frontiers | Frontiers in Sustainable Cities

TYPE Perspective
PUBLISHED 30 May 2024
DOI 10.3389/frsc.2024.1394056

OPEN ACCESS

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RECEIVED 29 February 2024
ACCEPTED 16 May 2024
PUBLISHED 30 May 2024

CITATION
Egerer M, Schmack JM, Vega K,
Barona CO and Raum S (2024) The
challenges of urban street trees and how to
overcome them.
Front. Sustain. Cities 6:1394056.
doi: 10.3389/frsc.2024.1394056

The challenges of urban street trees and how to overcome them

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City street trees are prominent features of urban green infrastructure and can be useful for climate change adaptation. However, street trees may face particularly challenging conditions in urban environments. Challenges include limited soil and space for growth surrounded by sealed surfaces, construction that damages roots, poor pruning and management, and direct vandalism. All of these challenges may reduce the capacity of street trees to provide social-environmental benefits, such as attractive landscapes, shading and cooling. Thus, street trees need specific care and resources in urban environments. In this perspective article, we call for a conversation on how to improve the conditions for city street trees. While research has broadly investigated street tree mortality and vulnerabilities, the social perspective may be missing, one that also involves the actions and care by human inhabitants. Here we share perspectives on current management options and discuss from a social-ecological perspective how these can be extended to involve urban residents.

KEYWORDS

ecosystem services, environmental ethics, human-nature relations, nature-based solutions, urban forests

1 Introduction

Street trees can provide a suite of environmental and social benefits that enhance the environmental and social quality of cities (Mullaney et al., 2015; Shibata and Tan, 2022). They are prominent features of urban green infrastructure and can be important for climate change adaptation. Urban street trees also provide shade, air filtration, habitat for wildlife, and aesthetic and cultural benefits (Salmond et al., 2016; Ordóñez et al., 2022). However, street trees may face challenging conditions in urban roadside environments, compared to, for instance, trees in urban parks or gardens. Challenges include difficult environmental growing conditions, neglect, and even vandalism (Mullaney et al., 2015; Hilbert et al., 2019).

These conditions create a stressful environment for street trees growth and longevity (see case studies and reviews by Mullaney et al., 2015; Jim et al., 2018; Hilbert et al., 2019; Tan and Shibata, 2022). Whether planted in orderly rows of a single tree type or species (i.e., monocultures), within cemented ground-level planters with surrounding protective infrastructure (e.g., usually metallic discs or grates), or planted inside an above-ground planting pot, a body of research shows how the growing conditions of street trees are often not ideal (Yang and McBride, 2003; Day et al., 2010; Mullaney et al., 2015; Figure 1). This has led to high recorded adult tree mortality rates (e.g., in

FIGURE 1
Examples of the challenges street trees in cities face. Trees are planted with limited soil for growth surrounded by sealed surfaces **(A–C)**, construction damages roots **(D)**, and human chemicals, refuse, and direct vandalism damages trunks and pollutes soils **(E–G)**. Photos are the authors.

United Kingdom, Heap, 2023; in United States, Roman et al., 2011; in Canada, Ordóñez et al., 2018a,b). Moreover, wherever street trees manage to survive, many trees suffer from prolonged poor health (Jim et al., 2018; Hilbert et al., 2019). Smith et al. (2019) have highlighted the "live fast die young" lives of newly planted street trees which, despite their initial growth rates being nearly four times higher than in rural conditions, have more than double the average adult mortality rate of rural tree maturity. Many street trees may only live up to a maximum of 20 years, a short life considering that many tree species can live decades or centuries, depending on the tree species (Smith et al., 2019). It can be a short hard-knock life for city street trees.

Much technical research in urban-tree growing conditions has focused on ameliorating some of these stressors through a better understanding of the optimal environmental growing conditions for trees, tree physiology, and the needed technological and design interventions (Mullaney et al., 2015; Shibata and Tan, 2022). Indeed, new approaches in street tree modeling may further provide insight into optimal growing conditions or potential stress mitigation (e.g., Cameron et al., 2017; Ossola et al., 2023) However, they may not necessarily consider the social-political context of trees, including resources, which may influence management decisions or realistic outcomes of tree longevity. In many parts of the world, urban residents get involved in the care and management of street trees (Fernandes et al., 2019; Ordóñez et al., 2022). This may be in the form of *ad hoc* grassroot initiatives (e.g., neighborhood residents stewarding a tree planted in a pit) or more coordinated programs (e.g., Tree Warden Schemes). These actions show gratitude for street trees and demonstrate that residents consider them important components of the city. However, such activities may not always be welcomed with some residents rejecting expanded tree planting due to concerns with pollen allergies, leaf litter, as well as management and safety concerns (Schroeder et al., 2006; Carmichael and McDonough, 2019; Roman and Walker, 2021; Devi et al., 2023). Thus, we argue that such actions and concerns instigate a dialogue around how to best align residents' activities with existing urban planning and green space management for improving the life for street trees in cities.

In this perspective article, we highlight the challenges faced by city street trees, while underscoring that street trees need better conditions and management in our densifying cities to thrive and supply their benefits. We focus on street trees as they are among the most visually pronounced city trees for urban dwellers, yet frequently have the toughest growing conditions of all trees in the urban forest (Czaja et al., 2020). First, we briefly discuss the situation of street trees under different environmental and social conditions for context, while acknowledging that the published work is extensive. Second, we argue for new directions in their management, involving urban residents in a more structured and coordinated way. While there is already much work on street tree mortality (Roman et al., 2011; Roman and Scatena, 2011; Hilbert et al., 2019) as well as on new monitoring tools and technologies to target tree vulnerability to improve street tree management (e.g., Jahani and Saffariha, 2022a,b; Ossola et al., 2023), we aim to provide a more nuanced social-ecological perspective on the lives of these street trees and offer suggestions on how to improve it by harnessing urban resident action and care.

2 The challenges of street trees

2.1 Environmental conditions

The environmental conditions that challenge city street trees to survive, grow, and thrive can occur at multiple spatial and temporal scales (Jim et al., 2018; Tan and Shibata, 2022). Physical stressors of street trees may be because the tree and the planting space in which it lives conflict with existing urban infrastructure (Stål, 1998; Jim, 2001; Östberg et al., 2012; Torres et al., 2017; Shi et al., 2023). The planting space (e.g., tree planters, pits, grates, discs, or beds) usually takes the form of isolated sections of shallow and low-quality soil along streets (Figure 1). The soil permeability of these growing spaces is usually poor, resulting in lack of water availability contributing to high street tree mortality and poor health (Jutras et al., 2010; Sjöman and Busse Nielsen, 2012; Fahey et al., 2013; Gillner et al., 2017). Car traffic and urban water runoff lead to heavy metal pollutant deposition into street tree soils, while salts commonly used to de-ice roads and pavements can lead to de-icing salt contamination reducing tree growth (Cekstere and Osvalde, 2013; Ordóñez et al., 2018a).

Environmental threats to street trees also include sunscald, insect borer, and canker-causing fungi damage (Roppolo and Miller, 2001; Poland and McCullough, 2006). Extended dry spells (Fahey et al., 2013; Gillner et al., 2017), frost damage, or wind breakage further weaken the tree, exacerbating and inciting additional pest attacks (Referowska-Chodak, 2019). Some tree pests and pathogens, however, may damage tree trunks so severely that even otherwise healthy street trees may die within only a few years (see review by Raum et al., 2023). Extreme heat waves (exacerbated by the urban heat island) can reduce photosynthesis, increase photo-oxidative stress, and, through stomatal closure for water conservation, increase leaf temperatures leading to leaf die-off and defoliation (O'Sullivan et al., 2017; Tabassum et al., 2021). Thus, climate change further puts urban tree species at risk to projected increases in mean temperature and changes in annual precipitation (e.g., about 70% of tree species across 168 cities worldwide are vulnerable; Esperon-Rodriguez et al., 2022).

2.2 Management and treatment of trees

Poor pruning, wounds, and injuries caused by lawn mowers, string trimmers, careless planting, vandalism, or vehicles can collectively impact the trunk's vascular transport of water, sugars, and other important substances from roots to stems and leaves (Shigo, 1991). Trimming and pruning of the tree can constrain the development of the canopy itself, resulting in stunted growth and reduced vigor, especially if done under poor standards (Tan and Shibata, 2022). Such trunk injuries also predispose street trees to environmental threats described above (2.1.).

2.3 Perceptions of trees

Despite governance movements to green cities, not everyone loves street trees in all situations and perceptions of street trees vary around the world (Roman and Walker, 2021). The social context in which street trees find themselves often makes them the victims of direct and indirect forms of anthropogenic abuse, as well as whether trees are considered to provide services or disservices. Residents may use trees as bike stands or the tree disc area as trash bins, construction can leave tree roots exposed to trampling and damage, and many newly planted street trees are targets of vandalism (Richardson and Shackleton, 2014; North et al., 2017; Ordóñez et al., 2018b). Some residents perceive street trees as a nuisance or a safety risk (Schroeder et al., 2006; Roman and Walker, 2021; Devi et al., 2023) and may place "no-tree requests" around their residences (Carmichael and McDonough, 2018). Street trees are often removed because of such attitudes, and due to more pragmatic reasons, such as inconvenience in construction (Croeser et al., 2020); their liability related to their risk of causing breakage (McPherson, 2007). Falling leaves, pollen, twigs, fruits, and excrements from tree insects and birds are frequently seen as an unwanted burden (Kuo, 2003; Lyytimäki, 2017).

3 Management options to improve the conditions of street trees

3.1 Technical and expert options

Management options to improve the conditions of street trees may include integrating new technology, technical standards, and improved management practices – but also the involvement of urban residents. Some of these options are one-off and implemented before the tree is planted, others are ongoing. Spaces where trees are to be planted can be designed to avoid conflicts with existing infrastructure and such infrastructure can be modified to enhance growing space. Planting standards can be improved, including planting depth, trimming of rooting systems, among others (Sherman et al., 2016). New technologies to improve planting sites can be used, including those that support irrigation, such as permeable pavements, those that improve soil quantity and quality (see below), and improved watering regimes (Sjöman et al., 2012; Fahey et al., 2013; Gillner et al., 2017; Dickenson et al., 2023). Soil technologies include structural soils and structural soil cells, which improve soil quantity and structure (Bartens et al., 2010; Day et al., 2010), with soil amendments for improving quality (Somerville et al., 2018). It has also been suggested that more natural street tree plantings, where trees grow in small groups may do better, as they would be able to share resources, whilst also reducing maintenance and costs.

Management standards, including species selection, can be improved to consider tree ecological functions (Paquette et al., 2021; Farell et al., 2022). This may also include improved monitoring and data management (Jutras et al., 2010). Methods for assessing potential tree hazard risks in urban areas (e.g., falling branches or trees due to storms, hurricanes, heavy snow, poor tree health) are also constantly evolving. These include prediction model techniques to develop decision support systems to assess the likelihood of tree failure (Jahani and Saffariha, 2022a,b), as well as utilizing big data and predictive modeling to identify potential conflicts between underground infrastructure and street tree root systems (Cameron et al., 2017; Ossola et al., 2023). Balancing the need for human safety and avoiding damages from hazardous trees to infrastructure whilst maintaining as many street trees as possible, especially older ones who often provide the greatest benefits, can be particularly challenging. Citizens may, for instance, be particularly sensitive towards overly cautious decisions on much loved, but potentially hazardous old trees (Jahani and Saffariha, 2021). Yet, we argue that improving the life of street trees is not just a technical fix to be worked out by local government institutions or expert practitioners. While street tree care often rests on local governments, local residents also can play a role in the work of caring for street trees, and local governments can facilitate this stewardship by residents. Unfortunately, this is often missing from management plans and interventions (Zare et al., 2015; Ordóñez et al., 2022).

3.2 Involvement of urban residents

In some parts of the world, urban residents already are involved in the management of street trees, demonstrating that residents consider them important and care for them (Fernandes et al., 2019; Laurian et al., 2019; Ordóñez et al., 2022; Figure 2). Such activities may be *ad hoc* and uncoordinated or regular and led by citizen voluntary organizations. This includes "Adopt a Tree" campaigns (Thacker, 2018; McNamara et al., 2022), protecting street trees as crowned "Heritage trees" (also called "Landmark," "Exceptional," etc.; Thaiutsa et al., 2008) or planting around them to create microcosms in the tree disc (e.g., "Garden around the corner" in Vienna, Austria; City of Vienna, 2023). Other voluntary actions by residents include watering trees during drought events to mitigate tree stress (McNamara et al., 2022). In London, for example, some local authorities encourage this behavior by hanging signs to encourage local people to water their street trees (London Borough of Richmond Upon Thames, 2023). The UK charity "The Tree Council" leads a network of voluntary "Tree Wardens," who plant and care for the trees in their local patch (The Tree Council, 2023).

Such neighborhood planting programs for street trees can involve many community members, from youth to elderly residents (Roman et al., 2015; Lachmund, 2022). In Los Angeles, United States, tree planting and watering campaigns increase not only street tree vitality but also resident environmental education, awareness, and overall acceptance across the sociodemographic spectrum (McNamara et al., 2022). In Berlin, Germany, street tree pits have become spaces for environmental stewardship (Lachmund, 2022), and the project "Gieß den Kiez" (English: "water the neighborhood") provides a web-based educational app to residents and public officials to explore tree water needs, coordinate irrigation, and mediate tree water stress. Over 1,000 'citizen-caretakers' are currently registered that care for over 7,000 trees (CityLAB Berlin, 2023). In Munich, Germany, the organization Green City e.V. coordinates a street tree gardening project in collaboration with the city's horticultural department, where city residents can sign a sponsorship agreement to maintain the tree area regularly by watering, weeding, and removing garbage (Green City e.V, 2024). The City of Melbourne, Australia, goes a step further and has developed in-person and on-line co-governance forums for citizens at the neighborhood scale to state their preferences for canopy cover, tree planting and tree removal strategies (City of Melbourne, 2013; Gulsrud et al., 2018). The City of Melbourne, for instance, also suggests that "in addition to careful species selection and the ongoing maintenance of trees, sustaining the quality and quantity of the urban forest in the City … will require ongoing community involvement" (The City of Melbourne, 2016).

Many of the above actions are examples of how urban residents can contribute to the management of street trees to improve their lives. We see such actions could be a path forward toward more integrated stewardship when coupled with tailored coordination, subsidization, and guidance by city government. Yet, such actions may require careful orchestration and a consideration of the social ecology and political ecology of street trees

FIGURE 2
Various images of street tree living environments that have been improved upon by resident's initiatives **(A,B,D–F)** and city initiatives **(C)**. Images show signs that state: **(A)** "have respect for the neighborhood," and **(D,F)** "do not cut." Photos are the authors.

(Kuo, 2003; Cameron, 2022). Furthermore, we believe that a wider discussion and research is needed that involves a range of different stakeholders on how to best integrate communities into urban street tree management as not all locations and approaches may be appropriate. A major issue is that there is a high motivation to plant street trees in cities, but low resources to do the hard and time-intensive work of management and care afterward. Some residents worry that it will fall on their shoulders to prevent new street tree plantings from turning into a dead eyesore (Olivero-Lora et al., 2020). With this perspective article, we would like to encourage discussions and further research into whether and how residents could be involved, and their actions elevated to help improve conditions for street trees. Some of the examples and pilot projects described above can lead the way in these discussions.

4 Conclusion

As urban society may increasingly demand the many benefits of street trees, a question remains of how living conditions and management can improve to help trees overcome the many social and environmental challenges they face (Supplementary Figure 1). Such direct interaction and stewardship between the public and their leafy neighbors are ways that we can shift the social norms in terms of street tree care, especially when an educational component is integrated into the program (Thacker, 2018; McNamara et al., 2022). Opportunities to help link communities directly to their street trees and the spaces they create as voluntary stewards, where appropriate and desired (Jack-Scott et al., 2013), need to be scaled up and financially supported by city governments, perhaps even becoming the new norm, rather than the actions of a few dedicated individuals covering only a limited number of street trees. This perspective aims to initiate a discussion on how to improve conditions for street trees through urban residents in a way that improves the health of street trees, feasible for those formally or legally in charge of street trees (i.e., often local authorities or highway agencies) and urban residents. We propose that street tree management by residents that is fully funded, supported, and orchestrated by city governments may be a fruitful pathway forward in the management of street trees now and for the future.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

ME: Conceptualization, Data curation, Investigation, Writing – original draft, Writing – review & editing. JS: Conceptualization, Data curation, Visualization, Writing – review & editing. KV: Conceptualization, Data curation, Visualization, Writing – review & editing. CB: Conceptualization, Data curation, Validation, Writing – review & editing. SR: Conceptualization, Data curation, Investigation, Validation, Visualization, Writing – review & editing.

Funding

The author(s) declare that financial support was received for the research, authorship, and/or publication of this article. SR received funding from the European Union's Horizon 2020 research and innovation programme under the Marie Sklodowska-Curie grant agreement NO. 101023713. The article reflects only the authors' views, and the Agency is not responsible for the information it contains.

Acknowledgments

We thank the Technical University of Munich and the European Union's Horizon 2020 research and innovation programme for supporting this work.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The author(s) declared that they were an editorial board member of Frontiers, at the time of submission. This had no impact on the peer review process and the final decision.

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Supplementary material

The Supplementary material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/frsc.2024.1394056/full#supplementary-material

SUPPLEMENTARY FIGURE 1
An illustrated summary of the ways in which street trees can be cared for and thrive (left), in contrast to ways in which street trees battle challenges to survive in urban conditions (right). Illustration by Julia Schmack.

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