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Heat: How to expand your city's tree canopy cover

Adapting to Climate Change | Spotlight On: Nature-based Solutions | Urban Planning and Design

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The cooling benefit of trees is striking. By providing shade and through evapotranspiration, they limit the build-up and storage of heat in urban surfaces.[1] Trees lower the risk of heat-related death and illness, reduce heat damage to asphalt and other built infrastructure and limit heat impacts on workers and labour productivity. They also reduce energy demand and costs, trap air pollutants, support urban biodiversity, reduce flood risk, increase property values, sequester carbon and make our cities more pleasant places to be.

> **Trees, permeability and flooding**
>
> While trees will reduce flood risk, the key factor for flooding is permeability. Integrate tree canopy and permeability strategies for efficient and cost-effective implementation. Read *How to increase your city's permeability* to learn more.

Trees tend to perform better and better throughout their lives, with bigger, mature trees delivering greater benefits. Here, we look at how cities can protect their current tree canopy and expand it, building on the broader *How to adapt your city to extreme heat* and *How cities can use nature to manage climate risks*.

Map your tree coverage, areas of greatest need and planting potential

Urban tree canopy coverage and the heat protection it offers are rarely uniform across a city. Higher-income areas are typically better served by mature trees, but also tend to have more space available for new planting, adding complexity to heat risk reduction and equitable planting goals.

Map and assess the tree canopy to understand the current status and distribution of the urban forest and plantable areas, working with urban foresters, arborists or spatial mapping experts. The assessment should cover the whole city, not just land managed by city departments. This is necessary to set targets, protect existing trees and inform decisions on which locations should be prioritised for new planting. This study can form part of a climate risk assessment.

- **Explore any existing data held by the city or other parties,** such as local universities, national government departments or civil-society organisations.[2] For example, Australian cities can benefit from the country's study on Benchmarking Australia's Urban Tree Canopy, summarised in Where are all the trees? Even if existing surveys are not very precise – they may provide only an overall figure for the whole city – they can allow city-level targets to be set and enable benchmarking against other cities.

- **Use digital tools to map the tree canopy,** working with geographic information system (GIS) or arboriculture experts. For the most accurate results, use lidar data combined with ortho-rectified aerial photographs (correcting for perspective (tilt) and relief (terrain)).[3] Los Angeles, for example, worked with TreePeople and the Center for Urban Resilience to develop a tree canopy map using ArcGIS Online, showing both existing and possible canopy cover from ZIP code to land parcel level – the associated storymap explains how. Such studies can be expensive and time consuming, however. Studies using tree canopy assessment tools (see box) can offer a cheaper alternative and provide mapping with sufficient accuracy to inform planning and monitor change. If historical land-use data are available, also track change over time – this study for the Australian city of Charles Sturt is a good example.

- **Undertake a tree inventory to assess tree health and age, the mix of species and vulnerability to climate-related risks,** working with arborists. Assess the proportion of trees that are already in the later stages of life, of native, introduced and invasive species, and the prevalence of pests and diseases. Understand your trees' vulnerability to climate and environmental risks, ideally informed by a climate change risk assessment – for example, exposure to damage from storms and suitability for a hotter and/or drier climate. Greater tree species diversity will reduce risks from pests and blight and may improve the tree population's climate resilience.[4] Melbourne's urban forest strategy, for example, responds to evidence that, without action, the city would lose 44% of its tree cover within 20 years due to the age of its trees and their lack of diversity.

The assessment should be repeated to monitor progress on a timeline appropriate to your canopy goals and

tree growth. Toronto's 2008 study of canopy and impervious surface cover was updated a decade later, for instance, finding that the tree population had increased, with street trees providing the greatest structural (economic) value.

Tools for tree canopy mapping and inventory

- **i-Tree tools.** i-Tree Canopy is the leading open-access tool available, estimating the tree canopy and its benefits. This free software was developed by the United States Department of Agriculture Forest Service and is available for use by cities internationally. It was used for Australia's benchmarking study and many city-level assessments.[5] An adapted version, i-Tree Eco, is tailored for use in Canada, Australia, the United Kingdom, Mexico, South Korea, Colombia and most of Europe.
- **Google tools.** Google Earth Engine, also free for academic and research use, has been used to develop high-resolution tree canopy cover maps for cities, including London, using machine-learning techniques. Google's Tree Canopy Insights tool, part of the Environmental Insights Explorer suite of tools, is being piloted by 15 cities in the United States. It is expected to provide a model that can be used by any city globally, but this is unlikely to be available in the short term.

Combine tree canopy with other data to develop a comprehensive assessment of planting needs and opportunities

This will help to identify areas of greatest need and inform decisions on what kind of tree planting is best suited to which locations.

In particular, map:

- **Urban heat and heat-related death and illness.** *How to adapt your city to extreme heat* explains more about how to map urban temperatures and heat-related risk.
- **Air pollution.** As trees help to reduce local air pollution, as well as heat, any data held by the city on air quality and local pollution hotspots should inform planting efforts.
- **The location of schools, parks, playgrounds and other public facilities,** especially those used by heat-vulnerable groups and those with large areas of public land available for planting.
- **Transit infrastructure,** including outdoor bus stops, and walking and cycling corridors.
- **Environmental data,** particularly soil type.
- **Socioeconomic data, particularly population density, land use, means of transportation and income levels.** For example, lower-income residential areas dominated by multi-family rental properties are likely to have greater need for planting, and receive less private investment in planting, than areas with large homes and large private gardens. Areas with low car ownership may have greater need for street tree coverage along walking routes and at bus stops.

Set targets to expand and improve the tree canopy

Targets usually take the form of:

- **Number of trees planted.** Monitoring for this type of target does not require a baseline assessment of tree canopy. Freetown, for example, has set targets to plant a million trees by the end of 2022 (up by 50% from 2018 levels), while Los Angeles aims to plant 90,000 trees by the same date. Lima aims to plant 4 million trees by 2030 and, by 2050, for all main metropolitan roads and public spaces with high pedestrian and cyclist usage to be 'green corridors'.

- **Percentage canopy cover.** Setting this type of target and monitoring progress, will only be possible if your city has done a tree canopy assessment to provide baseline data. Newcastle's tree strategy 2019-24 sets a target for 20% tree coverage by 2050, up from the 18.1% in the 2019 tree canopy cover assessment, amounting to an estimated 19,000 additional trees. Barcelona's target is 30% tree coverage, a 5% increase, as set out in Trees for Life: Master Plan for Barcelona's Trees 2017–2037.[6] Milan plans to plant 3 million trees by 2030, aiming to increase canopy cover by 5%.

- **Level of species diversity and/or inclusion of species that can thrive in the city's future climate.** Barcelona is working to rebalance the dominance of certain tree species with the aim of ensuring that no single species accounts for more than 15% of the tree population by around 2060 and that 40% of those tree species are adapted to climate change – an increase on the current 30%.[7]

- **Tree canopy equity.** For example, Los Angeles has set targets to increase the urban tree canopy by 50% in areas with the greatest need by 2028, informed by a 2021 urban forest equity assessment.[8] Cities in the United States can use the Tree Equity Score tool to support the setting and monitoring of these targets.

Work with city government departments, community groups, major landowners and other relevant local stakeholders to agree targets, informed by the tree canopy mapping and assessment.

Work with experts to choose the right mix of trees

The selection of tree species should be informed by their:

- **Cooling benefit.** Prioritise larger trees and species that have a high leaf area index (the ratio of leaf area to ground area under canopy), as they will cast greater and denser shade, making them more effective at reducing temperatures.[9] The initial planting and early-years maintenance cost for larger trees is often the same as for smaller trees, though they require more space.

- **Suitability for the city's climate.** Select a diverse mix of tree species that will be appropriate to the city's current and future climate, especially in terms of temperature tolerance and water needs.[10]

Prioritise native species, as these are usually more likely to thrive, have lower maintenance costs and offer the greatest benefits for local biodiversity, but also consider introduced species that are well adapted to the city's anticipated future climate.[11] Barcelona, for instance, includes introduced species in its inventory of existing adapted species.[12]

- **Suitability for the specific location.** Consider how much soil is available, how much sunlight the location gets, above-ground space (for example, the width of the sidewalk), permeability of surfacing and the groundwater table. These factors will influence which trees are suitable and their potential to thrive.[13] Melbourne's Urban Forest Diversity Guidelines are a good example of site-level tree selection criteria. Partner tree planting with permeability measures to support watering.

It's not just about trees. Large bushes can offer similar ecosystem services to trees and may be more suitable in some locations. Equally, vines can offer faster-growing shade. Heerlen's vine-covered bus station is a good example.[14]

Also consider wildfire and storm risk in the selection of trees

Cities at risk from wildfire should select trees that are adapted to fire and/or that burn less intensively. Cape Town, for example, is removing alien and highly flammable pine species and increasing the coverage of the native, fire-adapted vegetation to reduce risk from fire. Learn more in *How to protect urban lives, health and property from wildfire*.

Trees with shallow roots and a heavy canopy are at higher risk of being lost or damaged in the event of hurricanes, typhoons and other high-impact storms, and can be a danger to people, buildings and infrastructure. Kolkata lost over 5,000 trees during cyclone Amphan, for example, and planted 10 new saplings to compensate for each mature tree lost.[15] Cities in at-risk areas should identify and protect those trees – for example, by ensuring that any pruning doesn't undermine their stability – to reduce destruction during storms, and also prioritise the planting of more stable species.

Melbourne's guide to growing an urban forest explains 10 steps cities can take to expand their urban forest, covering narrative building, data requirements and assessing urban vegetation assets, establishing targets, engaging communities and creating a plan. It was written to support councils in Australia, but much of the advice is more broadly applicable.

The guide is informed by Melbourne's experience of developing and implementing the Urban Forest Strategy, which sets out a plan to expand urban tree cover from 22% today to 40% by 2040, while increasing species diversity, biodiversity and soil moisture. An online portal tracks progress and details the 10-year forest plans for each of Melbourne's precincts.

Regulate and incentivise the protection of the existing tree canopy

Larger, mature trees provide greater cooling benefits and require less maintenance than young trees. It is critical that mature trees are preserved as much as possible. Policies to preserve existing trees are likely to be popular, as Sheffield found (see box).

To protect mature trees, cities can:

- **Ban the removal of or damage to trees on public property.** In many cities, including Cape Town and New York City, it is illegal to remove, kill or damage a street or park tree, with violations punishable with a fine and/or prison term.

- **Ensure that tree protections are integrated into street and public-realm maintenance plans and contracts.** Mature trees can be more expensive than young trees from a street maintenance perspective, as they can cause pavement and road damage and greater leaf drop. Failure to integrate tree canopy and street management plans can drive their removal.

- **Require a permit for activities that could result in the injury or removal of a protected tree.** Toronto, for example, requires permits to injure or remove trees under bylaws that protect all street and mature private trees (diameter of 30cm or more).

- **Ensure proper maintenance of trees, especially street trees.** This will help to reduce the risk of damage to property and public nuisance from, for example, fallen branches or light obstruction, which can otherwise drive the removal of mature street trees. Cape Town's *Best Practice Guidelines: Trees* includes detailed guidance on the protection and good maintenance of trees.

In 2021, Sheffield issued a new Street Tree Partnership strategy to ensure the protection of existing street trees. The city council had faced years of high-profile, community-organised protest against mass felling, which saw more than 5,500 mature, healthy trees removed and replaced by young trees by a private company contracted to manage the city's streets. A further 12,000 trees were set to be replaced over the remaining 20 years of the contract.[16] Sheffield established a Street Tree Partnership to enable the council, the private contractor, local anti-felling campaigners and other partners to collaborate on the strategy's development and implementation.

Maximise tree canopy expansion on public land and facilities, especially those used by vulnerable groups

Approaches that offer the best tree-planting potential and benefits include:

- **School grounds and playgrounds.** Children are among the most heat-vulnerable groups. Green space has also been shown to benefit children's physical, mental and social development.[17] Prioritising planting here offers an opportunity to engage children and the wider community in tree-planting programmes. Paris, for example, is prioritising the greening of school grounds as part of its 15-minute city plans. Listen to a Sydney-based urban heat expert talk about using trees and other urban design elements to cool schools, playgrounds and public spaces in this 100 Climate Conversations podcast.

- **Walking and cycling corridors, as well as bus stops.** Integrate tree planting with transport planning to maximise benefits and cost efficiency – taking the opportunity to plant when streets are undergoing other planned works, for instance. Medellín's network of 'green corridors' is a good example.

- **Parking lots.** Most cities, especially those with current or historical minimum parking requirements, have large expanses of asphalt that raise urban temperatures and flash flood risk. Underused parking lots can be low-hanging fruit for tree-planting schemes. Begin by measuring actual parking usage, and allocate a portion of unused spaces to planting in locations designed to maximise cooling benefits for people. Update zoning to require trees in new parking lots, as New York City has done. Alternatively, consider whether **open space acquisition** can help to meet tree canopy goals.

Prioritise the needs of pedestrians in street tree planting projects

Wide and continuous sidewalks are critical to pedestrian use, especially for parents with young children and wheelchair users. Where sidewalk space is limited, look for opportunities to plant trees in the parking lane or include tree planting as part of kerb extensions. Alternatively, consider the use of walkable tree grates or other permeable tree pit surfaces that allow space for tree growth while maintaining an accessible path.[18] Where mature trees have encroached too far into sidewalk space, consider opportunities to expand the sidewalk into the road or parking space, around the tree, rather than cutting down the tree.

Consider categorising planting locations to give structure to planting decisions

Categories provide a common language to describe how easily new trees can be planted at a site and which tree species are likely to be suitable. This is the approach taken by Melbourne, which sets out 16 location types in its Urban Forest Diversity Guidelines, and Los Angeles, which uses the three tiers described below:[19]

The tiers are used throughout the Los Angeles Urban Forest Equity Streets Guidebook to make recommendations about the extent and quality of tree planting possible for 10 city streets or neighbourhoods. Research found that merely planting small trees in Tier 1 locations will not enable LA to achieve its tree canopy equity goals – larger trees in locations requiring more investment and effort are needed in most cases.

Incentivise or require tree canopy expansion on private la

The main approaches cities can take to do this are:

- **Provide free trees.** Allow people to sign up to receive free trees or provide free trees at events. Kampala, for example, provides seedlings to those willing to plant them, targeting 10,000 a year.[20] Austin allows residents, small businesses and community spaces to apply to 'adopt' a tree and provides free mulch. Applicants must commit to regular watering for at least the first two years of establishment and most go to multi-family properties.[21]

- **Require trees, along with the conditions that enable trees to grow, in new developments.** Consider adopting the Green Space Factor pioneered by Malmö, which provides a 'menu' of urban greening options, including tree coverage, and awards points to planned developments according to the extent and quality of green space. By requiring a minimum value, this approach allows flexibility while ensuring that targets for green space are met. The system has been adapted by cities including London and Seattle.

- **Introduce financial incentives for tree planting.** For example, Washington D.C. offers a Tree Rebate of up to US $100 per tree for residential and commercial property, with rebate values attached to the canopy spread of the selected tree species.

Involve communities and landowners in the planning, planting, establishment and maintenance of trees

While expanding tree coverage in a neighbourhood is often supported in principle, agreement on the specific siting can be challenging, especially for street trees. Residents and businesses often object to trees being planted outside their home or premises, or in parking spaces, for example.

Early and meaningful engagement is critical. Meet with diverse stakeholder groups, civil-society organisations and major landowners (including major land-owning city departments) to find and create local allies in the communities targeted for tree planting. Share the results of tree canopy mapping and related assessments, raise awareness of the benefits of an increased tree canopy, and involve them in decisions about where and how to site trees.[22] Invite communities and volunteers to support the planting and early-years maintenance of trees to maximise success and keep costs down. Information about the city's tree heritage and what has been lost can help to appeal to conservative attitudes. Programmes allowing residents to plant a commemorative tree in honour of a loved one can also help to build support and engage the public. Provide multiple platforms for engagement: online forums, in-person meetings, workshops, surveys and interviews are commonly used approaches.[23]

Good examples of community engagement in urban greening and tree planting include Lima's low-cost,

participatory Limeños al Bicentenario urban regeneration programme, and Philadelphia's Beating the Heat plan for Hunting Park (see box). The United Nations Food and Agriculture Organization's *Guidelines on urban and peri-urban forestry* also includes advice and city examples on community engagement, alliance building and many other issues.

Expanding the tree canopy is a key pillar of Philadelphia's neighbourhood-led heat risk reduction plan

Hunting Park is a neighbourhood in north Philadelphia that is particularly vulnerable to heat due to factors such as age, income and health conditions, as well as a lack of tree canopy and other cooling spaces. Tree canopy cover is only 9%, compared with 19% across Philadelphia and 48% in some wealthy neighbourhoods, and the neighbourhood is among Philadelphia's hottest. The City worked with community partners to deliver bilingual tree advocacy, surveys, interviews, community events and workshops to understand residents' perspectives on local heat issues and what would help them to stay cool. Survey results showed that 60% of respondents wanted to see more trees of the appropriate size and type as a cooling strategy. Beating the heat – Hunting Park: A community heat relief plan explains Philadelphia's approach to community engagement and next steps, as well as a toolkit to guide community-led heat projects elsewhere.

Funding for city-led tree-planting programmes typically comes from city budgets, grants, and private investment. Also explore national financing opportunities. Cities in the United States, for instance, can also now access federal funds for tree canopy projects through the Health Streets Program of the Infrastructure Investment and Jobs Act, and the Inflation Reduction Act.

It is critical that tree maintenance – not just planting – is incorporated into annual budgeting and planning processes to ensure young, vulnerable trees become established. Funding your urban forest program shares tips on financing based on experience in the United States. Freetown has pioneered an approach to financing tree planting and maintenance that has potential to be replicated elsewhere. Austin created a City Forest Carbon Credit scheme to fund its tree-planting programme. The resources shared in *Spotlight on: Urban climate finance*, and *How cities can encourage private sector adaptation finance*, provide more advice.

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