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UNLOCKING THE POTENTIAL OF URBAN FORESTS: Developing a Local Urban Forestry Action Plan

Juliet Achieng Owuor, Ian Whitehead and Rik De Vreese (European Forest Institute)

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Editors and affiliation
Juliet Achieng Owuor, Ian Whitehead and Rik De Vreese (European Forest Institute)

Authors and affiliation
Jorge Olivar (AGRESTA), Corina Basnou and Florencia Florido (CREAF), Erica Alghisi (ERSAF), Juliet Achieng Owuor, Ian Whitehead and Rik De Vreese (European Forest Institute), Colm O'Driscoll, Ilaria Doimo, Giulia Cecchinato, Arianna Ruberto and Annalice Nicolussi (ETIFOR), Petronela Candrea and Sergiu Florea (Forest Design), Cecil Konijnendijk (Nature Based Solutions Institute), Sofia Paoli and Maria Chiara Pastore (POLIMI), Mary-Lee Rhodes, Siobhán McQuaid and Esmee Kooijman (Trinity College Dublin), Joan Pino (UAB), Iaon Vasile Abrudan, Mihai Nita and Cristina Draghici (University of Brasov)

Reviewers and affiliations
Nadina Galle (GreenCity Watch)

Design
Serena Cesca (Etifor)

info@uforest.eu
www.uforest.eu

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GLOSSARY: KEY CONCEPTS IN URBAN FORESTRY

Bioeconomy ► The production, utilization, conservation, and regeneration of biological resources, including related knowledge, science, technology, and innovation, to provide sustainable solutions (information, products, processes and services) within and across all economic sectors and enable a transformation to a sustainable economy (IACGB, 2020).

Emerging urban forests ► spontaneously developing forests in cities (Kowarik et al., 2019).

Entrepreneurship ► the activity or skill in starting new businesses, especially when this involves seeing new opportunities and taking on financial risks in the hope of profit (Cambridge Advanced Learner's Dictionary, 2022; Oxford Advanced Learners' Dictionary, 2022).

Environmental "eco" entrepreneurship ► "an innovative, market-oriented and personality-driven form of value creation through sustainable environmental innovations in products and services exceeding the start-up phase of a company." (Mammadova et al., 2021).

Green Care entrepreneurship ► processes and outcomes of innovative value creation that harness health and well-being benefits of nature, and result in transformed human-nature attitudes, interactions and relationships (Mammadova et al., 2021).

Green infrastructure (GI) ► a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services' in both rural and urban settings (EEA, 2021).

Innovation ► The process, the outcome, and the mindset needed to create something novel in response to a problem (Kahn, 2018; Taalbi, 2014).

Internet of Nature (IoN) ► An approach where urban ecosystems can be described and represented through digital technologies and applications (Galle et al., 2019)

Nature-based enterprises ► is the most common organisation type and offers products or services where nature is a core element and engages in economic activity (mainly forestry and tourism). Community-benefit enterprises specifically involve communities in governance and management of forests, to provide direct and indirect benefits for the public and the community. Additional objectives include conservation, poverty alleviation, development, cultural revitalisation and political empowerment. For-profit forest enterprises can contribute to the conservation and sustainable use of forests while improving the livelihoods of local populations. Pro-biodiversity businesses contribute to biodiversity and sustainable use of ecosystems services while being financially profitable. The underlying principle is payments for ecosystem services, where beneficiaries are charged for its use through financial mechanisms, and profit is invested in conservation (Kooijman et al., 2021).

Nature-based learning (NBL) ► encompasses the acquisition of knowledge, skills, values, attitudes, and behaviours in realms including, but not limited to, academic achievement, personal development, and environmental stewardship. It includes learning about the natural world, but extends to engagement in any subject, skill or interest while in natural surroundings. It includes informal, non-informal and formal learning (Jordan and Chawla, 2019).

Nature-based organisations ► core use of nature, but no economic activity (public-private companies, community groups and network organisations in forestry, community gardens and tourism). They play an important role in the financing of, and in providing space and regulatory frameworks for NBS (e.g., city departments), as well as for the financing of nature, mainly for nature conservation, and for the empowerment of local communities (e.g., NGO environmental charities) (Kooijman et al., 2021).

Nature-based products and services ► delivered by enterprises or organisations, where nature is not at the core of activities (mainly, engineering and renewable energy companies that use nature as an input) (Kooijman, 2021).

Nature-based solutions (NBS) ► are defined as solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience; such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes,

through locally adapted, resource-efficient and systemic interventions (EC, 2021).

Novel ecosystems ► Ecosystems emerging after human-induced changes and composed of unprecedented species assemblages (Hobbs et al., 2006).

Smart green infrastructure ► green infrastructure that undergoes networked monitoring, management, and augmentation to ensure, for instance, adequate hydration of urban forests (Gabrys, 2022).

Smart urban forest management ► The design, establishment, monitoring, and management of urban trees and vegetation through the use of digital technologies, for the joint purpose of improving the urban environment and engaging all relevant stakeholders in its governance (Nitoslawski et al., 2019)

Social entrepreneurship ► aiming to provide innovative solutions to unsolved social problems, putting social value creation at the heart of their mission in order to improve individuals' and communities' lives and increase their well-being).

Urban ecosystem services (UES) ► benefits to sustain and improve human livelihood and the quality of life services provided by urban and peri-urban ecosystems: they include provisioning services, regulating services, habitat or supporting services, and cultural services (Haase et al., 2014).

Urban forests ► tree-based urban ecosystems comprising all woodlands, groups of trees, and individual trees located in urban and peri-urban areas; they include, therefore, forests, street trees, trees in parks and gardens, and trees in derelict corners (FAO, 2017).

Urban Forests as Nature-Based Solutions (UF-NBS) ► a subset of nature-based solutions that builds on tree-based urban ecosystems to address societal perceptions and demands, simultaneously providing ecosystem services for human well-being and biodiversity benefits. They are socio-ecological interventions that combine human management with nature's functionality within (peri) urban settings, offering great potential for more sustainable urban development (De Vreese, 2018).

Urban forestry (UF) ► integrated, interdisciplinary, participatory and strategic approach to planning and managing tree resources in urban areas for their economic, environmental and sociocultural benefits (FAO, 2017).

Urban forestry Initiative ► A given project or enterprise whose aim is to sustainably support, improve and/or promote urban forestry development and implementation.

ACRONYMS AND ABBREVIATIONS

BVOCs ► Biogenic volatile organic compounds

CO_2 ► Carbon dioxide

CICES ► Common International Classification of Ecosystem Services

COVID-19 ► Coronavirus disease 2019

CREAF ► Centre de Recerca Ecològica i Aplicacions Forestals

EDS ► Ecosystem disservices

EFI ► European Forest Institute

ES ► Ecosystem services

EU ► European Union

FAO ► The Food and Agriculture Organization of the United Nations

GPS ► Global Positioning System

Ha ► Hectare

ICT ► Information and communication technologies

IUCN ► International Union for Conservation of Nature

LAI ► Leaf Area Index

NBE ► Nature-based enterprises

NBL ► Nature-based learning

NBSI ► Nature Based Solutions Institute

NGO ► Non–governmental organisation

NO_2 ► Nitrogen Dioxide

NTFP ► Non-timber forest products

OSM ► OpenStreetMap

PM10 ► Particulate matter up to 10 microns in diameter

SDGs ► Sustainable development goals

SMEs ► Small and medium enterprises

SO_2 ► Sulphur Dioxide

UAB ► Universitat Autònoma de Barcelona

UN ► United Nations

UNDP ► United Nations Development Programme

UNECE ► The United Nations Economic Commission for Europe

UNEP ► United Nations Environment Programme

UFIF ► Urban Forestry Innovation Framework

WEF ► World Economic Forum

WHO ► World Health Organisation

UNLOCKING THE POTENTIAL OF URBAN FORESTS – THE KEY POINTS

In recent years, urban forestry has increasingly caught the attention of policymakers and politicians as a **nature-based approach to tackling some of our key societal challenges**. These include the impact of climate change, biodiversity loss, urban densification, the demand for forest products and the health and recreation needs of urban populations. Furthermore, urban forestry offers potential to deliver key aspects of **European Union (EU) policies** such as the **New Green Deal**, the **EU Biodiversity Strategy** and the **EU Urban Agenda**.

This document aims to **increase awareness** about urban forestry, the **numerous and diverse benefits** that it can provide and **practical steps** for developing an Urban Forestry Action Plan at a local level. In this respect, the **multifunctionality** of urban forestry and the cross-cutting outputs and services that it can deliver must be considered one of its greatest strengths. Themes which the document explores are:

- ▸ What urban forestry is and what can it deliver in terms of social, environmental and economic benefits. In addition, the negative impacts or disservices associated with urban forestry.
- ▸ How to better understand the urban forest resource through extensive mapping, audits and inventories, and how they can contribute to development of more integrated approaches to urban forestry.
- ▸ The importance of promoting the multiple benefits that can be derived through urban forestry and the multiplier effect that can be achieved, over and above levels of initial public investment.
- ▸ Consideration of how urban forestry can best respond to the needs and perceptions of local stakeholders and citizens to ensure effective integration into future planning, governance and management approaches.
- ▸ Mechanisms for the creation of diverse and enduring partnerships with a strong sense of local ownership for resilient and effective long-term governance.
- ▸ The importance of linking urban forestry strategies at regional scale with other key policy areas such as planning, health, transportation, social equity and climate change mitigation.
- ▸ The role and need for innovation within urban forestry management and how this can contribute to the development of a strong circular bioeconomy.
- ▸ The process for development and delivery of targeted Urban Forestry Action Plans at a local level with clearly defined objectives, outcomes and timelines.
- ▸ Effective promotion of urban forestry campaigns, both within the corridors of power and across wider society and the business community.

We therefore propose an integrated **Urban Forestry Action Plan** approach for local actors to deliver **multifunctional objectives** which promote **innovation** and respond effectively to the wide-ranging challenges and societal demands confronting our planet. Local action plans must link to the **cross-cutting policy themes of the EU** and be **effectively communicated** across different stakeholders whilst emphasising rural-urban connectivity and Sustainable Development Goals. Furthermore, urban forestry should be embedded into **mainstream policies**, planning and management practice.

1. INTRODUCTION

This chapter first sets the scene. It explains what urban forests are, provides a definition of urban forestry and what urban forestry entails. It highlights the existing policy frameworks and identifies the need to increase general awareness of urban forestry.

1.1 ABOUT THIS DOCUMENT

This document aims to provide background and guidelines for developing an **Urban Forestry Action Plan** based on an overview of the status, benefits and potential opportunities for developing urban forestry at a European scale. It has been prepared collaboratively through the UForest Project co-funded by the Erasmus+ Programme of the European Commission. The guidelines are aimed principally at non-specialist audiences who wish to gain a quick overview of the enormous potential offered by urban forestry to solve social, economic and environmental challenges in cities in alignment with global Sustainable Development Goals (SDGs). In this respect, the document will be of particular interest and relevance to **policymakers working at national, local and European level**, officers working at local authorities.

1.2 WHAT IS URBAN FORESTRY?

Urban areas are dynamic, socio-ecological systems capable of evolving to survive. In the face of climate change, cities need to build resilience through adaptation, mitigation and disaster risk reduction measures to continue offering multiple benefits and services to their inhabitants. In this sense, increasing and enhancing the presence of trees and other vegetation in cities can contribute to urban resilience.

Green Infrastructure approaches, which focus upon planned networks of natural and semi-natural areas, reflect the need to look at the whole urban and peri-urban environment, moving away from a focus on individual spaces. It is through a well connected and well functioning green and blue network that the multiple benefits of ecosystem services for human livelihoods can be generated. Urban forests are crucial contributors to greener, healthier, more resilient and liveable cities.

The concept of urban forests, defined as **all forest stands and other tree dominated vegetation in and near urban areas**, differs from other urban greenspace concepts through its focus on forests and trees as key components. This part of the urban ecosystem is the focus of the **integrated, interdisciplinary, participatory and strategic approach to planning and managing tree resources in urban areas for their economic, environmental and socio-cultural benefits**. Urban forestry is still relatively young as a well defined field of its own, as the concept was officially coined in North America in the mid-1960s. It has seen rapid growth over the years, however, in terms of policy, practice, research, and education, it is now a globally recognised approach, even though a precise translation of the term into national languages can sometimes be challenging.

Reference is often made to both urban and peri-urban contexts, with the forest cover usually being higher in peri-urban areas than in urban areas. Urban forestry builds upon a legacy of centuries, with many European cities having owned and managed forest areas for the provision of food, fodder, medicines, drinking water, fuel, recreational opportunities, clean air and building materials

[1] https://www.uforest.eu

since the 1800s, leading to a strong European tradition of 'city forests'. Urban tree planting and the establishment of urban parks also have a long history. However, through taking a long-term and integrative view of all forests, trees, and associated vegetation in cities, and by applying a socio-ecological systems perspective, innovation can be introduced through an urban forestry perspective. The city or metropolitan area is thus seen from the perspective of integrated ecological, social, economic and political systems, with forests and trees playing a central role. The integrated approach connects across the urban green infrastructure, from single trees to extensively forested areas, enabling a more coordinated and sustainable management approach.

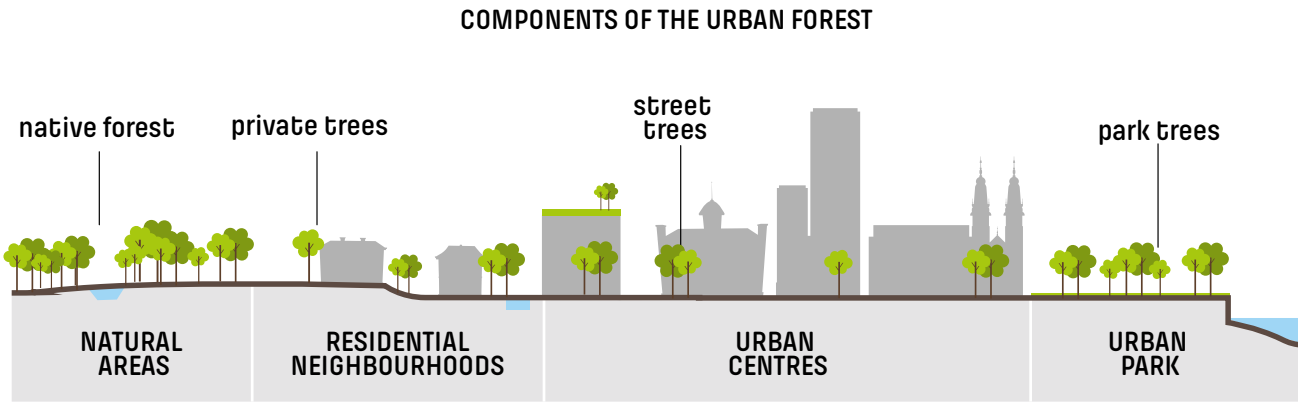


Figure 1: Components of urban forests. Adapted from City of Vancouver and Vancouver Park Board, 2018.

Urban forestry is concerned with all urban forests, classified by the Food and Agriculture Organisation of the United Nations (FAO) into five types: **peri-urban forests, city parks and urban forests (> 0.5 ha), pocket parks and gardens with trees (< 0.5 ha), trees on streets and public squares, and other green spaces such as botanical gardens, urban agricultural plots or riverbanks**[2]. The woodland part of the urban forest is a very important component, as it provides a series of key ecosystem services.

For urban forestry to be successful it needs to have a long-term focus on the sustainable management of urban forest resources and a continuous provision of ecosystem services, not only for today's urban communities, but also for future generations. While seeking to optimise and harness the psychological, sociological, aesthetic, economic, and environmental benefits provided to society, urban forestry should strive to minimise potential negative aspects such as allergies and safety concerns that may limit the recreational use of urban forests.

[2] FAO, 2016

1.3 POLICY FRAMEWORK

Urban forests are a building block of urban green infrastructure and urban green space worldwide. As such, urban forestry is an integral part of **SDG 11 – Make cities and human settlements inclusive, safe, resilient and sustainable. Target 11.7** is particularly of importance: **Provide access to safe and inclusive green and public spaces**. Similarly, the **UN's 2016 New Urban Agenda** calls for cities and human settlements that prioritise safe, inclusive, accessible, green and quality public spaces, and the **UN Decade on Ecosystem Restoration** includes the restoration of urban ecosystems, for the multiple benefits they have for citizens.

An important emerging EU policy framework is the **EU Green Deal** and, comprising both the EU 2030 Biodiversity Strategy and Forest Strategy, it recognise the important benefits of urban forests and urban trees, including cooling urban areas and mitigating the impacts of climate change and natural disasters. The **EU 2030 Biodiversity Strategy** not only calls for planting at least 3 billion additional trees in the EU by 2030, with cities being an important focal point for this action but also aims to reverse the loss of green urban ecosystems. The Biodiversity Strategy calls for a systematic integration of urban ecosystems and NBS into urban planning, and the design of buildings and their surroundings. Aligned with this strategy, the EC has called on all European cities to develop Urban Greening Plans, with a Green City Accords movement to facilitate the implementation of measures to create biodiverse and accessible urban forests and improve connections between green spaces.

The **EU 2030 Forest Strategy** is more specific on the 3 Billion Tree Pledge, by stating that the trees should be planted in full respect of ecological principles, and that the right tree should be planted in the right place and for the right purpose. The EU Forest Strategy further stipulates that reforestation and afforestation should mainly take place in urban and peri-urban areas, and agricultural areas to support new agroforestry systems (where trees and agricultural crops or pastures occupy the same land). It thus refers to the potential of forests as being one of the most effective climate change and disaster risk mitigation strategies, and to the socio-economic and health benefits of green and forested areas.

At the level of the European Member States, or their regions, urban forests are not usually classified as a particular type of forest in their own right. However, multiple **local, regional, national and multilateral initiatives** have been developed to emphasise the importance of urban forests and urban trees. These include initiatives by the FAO, the UNECE, European Committee of the Regions and the World Health Organisation (WHO), but also initiatives such as Trees for Cities, Cities4Forest and CitiesWithNature.

Moreover, the demand for NBS, such as those delivered by urban forests, is increasing globally, as a result of their mainstreaming into international policy and through the **initiatives of businesses, citizens, and others** recognising the benefits they offer. **Nature-Based Solutions (NBS)** have immense economic potential in the shift towards a nature-positive, carbon-neutral and equitable economy[3]. Investment and support are needed for developing NBS market sectors, in which urban forestry is identified as one of the subsectors. The potential of NBS to contribute to socio-economic development has been recognised in European policies within the **Green Deal**, such as the **2030 Biodiversity Strategy**, and internationally through organisations such as International Union for

[3] McQuaid et al., 2022

Conservation of Nature (IUCN), the **United Nations Environment Programme (UNEP)** and the **World Economic Forum (WEF)**.

Urban forestry is bound to play an even more significant role on urban ecosystems health and citizens' wellbeing after the approval of the 2030 Agenda for Sustainable Development by the UN. As recognized by the United Nations Economic Commission for Europe (UNECE) and FAO during the **UNECE 2022 Regional Forum on Sustainable Development**, urban forestry is key to the achievement of the SDGs by increasing the sustainability of cities and urban communities, providing food and clean water, increasing incomes and job opportunities, promoting outdoor recreation activities, cleaning the air, producing renewable energy, contributing to climate change mitigation and adaptation, improving soil quality, hosting biodiversity, and fostering a green economy, among others.

1.4 CO-BUILDING KNOWLEDGE IN URBAN FORESTRY

Urban forestry is a **highly interdisciplinary field**, drawing upon the natural and social sciences and humanities. Integrating this interdisciplinary focus within education and training to ensure the full potential of urban forestry is effectively realised is an important but challenging task.

Urban forestry has the potential of delivering lasting and tangible benefits across diverse social groups across a range of environmental, economic and cultural settings. A recently concluded survey by the Uforest project revealed that urban forests are widely acknowledged as a source of NBS which offers great prospects for innovation . Despite this, **urban forestry concepts are still not that widely acknowledged in many European countries**. Forestry is still frequently associated with wood production in rural areas, and is less frequently linked in the public mindset with the direct provision of quality-of-life benefits and the delivery of diverse ecosystem services for the urban population.

The **diverse aspects of urban forestry may not considered by those envisaging a career within the field**. Some of the aspects include, for example, the green economy, innovation, entrepreneurship, social economy and social equity. But there is **great potential for incorporating new topics into urban forestry education programmes** including: marketing, emerging technologies, urban design, environmental justice, socio-economics, governance and policy integration.

Current gaps in terms of knowledge and awareness also relate to the economic dimension of urban forestry, such as the provision and valuation of Non-Timber Forest Products (NTFP), assessing alternative forest management scenarios in terms of ecosystem service delivery and developing marketing strategies for trading ecosystem services.

Finally, it must be stressed that **communication skills are key in urban forestry**. In combination with rapidly developing information and communication technologies (ICT), there is great potential for strengthening education and practice through co-building knowledge. Communicating interdisciplinary approaches in urban forestry will be crucial to enhancing its impact. Cross cutting communication approaches (arts, storytelling, urban forest pedagogy, permaculture, artificial intelligence or connecting technology with urban nature) are relevant to innovative urban forestry dissemination. At the same time, there is a need for developing skills related to social aspects, including leadership, public participation and environmental equity in order to build capacity to co-delivering the urban forest through local partnership initiatives.

[4] Basnou et al., 2021

2. WHY DO URBAN TREES AND URBAN FORESTS MATTER?

This chapter highlights benefits provided by urban forests classified into three broad categories: environmental, social and economic benefits. Although urban forests generally have a positive impact, this section also briefly mentions the disservices which can arise.

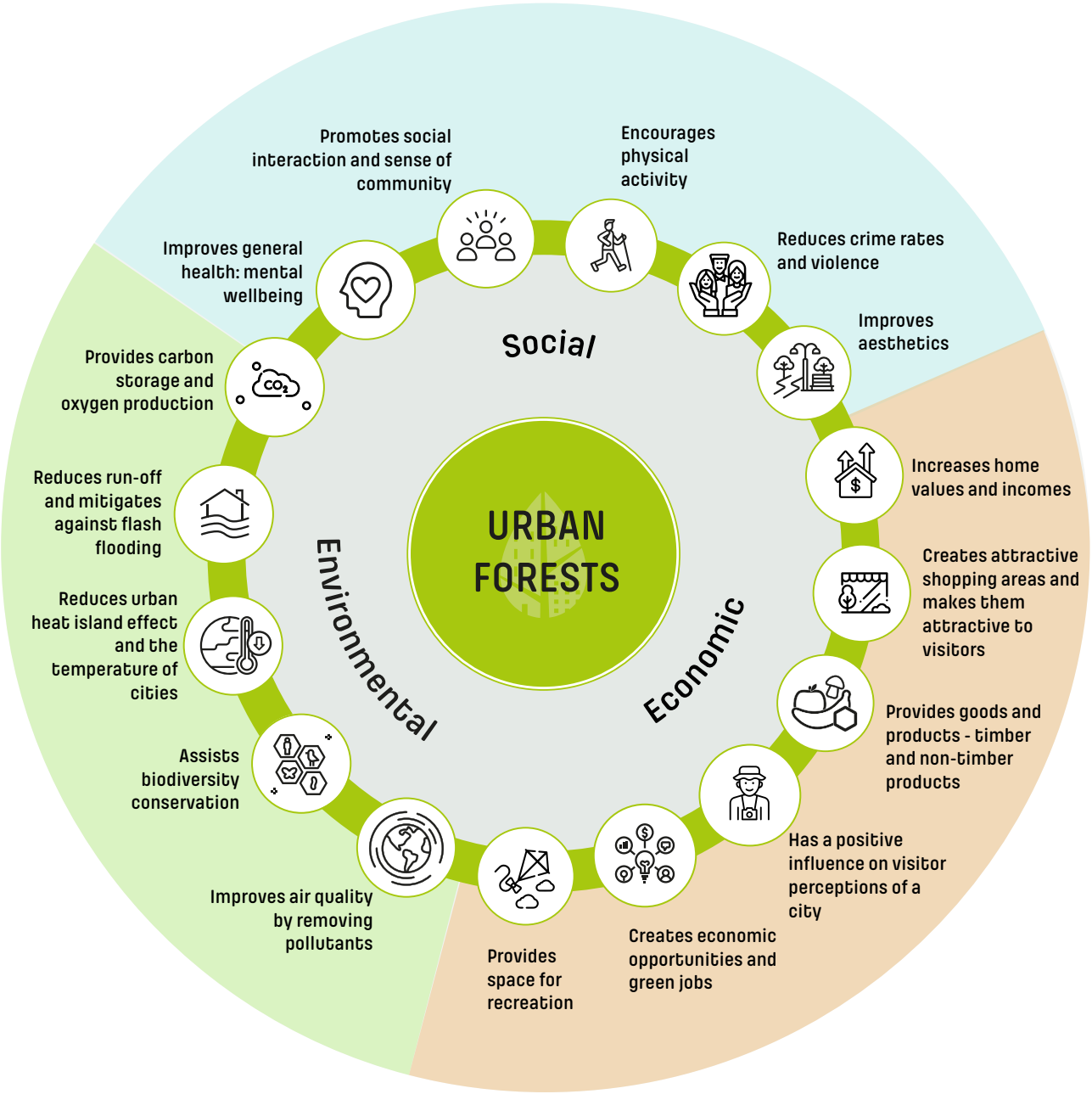


Figure 2: Multi-faceted benefits of urban forests. Adapted from UNECE, 2021.

2.1 ENVIRONMENTAL BENEFITS

Urban forests are the cornerstone of biodiversity conservation, ecosystem restoration, the maintenance of ecological function and the provision of ecosystem services to the population. Urban forests can be diverse; they often include remnants of pre-existing forests, historic parklands and newly planted areas and gardens with significant tree-cover. However, their capacity for biodiversity conservation varies greatly according to their structure and composition, degree of naturalness, extent and connectivity. The delicate balance between biodiversity and recreational demands in urban ecosystems calls for careful management to deliver maximum benefits.

Urban forests can maximise connectivity, ecosystem function and resilience if well planned and properly executed. Although they are sometimes simplified ecosystems dominated by generalist species with a wide geographical distribution, they can also include **biodiversity hotspots**, such as ancient woodland habitats or individual veteran trees supporting rare invertebrate and fungal species. Urban forests should be considered as a part of a wider habitat network, through adopting holistic Green Infrastructure principles, with the aim of maximising their potential for delivering biodiversity gain in tandem with other diverse environmental and social benefits.

According to the Common International Classification of Ecosystem Services, ecosystem services provided by urban forests mostly belong to the regulation and leisure categories, whilst provisioning (e.g. timber, non-wood products) generally plays a secondary role. Urban forests play a key role in **mitigating and adapting to local impacts of climate change**, thereby r**educing the costs of cooling buildings** and improving urban residents' quality of life[5]. Trees reduce day and night-time temperatures during hot periods through transpiration and provision of shade. A few trees can significantly improve the urban environment and can successfully **reduce the urban heat island effect** in cities, since trees shade streets and footpaths and their leaves reflect more sunlight and absorb less heat compared to buildings and synthetic materials. Transpiration on the other hand, allows the plants to draw water from the soil and release moisture through their leaves into the air. Depending on the ground surface, tree size, density and typology, shade from trees can cool the ground surface by more than 15C°, mostly through transpiration effects.

Urban forests contribute to **improving air quality by removing air pollutants and offsetting carbon emissions**. Trees are able to remove carbon dioxide (CO2), nitrous oxides (NO2), sulphur dioxide (SO2), carbon monoxide (CO) and ozone (O3) from the atmosphere and give off oxygen. Studies have shown that a typical mature tree can store as much as 10 tonnes of carbon[6]. However, this depends upon many factors, such as tree health, soil moisture availability, the foliage duration, the leaf area index (LAI), meteorology, and pollution levels. Research from Barcelona has shown that the contribution of urban forests to abating pollution is substantial in absolute terms, although modest compared to overall city levels of air pollution[7].

Urban forest planting to abate pollution must therefore be linked to wider environmental strategies. It should also be considered as part of a wider package of measures to reduce atmospheric pollution. These should include lower emissions targets and greater use of everyday non-polluting technologies for transport, heating and power generation.

[5] Konijnendijk van den Bosch et al. 2005
[6] Nowak, 2000
[7] Baró et al., 2014

Tree canopies intercept and mitigate the impact of heavy rainfall, hence **reducing stormwater flows and mitigating against flash floods**. Green roofs retain rainwater, filter the water that does run off, and delay the time at which runoff occurs, reducing the stress on sewerage systems at peak flow periods. The roots of the trees reduce the content of nitrogen, phosphorus and heavy metal in stormwater runoff, thus reducing pollution effects downstream.

2.2 SOCIAL BENEFITS

Urban forests can **foster community interaction and improve social cohesion**, thus ensuring greater levels of wellbeing within communities. The provision of dedicated places for people to meet, exercise and socialise can counteract loneliness and isolation. Spending time outdoors also strengthens social connections, lowers early mortality and reduces depression and anxiety symptoms, whilst improving physical health. Activities undertaken within woodlands and parks, not only foster social interactions and promote a sense of community, but also support meaningful connections with nature.

Nature and plants in urban areas are essential elements in helping create a **"sense of place", spirituality, shared purpose and mutual interest**. The benefits of green space on people's sense of connection to a place directly affects their social development and sense of self-confidence. Natural elements create deep emotional bonds with the local environment, thereby providing meaning and a sense of belonging. This results in community involvement leading to an increased sense of local ownership and responsibility. The use of native plants also helps people to connect directly with the ecological and cultural heritage of a place.

Moreover, there is increasing evidence suggesting that exposing children from an early age to natural settings may have long-lasting benefits in terms of pro-environmental behaviour in later years, cognitive development and physical health. This helps to create the foundations for a resilient generation and avoidance of so-called "nature deficit disorder". Urban forests should therefore be valued as powerful tools to provide ready-made and inclusive opportunities to connect with nature and other people. Properly designed and well-maintained green spaces can also **deter antisocial behaviour**, thereby creating safe and secure spaces for a wider community. To achieve this, it is crucial to engage with the community from the outset and to encourage residents and businesses in the area to become actively involved in urban forestry planning, use and management.

It is commonly observed that property prices are higher in many cities near urban parks and greenspaces, reflecting the increased value placed upon living in attractive leafy environments. However, this phenomenon can also lead to gentrification and inequality. It is therefore important to carefully consider ways to reduce such social inequality through urban forestry programmes. The distribution of green spaces should provide a diverse, connected network of green spaces throughout the city, with **associated equity of access to all citizens**, with urban planning ensuring housing stability and managing the impacts of green gentrification.

If effectively managed, urban forests and urban greenspaces can play a significant role in **supporting public health through reducing health inequalities**. Recent research has shown that disadvantaged groups may derive greater health benefits from public green spaces, as they may lack other opportunities for exercise and contact with nature. Wealthier social groups, by contrast, are more likely to have access to private gardens, sports facilities or more convenient access to out-of-town countryside areas through car ownership.

Urban forestry can also **improve physical and psychological health and wellbeing** of urban residents. The main mechanisms (or pathways) which allow contact with nature to positively influence human health are:

- **mitigation**: reduction of harm such as reduced exposure to noise, air pollution and excessive heat,
- **restoration:** recovery from stress through psychological relaxation, reduced negative thoughts and restoration from attentional deficit, and
- **connectedness:** promotion of positive outcomes such as providing enhanced opportunities for physical activity and encouraging nature connectedness[8].

In addition to these benefits, evidence-based research suggests that spending time in woodlands and forests might offer additional advantages. Trees, particularly pine, spruce and fir, are emitters of powerful biogenic volatile organic compounds (BVOCs) known as forest aerosols. Breathing in these compounds, even for short periods of exposure, has been found to assist **psychological relaxation and boost the immune system** . Exposure for as low as two hours in the forest has been reported to decrease the levels of the stress causing hormone known as cortisol . Furthermore, direct exposure to healthy forest microbiota through touching, inhaling and ingestion, can protect against allergies and autoimmune diseases. Sensory experiences such as encounters with wildlife, appreciating natural textures and hearing woodland bird songs can also be effective in **restoring attention and improving mental health**.

It is important to bear in mind that many health and wellbeing effects of forest exposure are non-specific; a visit to the forest generates a general state of increased health but is not comparable with the effects produced by a specific medicine. Nevertheless, every experience in a forest is invaluable for human wellbeing. In recent years, forest-based wellbeing approaches and therapies such as **"forest bathing"** have become increasingly popular, having initially developed in East Asian countries such as Japan and Republic of South Korea.

2.3 ECONOMIC BENEFITS

Urban forests provide significant economic benefits through different ecosystem goods and services. These represent the benefits human populations derive, directly or indirectly, from ecosystem functions. Indirect economic benefits of urban forests include reduced expenditure (for example, related to public health and wellbeing benefits), climate change mitigation or biodiversity benefits. However, in this section, we focus on direct economic benefits.

Green cities with a high percentage and diversity of tree cover can benefit from **increased property values and stimulate inward investment** within urban areas (aesthetic and amenity benefits). The effects of trees on property sale prices were found to range between €7 and €165 per tree per year. For example, in Utrecht, the Netherlands, urban nature interventions (including creating urban parks, neighbourhood greenspaces and adapting canals for a sustainable drainage system) have increased local property values up to 20%, compared with properties which are not affected by green interventions. In Perth, Australia, it was found that presence of broad-leaved street trees increased the median property price by over 4%. The presence of trees and green spaces attracts new residents, tourists and businesses, whilst generally **increasing footfall** (the number of people visiting shops) within the area. Increasing property values, can of course, also have negative

impacts through increasing social inequality, reducing access to the housing market for those on lower incomes and assisting the process of gentrification.

Urban trees and forests provide multiple **regulating benefits** that can be translated into economic benefits. **Tree shading/cooling benefits** can result in energy savings due to reduced use of air conditioning. Annual economic benefits for this are valued at €4 to €166 per tree. **Water regulating benefits** due to rainfall interception by the canopies of individual trees, which range from 0.3 to 11 m3 per tree. When translated into stormwater mitigation costs, the annual economic benefit due to carbon capture from the atmosphere ranged from €0.35 to €13.40 per tree.

In addition, the increased involvement of the private sector and community organisations in delivering NBS has a great potential to contribute to **sustainable economic development. In general, the economic benefits of NBS consider new innovations, including social innovations, new enterprise creation, the upscaling of existing enterprises, skills development and job creation**.

Urban forests are part of multiple economic activities:

- **NBS for urban landscapes:** landscape planning and design, co-creation of green areas, implementation and management of green areas, etc;
- **sustainable forestry:**
  - **wood products:** using timber from sustainably managed urban forests for example Sonian Wood Coop Case Study (Annex 1);
  - **Non-Timber Forest Products (NTFP),** including food (edible landscapes): wild foods, berries, mushrooms, game, etc;
  - **related services:** forest management, planning, and inventory, tree planting initiatives, etc;
- **smart technology:** data science applications and geospatial tools (such as satellite imagery, environmental sensors, and data analytics) for monitoring and improving the efficacy of NBS;
- **sustainable tourism:** recreation charges, fees to enter botanical gardens, spending in local businesses, etc;
- **health and wellbeing:** forest-based therapy and forest care initiatives;
- **employment:** job creation in the green sector. A study from the United States found out that 0.5 million people are employed in urban forestry activities[11].

BOX 1

CASE STUDY - POCKET FORESTS, DUBLIN, IRELAND

Pocket Forests was founded in 2020 as a nature based social enterprise to plant compact urban forests in Dublin and its surrounding areas. Based on the 1970s concept of **'tiny forests' by botanist Akira Miyawaki**, this initiative brings lush miniature forest ecosystems to neighbourhoods and gardens by creating dense, fast-growing, self-sustaining native woodlands in tight urban spaces, from 6m^2 up to 100m^2.

The 'tiny forests' methodology, allows for the establishment of small woodlands in under a year. The project works in partnership with The Digital Hub, and have installed the Pocket Forests Tree Hub, **Ireland's first native tree nursery** in a city centre location.

Source: www.pocketforests.ie

[11] Thomson et al., 2021

2.4 ECOSYSTEM DISSERVICES (EDS)

As much as urban forests provide a wide array of benefits as shown in sections 2.1 to 2.3 above, we cannot disregard the negative effects arising from the same which are unwanted or undesirable because they can be socially, economically or physically harmful. Ecosystem disservices (EDS) are "functions of ecosystems that are perceived as negative for human wellbeing"[12],[13]. However, overly focusing on perceived ecosystem disservices can preoccupy stakeholders to a disproportionate level and can exert undue influence upon policy and planning decisions. We therefore need to understand what these disservices are, their impacts and how we might realistically mitigate them. Some of the most common ecosystem disservices include:

- **health and safety impacts**: can include tree pollen allergies, dermatitis, avian influenza transmitted by migratory birds and poisoning by ingestion. Additionally, air pollution from biogenic volatile organic compounds (BVOCs) can contribute to urban smog and ozone problems through CO2 and O3 emissions. Physical injuries from falling trees or tree parts during storms, pest outbreaks (e.g., rats or other pathogenic vectors) are amongst other hazards;
- **mobility and infrastructure**: Some trees have strong and extensive root systems which can damage buildings, underground services and pavements. Additional damage can result from nesting animals, microbial activity causing decomposition of woodwork, the corrosion of stone buildings or damage to statues, cars or surfaces by bird droppings. Parts of the trees, fallen trees and roots can act as obstacles blocking views, light, movement and creating general inconvenience;
- **financial:** There are direct costs related to forest management (e.g., removing fallen trees and branches, clean up, damage, repairs), maintenance (e.g., watering, pruning), risk management and healthcare costs;
- **informal and illicit activities:** Vegetation evokes the fear that it provides a space for marginalised, stigmatised or criminal behaviour, such as drug use, theft, prostitution, or vandalism. Urban forests can also become locations for fly-tipping;
- **aesthetics:** Some people consider "wild areas" to be unsightly and unmanaged. They might perceive deadwood, tree stumps, veteran trees, fallen fruit, leaves and "weed" species from a negative perspective;
- **environmental:** Pollution and energy use are associated with management activities which often require fossil fuels;
- **gentrification and inequality:** There are also potential negative effects of increasing property value.

Other disservices include habitat competition with humans due to an increase in the populations of wild animals, insects or invasive plant species. In recent years there have been concerns about the increase in wild boar and wolf populations across Europe and perceived risks that they could create for people. Wild boar, for example, are routinely seen in urban parks in large cities such as Berlin. Similarly, non-native plant species such as Japanese knotweed can quickly become established and spread through woodlands.

[12] Lyytimäki, 2017
[13] Shuyao et al., 2021

3. IS URBAN FORESTRY COST EFFICIENT?

Urban forestry as a Nature Based Solution (NBS) provides a set of integrated and multifunctional outcomes which can be cost effective. However, there are also other potential mechanisms for delivering some of these outcomes. This chapter briefly highlights examples of costs and benefits of urban forests from different cities to justify that urban forests are cost effective.

The environmental, social and economic benefits provided by urban forests benefit a wide range of stakeholders ranging from the local residents, private companies, national and local governments, as well as the society at large. Residents and private companies directly benefit through provision of regulating services and products such as fuelwood, crops, and timber. National and local governments and society at large also depend on urban forests to regulate the functioning of ecosystems, but they can also directly benefit from the goods and services.

Urban forests can be regarded as effective NBS for delivering multiple benefits for human wellbeing and biodiversity, but we should also consider whether they are cost-efficient solutions to urban problems. Even though the multifunctionality of urban forestry is one of its key strengths, the diverse benefits that urban forests deliver need to be weighed against the costs of establishing, maintaining and managing these resources. Their cost efficiency against expensive engineered solutions to urban problems such as water management, also should be considered.

Economic valuation helps to place a monetary value on ecosystem goods and services and puts ecological and biodiversity values on an equal footing with other economic benefits and costs. This presents a challenge, as some of the benefits of urban forests and trees are less tangible and are delivered across a wide cross-section of society, whilst not being accrued directly by the managers of the forest resources themselves. We therefore need to consider urban forests as resources which provide a greater common good; in this respect, they "punch above their weight" in terms of the overall value of the goods and services they deliver.

URBAN FORESTRY COSTS

Managing urban forests can be expensive and has its associated costs, as shown in Figure 3. These include planting and protection of young trees, ongoing maintenance, public safety and liability issues, management costs related to ecological disturbances (e.g., removing fallen trees and branches, clean up, damage repairs), risk management, harvesting operations and the creation of inclusive facilities for public access and enjoyment.

However, these need to be considered as investments which go beyond their immediate financial value as an asset, as urban forests appreciate in value over time, offering long-term, wide-ranging assets and services. Moreover, their multidimensional quality allows for funding schemes that are shared by diverse government areas e.g., environment and health departments and public-private collaboration.

TREE ESTABLISHMENT & MANAGEMENT costs

- land aquisition/agreements
- ground preparation
- planting
- tree protection
- weeding/watering
- pruning thinning and harvesting
- monitoring (tree health)

ADMINISTRATIVE costs

- staff time
- planning and design
- funding applications and reporting
- project management and tendering
- training
- public liabilities
- health and safety

PUBLIC ACCESS INFRASTRUCTURE costs

- information and signage
- paths and public access provision
- wildlife management
- infrastructure repairs
- public consultation
- education programmes

Figure 3: Costs related to urban forestry.

EXAMPLES OF COST BENEFIT ANALYSIS OF URBAN FORESTRY

Urban forestry creates a positive return on investment. Studies have been undertaken on the cost/benefit analysis of urban forestry. These consider the wider provision of ecosystem services such as employment, climate change mitigation and cooling effects, or in terms of the wider health and wellbeing benefits that urban forests provide. A few examples are provided below.

BOX 2
COST BENEFIT ANALYSIS OF THE CITY OF LISBON

A study on the City of Lisbon showed that the City's 40,000 street trees **provide services worth €8.4 million annually**, whilst the cost of maintaining the trees has been €1.9 million per year.

This means that for every euro invested in tree management, **residents have received €4.5** in terms of energy savings, cleaner air, increased property value, reduced stormwater runoff and CO^2 sequestration.

€ 8,4 million of services
€ 1 invested = € 4,5 received

Source: Soares et al., 2011

BOX 3
COST BENEFIT ANALYSIS STUDY OF CITY OF PITTSBURGH

€ 2,4 million of services
€ 1 invested = € 3 received

Some US cities report even greater return on investments with New York City and Indianapolis showing benefits equating to a six-fold return upon initial investment.

A cost benefit analysis carried out in the City of Pittsburgh showed that the benefits from almost 30,000 street trees in the city are estimated to be three-fold in stormwater runoff reductions, energy savings, atmospheric CO^2 reductions, and other benefits.

The trees provide approximately **€2.4 million (€80 per tree) in annual gross benefits**. Taking into account the costs involved in managing this resource, Pittsburgh's street trees provide **€1.6 million (€53 per tree) in net annual benefits**. The citizens of Pittsburgh therefore **receive nearly €3** in benefits for every €1 spent on management.

Source: City of Pittsburgh, 2008

BOX 4
COST BENEFIT ANALYSIS EXAMPLE FROM THE UNITED KINGDOM

€ 2,5 million of services
€ 1 invested = € 5,6 received

Figures from the UK on the economic benefits of trees and woodlands have revealed a tenfold return on investment. Although these figures are impressive they tend to focus on some of the more obvious direct benefits of urban forestry. Other studies, however, have evaluated the more intangible and indirect benefits particularly regarding health outcomes and the wider wellbeing benefits derived for the population.

An evaluation of Forestry Commission Scotland's WIAT (Woods in and Around Towns) Challenge Fund found that **€2.5 million invested in urban forestry** per annum resulted in health and recreation benefits equating to a value of €14 million. This also considered the impact of savings in conventional healthcare budgets realised through improving the overall health and mental wellbeing of the urban population.

Source: Forestry Commission Scotland, 2015 [14]

[14] https://forestry.gov.scot/publications/300-the-urban-forest/viewdocument/300

Other benefits from urban forestry can include financial leverage and additional help in kind generated through volunteering activity, which can be accorded a financial value according to person days. Extensive experience from the UK[14] indicates that core funding for urban forestry can effectively be used as leverage for acquisition of additional targeted resources from public and private funders. This requires effective mentoring organisations which possess good partnership working capability, mentoring skills and outreach capacity. This additional leverage generated and its ability to add considerable value, beyond the original investment of public or private funding, must be considered one of the key strengths of multi-stakeholder urban forestry projects.

In this respect, when considering the relative cost/benefits of urban forestry we have to think outside the traditional box and recognise the significant and overall added value and the multiplier effect of urban forestry. This might mean creativity in terms of how resources are accessed, including from non-traditional sources such as tapping into healthcare budgets, voluntary efforts from civil society organisations, crowdfunding initiatives and payments for delivering ecosystem services including carbon sequestration through urban "rewilding" projects.

This creates both opportunities and challenges, to ensure that the diverse range of benefits provided are recorded and that the range of outcomes is acknowledged by policy makers. Through such approaches, and given the enormous potential for leverage and added value, the overall costs of implementing urban forestry programmes should be regarded as minimal given the enormous societal value that can result. As illustrated above, many urban forest projects generate a positive return on investment.

Berlin, DE - credits Ian Whitehead

4. DEVELOPING THE ACTION PLAN

This chapter sheds light on how to develop a plan for urban forestry projects by defining overall principles. Whilst it is necessary to adapt approaches to local circumstances, the chapter proposes 7 steps for developing an Urban Forestry Action Plan: these include societal needs assessment, mapping of forest resources, defining principles and establishing goals, developing detailed proposals, the implementation, monitoring and communicating urban forestry.

DEVELOPING AN URBAN FORESTRY ACTION PLAN

Figure 4: Steps involved in developing an Urban Forestry Action Plan

STEP 1: ASSESSING SOCIETAL NEEDS

It is imperative to ensure that any proposed urban forestry initiative meets the needs and interests of stakeholders, particularly local citizens. Although this might require significant time input, developing and identifying outcomes that benefit the society will create a strong sense of shared vision amongst participants and will ultimately ensure successful implementation, appreciation and use. This process can be broken down into five broad components as described below.

Define the objectives of the assessment

The rationale for conducting the needs assessment should be clear from the outset and objectives must be realistic and achievable. Activities should respond to the key questions about the project.

- How are existing urban forests and trees used and perceived by the public?
- What urban forest and greenspace resources do local people value?
- Is greenspace provision currently adequate, equitable and geographically distributed?
- How should the urban forest be managed to maximise benefits, and for whom?
- What conflicts or gaps exist?
- Are there tensions and contradictions between social groups?
- What problems and disservices exist and how might these be resolved?

It might also happen that the needs assessment provides unexpected answers or new insights.

Determine your stakeholders

Stakeholders refer to people whose needs the proposed project intends to address, or who, in some way, will have an interest or will be affected by the initiative. Defining this group correctly creates an understanding of any gaps that exist and identifying who needs to be involved. This might include, for example: local residents, schools, youth groups, sports clubs, naturalist societies, dog walkers or other people who use the greenspaces regularly including occasional users/non users, and socially marginalised groups.

Figure 5: Urban forestry stakeholders and actors. Adapted from FAO, 2016.

The stakeholders can be identified through desktop research or participatory workshops among many other methods. Their composition, activities, credibility, key contact points, etc need to be identified. The next crucial step is the prioritisation: all stakeholders are important and valuable, but you always need to keep in mind your objectives and prioritise stakeholders that are more directly involved and useful for your assessment. Some criteria to rank your stakeholders are visibility, relevance, power, credibility, influence and availability.

Following the identification of your stakeholders group, and with reference to the available resources, the next step is to reach out to them. The challenge is to work out the best means of communication and the places to most easily reach these groups, and the techniques to engage and involve them in the assessment.

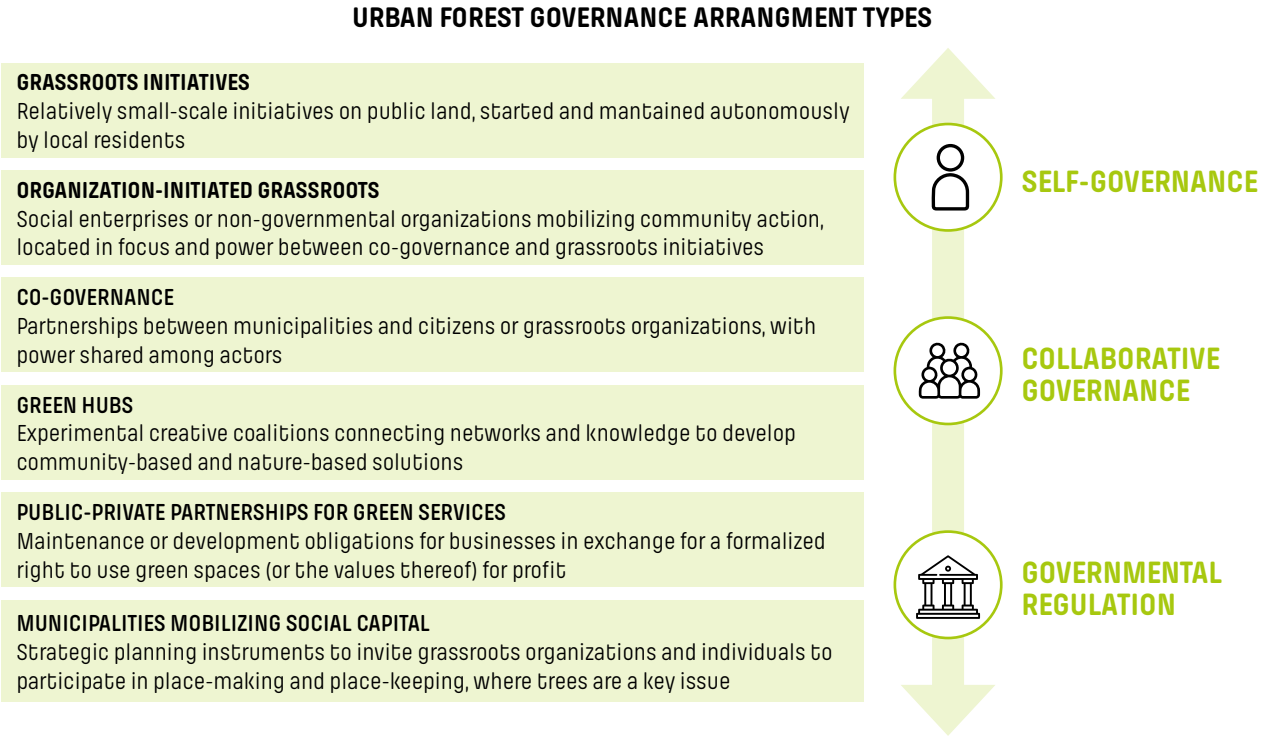


Figure 6: Urban Forest Governance arrangement types. Adapted from FAO, 2016.

Determine the available resources

The availability of resources is essential as it has a considerable impact on the needs assessment methodology and activities you are able to conduct. You should work out how much time, funding and staff resources are available for gathering information. Are professional facilitators required or might existing staff of the key partners involved fulfil these roles? It's worth considering alternative ways to gather data through involving and mobilising local people themselves in the process. Inclusive approaches such as participatory appraisal and action research have become increasingly popular in recent years and have the added benefit of developing local capacity, encouraging participation and creating a sense of local ownership.

Data collection

The data and information collected can provide the basis for the project to be developed. Quantitative information from governmental organisations can be supplemented with qualitative research which captures the thoughts, concerns and knowledge of local community members. A wide range of methods are available depending on the information you want to collect and availability of resources. Examples might include: informal interviews, focus groups, surveys, public fora, exploratory walks, participatory mapping and direct observation.

Analysis of findings

Patterns and trends from your data should be analysed to identify the key points and the gaps present. Recurring themes provide insights on how to tailor an urban forestry initiative to deliver positive outcomes and solutions. Also, check whether there are existing opportunities that can be built upon, such as existing local projects or specialist expertise within the community. Always consider, especially when stakeholders have been directly engaged during the previous steps, to validate the results of your analysis through participatory workshops, where your stakeholders can discuss, vote and integrate your results.

STEP 2: MAPPING AND AUDITING UF RESOURCES

The ability to map an urban forest accurately over time, facilitates better planning by decision-makers and residents of where to plant new trees, which species are better suited for the local context, and how to optimise conservation and management of existing woodland and street trees. A map of all trees within the city can provide a detailed, real-time inventory and help to determine future needs and spatial distribution of the urban forest. This can include identifying areas of deficit and concerns such as tree health. Whenever possible, inventories should also include trees on private and institutional ground, as these make up a major component of the urban forest, typically 50-70% of the urban forest stock.

Urban forest mapping allows assessment of the current status and thereby lays the ground for analysis and planning, constituting the basis of sustainable urban forest management. Planners need to overlap data sets with other environmental and demographic layers, such as income, poverty indicators, diseases, heat islands and flood zones. In this way we can establish a clearer relationship between urban forestry and resilient communities. Mapping of green infrastructure requires specialised methods which are able to provide precise results. It is also essential as urban areas are high-pressure, dynamic areas where changes occur frequently. Some useful mapping tools are as follows; many of these being freely available:

Tools and software (EO, LiDAR, Google Earth, QGIS)

Earth Observation (EO) Browser

Makes it possible to browse and compare full resolution satellite images from diverse data sources. Users can choose a time range and cloud coverage based upon an area of interest, then view the results in the browser. It allows downloading of high-resolution images, experimentation with different visualisations, and creation of time-lapse sequences.

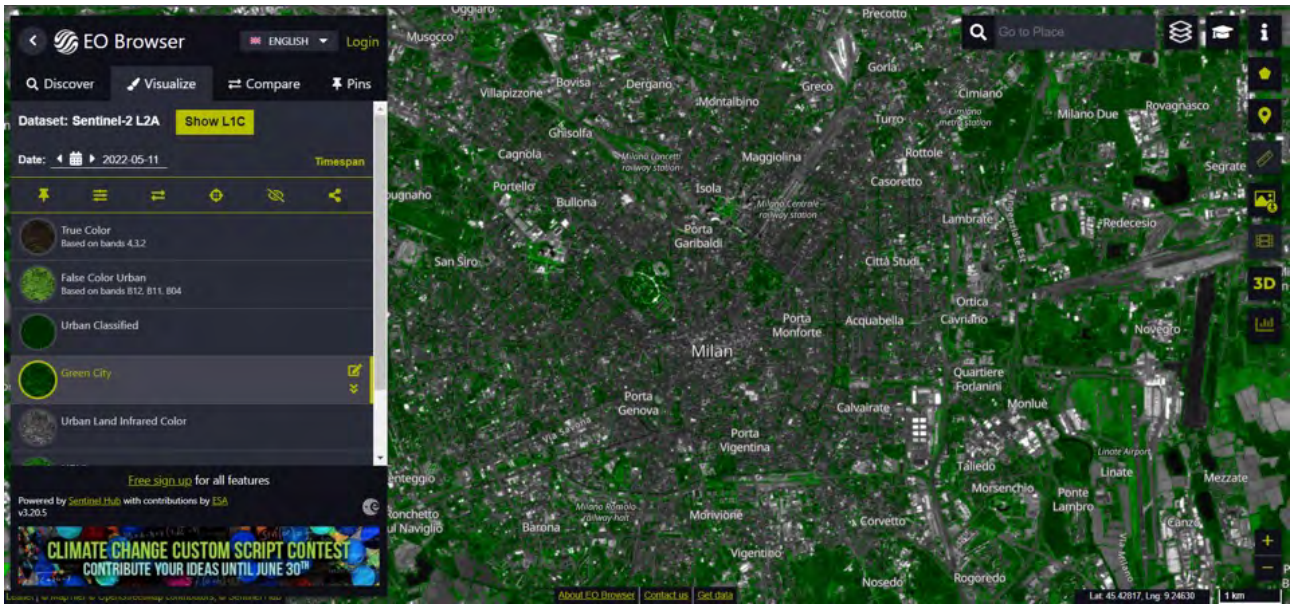


Figure 7: Earth Observer Browser. ©Earth Observer

LiDAR

LiDAR devices are used to map entire streets, construction areas, parks, street trees and other assets. LiDAR can map all identified features into the form of a 3D stereo image. It can identify trees, water features and other types of greenspace present and assist future planning of an area. LiDAR provides high resolution data on forest tree height that can be related to essential forestry variables (e.g. forest biomass).

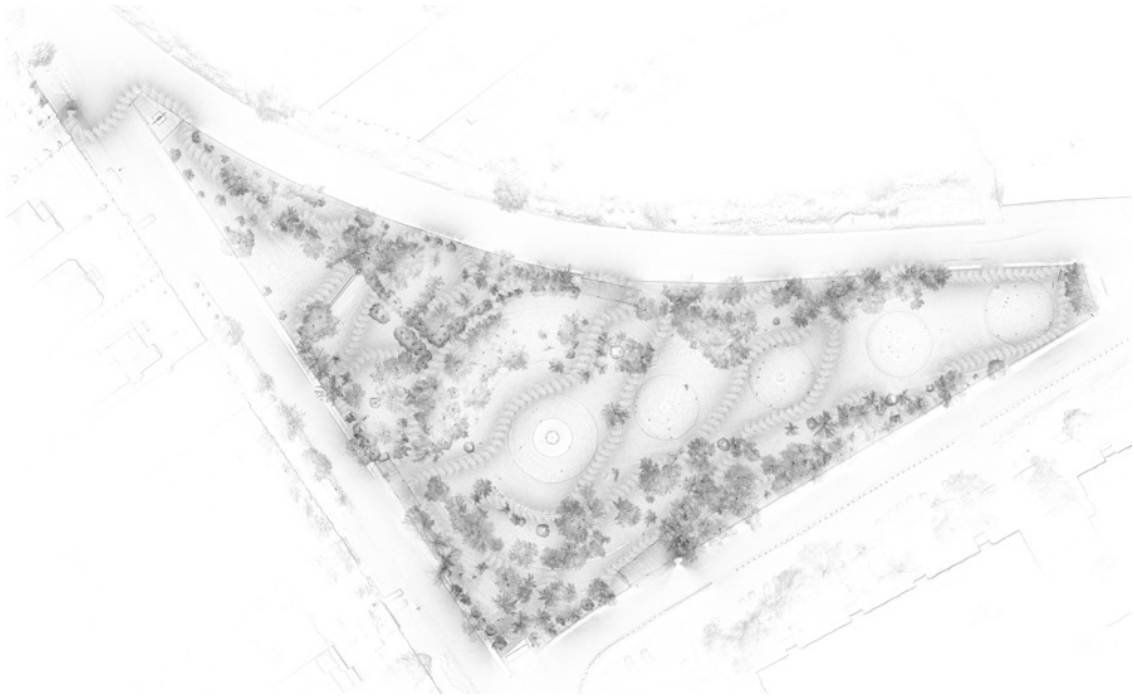


Figure 8: 2D top view of a park.

Google Earth Engine

Provides free access to geospatial datasets for scientific analysis and visualisation. It allows the analysis of forests and water features and creation and customisation of algorithms that map land-use change within cities. Public data archives can store historical images spanning 40 years. It provides easy, web-based access to satellite imagery and other geospatial data in an analysis-ready format.

QGIS

QGIS is a popular, free, and open-source Geographic Information System (GIS), which runs on all major operating systems. People often use QGIS to view, edit, and analyse geospatial data. QGIS is also a geospatial programming environment, which can be used to build geospatial applications using Python, a scripting language used in many GIS applications.

Digital data (Urban Atlas, Google Maps and Google StreetView, OpenStreetMap)

Urban Atlas

A land monitoring service that creates maps of land cover and land use for all European states usually for cities with more than 100,000 residents. Maps are coloured in 17 different classes, with red being the continuous urban fabric class ranging through to green, which represents green areas,

parks, or forests. This is a helpful resource for policy making and city development since it makes understanding the urban ecosystem simpler.

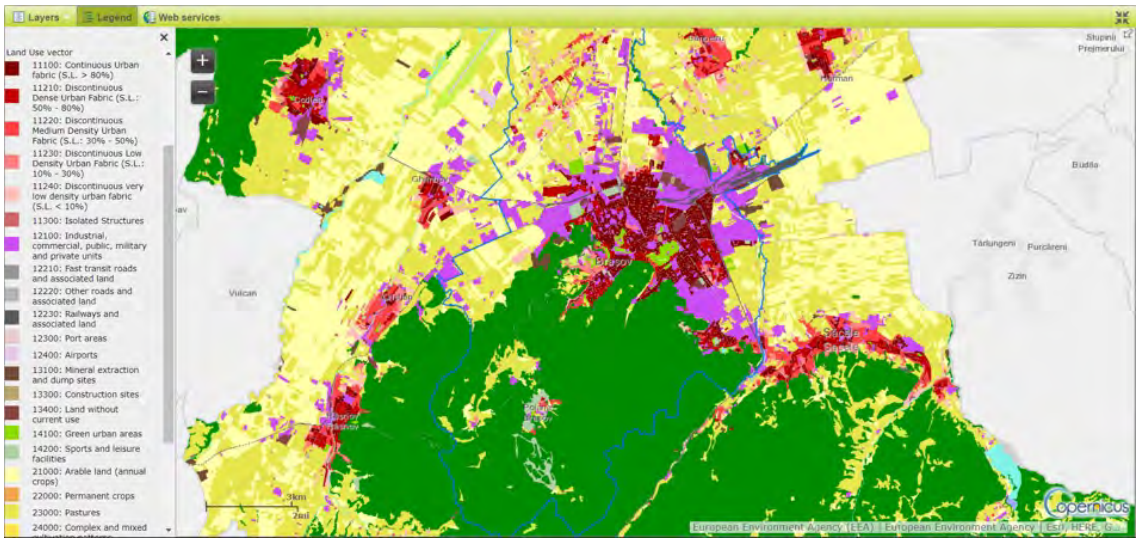


Figure 9: Urban Atlas classification of the city Brasov, Romania. ©Copernicus

Google Maps, and Google Street View

Google Maps is one of the most popular mapping applications in the world. It offers satellite imagery, aerial photography, street maps, and 360° interactive panoramas. Google Street View is a helpful tool when it comes to urban planning, as it provides a view of the terrain on the ground. Google satellite images provide a history of urban development over time.

OpenStreetMap (OSM)

OSM was created by a community of mappers to provide map data about transportation facilities, shops, points of interest, among others. Plugins for core compatibility have been created by GIS software developers. GIS applications offer the option of directly importing OSM data into a project and converting the required information into other formats.

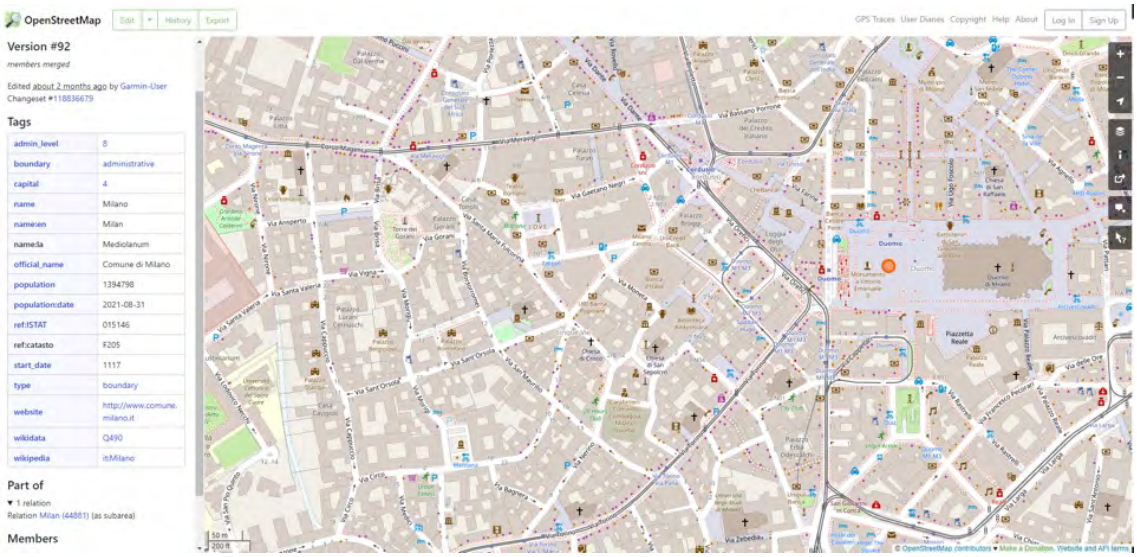


Figure 10: OpenStreetMap view of city Milan, Italy.

Field Surveys and use of i-Tree software

Mapping work involves auditing and collecting information from urban greenspaces and the forest and tree resources that these spaces host. This should involve detailed assessments for each tree, including for height, diameter, species, condition (including risks of potential damage), management interventions done, population size, GPS location and any risks, to the public or property, associated with accidents such as falling branches. Ideally, every greenspace should be surveyed for its facilities (litter bins, flower beds, benches, ornamental areas etc), function (green areas, alleys, fountains, etc) and for any constraints (including underground services such as sewage, sprinklers, electrical cables, and water pipes).

Increasingly, the collection of data on the ground can be complimented through the use of tailored software packages, particularly for the collation and further analysis of the data. For example, **i-Tree is a state-of-the-art software suite** from the US Department of Agriculture (USDA). It provides urban and rural forestry analysis and benefits assessment tools. The i-Tree tools can help strengthen forest management and advocacy work by quantifying forest structure. Furthermore, i-tree can also help to quantify the environmental benefits that trees provide.

Since the initial release of the i-Tree Tools in 2006, many communities, non-profit organisations, consultants, volunteers and students around the world have used the tools to report on individual trees, parcels, neighbourhoods, cities, and even entire states. Through understanding the local ecosystem services that trees provide, i-Tree users can link forest management activities with environmental and quality of life data.

Stirling, Scotland, UK - credits Ian Whitehead

STEP 3: DEFINING PRINCIPLES AND GOALS

This step outlines the principles and goals that guide the implementation of urban forestry. Selection of the most appropriate goals are dependent on the societal needs identified and the existing conditions. Below are some goals or principles that local authorities and stakeholders can select for their location.

3a. Increase green cover

Over the years there have been high-profile campaigns to increase canopy cover. These include the United Nations Development Programme's (UNDP) "Plant a Billion" campaign, which was later superseded by, a yet more ambitious, "Plant a Trillion" campaign under the auspices of the WEF. In addition, there are a number of projects focusing on networks of cities which include "Tree Cities of the World" and the UNECE "Trees in Cities Challenge". The 3 Billion Trees Pledge under the EU biodiversity strategy for 2030 aims to increase the forest area and tree coverage in the EU, increase the resilience of forests and their role in reversing biodiversity loss and climate change mitigation and adaptation. Through the initiative, 600 million trees are to be planted annually, up from 300 million trees planted annually between 2010 and 2015, which will translate to 3 billion additional trees by 2030[15]. However, faced with the issues of rapid population growth and a changing climate, achieving targets to increase canopy cover remains a challenge for many urban areas around the globe.

To overcome the loss of tree cover, simple and easy to adopt, evidence-based guidelines can be helpful. As an example, a new rule of thumb for urban forestry and urban greening is currently being widely advocated. This is known as the 3-30-300 rule[16]. It focuses upon the crucial contribution of urban forests and other urban nature to health and wellbeing, as well as to climate change adaptation, whilst recognising the multifunctional goods and services that urban forests provide. Moreover, the 3-30-300 rule is straightforward to implement and monitor, as well as being easy for professionals and members of the public to remember. The rule of thumb provides clear criteria for the minimum provision of trees and public green spaces in our urban communities (Figure 11).

THE 3-30-300 RULE FOR GREENER, HEALTHIER AND MORE RESILIENT CITIES

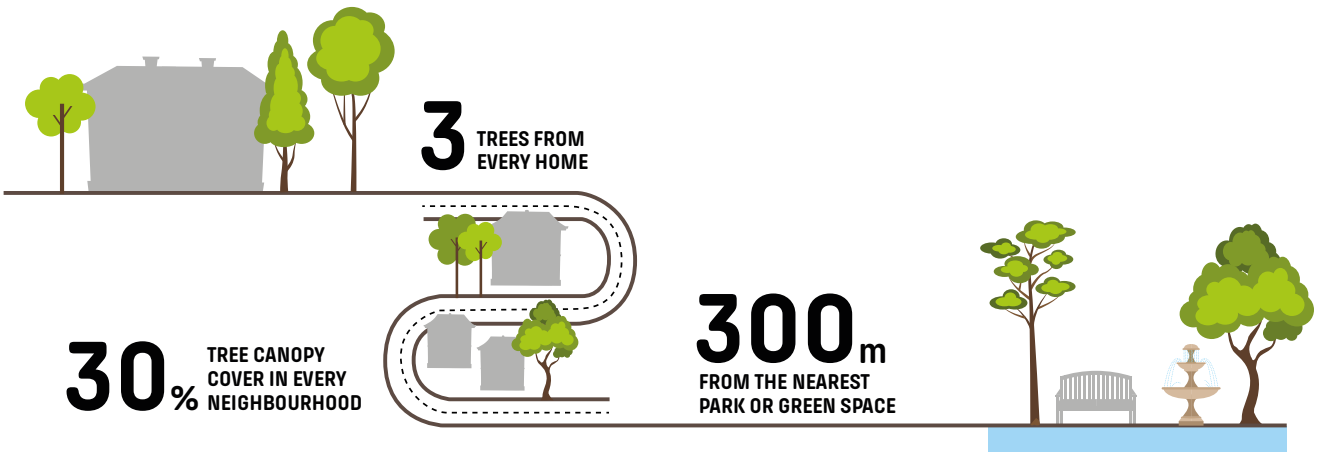


Figure 11: 3-30-300 rule. Adapted from UNECE, 2021.

[15] https://environment.ec.europa.eu/strategy/biodiversity-strategy-2030/3-billion-trees_en
[16] https://iucnurbanalliance.org/promoting-health-and-wellbeing-through-urban-forests-introducing-the-3-30-300-rule

Achieving such targets will require significant investment from municipalities, potentially with additional support of local residents and businesses, who might wish to adopt or sponsor mature trees or potentially help with the establishment of new planting.

OPPORTUNITIES FOR PLANTING TREES

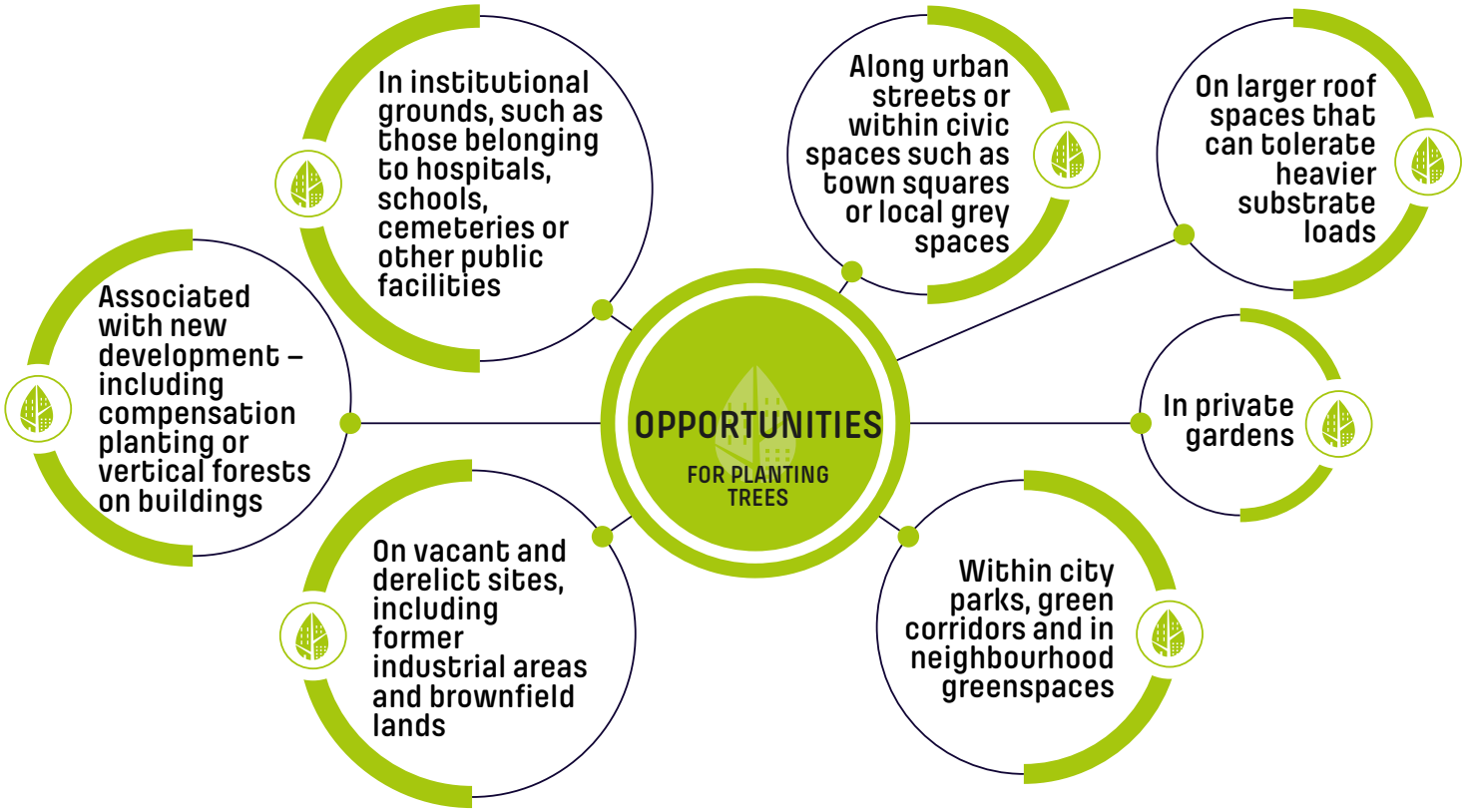


Figure 12: Opportunities for planting trees.

The task of undertaking this and the stakeholders responsible will vary considerably according to the situation. Ideally, it will involve cooperation between a range of diverse groups, through a process of co-management which develops a wider sense of ownership of the urban forest. Such tasks might be coordinated by the municipality or an NGO, but could also be championed by local civil society organisations. Local schools and residents' groups should also be extensively involved in the planning, establishment and management of planting projects wherever possible. This participation can help to strengthen social capital and develop the potential for building local capacity.

Incentives and funding schemes can encourage those who are responsible for managing private spaces to plant more trees on their own ground. Such incentives might include donations of "Free Trees" which are specifically targeted to private gardens, school grounds, community centres or hospital grounds. Equally, incentives might include technical help, assistance with the organisation of volunteer labour, the loan of tools, or assistance in identifying planting sites.

It is worth noting that there are low cost and nature-based approaches to increasing canopy cover. In particular, the potential for natural regeneration on vacant and derelict land should

not be underestimated as a means of increasing tree cover with little formal input. Many former industrial areas, for example, in Germany's Ruhrgebiet, are now characterised by extensive swathes of naturally regenerating forest, or so-called "Industriewald". These areas have been established through dispersal of seed from existing sources and without any planting or direct intervention but have resulted in robust and resilient ecosystems.

A few city plans that take increasing canopy cover into consideration also exist, for example, the new Piano del Verde of the city of Padua, in Italy has set the first objective for 2041 as increasing tree cover of public spaces from 1.8% to 5% of the city's surface. The Metropolitan City of Milan through the Forestami project (Box 5) intends to increase the tree canopy cover by 5% between 2020 to 2030. Similarly, the Plan del Verde y de la Biodiversidad of the city of Barcelona, approved in 2020, is a good example of long-term vision and planning.

For the future, we have to consider the fact that the overall urban area will increase and expand. It is projected to nearly triple between 2000 and 2030 at a global level. This expansion will mostly take place within former rural areas, and there is the potential to include trees which were once within the rural hinterland within the urban tree canopy.

BOX 5

CASE STUDY - FORESTAMI, MILAN, ITALY

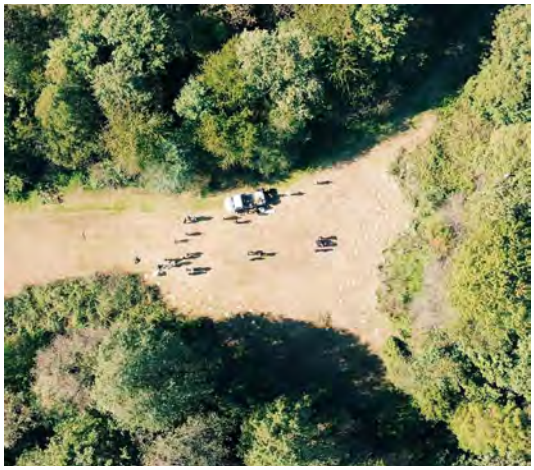
Forestami

ForestaMi is an urban forestry project that was established in 2018 as a result of a research project carried out by the Politecnico di Milano where the city's tree canopy cover was assessed and urban zones deficient of natural greenery identified.

The project's goal is to **plant 3 million trees in the Metropolitan area of Milan** by 2030 and to transform it into one of the greenest cities in Italy. It aims to achieve its afforestation goals through activities such as planting trees in school grounds, university campuses, hospital grounds and private courtyards into green areas.

It will create new urban gardens, establish peripheral woodlands around the metropolitan area and improve greenery in public parks.

Source: forestami.org/en



3b. Improve management and maintenance

Attempts to increase urban tree canopy cover generally are more likely to be successful when high standards of management and maintenance are practised. Every year huge numbers of urban trees are lost as result of poor management practices and through basic neglect. This results, not only, in a loss of valuable canopy cover and ecosystem services derived from urban trees, but also represents an inefficient use of public resources. Common challenges include:

- **lack of watering:** particularly during the critical first year or two after planting. Increasingly, periods of drought and soil moisture deficit can result in high mortality rates;
- **weed competition:** without adequate mulching, weeds and competitive grasses can quickly become dominant;
- **browsing animals:** trees are left unprotected against herbivores including rabbits, grey squirrels and urban deer populations, which can strip bark;
- **careless strimming and grass management:** this can remove the bark and kill the young plants;
- **stakes, ties and tree guards:** ties or guards are not loosened and can strangle the trees;
- **plantations are not thinned or managed:** they can develop an unhealthy, spindly and unattractive structure;
- **pest and disease issues:** these have been growing exponentially in recent years, aided by a warming climate. Series diseases include chalara (ash dieback), sudden oak death and chestnut blight. Conifers have also been decimated by plagues of spruce bark beetles, assisted by milder winters and summer drought;
- **vandalism and deliberate damage:** this can occur as a result of antisocial behaviour or underlying conflicts which were not previously identified.

Lack of resources and expertise has meant that municipalities and urban forest managers have not identified pest and disease problems until it is often too late, thereby creating conditions for diseases and pathogens to thrive. In addition, trees are often felled unnecessarily through management programmes resulting from, sometimes overstated, concerns about safety, tree health, potential litigation due to risk of falling branches, or aesthetics: fallen leaves and fruit, tree stumps, etc.

Much more needs to be done to help cities to maintain their newly planted and existing trees. However, this requires resources to undertake management work in a climate of declining budgets. It also requires specialist knowledge, and often, rapid responses to ensure that poor maintenance does not compromise the health of existing trees.

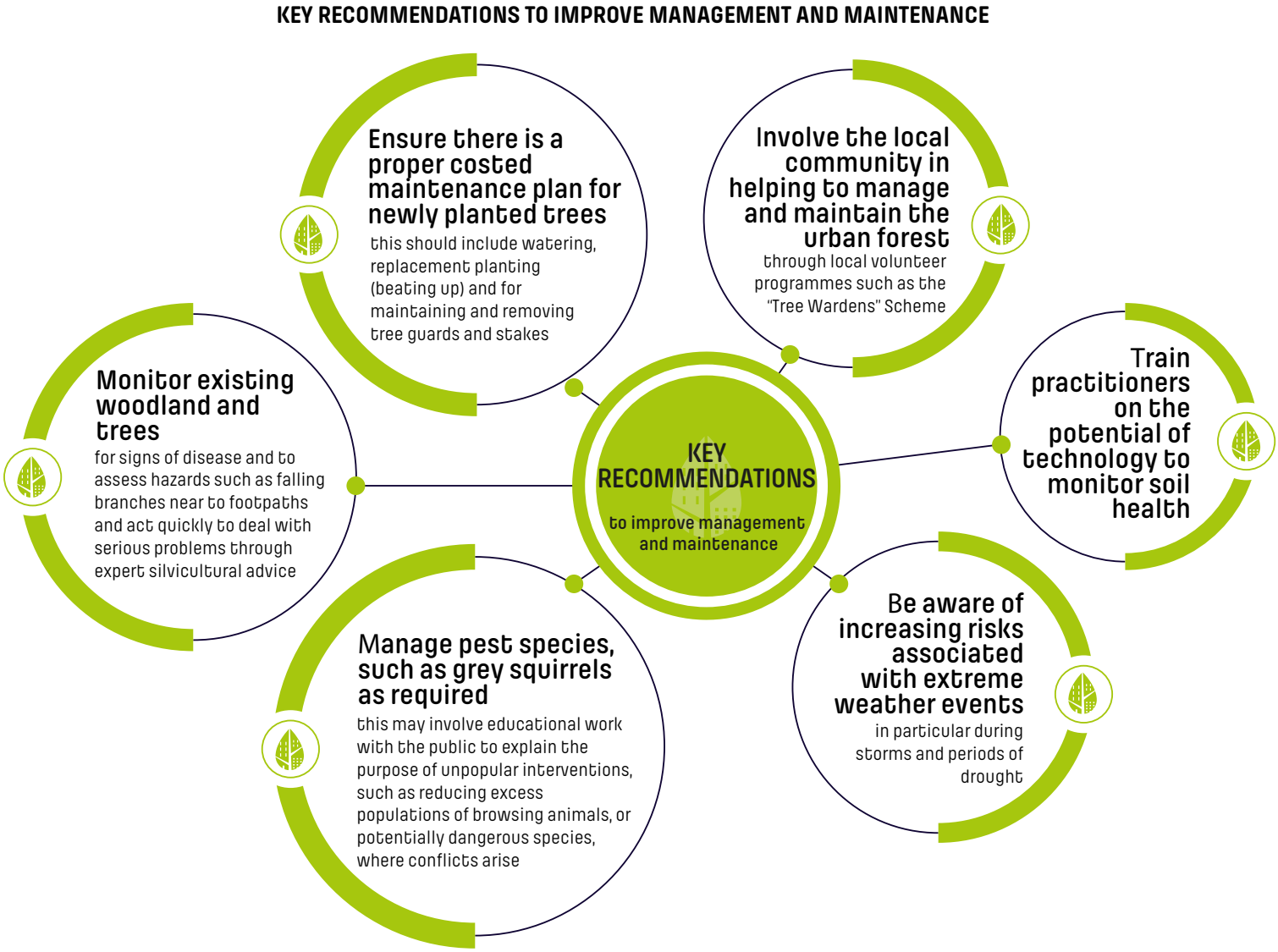


Figure 13: Key recommendations to improve management and maintenance.

3c. Increase impact for human health

The positive link between urban forest and urban green and human health, wellbeing and social inclusion is well proven, supported by evidence-based medicine and social research. Providing access and opportunities to connect with urban forests can support three levels of action and their associated public health objectives, targeting different demographic groups:

- **Promotion of healthy lifestyle:** provision of green accessible areas is key to encouraging everyday use of nature, which supports more healthy and active lifestyles and encourages connection with nature from an early age. Urban forests can also contribute to resilient urban food networks and provision of a healthy diet through projects such as establishment of community food forests.

- **Prevention of illness:** urban forests offer a setting for organising initiatives which benefit people at risk of physical and psychological diseases, including those who are socially vulnerable. Forest walks and exercise can prevent the risk of obesity and reduce the incidence of cardiovascular diseases. The use of urban forests for health preventive purposes can therefore be fostered through "green prescription" schemes.

- **Treatment and rehabilitation:** health interventions are addressed to people with specific needs and require the involvement of health and social care professionals. Treatments can be done a) in urban forests by organising specific activities led by social care and health professionals, b) in purposefully designed urban gardens and forests to enable the healing interaction of specific groups of people. Increasing urban forestry cover around hospital and social care facilities can have multiple benefits.

Good planning and management are crucial for encouraging everyday use for physical activity and contact with nature. The recommended "dose" of nature is 120 minutes per week[17], unfortunately about 60% of EU citizens[18] do not have enough access to urban nature as recommended by WHO.

Proposed criteria to enable an increase the impact for human health and wellbeing of urban forests

A - Equity, accessibility and diversification: Access to green space is an environmental justice issue, as ecosystem services provided by urban forests support the ecological integrity of cities and protect the mental and physical health of the urban population. Nevertheless, within cities, green space is often unequally distributed, and access is often highly variable based on income, ethno-racial characteristics, age, gender, (dis)ability, and other factors. Therefore, not all city dwellers have equal access to the benefits derived from urban greenspaces. Assessing and planning for more equitable patterns of urban forest distribution is therefore crucial for improving citizen access to health and greenspace. Not every green space needs to be accessible for all people and suitable for every kind of activity but a fair distribution should be in place. It is useful to characterise spaces in terms of activities and people that can benefit the most (e.g. urban forest for exercise, those accessible for people on wheelchairs or strollers, playgrounds for children, nature connection, tiny and pocket forests for regeneration, etc.).

B - Information: improving availability of clear information on the urban forest as well as on green health, is crucial for fostering the delivery of wellbeing and social benefits to people. urban forest spaces should be clearly characterised (as mentioned above) in terms of accessibility, infrastructure and type of activities. This enhances the sense of security and comfort, stimulating meaningful use, mitigating conflicts and proper management. Clear information on the accessibility of an urban forest enables people with disabilities (or reduced mobility) and their caregivers to make informed choices, fostering the right to nature for all.

C - Supportive programmes & community engagement: some people need supportive programmes to foster meaningful connections with the natural environment. Associations, national and local health authorities and local institutions should create cross-sectoral partnerships which focus on forest-based health interventions tailored to different groups. The effectiveness of developing diverse programmes has been proven through practice within Europe and beyond. These range from creating walking or green exercise programmes for people with cancer or type 2 diabetes, to forest and wilderness therapy programmes for people with mental health or addiction issues. Citizen engagement and participation in all stages of the development of an urban forest is key to increasing the sense of ownership and changing the negative attitudes of the citizens towards urban forestry which can be a barrier to its development and maintenance.

[17] White et al., 2019
[18] https://isglobalranking.org

If such forest-based interventions are to be implemented and integrated within our cities, we need a variety of greenspace including large, extensive areas of forests, well distributed local greenspaces, linear parks and a rich network of green streets to create convenient spaces for exercise and to engage with nature. It is important to consider that people tend to identify locations and spaces which meet their immediate needs and feelings (i.e., spaces for quietness, spaces with a special value, spaces which encourage social contact).

3d. Increase biodiversity

Biodiversity is globally under threat due to a combination of factors such as habitat loss resulting from development pressures, the intensification of agriculture and increasingly from the impacts of climate change. Meanwhile, our cities expand at ever increasing rates, resulting in loss of valuable greenspaces, habitats and urban fringe woodlands. Urban forestry can have a pivotal role to play in reversing these trends. Trees in urban areas provide important refuges for flora and fauna in otherwise highly modified and sterile urban environments. Whilst individual trees can have a positive role to play, biodiversity benefits are greatly increased when the trees and forests are managed according to green infrastructure principles as part of a wider network of interconnected habitats.

These habitat networks should ideally include pockets of ancient or high biodiversity woodland which have existed over long periods and which have developed a complex assemblage of flora and fauna. It is important that such core areas are afforded a high degree of protection as reservoirs of biodiversity and managed accordingly. They might be considered as biodiversity "stepping stones", or ideally, linked together through permeable green corridors allowing the movement and dispersal of plant and animal species.

These networks and corridors might include other types of green spaces such as formal parks and gardens, community allotments and other nature sites such as ponds and wetland areas. They can also be areas under diverse ownership, including public forests, private gardens and land belonging to institutions such as schools or cemeteries. In more densely built-up areas, greater connectivity might be achieved through the increased planting of street trees, where greenspaces are more limited.

Individual trees provide nesting and roosting sites for birds and small mammals, sources of food for pollinating insects and a whole host of micro habitats which support a myriad of invertebrates. This is particularly the case for older, mature trees which often provide specialist habitats for many unique types of insects and fungus species. Veteran oaks for example are known to support over 2,300 different species which include birds, bryophytes, fungi, invertebrates, lichens and mosses[19]. Many of these species in turn support other mammals and birds higher up the food chain.

Ancient trees can often provide nesting cavities for birds such as woodpeckers or tits, or for small mammals. They can also support unique species of beetles, mycorrhizal fungi or lichens which are exclusive to those localities. The understory associated with these gnarled, ancient trees can be important and might include woodland wildflowers such as bluebells, wood anemones and wild garlic which do not readily colonise new areas.

[19] https://www.whatthesciencesays.org/briefing-sheet-ancient-and-veteran-trees

Trees in urban areas can also help to preserve local genetic provenance of species which might be adapted to local conditions. Similarly, old fruit tree varieties can be part of the local intangible cultural heritage and associated with seasonal festivals and events. Nurturing these varieties helps to conserve future diversity and resilience within our local food systems, whilst providing a link with our horticultural past. Furthermore, the collection and processing of fruit from urban orchards provides unique environmental education opportunities.

WAYS TO INCREASE BIODIVERSITY IN URBAN FORESTS

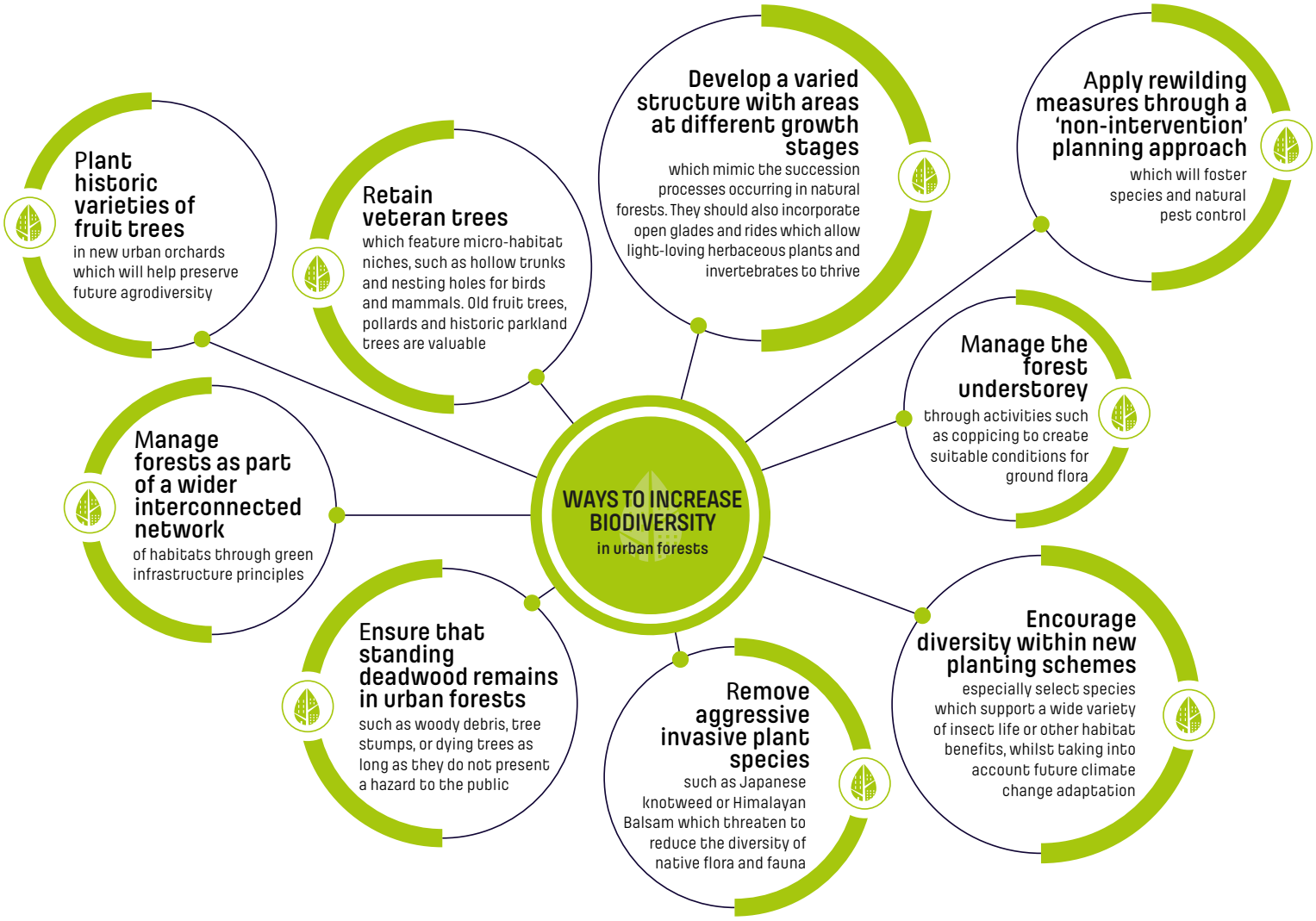


Figure 14: Ways to increase biodiversity in urban forests

3e. Conserve what you have

It is most important to place a value upon what we already have; the trees that define our existing townscapes and which create a sense of local identity and continuity down through the ages. Mature trees in cities provide beauty, diversity, texture and character and create a local sense of place. They have significant local, historical or cultural associations which can be the focus of celebrations, traditions and folklore. The historical legacy and context that these trees provide echoes our own social history and the development phases of our cities. Along with native species, city parks and gardens often also pay host to many exotic species such as giant redwoods, monkey puzzles from the Americas and gingko trees from China; these trees also have an important story to tell about the changing relationship between Europeans and their perspectives upon the wider world.

Stem counts (or simply, numbers of trees in the ground) alone do not provide effective guidance on the overall value of the urban forest. Large mature trees offer greater ecological benefits than newly established areas, yet most urban trees do not get very old. These majestic trees provide greater canopy cover, increased carbon storage, climate, biodiversity and wellbeing benefits. We therefore need to ensure that older trees are retained within new development and quality should not be compromised or substituted through the planting of larger numbers of younger, but less beneficial trees.

However, we also do have to think about the trees of the future and how our townscapes will function. In this respect we need to consider how our future urban forests will look like in the next 50 or 100 years; **what species will they consist of? What services should they provide and to whom and how can urban forests adapt to unpredictable climatic extremes?** In this respect, urban forestry should not be about a cost saving "race to the bottom", or about providing the cheapest or most convenient tree species to manage, as this might bring about unwanted consequences, creating public negative perceptions about the presence of trees in cities.

It must be about **selecting quality trees that will provide the greatest range of benefits for the future, whilst consolidating the urban forestry legacy of the past**. Furthermore, we must apply, where possible, **green infrastructure approaches** to ensure that **urban forestry is part of a robust and functioning habitat network** which links cities with their hinterlands. This must be undertaken on a comprehensive basis including areas of public and private land, through appropriate incentivisation if need be.

Some cities have promoted schemes for citizens to adopt mature trees in streets and parks, either through simple financial sponsorship or through providing direct support such as watering during periods of drought. In the UK, local authorities have also provided training to volunteer "tree wardens" to assist with monitoring pest and disease issues or other threats.

3f. Develop and support a Nature Positive Economy

The Economic benefits section of this report shows the potential of urban forestry to a nature-positive, carbon neutral and equitable economy. However, there are still a myriad of challenges to overcome to develop NBS market sectors and to increase the much needed investment in urban forests as an asset at the local scale.

One or more of the proposed aspects of NBS as driver of the nature-positive economy[20] can be integrated in the Urban Forestry Action Plan:

Figure 15: Urban Forestry Action Plan

[20] McQuaid et al., 2022

STEP 4: DEVELOPING THE ACTION PLAN

Urban Forestry Action Plans are needed to outline targets, activities, resources, timelines, and roles and responsibilities. These plans guide day-to-day urban forestry activities, with a longer-term management perspective in mind. Action plans should be more detailed and practical working documents which focus on the individual forest area.

Action plans, linked to sound overall strategies and based on scientific guidance, can contribute to urban forestry implementation, thereby realising their full potential for biodiversity and resilience, public health, recreation and other benefits. It is essential to plant the right tree species in the right locations, to improve species diversity and ensure good standards of stewardship and management. Other priorities include maximising the provision of ecosystem services, creating urban ecosystems that are more resilient against major threats such as the impacts of climate change and pests and diseases, and reducing ecosystem disservices. In summary, action plans provide the strategies and actions needed to help create a successful and healthy urban forest that targets context-specific challenges in alignment with global sustainability goals.

Urban Forestry Action Plans start from an **overall vision** for the local urban forestry initiative, with associated objectives, priorities, and strategic considerations and principles. These are often covered in an urban forestry strategy or policy document. Based on this, the action plan presents a roadmap for the successful implementation of specific urban forestry interventions. Moreover, Urban Forestry Action Plans are necessary to improve technical implementation based on best practice. Action plans should also identify opportunities to **engage stakeholders** and create the ground for active listening of their views. **Creating strong partnerships across different sectors,** with the goal of fostering relations between people and trees, nature and cities, will build a sense of ownership between other stakeholders which will help in monitoring and maintaining urban forests and creating the opportunity for active dialogue.

Action plans need to ensure that the set **objectives and targets are achieved** with a clear indication of timelines, responsibilities, and resources. Typically, an action plan will be set up for a period of 3-5 years, after which it should be updated. Action Plans also need to include **clear criteria and indicators** for monitoring progress and success. These can include, for example, canopy cover changes, tree diversity aspects, survival rates of new trees planted, but also increases in functionality and engagement of local communities, the improvement of public health and economically quantifying the attributable benefits of urban forests.

Eupen, BE - credits Ian Whitehead

STEP 5: IMPLEMENTING THE ACTION PLAN

Implementation presents challenges for local governments who lack the capacity and resources to act alone. Increasingly this results in mosaic governance[21] and partnership-led approaches to urban forestry implementation. The practical business of implementing the plan, therefore starts with the establishment of a steering group to coordinate the programme on the ground. They will identify responsible parties and key steps in the process, which will include the following:

- defining detailed aims, objectives, and targets
- securing funding and resources required
- preparation of detailed management prescriptions, resource allocation and timelines
- managing work on the ground
- ongoing communication with wider stakeholders
- continuous monitoring and evaluation

Defining detailed aims, objectives and targets

This has been discussed in the previous section. Essentially, the plan should be part of a tiered system with an overall urban forestry strategy at city or city regional level, which considers broader strategic themes such as rural urban linkage and green infrastructure.

Securing funding and resources required

Urban forestry initiatives receive funding from diverse sources, including public funding through local, national or EU grants. Increasingly, there are additional funding opportunities through charitable donations, lottery or crowdfunding schemes. Finances may be coordinated directly by the municipality, or through a civil society partner organisation. Local community groups or NGOs, for example, might be eligible for funding which is normally directly unavailable to government institutions.

Although obtaining capital funding for new projects might be relatively easy, revenue funding for management and maintenance can prove more challenging. Potential revenue might come from urban forestry management activities themselves, including timber production or through leasing of areas for events and concessions. Other potential ways of generating income include ecotourism activities, health programmes and through offering vocational training opportunities or rehabilitation to young people, offenders or vulnerable adults. Thinking creatively and outside the box can open up new potential funding streams.

Preparation of detailed management prescriptions, including resource allocation and timelines

This includes detailed prescriptions for various forest compartments and for urban trees within parks, streets and civic areas. The specifications should be worked up by a professional forester or arboriculturist. Details to include could are:

- planting density, species composition and tree protection on new sites,
- harvesting, thinning, pruning and other tree related management works on existing sites,
- public access infrastructure, including path specifications, interpretation, parking, signage etc.,
- detailed costings, work schedules and timelines for all activities,
- staff involved and their actual roles and responsibilities in project management,
- tendering and procurement procedures,

[21] *Buijs et al.*, 2019

- guidelines for resolving disputes.

Managing work on the ground

Arrangements must be put in place for managing all aspects of the work on the ground such as:

- supervision and coordination of contractors on site to ensure high standards are met;
- compliance with legislation, particularly with regard to health and safety practices and environmental standards;
- ensuring appropriate risk assessment procedures and signage are in place, both for site workers and for members of the public;
- efficient troubleshooting to resolve any unexpected issues/ problems encountered;
- effective financial management to ensure timely processing of payments/grants claims;
- maximising and integrating the role of local volunteers with contracted work.

Ongoing communication with wider stakeholders

With any urban forestry project, it is important to keep members of the public well informed about the work and its progress. Tree management activities, particularly felling, can be an emotive topic for members of the public and can create misunderstandings due to a lack of awareness or information. Appropriate media, such as site signage, press campaigns and public events should be an essential part of any urban forestry initiative. The aim should be to keep the public informed and involved in the project. As mentioned in other sections, a solid citizen engagement process helps to build trust and communicate the right message. Furthermore, citizens who are engaged in the process can become the best advocates for the project.

Continuing monitoring and evaluation

Even if the physical work has been completed, the task of managing the urban forest is far from over. Any work undertaken should be part of a longer-term vision which may span several decades. It is therefore necessary to undertake monitoring and evaluation in the longer term. This should achieve the following aims:

- to ensure the aims of the intervention have been effectively achieved;
- there are no adverse consequences arising from the work, such as public safety issues;
- the work has satisfied the intended management objectives;
- the approaches have represented value for money and have proved effective;
- the potential for delivering benefits has been fully achieved, and
- further planned interventions reflect the latest knowledge and respond to current opportunities or threats.

In the following section the monitoring of the action plan after its implementation is described in detail.

STEP 6: MONITORING AND EVALUATION

The monitoring process involves repeated measurements over time that allow for the changes taking place to be observed and described. The need for standardised monitoring has increased as a result of the increasing knowledge about ecosystem services, as well as increased government responsibility and liability for managing urban forests. Robust monitoring plans can highlight strengths and weaknesses of nature-based interventions, and can show the extent to which the strategic objectives have been achieved[22]. A thoughtful, step-by-step approach and active collaboration with local stakeholders are key to the effective development and implementation of monitoring plans, but the critical question is how can we do that?

Define the purpose to be achieved through monitoring

This could range from informing policy and decision-making, improving urban forest management to estimating ecosystem services, minimising risk within the tree conditions in urban forests or even estimating benefits and costs. Defining what is to be monitored should be specified before setting the indicators. It is important to ask questions such as whether the intervention to be monitored contributes to the wellbeing of the community and how? The effectiveness can be compared to having no intervention, or with alternative, non-NBS interventions. It is also important to determine where monitoring will take place and who will do it and when it will take place (time), and frequency. Issues that may cause delays in the process should be factored in. Developing a risk mitigation plan beforehand is critical to help avoid delays and other unexpected inconveniences[23].

Data collection

This is a crucial step which provides data to be used for assessing the impact of the interventions in place, in this case urban forestry. A data collection plan outlining the type of data, target populations and samples to be used, data analysis techniques and provisions for the protection and storage of data is recommended for this step. The roles of different stakeholders and the tools to be used in the process should be highlighted. The attributes to be measured usually depend on the purpose of the measurement and could range from physical attributes of trees to the added social and cultural values provided by urban green infrastructure. Field data for the assessments can be obtained from inventories or by sampling as well as through aerially-based assessments for large tree populations. Various stakeholders can engage in the data collection process such as researchers interested in quantifying the ecosystem services provided by urban forests, and governments, especially at the local level, for the purposes of budgeting and developing management plans. Citizen volunteers can also be involved in the process, through neighbourhood organisations, local tree groups, or garden clubs, as this helps to create connections between communities and their forests and increases levels of appreciation. One such initiative that involves local citizens is Pla Natura from Barcelona (Box 6) while Kronstadt Forest is an example that takes into account the social measurements of urban trees and forests (Box 7).

Data analysis

Results obtained should be in line with the questions asked when defining the purpose of monitoring. It should be noted that some impacts do take some time to manifest compared to others, therefore evaluations should be carried out continuously for better understanding of the

[22] Verdone, 2015
[23] Dumitru & Wendling, 2021

changes. Conclusions should be drawn, both from numerous evaluations and from existing scientific standards.

Dissemination of results

It is essential to target the widest audience possible including governments (who are the policy and decision makers), the scientific community, everyday citizens and businesses. Official reports, scientific articles, interviews and talks are some of the channels that can be used for dissemination, depending on the target audience. The strategy to be applied in communication is described in Step 7.

BOX 6
CASE STUDY - PLA NATURA BARCELONA (BARCELONA NATURE PLAN), SPAIN

It is a public initiative by the Barcelona City Council whose goal is to **improve and increase green spaces and biodiversity in Barcelona by 2030**. The initiative has managed to actively promote active engagement of the citizens in nature activities since 2019 (120,000 in total) and has created **40 new projects** for the urban community agriculture programme Mans al verd (Green fingers).

Barcelona's citizens who sporadically participate in nature activities and sessions and those with a strong commitment to urban nature and over 1,000 organizations that have signed the Barcelona + sostenible agreement: https://www.barcelona.cat/barcelonasostenible/ca benefit from the initiative.

Pla Natura Barcelona's promotes its activities through Barcelona City Council's communication channels and teams such as District nature centres and departments; high priority, annual city campaigns; information boards in public parks and social media, newsletters and websites among others.

Source: ***https://bcnroc.ajuntament.barcelona.cat/jspui/handle/11703/122958***

BOX 7
CASE STUDY - KRONSTADT FOREST, BRASOV, ROMANIA

The project was initiated in 2019 by RPLP Kronstadt (Regia Publică Locală a Pădurilor Kronstadt R.A.) and the INCDS Marin Drăcea (Institutul Național de Cercetare - Dezvoltare în Silvicultură „Marin Drăcea"). They perform a comprehensive evaluation of forests through sociological analysis which includes evaluation of forest-related leisure and cultural values, social services, infrastructure and facilities, and economic sustainability. It also includes analysis of forest biometrics, physical and chemical soil properties, assessment and monitoring of biodiversity and description of topo climates.

Source: ***https://bit.ly/3vxtwTc***

STEP 7: COMMUNICATING

Communication is a key aspect of urban forestry, as there is a continuous need to communicate about urban forestry programmes and projects with a wide range of stakeholders and target groups. The aim of communication is to provide urban forestry projects with a recognisable identity, differentiating it from the others and building public support by creating a community of "followers" from different stakeholder categories and audiences. Converting an urban forest project into an activity with a clear 'brand' of its own requires a strategy designed to translate the project goals into a specific identity and a set of marketing and communication activities that must be integrated into the operations of the project planning. Addressing communication should occur through all phases of the project.

Although appropriate marketing, communication, and branding tools for urban forestry projects are not always developed and implemented, the benefits and need for communication for urban forestry projects are made evident in some research and practice such as:

- raising awareness of the importance of benefits and services of urban forestry in public and private sectors and civil society to attract support;
- positioning urban forestry projects in high-pressure urban contexts with many competing demands (for funding, land, attention);
- enhancing the legitimacy of professional urban forest managers;
- communication tools can carry strong messages of transparency, quality assurance and reliability, including e.g., management standards Stewardship Council (FSC) certification for forest management.

Based on an assessment of communication strategies for existing urban forestry projects analysed in the Uforest project , we propose a process for designing a communication strategy. All these steps, described in detail below, can be addressed while developing or improving a project and answering the "why, what, where, who and when" of the strategy.

DESIGNING A COMMUNICATION STRATEGY

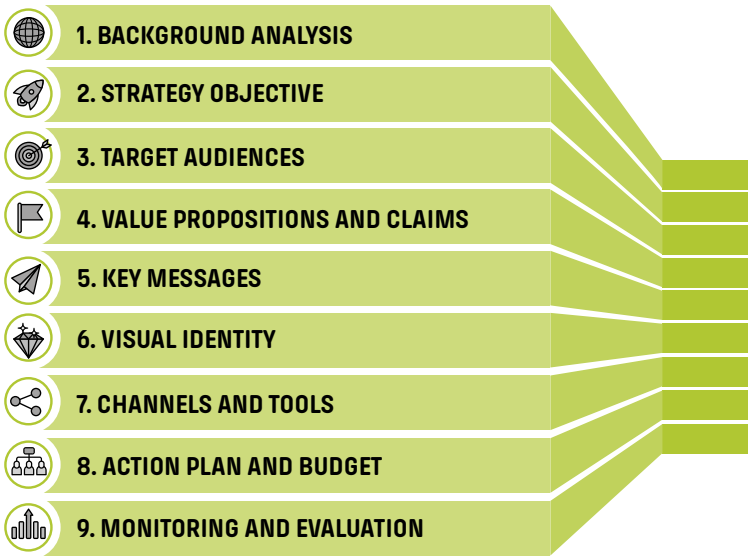


Figure 16: Process for designing a communication strategy.

Background analysis

This step supplements step 2 by further analysing the stakeholder groups identified to better understand where, how and who to communicate the project to. It is likely to be useful to gather information from similar projects and to involve key staff on communication and marketing.

Strategic objective(s)

This should clarify the questions "Why?" and "What change does the project bring?". The analysis should start with discussing the key objectives of the project and gaining understanding of the desired behaviour change. Possible specific questions might be: "Do we want citizens to be part of urban forest planning and development?" "Do we want urban forest managers to improve their management to ensure management and maintenance of urban forests?" "Do we want investors or supporters to finance our urban forestry project?" List objectives in order of importance. Forestami (Box 5), one of the project case studies, provides a good example of a clearly stated goal and specific objectives and how to reach them.

Target audiences

Analyse the potential stakeholders involved in the urban forestry project as customers or beneficiaries and categorise them in terms of scale, influence and interest (see Step 1). Who are the key partners? What people, and groups of people, will be affected by or will benefit from the venture? Which actors could influence these stakeholders (e.g. influencers, media and policymakers)? Stakeholders should be grouped into audience categories and then listed in order of importance.

Value proposition and claims

A value proposition is a promise of the value to be delivered, communicated and acknowledged by the project. It is also a belief held by beneficiaries about how the value (benefit) will be delivered, experienced and acquired. Identifying the value proposition is the first step towards developing an effective claim by which to communicate the project to key audiences. Questions to pose include, "What are the main gains the key audiences will get from the project?" (e.g. improved air quality); and "What pains/problems will the project solve for them?" (e.g. reducing urban heat effect). The following are examples of claims that communicate key benefits for audiences:

- The Mersey Forest in the United Kingdom of Great Britain and Northern Ireland which combines the name of the project, "The Mersey Forest", with the catchy tagline, "more from trees", to get "The Mersey Forest – more from trees".[25]
- Or WOWnature (Box 8) with "Nature is good for you. Take care of it."
- The way in which the urban forestry programme in the town of Oakville, Ontario, Canada was implemented under the slogan "Our Solution to Pollution".

Key messages

Key messages should target specific audiences relevant to the project, and they should have the following characteristics: clarity, consistency, repetition, tone, appeal, credibility, public need, and language of communication. There should not be too many key messages, but rather few messages which are simple and easy to understand and help motivate the audience. List the key messages and provide a content description for each, with references and key facts and figures.

[24] https://www.uforest.eu/case-studies
[25] www.merseyforest.org.uk

Visual identity

This can be formed by various components to attract the viewer's attention and communicate, even before words, the venture's intrinsic values. A strong visual identity is one that:

- is easily recognizable – a single design direction and visual identity makes it easier for stakeholders and audiences to recognize a venture's products;
- builds trust and confidence – when materials are neatly designed and organised, there is greater trust that things are working well. An inherent messiness, on the other hand, starting from the design and use of branding, risks confusing audiences (who do not know what to expect) and reducing their trust in the knowledge materials; and
- stands out from the crowd.

BOX 8

CASE STUDY - WOWNATURE® INITIATIVE, ITALY

This is an initiative developed by Etifor at the end 2018, a spin-off of the University of Padova. Through the tagline "Forests are good for you. Take care of it" (from the Italian "Le foreste ti fanno bene. Prenditene cura) the initiative applies a forest-multifunctionality approach which ensures trees are planted according to each area's needs, combining science, innovation and good governance. Individuals or organisations can grow or donate a tree to make their cities, countries, and their world a better place. More than 155,000 trees have been adopted so far by about 14,000 individuals and/or organisations. To date, the platform has recorded 699,479 unique page views and received visits from users from 180 different countries, an interesting figure if we take into account that some of the proposed projects are located in Italy.

Source: ***www.wownature.eu***

Channels and tools

This step answers the questions of "Where?" and "How?". Appropriate communication channels and tools that can be used for communicating with different stakeholders include field trips and guided walks, seminars, events such as festivals, campaigns and competitions, television and other media (including social media), film, posters and flyers, online outreach with websites and newsletters, and information workshops (offline and online). Communication channels should be selected and planned for different audiences, bearing in mind constraints related to funds, time and human resources. Sometimes, conservation actions might be adapted to act as communication channels themselves, for example, tree-planting to buffer an ugly factory or road could be carried out by organising community tree planting days for families, which also serve as opportunities for communication about the project.

Action plan and budget

A clear set of work packages and activities should be planned and implemented. The action plan should specify the human and financial resources required for implementation.

Monitoring and evaluation

A monitoring and evaluation plan should answer the following key question: What are the objectives of the evaluation? (They should be tied to the objectives of the communication strategy and the broader goals of the project). Monitoring and evaluation should track progress in the implementation of key communication activities, including indicators of the impacts of communication.

Edinburgh, Scotland, UK - credits Ian Whitehead

5. INNOVATION IN URBAN FORESTRY

This chapter explores what innovation in urban forestry is, its importance and highlights emerging opportunities for innovation in urban forestry.

Urban forestry innovation is an original set of management concepts and practices that sustainably support, maintain or promote trees and forest resources in and around urban community ecosystems, thus helping to solve prevailing challenges and to achieve objectives related to the presence and role of forests, trees, and associated vegetation in the urban environment[26].

In urban-nature interactions, innovative responses are place-based and designed to solve local needs and priorities. Thus, they are driven by local conditions that range from ecosystem features to socio-economic and cultural dynamics. Ecological contexts provide unique services for different urban stakeholders and present specific contextual challenges.

5.1 IMPORTANCE OF INNOVATION IN URBAN FORESTRY

Designing, planning, implementing, and managing an urban forestry initiative in the 21st century is a complex endeavour, with multiple context-specific and global pieces that hinder its success (Figure 17).

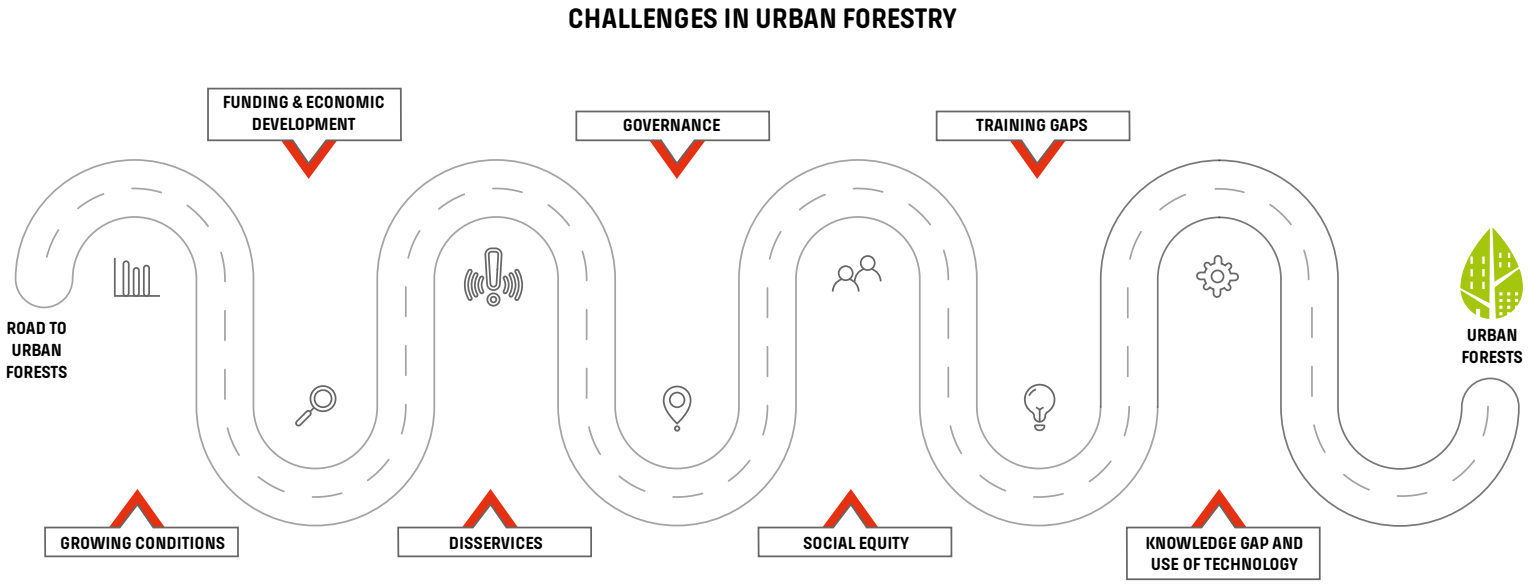


Figure 17: Main urban forestry challenges. Source: *Pino et al.*, 2022

The physical aspects intertwine with intangible challenges that impact the whole urban social-ecological ecosystem, such as social and economic inequality, extensive infrastructure development, ageing grey infrastructure, air and water pollution and disservices such as wildfires, litter, or crime. Also, there are specific constraints urban forests face: a harsh environment for establishment and growth, encroachment due to urban development, overuse and visitor pressure, the spread of invasive alien species, low political prioritisation, low public recognition, inadequate funding and the absence of effective dialogue between stakeholders.

[26] Pino et al., 2022

Addressing the aforementioned challenges is not necessarily synonymous with success. Traditional, business-as-usual strategies and practices in urban forestry are not optimal at the moment, and overlook the ever-changing, contextual socio-environmental barriers urban forests face, thus limiting the success and impact of urban forestry. Dynamic, unpredictable factors require theory and practice to constantly evolve to be able to provide innovative and sustainable solutions and to balance priorities, provide access to resources and information, and to engage the community.

A global, holistic perspective has led to the endorsement of a set of 17 SDGs by the UN in 2015. These goals are meant to preserve earth functioning as well as to meet human needs. Therefore, ending poverty and other deprivations must go hand-in-hand with strategies that improve health and education, reduce inequality, and spur economic growth, whilst tackling climate change and working to preserve the oceans and forests.

The urban forestry innovation framework (UFIF) is a specific innovation pathway developed under the Uforest project that outlines and contextualises innovation as a process, an outcome and a mindset within urban forestry (Figure 18).

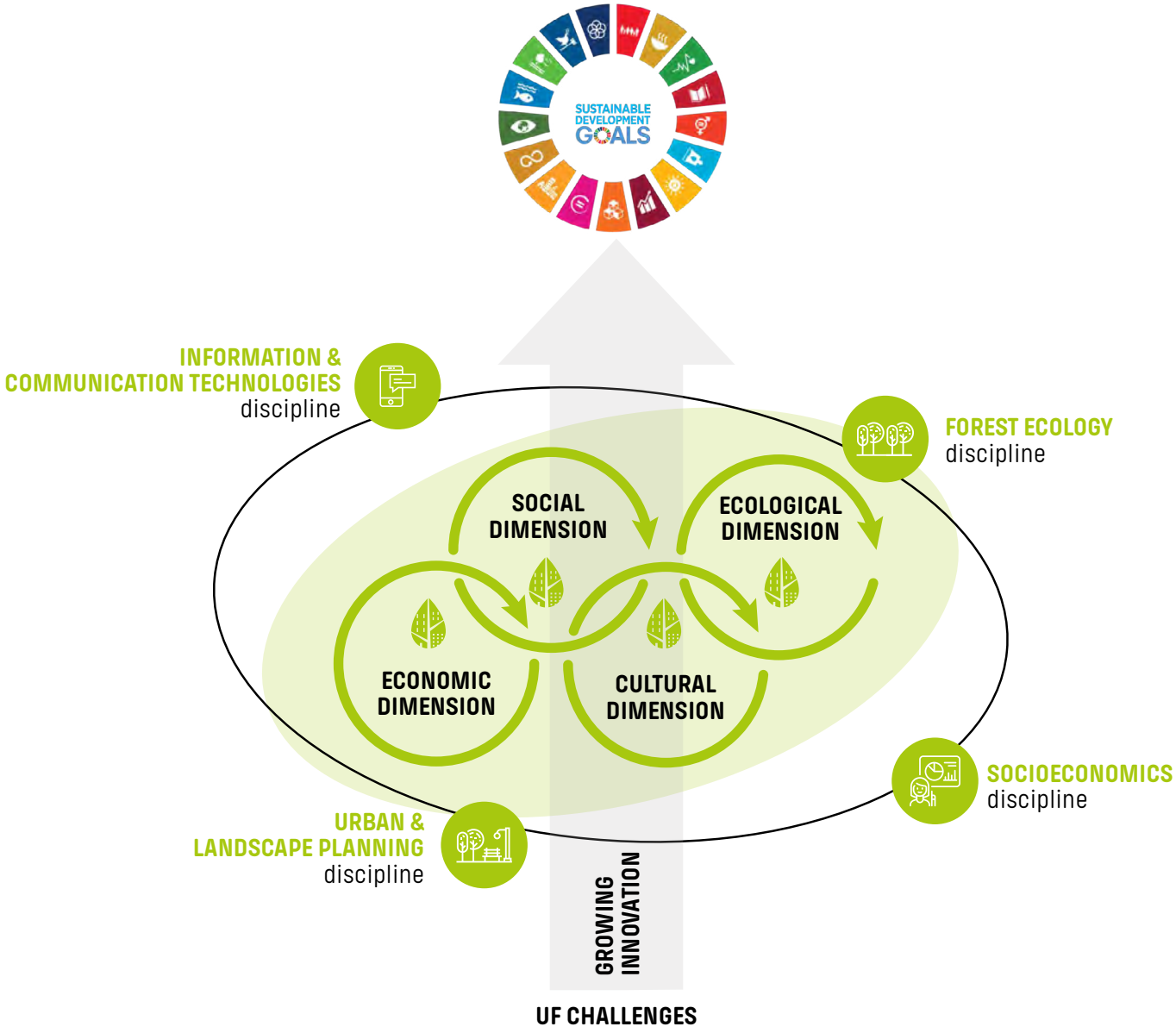


Figure 18: The urban forestry innovation framework (UFIF). Source: *Pino et al.*, 2022

The proposed UFIF is based on the development of a given degree of innovation (incremental, complementary, radical and disruptive). It is a comprehensive, interdisciplinary process that starts with the identification of the challenges faced by urban forests, and concludes with the achievement of the main economic, social and environmental goals pursued by urban forestry. Coherent with current policies and priorities, the SDG framework is used to assess the goals, and the societal challenges addressed by the innovative urban forestry solutions. Finally, this process is framed by the specific environmental context (ecological, social, cultural, economic) and the main urban forestry interdisciplinary approaches described in the Uforest project which are usually independent, non-collaborating areas. In this way, urban forestry innovation processes should pursue the achievement of defined SDGs embedded within a multidimensional perspective that links science, technology, field practice, governance, funding and socio-economic development.

Aachen, DE - credits Ian Whitehead

5.2 EMERGING OPPORTUNITIES FOR INNOVATION IN URBAN FORESTRY

Stimulating innovative approaches in urban forestry can help optimise services and minimise disservices even in dense urban contexts, whilst also solving local problems within a multidisciplinary perspective. However, there is a need to further explore innovation in urban forestry at all levels, (i) scaling up the initiatives, (ii) exploring and strengthening the collaborations among disciplines and between public and private sectors, as well as civic society; and (iii) facilitating the co-creation of knowledge at the university-city-business partnership in the EU, all the while promoting a mosaic governance of natural resources and their ecosystem services.

Moreover, urban forestry innovation should go hand-in-hand with entrepreneurship, exploring sectors and collaborations for creating new opportunities. Cross-cutting areas that mobilise new ecologies, the green economy, ICT, social services and human health are promising sources of innovation and entrepreneurship. These should also consider social, economic and environmental sustainability practices and promote inclusivity, participation, and engagement in the different stages of project development.

AREAS GAINING ATTENTION THAT ARE WORTH EXPLORING IN THE FIELD OF URBAN FORESTRY

Innovation in growing conditions

- **novel forest ecosystems**: create new urban forests in unexpected places, protect emerging urban forests and plant forests in degraded urban areas to restore them
- **urban versus regional ecology:** promoting connectivity and species exchange between more natural urban woodland and the regional green infrastructure provides an opportunity for ensuring ecological movement at regional scale
- '**trees first' thinking:** urban design, planning, and building practices need to include trees and their requirements right at the beginning of the planning and design process, ensuring sufficient growing space, protective measures, and management

Innovation in social equity

- **environmental justice:** evenly distributing green infrastructure should be the primary goal of new urban forestry projects. Moreover, it should not cause green gentrification and displacement

Innovation in governance

- **mosaic governance:** new forms of governance and participation can be incorporated into the framework of urban forests to bring more (and younger) voices to the corridors of power. These can help to better inform policy makers and decision takers on social and environmental realities

Innovation in funding and economic development

- **bioeconomy:** urban forestry is included in food systems, which occupy the biggest niche of the bioeconomy. Urban forestry experts will be able to deal with the challenge of prioritising local production and exploitation (ex. Timber and food in urban forests) and key social aspects of ecosystem service provision (ex. recreation) in urban forests
- **urban forests and ecosystem service valuation:** the monetary value of ecosystem services has been only defined to a small extent at the local level but tools such as i-Tree can be useful in the valuation. More work is needed to set up the causal connections between ecosystem services management and economic benefits in urban forests. There is an urgent need for clear cost-benefit analysis to prove that urban forests are cost efficient.

▸ **urban forests and wellbeing:** the wellbeing and public health potential of nature and ecosystems could be harnessed more systematically, in order to create opportunities and development into services (public or private) which address the needs of different types of beneficiaries

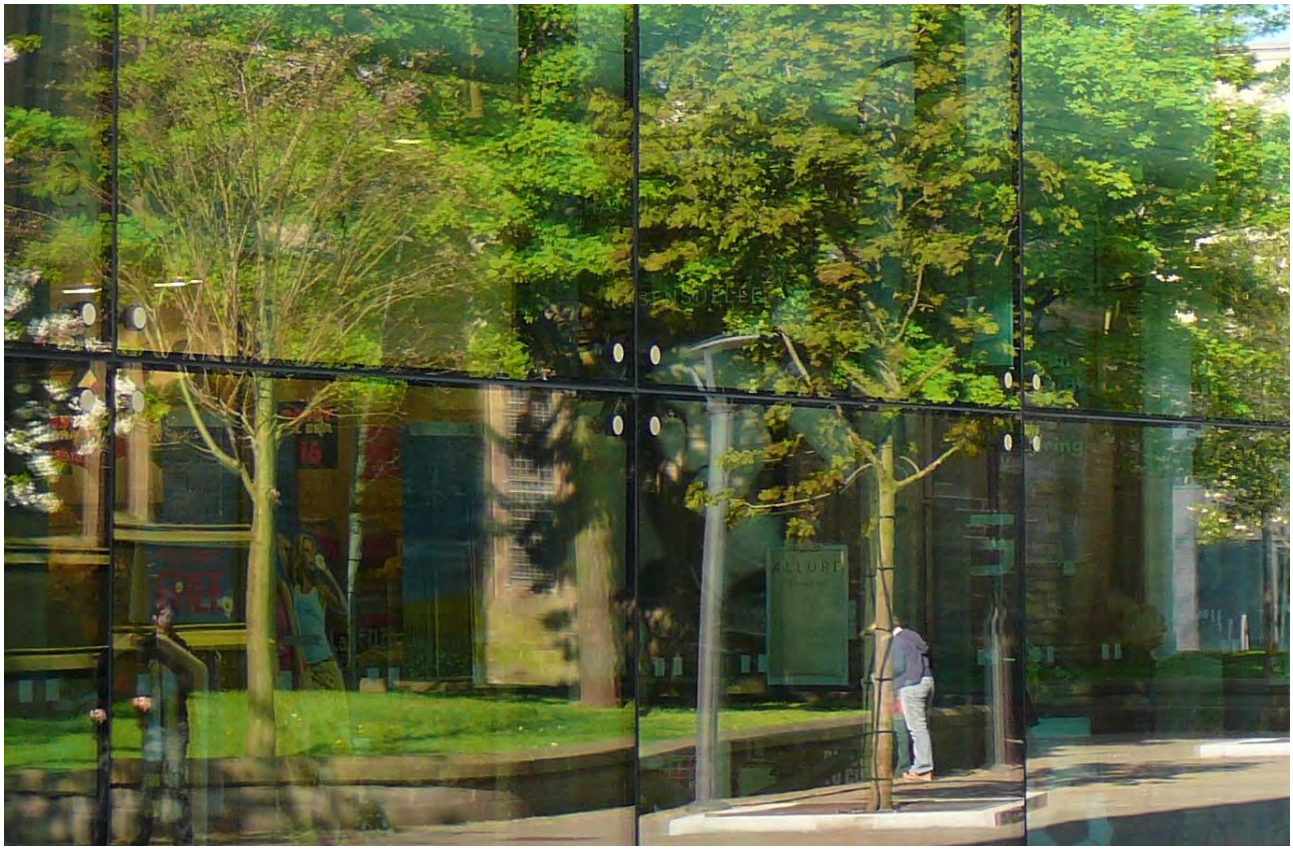
Innovation in knowledge gaps and the use of technology

▸ **internet of nature:** an innovative approach[27] to deploy emerging technologies to provide standardised and transparent data stewardship, and therefore, map, manage and monitor the urban forest more effectively

▸ **nature-based learning (NBL)**: urban forests and urban greening provide excellent opportunities to reconnect with nature and for outdoor learning. One of the outcomes of this approach is how NBL can contribute to stewardship values or conservation behaviour, or to understand the key elements of nature experiences that affect children

▸ **species selection:** proposals to integrate native and climate-change resistant, non-invasive and no-native species are needed to adapt the urban green infrastructure to ever-frequent extreme weather events.

In conclusion, there is great potential for innovation in urban forestry, in terms of addressing current societal and more specific challenges, offering the best framework for meeting SDGs, and for providing novel opportunities for developing the profession.



Dundee, Scotland, UK - credits Ian Whitehead

[27] *Galle et al.*, 2019

SUMMARY OF KEY MESSAGES

► Understand the urban forest resource through extensive mapping, audits and inventories.

► Consult extensively with stakeholders and citizens to understand local perceptions on the urban forest and how these can be mainstreamed into future planning, governance and management approaches.

► Create diverse and enduring partnerships with a strong sense of local ownership for resilient and effective governance.

► Develop an overall Urban Forestry Strategy at a city regional scale with links to other key public policy areas including planning, health, transportation, social equity and climate change mitigation.

► Develop and deliver targeted Urban Forestry Action Plans at a local level with clearly defined objectives, outcomes and timelines.

► Promote the multiple social, environmental and economic benefits that can be derived through urban forestry and the multiplier effect that can be achieved, over and above levels of initial investment.

► Be aware of ecosystem disservices and develop effective mitigation strategies to address these whilst focusing on the positive benefits of urban forestry.

► Consider innovation in urban forestry management and how this can contribute to the development of a strong circular bioeconomy.

► Seek out influential local champions to promote the urban forestry message, both within the corridors of power and out and about within wider civil society and the business community.

► Think long term; the full potential of the urban forest will take time to realise, but over time, mighty trees can grow from small seeds.

► Promote results as widely as possible and celebrate success!

Berlin, DE - credits Ian Whitehead

ANNEX

ANNEX 1: CASE STUDY 'SONIAN WOOD COOP'

The Sonian Wood Coop is a cooperative that sources local wood for the local market resulting in reduction in carbon emissions, provision of jobs and value addition to local resources. It operates in the Sonian Forest - a unique peri-urban ecosystem of approximately 5000 hectares just outside Brussels. This forest is dominated by beech trees, but it also hosts oak, maple, pine, chestnut and other species. Every year, a selection of trees is felled in this forest (around 20,000m3) and replaced by new trees to adapt the forest to future climate change, to increase biodiversity and to produce timber. 85% of this wood is exported to Asia, producing a negative environmental footprint and little local value (whilst local furniture makers and builders often purchase wood from Scandinavia, Canada or even Asia).

The Sonian Wood Coop buys trees from private and public forest owners, and works with forest owners, sawmills, carpenters and other partners to keep wood produced in the Sonian Forest as local as possible. It encourages use of this resource for projects in architecture, construction, design and art. In addition to environmental and economic benefits, use of the wood locally also strengthens the local community's emotional connection to the forest. Since its start in 2020, the cooperative has created a coalition of local organisations for the development of the local value chain. For its start-up costs, the cooperative received generous support from citizens in Brussels (through investment in a crowdfunding campaign). This helped to finance the initial operations and provided legitimacy for the cooperative's cause, even leading to capital investment in the form of private equity.

Sources: www.sonianwoodcoop.be, www.osmosnetwork.com, Kampelmann, 2021

REFERENCES

Bach, A., Ceron, J. J., Maneja, R., Llusià, J., & Penuelas, J. (2021). Evolution of Human Salivary

Stress Markers during an Eight-Hour Exposure to a Mediterranean Holm Oak Forest. A pilot study. *Forests*, 12(1600).

Basnou, C., Doimo, I., & O'Driscoll, C. (2021). *Uforest Training Needs' Assessment and Stakeholder Analysis Report.*

Baró F, Chaparro L, Gómez-Baggethun E, Langemeyer J, Nowak D J, Terradas J (2014) Contribution of Ecosystem Services to Air Quality and Climate Change Mitigation Policies: The Case of Urban Forests in Barcelona, Spain. AMBIO 43:466–479

Buijs, A., Hansen, R., Jagt, S. V., Ambrose-Oji, B., Elands, B., Rall, E. L., . . . Møller, M. S. (2019). Mosaic governance for urban green infrastructure: Upscaling active citizenship from a local government perspective. U*rban Forestry & Urban Greening*, 40, 53-62.

Davey Resource Group. (2008). City of Pittsburgh, Pennsylvania.

De Vreese, R. (2018). Urban Forest-Based Solutions for Resilient Cities. The Resilience Blog. https://resilienceblog.com/2018/10/01/urban-forest-based-solutions-for-resilient-cities/

Dumitru, A., & Wendling, L. (Eds.). (2021). *Evaluating the Impact of Nature-Based Solutions.* Brussels: European Commission. doi:10.2777/244577

EC. (2021). Evaluating the Impact of Nature-based Solutions: A handbook for Practitioners. (A. Dumitru & L. Wendling, Eds.; 1st ed.). Publications Office of the European Union. https://data.europa.eu/doi/10.2777/244577

EEA. (2021). What is green infrastructure? European Environment Agency. https://www.eea.europa.eu/themes/sustainability-transitions/urban-environment/urban-green-infrastructure/what-is-greeninfrastructure

FAO. (2017). Urban and Peri-urban Forestry. Definition. The Food and Agriculture Organization of the United Nations. https://www.fao.org/forestry/urbanforestry/87025/en/

Food and Agriculture Organization. (2016). *Guidelines on urban and peri-urban forestry* (Vol. 178). (F. Salbitano, S. Borelli., M. Conigliaro, & Y. Chen, Eds.) Rome.

Gabrys, J. (2022). Programming Nature as Infrastructure in the Smart Forest City. Journal of Urban Technology, 29(1), 13–19. https://doi.org/10.1080/10630732.2021.2004067

Galle, N. J., Nitoslawski, S. A., & Pilla, F. (2019). The Internet of Nature: How taking nature online can shape urban ecosystems. The Anthropocene Review, 6(3), 279–287. https://doi.org/10.1177/2053019619877103

Haase, D., Larondelle, N., Andersson, E., Artmann, M., Borgström, S., Breuste, J., Gomez-Baggethun, E., Gren, Å., Hamstead, Z., Hansen, R., Kabisch, N., Kremer, P., Langemeyer, J., Rall, E. L., McPhearson, T., Pauleit, S., Qureshi, S., Schwarz, N., Voigt, A., … Elmqvist, T. (2014). A Quantitative Review of Urban Ecosystem Service Assessments: Concepts, Models, and Implementation. AMBIO, 43(4), 413–433. https://doi.org/10.1007/s13280-014-0504-0

Hobbs, R. J., Arico, S., Aronson, J., Baron, J. S., Bridgewater, P., Cramer, V. A., Epstein, P. R., Ewel, J. J., Klink, C. A., Lugo, A. E., Norton, D., Ojima, D., Richardson, D. M., Sanderson, E. W., Valladares, F., Vilà, M., Zamora, R., & Zobel, M. (2006). Novel ecosystems: Theoretical and management aspects of the new ecological world order. Global Ecology and Biogeography, 15(1), 1–7. https://doi.org/10.1111/j.1466-822X.2006.00212.x

IACGB. (2020). Expanding the Sustainable Bioeconomy—Vision and Way Forward. Communiqué of the Global Bioeconomy Summit 2020.

Jordan, C., & Chawla, L. (2019). A Coordinated Research Agenda for Nature-Based Learning. Frontiers in Psychology, 10, 766. https://doi.org/10.3389/fpsyg.2019.00766

Kahn, K. B. (2018). Understanding innovation. Business Horizons, 61(3), 453–460. https://doi.org/10.1016/j.bushor.2018.01.011

Kampelmann, S. (2021). Knock on wood: Business models for urban wood could overcome financing and governance challenges faced by nature-based solutions. *Urban Forestry & Urban Greening*, 62, 127108.

Konijnendijk, C.C., Nilsson, K., Randrup, T.B. and Schipperijn, J. (eds.), (2005). *Urban Forests and Trees.* Springer, Heidelberg.

Kooijman, E. D., McQuaid, S., Rhodes, M.-L., Collier, M. J., & Pilla, F. (2021). Innovating with Nature: From Nature-Based Solutions to Nature-Based Enterprises. Sustainability, 13(3), 1263. https://doi.org/10.3390/su13031263

Kowarik, I., Hiller, A., Planchuelo, G., Seitz, B., von der Lippe, M., & Buchholz, S. (2019). Emerging Urban Forests: Opportunities for Promoting the Wild Side of the Urban Green Infrastructure. Sustainability, 11, 6318. https://doi.org/10.3390/su11226318

Kim, T., Song, B., Cho, K. S., & Lee, I.-S. (2020). Therapeutic Potential of Volatile Terpenes and Terpenoids from Forests for Inflammatory Diseases. Int J Mol Sci. doi:10.3390/ijms21062187

Lyytimäki, J. (2017). Ecosystem disservices: Embrace the catchword. Ecosystem Services. doi:10.1016/j.ecoser.2014.11.008

Mammadova, A., O'Driscoll, C., Burlando, C., Doimo, I., & Pettenella, D. (2021). Background report for the EU blueprint on Green Care. Nature for health, well-being ans social inclusion: Analysing factors influencing innovation in Green Care (p. 86). Green4C.

McQuaid, S., Kooijman, E., Rizzi, D., Andersson, T. and Schanté, J. (2022). *The vital role of nature-based solutions in a nature positive economy*, Publications Office of the European Union, 2022, https://data.europa.eu/doi/10.2777/307761

Nitoslawski, S. A., Galle, N. J., Konijnendijk van den Bosch, C., & Steenberg, J. W. N. (2019). Smarter ecosystems for smarter cities? A review of trends, technologies, and turning points for smart urban forestry. Sustainable Cities and Society, 51, 101770. https://doi.org/10.1016/j.scs.2019.101770

Nowak, D (2000). *The Effects of urban trees on air quality. USDA Forest Service, Northeastern Research Station 5 Moon Libra*ry, SUNY-CESF, Syracuse, NY 13210

Oxford Advanced Learner's Dictionary. (2022). Entrepreneurship. Oxford Learners' Dictionaries. https://www.oxfordlearnersdictionaries.com/definition/english/entrepreneurship?q=entrepreneurship

Pino, J., Florido, F., O'Driscoll, C., Doimo, I., & Konijnendijk, C. (2022). *Blueprint for Innovation in Urban Forestry: Analysing factors influencing innovation within Urban Forestry*.

Shuyao, W., Binbin, V. L., & Li, S. (2021). Classifying ecosystem disservices and valuating their effects - a case study of Beijing, China. *Ecological Indicators*, 129.

Soares, A., Rego, F., McPherson, E., Simpson, J., Peper, P., & Xiao, Q. (2011). Benefits and costs of street trees in Lisbon, Portugal. *Urban Forestry & Urban Greening*, 10, 69-78.

Taalbi, J. (2014). Innovation as Creative Response. Determinants of Innovation in the Swedish Manufacturing Industry, 1970-2007 [Doctoral dissertation]. Lund University.

Thompson, E., Herian, M., & Rosenbaum, D. (2021). Final Report. The Economic Footprint and Quality-of-Life Benefits of Urban Forestry in the United States

United Nations Commission for Europe. (2021). *Sustainable Urban and Peri-urban Forestry An Integrative and Inclusive Nature-Based Solution for Green Recovery and Sustainable, Healthy and Resilient Cities. United Nations.*

Verdone, M. (2015). *A Cost-Benefit Framework for Analyzing Forest Landscape Restoration Decisions*. Gland, Switzerland: IUCN.

White, M.P., Alcock, I., Grellier, J. et al. (2019) Spending at least 120 minutes a week in nature is associated with good health and wellbeing. Sci Rep 9, 7730. https://doi.org/10.1038/s41598-019-44097-3

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For further information

info@uforest.eu

www.uforest.eu