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Planting for the sake of planting: a denser city can be greener

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1 Introduction

Urbanization began ~10,000 years ago with agricultural settlements. The earliest urban centers arose in Mesopotamia, the Nile Valley, and the Indus Valley, functioning as political, religious, and commercial centers (Mumford, 1961). However, large-scale urbanization did not occur until the 18th century, when the Industrial Revolution in Europe triggered rapid migration from rural to urban areas (OECD, 2020; ONU-Hábitat, 2020). Global urbanization then accelerated from ~30% in 1950 to >55% today, projected to reach 68%–70% by 2050, primarily in Africa and Asia [United Nations, Department of Economic and Social Affairs (UN DESA), 2019; ONU-Hábitat, 2022; OECD, 2020].

This continuing migration drives urban densification and intensifies demand for housing, transportation, and other basic services. It also intensifies pressure on infrastructure, resulting in informal settlements, congestion, and strain on resources [ONU-Hábitat, 2020; United Nations, Department of Economic and Social Affairs (UN DESA), 2019]. Urban growth increases energy and water consumption, pollution, and waste generation, while accelerating the loss of green spaces, factors that amplify climate change and environmental vulnerability (Seto et al., 2012; UNEP, 2021).

Cities therefore face two critical challenges: **increasing density** and declining **green space**. To address these, many local governments have implemented urban greening and reforestation initiatives, such as the “Greening of London” project in the UK, the “Urban Forest Fund” in Melbourne, Australia, and “The Smart City” in Kuala Lumpur, Malaysia (City of Melbourne, 2025; Internet Geography, 2025; Nizarudin and Zakariya, 2025). These projects demonstrate how policies can integrate trees and vegetation into urban design. However, such efforts often prioritize aesthetics or broad sustainability goals rather than being grounded in ecophysiological evidence that ensures long-term resilience and ecosystem function.

Large-scale tree planting initiatives, such as the Million Trees programs in Los Angeles (USA), New York (USA), Beijing (China), and Ontario (Canada), have become common urban greening strategies in developed countries (Campbell, 2014; MacDonald et al., 2018; Pincetl, 2010; Yao et al., 2019). These projects aim to reduce CO₂ concentrations, improve air quality, and deliver social and aesthetic benefits (McPherson et al., 2011; McPherson, 2014). Nevertheless, despite their ambitious scope, most lack clear scientific criteria for species selection. For instance, the Million Trees initiative in Los Angeles emphasizes carbon reduction and energy recovery from wood waste and includes cost-benefit analyses

of reforestation benefits (McPherson, 2014; MTI, 2010), yet provides little guidance on which species should be planted or their long-term survival requirements.

Similar programs have emerged in developing countries. In Spain, the Manzanas Verdes (Green Blocks) project seeks to mitigate climate change, improve air quality and enhance urban water retention capacity through reforestation (UGA, 2025). In Curitiba, Brazil, city authorities have promoted the restoration of degraded green spaces, the planting of native species, and the creation of urban parks (cities4forests, 2016). However, in many cases, the emphasis remains on meeting numerical planting targets rather than ensuring ecological suitability and functionality, risking suboptimal ecological outcomes.

Urban reforestation is undoubtedly vital in cities, but should not be done indiscriminately, nor should be driven by quantity alone. The success of these efforts depends on strategic planning that considers local conditions, species traits, and long-term ecosystem performance. In other words, planting a million trees is far less valuable than planting the right trees in the right places, guided by ecological evidence and urban environmental needs. The question, therefore, is not whether cities will continue to densify, but how they can do so while maintaining, and even expanding, urban greenery that supports livability, biodiversity, and climate resilience.

Current tree planting strategies are often insufficient because they focus on meeting numerical targets rather than ensuring that species are ecologically suited to local conditions and capable of delivering specific ecosystem services. The functional approach proposed here improves urban greening by grounding species selection in ecophysiological evidence and maximizing service delivery per unit area, thus enabling denser cities to become not only greener but also more climatically and ecologically resilient.

2 Denser and greener

In urban planning, “greener” is often understood simply as having more vegetation. However, space constraints in dense cities can make this implementation unrealistic. We therefore define greenness as the effectiveness of existing vegetation in delivering ecosystem services, such as shading, cooling, and pollutant absorption, relative to available space. In this context, optimal performance can be defined as maximizing specific ecosystem services per unit area (Wu et al., 2018), such as degrees of temperature reduction, volume of stormwater retained, or pollutant mass removed, rather than simply increasing vegetated cover. From this perspective, individual species differ markedly in their capacity to achieve optimal performance for a given service. For cooling, for example, plant transpiration is a vital physiological process that cools surrounding air and thus mitigates the urban heat island effect. Therefore, a species could be considered “greener” if it has a higher transpiration rate and, consequently, greater cooling potential under urban conditions. When designing or managing urban green spaces, selecting species with high transpiration efficiency can substantially enhance microclimatic regulation and overall ecological performance.

In a study conducted in Mexico City, Barradas et al. (2022) measured differences in stomatal conductance, transpiration rate, and cooling potential among 10 tree species. Their results (Table 1) demonstrate large interspecific variation, suggesting opportunities to design urban park modules that maximize cooling efficiency and improve local thermal comfort. The authors found that several species, such as *Liquidambar styraciflua* and *Alnus acuminata*, exhibited notably high transpiration and cooling potential, implying their strong suitability for mitigating heat in compact urban environments. Other species, such as *Buddleja cordata* and *Lagerstroemia indica*, showed low cooling efficiency and would likely contribute less to thermal regulation, particularly under cooler air temperatures that limit vapor pressure deficit. Targeted management practices, such as canopy pruning to optimize light and airflow, can further enhance vapor pressure deficit and transpiration performance. These findings highlight the need to redefine urban “greenness” in physiological and functional terms. In dense cities where space is limited, maximizing ecological function per unit area, rather than simply planting more trees, offers a more realistic and achievable path toward sustainable urban cooling and climate resilience.

3 Discussion

Translating these insights into practice requires designing green spaces that maximize specific service performance within urban areas; for example, the greatest possible cooling ($^{\circ}\text{C}$ reduction) per square meter of planting. A good design that guarantees a high cooling efficiency will be one that contains species with high transpiration rates. According to the TUNEE model (Ballinas and Barradas, 2016), an arrangement of 19 individuals representing six tree species within a 2,500 m^2 area could lower air temperature by up to 5.3 $^{\circ}\text{C}$. This cooling effect could likely be enhanced further through systematic pruning programs that improve the microclimate conditions and increase transpiration efficiency. These results show that even in very compact urban areas, carefully selected and arranged species can deliver substantial cooling and other ecosystem services, showing that high urban density does not inherently prevent high ecological performance. Importantly, such multi-species configurations also support urban biodiversity, maintaining ecological stability while providing measurable climate benefits.

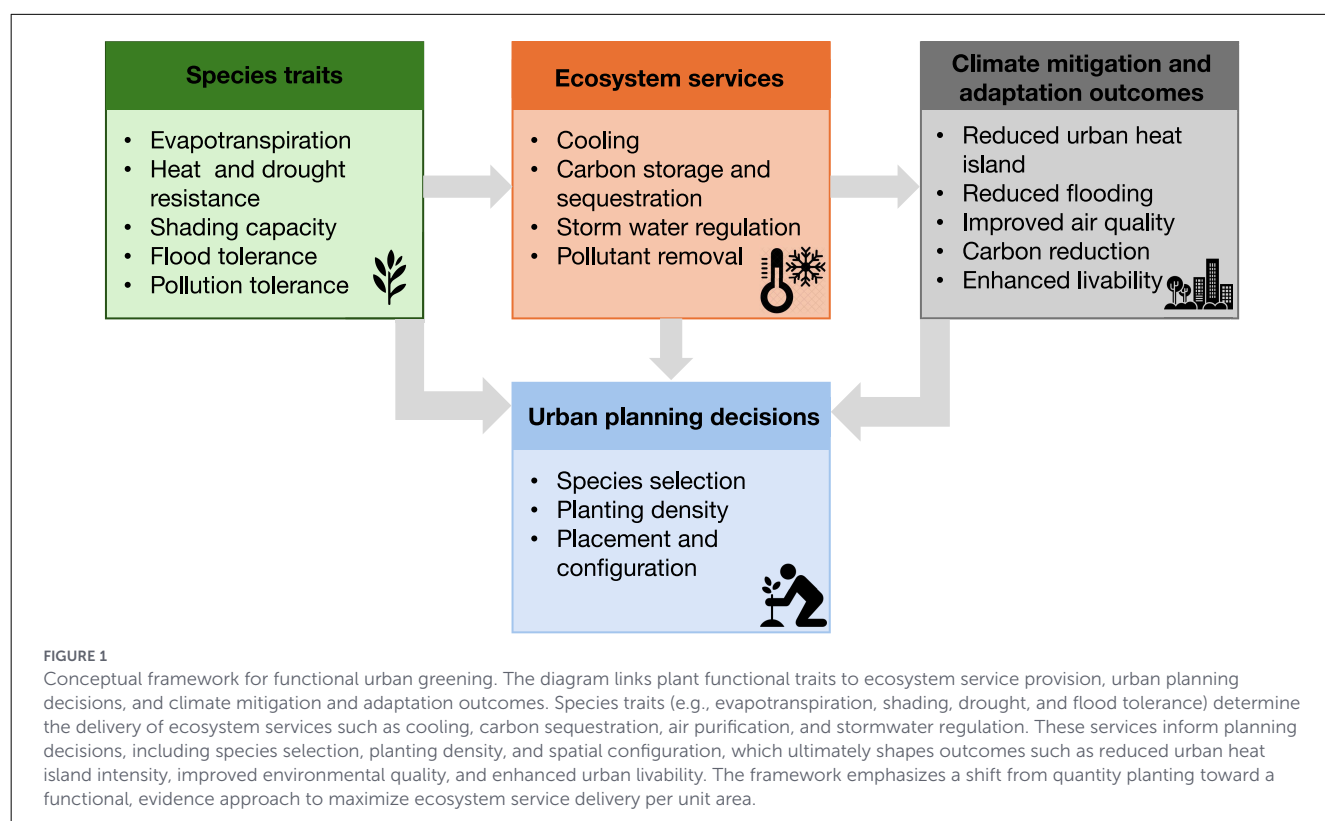
A simple conceptual framework supports these insights. Species traits such as transpiration rate, shading capacity, flood tolerance, and drought resistance determine ecosystem service provision under local climatic conditions. These services, in turn, inform urban planning decisions about species selection, arrangement, and management, which ultimately shape climate mitigation and adaptation outcomes, such as reduced urban heat island intensity, improved stormwater retention, and enhanced biodiversity (Figure 1).

The same logic applies to other ecosystem services. If the urban objective is to increase carbon sequestration, improve stormwater management, or enhance air quality, species should be selected based on quantitative evidence of their specific performance in these functions rather than on availability alone. Effective greening

TABLE 1 Averages of stomatal conductance (g_s , cm s^{-1}), transpiration (E , $\text{g m}^{-2} \text{s}^{-1}$), cooling potential (CP , $\text{J m}^{-2} \text{s}^{-1}$), of 10 tree species from different urban parks and green areas within the Metropolitan Area of Mexico City (Barradas et al., 2022).

Species	g_s	E	CP
<i>Liquidambar styraciflua</i>	3.81	0.0357	87.2
<i>Alnus acuminata</i>	3.52	0.0352	86.0
<i>Quercus rugosa</i>	3.65	0.0348	84.9
<i>Ligustrum lucidum</i>	2.89	0.0324	79.2
<i>Ficus benjamina</i>	3.01	0.0307	74.9
<i>Populus deltoides</i>	2.17	0.0215	52.5
<i>Fraxinus uhdei</i>	2.6	0.0194	47.5
<i>Populus alba</i>	2.57	0.0187	45.5
<i>Lagerstroemia indica</i>	1.26	0.0102	25.1
<i>Buddleja cordata</i>	1.08	0.0089	21.7

The values in bold represent the highest potential cooling values, making them the most recommended species.



depends on functionally designed systems rather than arbitrary or purely aesthetic planting targets.

These principles are broadly applicable across climates but require context-specific adaptation. Mexico City is the main case study for this opinion piece, but similar trade-offs arise in other urban contexts. In arid cities, high-transpiration species may be constrained by water availability, making drought tolerance and irrigation access critical. Temperate cities might emphasize higher transpiration for cooling under humid conditions, while in tropical cities, flood tolerance and heat mitigation may be more important. In rapidly urbanizing Asian cities, species selection must also account for pollution, land scarcity, and maintenance capacity. The central principle remains the same: urban greening should

maximize ecosystem service delivery per unit area, but the optimal trait profile will vary by hydroclimate, management capacity, and local objectives.

Implementation of functional greening also depends on practical capacity. Species selection must be matched to available maintenance budgets, irrigation requirements, and institutional support, particularly in cities with limited staffing or fragmented governance. Community participation is also important, both to improve stewardship and to ensure that planting decisions reflect local priorities and social context. Finally, planted species should be monitored over time so that cooling, survival, and other ecosystem services can be evaluated and planting designs adjusted accordingly.

We acknowledge that our analysis draws primarily from a Mexico City case study representing a high-altitude tropical climate, so trait priorities may differ across biomes. High-transpiration species thrive where water is available but may underperform in arid regions without irrigation. Species interactions, soil constraints, and long-term maintenance costs also require consideration beyond single metric performance. Future research should validate trait-performance relationships across diverse urban climates and quantify multi-service trade-offs (e.g., cooling vs. carbon vs. stormwater) to refine functional greening frameworks for global application.

Emerging tools and frameworks are already demonstrating this functional approach. In Montreal (Canada), the SylvCiT platform recommends species combinations that maximize functional diversity based on traits, planting location, and neighboring trees (Nicol et al., 2026). Also in Canada, Vancouver's TreePlotter (VTP) (2021) tool matches species to site conditions to optimize cooling and stormwater benefits, while Europe's CoolTowns initiative prioritizes high-transpiration species for heat mitigation in dense neighborhoods (Bartlett and Jain, 2019). These examples illustrate how science driven greening can deliver superior outcomes within urban environments with limited space.

These principles are consistent with several established frameworks in urban ecology. Dense cities can achieve high ecological performance when urban green spaces are treated as essential infrastructure (Esperon-Rodriguez et al., 2025a). This approach is consistent with broader conceptual frameworks in urban ecology. From the perspective of urban ecosystem services, functional greening maximizes cooling, carbon sequestration, stormwater retention, and other benefits per unit area. From the viewpoint of nature-based solutions and urban green infrastructure, it treats trees not as ornamental components but as essential assets of resilient urban systems. Finally, from the standpoint of climate resilient urban design, it aligns species selection with local heat, hydrological, and social conditions, ensuring that greening strategies support both adaptation and mitigation (Bush and Doyon, 2019; Fernandes et al., 2025; Russo and Cirella, 2024). This requires policymakers to support research on species ecophysiological performance and integrate these findings into urban planning and nursery production (Esperon-Rodriguez et al., 2025b). Such approaches enable cities to implement climate-resilient greening strategies that enhance livability beyond symbolic tree planting campaigns.

4 Conclusion

Urban density and greenness do not need to be opposing forces. The examples discussed here show that, even within small, highly built-up urban areas, functionally selected and arranged species can deliver substantial cooling and other ecosystem services per unit area. The challenge lies in designing urban ecosystems where green spaces perform optimally to enhance cooling, biodiversity, and human wellbeing. Achieving this balance demands a shift from

tree-planting campaigns based on numbers to greening strategies grounded in ecophysiological evidence, functional diversity, and adaptive management (i.e., frequent monitoring and adjustment of planting designs based on observed performance). Some cities are already proving this vision possible through trait species selection and functional design. Cities that integrate ecological science into their planning can transform limited space into high performing green infrastructure, using species' functional traits and climate responses to maximize services per unit area, thus demonstrating in practice that a city can indeed be both dense and green. These strategies require not only trait species selection, but also adequate maintenance, irrigation where necessary, institutional coordination, and long-term monitoring.

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VB: Conceptualization, Formal analysis, Investigation, Supervision, Writing – original draft, Writing – review & editing. MB: Investigation, Writing – original draft, Writing – review & editing. ME-R: Writing – original draft, Writing – review & editing.

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