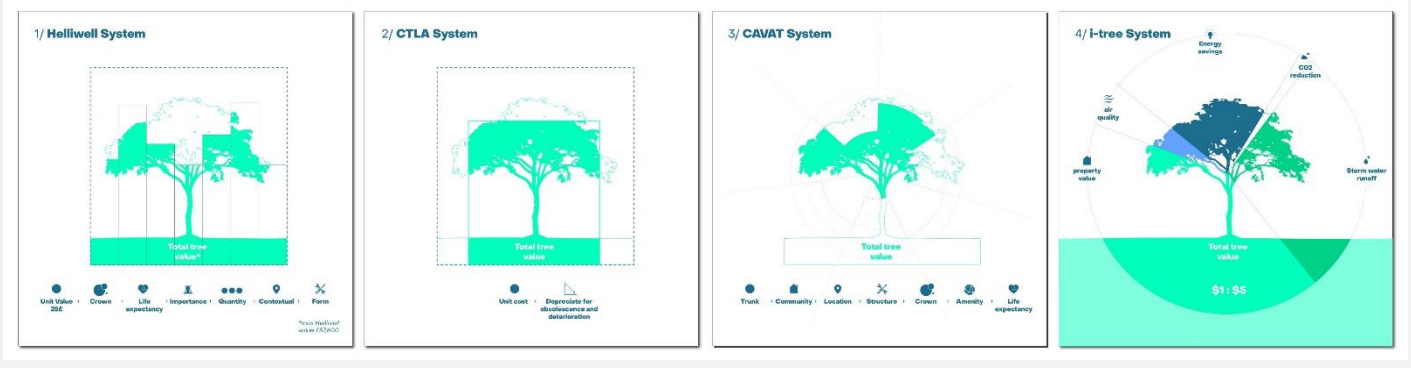
8. Study showing sustainable metrics before and after completion of the Greener Grangetown green infrastructure project in Cardiff

As Kate Raworth points out we need to recognise that 'for the first time we can describe and measure nature's generosity and life systems in nature's own metrics […] we can measure the depletion of ecosystems, we can measure the quality of the soil, […] the health of humans, our nutrition, our educational level, our self-reported levels of happiness. We can actually measure the well-being of people and planet in natural and social metrics, on the terms of life itself'.

3 / We simplify the financial returns of trees

Initially tree valuation models were mainly set out to assist local authorities in achieving an appropriate level of compensation where publicly owned trees were damaged or removed without consent. Due to the urgency of planting trees and the lack of financial resources, there are now a number of different tools that provide methods to quantify the monetary value of trees.

The Helliwell system places 'a monetary value on the visual amenity provided by individual trees or woodland'. CAVAT (Capital Asset Valuation of Amenity Trees), widely adopted by authorities across the UK, values individual trees and tree stocks and provides both a compensation value for damage to or loss of a tree and also provides a basis for presenting the monetary worth of trees to create the 'business case' for managing trees as assets rather than liabilities. More recently i-Tree, a USDA software suite, quantifies performed environmental functions including air quality improvement, stormwater control, carbon sequestration and carbon storage and values annual and total benefits using standard ecosystem services approaches. New York City used the i-Tree platform to calculate the ecosystem services flowing from the city's trees and concluded that the city's trees provide $5.60 in benefits for every dollar spent on tree planting and care, developing the model known as $1:5. As explored in *Smart Commons* a large portion of that value is captured by increasing land property values, as is the case with other civic assets.



9. Different methodologies exist for valuing trees as assets: (1) focused on their visual relevance, (2) their market value, (3) their amenity value, and (4) the total value associated with ecosystem services

Amongst others, the above valuation models simplify the benefits flowing from urban forestry, either by relying on generic measures (eg. the Helliwell system uses an arbitrary value point system which caps a single tree value at £127,590), on fixed parameter averages (eg. CAVAT relies on the size of tree trunks) or by bulking together a number of benefits (eg. the $1:5 model). Returning to the Greener Grangetown project in Cardiff, the authority did conduct a valuation study that estimated a total of benefits worth over £8.4 million spanning a 30 year period, but the resulting

report was of no use to influence any policy update or funding allocation, since there was no breakdown of the value that would allow to determine the beneficiaries of the urban forestry services.

Simplifying and bulking the benefits flowing from urban trees also constrains authorities from involving more financial beneficiaries who can provide funding for the development of green infrastructure projects by paying for ecosystem services. At the same time we lack mainstream funding mechanisms that encourage the development of projects that consider multiple financial beneficiaries. As the drainage officer at Greener Grangetown, Ian Titherington, explains 'since these sort of projects are not labelled to attract one specific funder (eg. flooding), but are addressed towards multiple beneficiaries, municipalities are finding it difficult to get any funding because ideally investors prefer to invest in the whole project. This is just the way silo funding works in the public sector'.

4 / We tend to focus on centralised man-made infrastructures

We have forgotten to truly notice the existence of trees in the context of our cities. We know that trees survive by being reliant on connections, as Suzanne Simard has pointed out trees use a network of latticed fungi buried in the soil to communicate, exchanging warning signals about environmental change, searching for kin and transferring nutrients to neighbouring plants. Trees are part of a cooperative system that, if seen as a whole, form a distributed infrastructure providing a number of ecological services.

10. Suzanne Simard has proven that trees exchange nutrients, compete and communicate via a network of underground fungi

Existing large-scale engineering-driven infrastructures in transportation, water management, industrialised energy, food production and distribution systems persevere as the dominant solutions to servicing urban living processes. For example, in London the growing demand for waste water management has resulted in the decision for building and extending the existing centralised sewer system. But as environmental phenomena become more unpredictable, the risks generated by centralised grey infrastructures escalate, creating increasingly precarious systems. At the same time the performance of such man-made infrastructures depreciates over time and requires additional funding for maintenance or re-building. Well-managed natural systems on the other hand, which are by definition more distributed, can develop to provide a constant return of multiple benefits, while being less reliant on centralised capital investment and maintenance. What if, as part of a broader revaluation of the diverse capital in our cities, we start focusing on these natural infrastructures that can serve us as sewage and flood management, preventative healthcare, heat island and pollution mitigation, and waste management infrastructure simultaneously?

THE NEED FOR A BORING REVOLUTION, AND A RELATION-SHIFT

We argue our systems require a *Boring Revolution*: a revolution within the very bureaucracies that manage how we account, contract, govern and manage city trees. And at the same time we require a socio-cultural shift of our human perception, to augment participation and empathy towards urban forestries by re-building our social contracts with place. Stefano Mancuso, an internationally renowned plant neurobiologist, has pointed out that in persistent popular views plants are evolutionarily inferior, writing that 'the plant world always gets second ranking'; for example, no plants appear on Noah's ark. Trees are vital for humans and other species, but we currently don't value them. We barely notice them. But to overcome the challenges inherent in today's rapidly unfolding ecological catastrophes, we need to start foregrounding the trees in our cities.

Conservation finance innovation and green infrastructure metrics have been developing since the 70s, establishing institutional models, like REDD+ for offsetting carbon footprints and a plethora of other emerging models like terra0 and GainForest, to tackle our growing deforestation and forest degradation. However we are fooling ourselves if we think such offsetting systems in remote locations are the solution to our climate emergency. Cities are at the core of the climate crisis — they are the largest environmental polluters whether through their direct or their consumption based emissions, and it is therefore in cities that we must look for solutions.

A recent London environmental strategy has shown evidence that whilst the current market-based logic favours tree-planting in uplands and peatlands, afforesting urban and peri-urban areas could actually be more effective in the long term. Uplands and peatlands are already precious custodians of our global carbon storage, where more tree-planting, if done badly, can be harmful rather than beneficial. To do justice to the potential of urban regions to be carbon sinks as well as emitters, we need to create models to finance green infrastructure and nature conservation within the context of our cities.

However little can be done unless we all take a stake in the process. As Floor Gordon, Amsterdam's City Councillor in charge of Sustainability, has stated as part of the Amsterdam Rainproof project, "It is up to the municipality when it comes to adaptations to public spaces and the construction of a separate sewer. But in order to make Amstelveen climate-proof, we also need our residents and companies". REDD+ has already learnt this lesson and has started to place an increased emphasis on nursing the people that depend on and can care for forests, because *"they are the best guardians our forests can have. We cannot effectively conserve our forests without the active participation of the*

communities." In other words, the revolution we need has to be a cultural shift and a deeply human endeavour as well as a bureaucratic transformation.

WHAT NEXT?

During the following weeks we will be developing the second part of this blog series: we will outline a model for a piece of institutional infrastructure — or rather, a sequence of coherent institutional propositions that create leverage points across our broken system — to rise to the challenge of supporting cities and communities to develop thriving urban forest environments and a technology enabled yet deeply humane transition towards a green infrastructure-rich future.

11. How do we value our urban forests? Exhibition, Somerset House, 2019

This is a project developed by Dark Matter Labs, supported by EIT Climate-KIC.

Trees As Infrastructure is one of a number of experiments we're working on across Dark Matter Labs. If you're interested in getting involved, or want to know more let us know @Dark MatterLabs.

References

Image 2 /

Left: Cox's proposal for the organization of a Bureau of City Forestry, 1915. Laurie Davidson Cox, *A Street Tree System for New York City, Borough of Manhattan: Report to Honorable Cabot, Commissioner of Parks, Boroughs of Manhattan and Richmond, New York City* (Syracuse: Syracuse University, 1916)

Right: Celebrating the tree surgeon's work, Dermody Square, Queens, 1930. Courtesy NYC Municipal Archives

Image 3 /

Left: A section from the cadastral survey map of trees with the marked felled trees. Red: felling; green: registered street trees. Silvan Linden, *Wildwuchs, or the worth of the Urban Wild,* in Anna-Sophie Springer & Etienne Turpin (eds), *The Word for World is still Forest* (Berlin: K. Verlag and Haus der Kulturen der Welt, 2017), 170.

Right: Numbered stumps of the felled trees viewed westward from the border of Mitte district. Silvan Linden, *Wildwuchs, or the worth of the Urban Wild,* in Anna-Sophie Springer & Etienne Turpin (eds), *The Word for World is still Forest* (Berlin: K. Verlag and Haus der Kulturen der Welt, 2017), 172–173.

Image 5 / Optimised Urban Tree Benefits Rotation Lenght by Jeremy Barrell FICF Managing Director Barrell Tree Consultancy in Tree benefits; the missing part of the street tree cost benefit analysis equation, Institute of Chartered Foresters.

Image 8 / Greener Grangetown, Sustainable Project Appraisal Routine (SPeAR) assessment, ARUP.

Image 10 / On the left, the top down spacial topology of *Rhizopogon species Pluralis Genets* and *Douglas-fir* trees in a thirty-by-thirty-meter plot. Suzanne Simard's research has shown how forests are not just a competitive system but a cooperative once too. In fact trees exchange nutrients, defense signals and kin recognition signals via a symbiotic association with below-ground fungi (a mycorrhizal network). The arrow points to the most highly connected tree, the "mother tree" which was linked to forty-seven other trees inside the plot. Simmard's research also shows that climate change, pine beetle infestations, and clear-cut logging are affecting "mother trees", thus affecting the underground funghi network. On the right, a topology of tree-mycorrhizal fungus interaction networks in Douglas-fir forests, visualisations by Kevin J. Beiler, Suzanne Simard and Daniel M. Durall.

Image 11 / ***How do we value our urban forests?*** is *a* prototype questioning our current and potential future relationship with street trees. From one of control and dependence to one of symbiosis and mutual development. Trees are vital for human flourishing, but we currently don't value them, barely notice them.
Building on how urban trees' networks express positive or negative signals about their surroundings, *How do we value our urban forests?*, rethinks how we involve trees in urban decision-making processes. It is a mind-shift tool, that supports holistic urban afforestation strategies by shifting the valuing of trees from aesthetic ornaments or cost to valuable assets, accounting (and visually displaying) trees' multi-point benefits for human and non-human actors. These are the conditions for thriving humans and our broader biodiversity.