Urban plants biodiversity

Francesco Ferrini, Ermes Lo Piccolo

Abstract: Biodiversity in the urban setting plays an important role in preserving ecological processes and social well-being. Urban green spaces such as parks, gardens, hedgerows and road verges also in densely urbanized environments,, can provide refuge for pollinators, birds, small mammals, and native plants. These 'mini-biodiversity hotspots' not only provide ecosystem services like water management, air filtration, microclimate regulation, and health benefits for dwellers, but can be essential hubs for the urban ecological network. However, the biodiversity richness of these spaces can be limited by their fragmentation and simplification (i.e., low plant species adopted), and in some cases, by intensive management (i.e., excessive mowing). Therefore, this section analyses the current state of urban biodiversity to highlight the importance of a strategic planning and management of urban green spaces. We propose strategies, like habitat diversification, native planting, and lower maintenance schedules, that can greatly increase biodiversity in alignment with sustainability and public health goals. Moreover, we show the most widely used indicators for assessing biodiversity, useful tools for integrating biodiversity into urban development policies. In an era in which environmental sustainability and ecosystem conservation are global priorities, landscape architects have a crucial responsibility in embedding biodiversity-focused practices into urban projects.

Keywords: Green Infrastructure, Nature conservation, Plant species diversity, Urban ecosystems, Urban green spaces.

1. Understanding urban biodiversity

The term «urban biodiversity» has been described in different ways by previous authors, based on its complexity and ecological significance. For instance, Werner and Zahner (2010) defined it as the whole aggregation of animals and plants within cities. While the MAMROT (2013) expanded this concept, highlighting the inclusion of genetic variation among species and habitat heterogeneity in and around urban settings. Moreover, Puppim de Oliveira et al. (2014) highlighted both the diversity of living organisms and the ecological systems they inhabit. It must be noted that, contrary to common assumptions, cities are not just a mix of concrete, asphalt, and steel. Empirical studies confirmed that urban areas can support many biodiversity hotspots that can have ecological conservation functions. Consequently, the capability for urban areas to host a huge amount of biodiversity needs to be acknowledged by city planners so that management practices that maintain and support such diversity can be pursued (Gentili et al. 2024). In Switzerland, urban tree species richness was found to be up to 17 times greater than that of near forests (Augustinus et al. 2024), illustrating the potential of urban areas not only to maintain but also to enhance biodiversity so that cities often exhibit higher species richness than surrounding rural areas (Wania et al. 2006). Such complexity places cities as potentially emergent hubs of biodiversity. Nevertheless, urbanization may also drive biotic homogenization and the spread of invasive species (McKinney 2006; Gentili et al. 2024; Xie et al. 2024), threatening local biodiversity, highlighting the need for expert planning and management of urban green spaces.

Francesco Ferrini, University of Florence, Italy, francesco.ferrini@unifi.it, 0000-0003-2222-0437
Ermes Lo Piccolo, University of Florence, Italy, ermes.lopiccolo@unifi.it, 0000-0001-9789-2524

Referee List (DOI 10.36253/fup_referee_list)
FUP Best Practice in Scholarly Publishing (DOI 10.36253/fup_best_practice)

Francesco Ferrini, Ermes Lo Piccolo, *Urban plants biodiversity*, © Author(s), CC BY 4.0, DOI 10.36253/979-12-215-0966-3.08, in Roberto Bologna, Anna Lambertini, Luca Solari (edited by), *Nature and City. An Integrated Approach to Urban Biodiversity*, pp. 51-60, 2025, published by Firenze University Press, ISBN 979-12-215-0966-3, DOI 10.36253/979-12-215-0966-3

Plants in urban environments can adapt to a broad range of microhabitats. Urban vegetation is shaped by silvicultural expertise, nursery availability, and administrative regulations, and in certain cases, also by the lack of these factors. Different land uses and habitat types (e.g., street edges, riverbeds, public parks, gardens, private green areas, abandoned areas, and remnant natural patches) create distinct urban floristic compositions. A proper alignment between plant characteristics, site conditions, and management goals is fundamental to ensuring the delivery of ecosystem services. Preserving biodiversity, incorporating biodiversity into urban design, and promoting sustainable building practices are fundamental to a greener, healthier, and more resilient urban environment.

2. Components and scales of urban biodiversity

Urban biodiversity can be categorized into different levels, each interacting with the built environment and city dwellers. Understanding the different biodiversity levels and the scale-related factors that influence them is important to creating sustainable and resilient cities.

2.1. Levels of urban biodiversity

Urban biodiversity comprises several levels:

Genetic diversity is important for species survival and adaptability in urban environments marked by extreme and very variable microclimatic conditions. The genetic variability within populations allows individuals to respond differently to the urban environmental constraints such as pollution, heat, and resource scarcity, thus improving the survival rates. Therefore, the consequent natural selection of urban plants can result in specific genetic adaptations enhancing tolerance to urban stressors and improving the whole ecosystem resilience (Williams et al. 2009).

Species diversity in the urban environment, although often underestimated, can be, as previously said, considerable. Urban green spaces host both native and newly introduced species. Some non-native species become invasive, replacing native flora and fauna. Parks and gardens serve as habitats and ecological corridors that facilitate species movement between urban and rural areas, enhancing ecological connectivity and urban ecosystem resilience (Aronson et al. 2014).

Ecosystem diversity refers to the variety of ecosystems within urban areas, including green roofs, parks, artificial wetlands, tree-lined streets, and spontaneous vegetation. These ecosystems provide critical services, including climate regulation, water retention, and air purification (Pickett et al. 2013). Their conservation and especially management are increasingly essential in rapidly urbanizing contexts.

2.2. Spatial scales influencing urban biodiversity

Urban biodiversity is shaped by factors acting at multiple spatial scales:

At the local scale, biodiversity is influenced by habitat heterogeneity, resource availability, and management practices and planning (Niemelä 1999). For instance, different plant formations in parks can support a wide range of species. Conversely, monocultures reduce ecological complexity and resilience.

At the neighborhood scale, the connectivity between green spaces and the presence of ecological corridors are important to species dispersion and new habitat colonization. Corridors such as rivers, hedgerows, road verges, or green roofs facilitate movement and genetic flow, enhancing biodiversity (Hostetler et al. 2011).

At the metropolitan scale, factors like land use planning, habitat fragmentation, and urban sprawl are dominant. Sustainable cities should mitigate fragmentation and biodiversity loss through integrated green networks and land-use strategies (McKinney 2008).

Urban planning must recognize that biodiversity is driven by processes across scales and must involve urban planners, scientists, landscape architects, and local communities, as an integrated, multi-scale approach is essential for urban biodiversity conservation.

2.3. Beyond a simple tree species selection

Urban forest planning and management must consider age, size, and genetic diversity:

Species diversity buffers against pest and disease outbreaks and ensures the provision of different ecosystem services such as carbon sequestration, microclimate regulation, and wildlife habitat.

Age diversity enhances habitat heterogeneity. Older trees often support symbiotic communities (e.g., fungi, lichens, insects, birds), increasing ecosystem richness and resilience.

Size diversity reflects structural differences among species. Larger trees offer more ecological benefits due to greater biomass.

Genetic diversity within tree populations is often ignored. Many urban trees are clonally propagated, reducing the variability and increasing the vulnerability to potential stressors (i.e., heat and drought). The adoption of different genetic backgrounds within species by expanding the range of used varieties and provenances can mitigate this risk.

A resilient urban forest should avoid overrepresentation of any single species, genus, or family. Guidelines from Santamour (1990) and others suggest no single species should exceed 10% of the total population, no genus more than 20%, and no family more than 30%. This taxonomic diversification enhances resistance to biotic and abiotic threats and ensures continuity of ecological functions across urban landscapes.

3. Urban habitats and ecological dynamics

Cities are increasingly recognized as complex and dynamic ecosystems. An ecological interpretation of the urban environment moves to understand the interactions between built and natural components, highlighting how urban habitats cannot only support but also promote a rich and evolving biodiversity, as previously mentioned. This ecological approach perceives the city not merely as an assembly of infrastructures but as a mosaic of interconnected habitats, including parks, gardens, green roofs, courtyards, abandoned industrial areas, hedgerows and road verges, each providing unique characteristics to support different wildlife. Indeed, when adequately managed, these spaces can serve as refuges for a wide range of plant and animal species, thereby contributing to both local and global biodiversity conservation.

An important aspect of urban ecological analysis lies in the understanding of the different types of habitats and their specific roles in maintaining biodiversity:

Public green spaces, such as parks and gardens, represent key habitats by providing refuges and food resources. Vegetation diversity within these areas is critical for attracting a wide range of fauna, including pollinating insects, birds, and small mammals (Gill et al. 2007; Kaiser and Resasco 2024). For instance, Kaiser and Resasco (2024) demonstrated that pollinator abundance is significantly reduced in gardens surrounded by large impervious surfaces, suggesting that decreasing such surfaces in the urban matrix may enhance bee abundance and then pollination.

Semi-natural areas, including urban woodlands, artificial wetlands, and riparian margins, are crucial for species that require more natural conditions. The presence of native vegetation and an ecologically oriented management significantly increases the biodiversity of these areas.

Green roofs and *Living walls* represent innovative solutions to increase the availability of habitats in densely built environments. When designed with different plant species, these architectural elements create microhabitats suitable for insects, birds, and even rare plant species. Beyond supporting urban wildlife, they also contribute to urban ecosystem resilience (Oberndorfer et al. 2007; Francis and Lorimer 2011).

Vacant and unmanaged spaces such as abandoned fields and spontaneously vegetated areas, though often ignored in urban planning, can serve as biodiversity refuges (Gandy 2013). These unmanaged areas allow pioneer species to establish and thrive, offering significant ecological benefits, including native species conservation, urban climate mitigation, and ecological enrichment of highly anthropized environments. However, the uncontrolled nature of these green areas can pose some risks. Indeed, without proper management, they may degrade, increasing the spread of potential invasive alien species such as *Ailanthus altissima*, *Robinia pseudoacacia*, *Paulownia tomentosa*, and *Broussonetia papyrifera*. These opportunistic plants are characterized by rapid growth and high adaptability; they may dominate native habitats, transforming them into poor and homogeneous landscapes.

4. Ecosystem services and the integration of biodiversity into urban planning

4.1. The impact of biodiversity on the ecosystem services provided by urban forests

Urban forests provide a range of ecosystem services, including regulatory, habitat, and provisioning functions (Dobbs et al. 2011; Nowak et al. 2016). Regulatory services sustain ecological processes and support life through biogeochemical cycles, contributing to ecosystem stability and human well-being via air, water, and soil purification and biological control. Urban forests also serve as essential habitats, promoting the conservation of genetic and biological diversity and enhancing resilience against potential biotic and abiotic stressors.

The role of tree species diversity in ecosystem services delivery is particularly relevant in urban contexts. However, not all species contribute equally, as services depend on species-specific morphological traits and temporal dynamics (Clapp et al. 2014). The presence of different tree species can affect rainfall interception (Xiao et al. 2000), temperature regulation (Bowler et al. 2010; Rendon et al. 2024), pollution removal (Vigevani et al. 2022), and the biological richness (Nielsen et al. 2014; Scherber et al. 2014). For example, Rendon et al. (2024) linked species diversity to lower peak summer temperatures, suggesting that the enhanced diurnal cooling effect was favoured by tree structural diversity. While single species can be effective in providing unique specific services, studies show that multifunctionality is best achieved through the use of a mix of species (Zavaleta et al. 2010; Lundholm et al. 2010). Thus, diversity is critical to create a resilient urban green infrastructure. However, as already stated in previous paragraphs, increasing species diversity does not always improve ecosystem performance. Some species may be undesirable due to invasiveness, allergenic pollen, volatile emissions, or damage to infrastructure (Potgieter et al. 2017). Therefore, a strategic selection is required to balance service optimization with minimization of ecological disservices.

Biodiversity can also be linked to human health. Indeed, exposure to nature can enhance mental and physical well-being. Healthy, diverse ecosystems can help regulate the spread of pathogens, reducing the prevalence of some infectious diseases (the so-called "dilution effect")(Civitello et al. 2015; Robinson et al. 2024). When ecosystems are disrupted, animals and humans may come into closer contact, increasing the risk of diseases jumping from animals to humans (zoonotic diseases). Also, access to natural environments rich in biodiversity supports mental health through calming effects and provides spaces for physical activity. A healthy human microbiome, which influences our immune systems, also benefits from exposure to diverse natural environments. However, while many studies support this, results are not always consistent, highlighting the need for interdisciplinary research. Integrating ecological, psychological, and public health perspectives may yield a more complete understanding of biodiversity role in promoting human well-being.

4.2. Biodiversity is about the planning, design, and management of cities and open spaces

The relationship between biodiversity and urban planning has been recently explored in depth by Lazzarini et al. (2024). Authors highlighted a critical role that biodiversity can play in promoting human well-being, planetary health, and economic prosperity.

Urban areas have the potential to conserve and promote biodiversity through actions such as habitat preservation, improving landscape connectivity, incorporating green infrastructure into planning processes, and promoting management strategies that draw attention to biodiversity. Despite this potential, the practical implementation of biodiversity in urban contexts still encounters significant challenges, including political inertia, limited competencies, and insufficient stakeholder engagement. Conventional urban planning often fails to address the complexity required to sustain biodiversity, and thus, radical transformations are necessary. Indeed, Lazzarini et al. (2024) suggest key issues that should be addressed, including i) the consistent implementation of biodiversity-enhancing measures across spatial scales; ii) the development of effective monitoring and evaluation systems; iii) the establishment of governance frameworks and political will to promote the biodiversity benefits; iv) the long-term engagement of citizens in urban regeneration processes.

Landscape ecology offers key tools to understand and preserve urban biodiversity (Norton et al. 2016). This field of study has significantly contributed to the scientific knowledge about urban landscapes and ecological communities. Factors such as city size, total green space area, settlement age, and regional context are fundamental for planning urban plant communities. Nevertheless, these variables have often been neglected in urban research. Traditional principles of landscape ecology, such as patch size, shape, and composition, continue to influence biodiversity in urban environments. However, the spatial fragmentation and altered temporal dynamics of urban areas necessitate the use of hierarchical, multiscale models specifically adapted to these settings. A major challenge lies in translating these scientific insights into concrete planning practices.

Historically, the spatial distribution and accessibility of green spaces have been evaluated primarily in terms of their proximity to human activity, often ignoring the mobility ranges of other biological species. Nowadays, green infrastructure and sustainable construction approaches are redefining urban development, generating spaces that not only offer aesthetic and recreational value but also protect habitats and contribute to the survival of urban wildlife. To enhance biodiversity outcomes in the urban environment, green spaces should be spatially arranged to remain within the dispersal range of various species, thus reducing barriers to movement and enabling genetic exchange. This can be achieved by creating stepping-stones at multiple scales, linking large green spaces with medium and small patches such as roadside vegetation. These ecological corridors serve as temporary stations that facilitate species migration and reproduction. For example, design solutions such as green roofs, vertical gardens, and elevated migration pathways that connect rooftops to ground-level vegetation can create a three-dimensional ecological network that can be essential for different species. The integration of strategies that prioritise biodiversity into urban projects is a critical duty of landscape architects.

5. Indicators for urban biodiversity

The most widely used indicator for assessing biodiversity is the Shannon-Wiener Index, also known simply as the Shannon Index (Fedor and Zvaríková 2019). This is an ecological measure that allows the quantification of the diversity of species within a community, considering both the richness and the evenness of the species present. A higher value of the Shannon Index indicates greater biodiversity, as it reflects not only a greater number of species but also a more balanced distribution of individuals among the species. Conversely, a lower value of the Shannon Index suggests lower biodiversity, characterized by a dominance of one or a few species. This makes the index particularly useful for comparing biodiversity between different ecosystems or for monitoring changes over time within the same ecosystem. Despite its widespread use, the Shannon Index has received various criticisms over time. One of the most frequently mentioned limitations is the difficulty of interpretation: the index uses logarithmic calculations that may not be intuitive for users unfamiliar with this type of mathematical function. Unlike more straightforward measures such as species richness, the Shannon Index requires more complex interpretation. Another limitation relates to the influence of sample size. In some cases, if the sample is too small or not representative, the index may overestimate or underestimate biodiversity. This is particularly problematic when not all species present in the ecosystem are adequately sampled. Some researchers also argue that the index lacks a strong biological or ecological foundation, as it is essentially a mathematical abstraction. This makes it difficult to use the index to infer the ecological functioning of a system. Moreover, comparing Shannon Index values among very different ecosystems may have limited usefulness due to their differing ecological characteristics and structural complexity. A further point of criticism concerns the index limited sensitivity to dominance. In ecological systems, the dominance of one or a few species can significantly affect ecological functioning, but the Shannon Index does not fully capture this aspect. Nevertheless, despite its limitations, the Shannon-Wiener Index remains one of the most widely used tools in ecological and biodiversity studies due to its ability to combine richness and evenness into a single value. For this reason, it is often used alongside other indices to provide a more comprehensive and detailed picture of biodiversity.

Other biodiversity indices (Fedor and Zvaríková 2019), commonly used include:

Simpson's Index (Simpson 1949), measures the probability that two individuals randomly selected from a community belong to the same species. There are two main variants: the original Simpson's Index (D) and its complement (1-D), known as Simpson's Diversity Index. While the Shannon-Wiener Index is sensitive to the presence of rare species, Simpson's Index is more influenced by dominant species, making it particularly useful in contexts where species dominance is a key feature.

Pielou's Evenness Index (Pielou 1966), quantifies the evenness of species distribution, showing how evenly individuals are spread across species in a community. It is calculated as the ratio between the Shannon-Wiener Index and the natural logarithm of the number of species (S), providing a measure of uniformity in species abundances.

Fisher's Alpha Index (Fisher et al. 1943), is a statistical model that assumes a logarithmic species distribution and estimates diversity based on species richness and relative abundance. It is especially useful when comparing ecological communities of different sizes.

The Top Diversity Index (TD-50) (Love et al. 2022), describes the cumulative number of species accounting for 50% of tree abundance in an urban forest. It is a robust diversity metric and a reliable predictor of more comprehensive measures such as the Shannon Index.

Each of these indices offers a peculiar perspective on biodiversity and is often used together to obtain a multidimensional analysis of species diversity.

In addition to quantitative indices, it is also essential to identify specific biodiversity indicators for urban ecosystems, especially given the rapid growth of cities and the increasing pressure on biodiversity caused by urbanization. Such indicators help monitor the state of biodiversity, allowing timely interventions and guiding urban planning and management toward sustainable solutions.

Examples of useful urban biodiversity indicators include:

i) The proportion of natural or semi-natural areas within the city.
ii) The ratio of native to non-native species.
iii) The degree of permeability of surfaces.
iv) The abundance and diversity of fauna species, particularly birds, are often used as bioindicators.

One of the most structured and widely adopted tools in the international context is the City Biodiversity Index (CBI), also known as the Singapore Index, developed within the framework of the 2010 Conference of the Parties (COP) of the Convention on Biological Diversity (Kohsaka et al. 2013). The index includes 23 indicators grouped into three main areas: native biodiversity, ecosystem services, and governance and management. This tool allows municipalities to self-assess the state of urban biodiversity and monitor changes over time. The CBI promotes awareness of biodiversity among policymakers and urban planners, encouraging the development of local strategies to conserve and enhance biodiversity. It also facilitates comparison between different cities and the sharing of best practices. Thanks to its flexibility, the index can be adapted to different local contexts and levels of data availability, making it a highly useful instrument for integrating biodiversity into urban development policies. Cities that adopt the CBI are better equipped to respond to the challenges of urbanization and contribute to the global goals of biodiversity conservation.

References

Aronson, Myla F.J., Frank A. La Sorte, Charles H. Nilon, Madhusudan Katti, Mark A. Goddard, Christopher A. Lepczyk, Paige S. Warren, Nicholas S.G. Williams, Sarel Cilliers, Bruce Clarkson, Cynnamon Dobbs, Rebecca Dolan, Marcus Hedblom, Stefan Klotz, Jip Louwe Kooijmans, Ingolf Kühn, Ian MacGregor-Fors, Mark McDonnell, Ulla Mörtberg, Petr Pyšek, Stefan Siebert, Jessica Sushinsky, Peter Werner, e Marten Winter. 2014. "A Global analysis of the impacts of urbanization on bird and plant diversity reveals key anthropogenic drivers." *Proceedings of the Royal Society B: Biological Sciences* 281, 1780: 20133330. https://doi.org/10.1098/rspb.2013.3330.

Augustinus, Benno A., Meinrad Abegg, Valentin Queloz, e Eckehard G. Brockerhoff. 2024. “Higher tree species richness and diversity in urban areas than in forests: Implications for host availability for invasive tree pests and pathogens.” *Landscape and Urban Planning* 250: 105144. https://doi.org/10.1016/j.landurbplan.2024.105144.

Bowler, Diana E., Lisette Buyung-Ali, Teri M. Knight, e Andrew S. Pullin. 2010. “Urban greening to cool towns and cities: A systematic review of the empirical evidence.” *Landscape and Urban Planning* 97, 3: 147-55. https://doi.org/10.1016/j.landurbplan.2010.05.006.

Civitello, David J., Jeremy Cohen, Hiba Fatima, Neal T. Halstead, Josue Liriano, Taegan A. McMahon, C. Nicole Ortega, Erin Louise Sauer, Tanya Sehgal, Suzanne Young, e Jason R. Rohr. 2015. “Biodiversity inhibits parasites: Broad evidence for the dilution effect.” *Proceedings of the National Academy of Sciences* 112, 28: 8667-71. https://doi.org/10.1073/pnas.1506279112.

Clapp, J. Casey, H. Dennis P. Ryan, Richard W. Harper, e David V. Bloniarz. 2014. “Rationale for the increased use of conifers as functional green infrastructure: A literature review and synthesis.” *Arboricultural Journal* 36, 3: 161-78. https://doi.org/10.1080/03071375.2014.950861.

Dobbs, Cynnamon, Francisco J. Escobedo, e Wayne C. Zipperer. 2011. “A framework for developing urban forest ecosystem services and goods indicators.” *Landscape and Urban Planning* 99, 3-4: 196-206. https://doi.org/10.1016/j.landurbplan.2010.11.004.

Fedor, Peter, e Martina Zvaríková. 2019. “Biodiversity indices.” In *Encyclopedia of Ecology*, 337-46. Elsevier. https://doi.org/10.1016/B978-0-12-409548-9.10558-5.

Fisher, R.A., A. Steven Corbet, e C.B. Williams. 1943. “The relation between the number of species and the number of individuals in a random sample of an animal population.” *The Journal of Animal Ecology* 12, 1: 42. https://doi.org/10.2307/1411.

Francis, Robert A., e Jamie Lorimer. 2011. “Urban reconciliation ecology: The potential of living roofs and walls.” *Journal of Environmental Management* 92, 6: 1429-37. https://doi.org/10.1016/j.jenvman.2011.01.012.

Gandy, Matthew. 2013. “Marginalia: Aesthetics, ecology, and urban wastelands.” *Annals of the Association of American Geographers* 103, 6: 1301-16. https://doi.org/10.1080/00045608.2013.832105.

Gentili, Rodolfo, Lara A. Quaglini, Gabriele Galasso, Chiara Montagnani, Sarah Caronni, Elisa Cardarelli, e Sandra Citterio. 2024. “Urban refugia sheltering biodiversity across world cities.” *Urban Ecosystems* 27, 1: 219-30. https://doi.org/10.1007/s11252-023-01432-x.

Gill, S.E., J.F. Handley, A.R. Ennos, e S. Pauleit. 2007. “Adapting cities for climate change: The role of the green infrastructure.” *Built Environment* 33, 1: 115-33. https://doi.org/10.2148/benv.33.1.115.

Hostetler, Mark, Will Allen, e Colin Meurk. 2011. “Conserving urban biodiversity? Creating green infrastructure is only the first step.” *Landscape and Urban Planning* 100, 4: 369-71. https://doi.org/10.1016/j.landurbplan.2011.01.011.

Kaiser, Asia, e Julian Resasco. 2024. “The impact of impervious surface and neighborhood wealth on arthropod biodiversity and ecosystem services in community gardens.” *Urban Ecosystems* 27, 5: 1863-75. https://doi.org/10.1007/s11252-024-01560-y.

Kohsaka, Ryo, Henrique M. Pereira, Thomas Elmqvist, Lena Chan, Raquel Moreno-Peñaranda, Yukihiro Morimoto, Takashi Inoue, Mari Iwata, Maiko Nishi, e Maria da Luz Mathias. 2013. “Indicators for management of urban biodiversity and ecosystem services: City biodiversity index.” In *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities: A Global Assessment*, 699-718. Dordrecht: Springer Netherlands.

Lazzarini, Luca, Israa H. Mahmoud, e Maria Chiara Pastore. 2024. “Urban planning for biodiversity. An assessment of green plans in northern Italy.” *TEMA* 1: 45-60.

Love, Natalie L.R., Viet Nguyen, Camille Pawlak, Andrew Pineda, Jeff L. Reimer, Jennifer M. Yost, G. Andrew Fricker, Jonathan D. Ventura, Jacqueline M. Doremus, Taylor Crow, e Matt K. Ritter. 2022. “Diversity and structure in California’s urban forest: What over six million data points tell us about one of the world’s largest urban forests.” *Urban Forestry & Urban Greening* 74: 127679. https://doi.org/10.1016/j.ufug.2022.127679.

Lundholm, Jeremy, J. Scott MacIvor, Zachary MacDougall, e Melissa Ranalli. 2010. "Plant species and functional group combinations affect green roof ecosystem functions." *PLoS ONE* 5, 3: e9677. https://doi.org/10.1371/journal.pone.0009677.

MAMROT. 2013. "Ministère des Affaires Municipales, des Régions et de l'Occupation du Territoire du Québec." https://ville.montreal.qc.ca/pls/portal/docs/PAGE/GRANDS_PARCS_FR/MEDIA/DOCUMENTS/LAB_REPORT_FINALE_EN_WEB.PDF (2025-12-23).

McKinney, Michael L. 2006. "Urbanization as a major cause of biotic homogenization." *Biological Conservation* 127, 3: 247-60. https://doi.org/10.1016/j.biocon.2005.09.005.

McKinney, Michael L. 2008. "Effects of urbanization on species richness: A review of plants and animals." *Urban Ecosystems* 11, 2: 161-76. https://doi.org/10.1007/s11252-007-0045-4.

Nielsen, Anders Busse, Matilda Van Den Bosch, Sreetheran Maruthaveeran, e Cecil Konijnendijk Van Den Bosch. 2014. "Species richness in urban parks and its drivers: A review of empirical evidence." *Urban Ecosystems* 17, 1: 305-27. https://doi.org/10.1007/s11252-013-0316-1.

Niemelä, Jari. 1999. "Ecology and urban planning." *Biodiversity & Conservation* 8, 1: 119-31. https://doi.org/10.1023/A:1008817325994.

Norton, Briony A., Karl L. Evans, e Philip H. Warren. 2016. "Urban biodiversity and landscape ecology: Patterns, processes and planning." *Current Landscape Ecology Reports* 1, 4: 178-92. https://doi.org/10.1007/s40823-016-0018-5.

Nowak, David J., Robert E. Hoehn, Allison R. Bodine, Eric J. Greenfield, e Jarlath O'Neil-Dunne. 2016. "Urban forest structure, ecosystem services and change in Syracuse, NY." *Urban Ecosystems* 19, 4: 1455-77. https://doi.org/10.1007/s11252-013-0326-z.

Oberndorfer, Erica, Jeremy Lundholm, Brad Bass, Reid R. Coffman, Hitesh Doshi, Nigel Dunnett, Stuart Gaffin, Manfred Köhler, Karen K.Y. Liu, e Bradley Rowe. 2007. "Green roofs as urban ecosystems: Ecological structures, functions, and services." *BioScience* 57, 10: 823-33. https://doi.org/10.1641/B571005.

Pickett, Steward T., Mary L. Cadenasso, e Brian McGrath. 2013. *Resilience in Ecology and Urban Design: Linking Theory and Practice for Sustainable Cities*. Dordrecht: Springer.

Pielou, E.C. 1966. "The measurement of diversity in different types of biological collections." *Journal of Theoretical Biology* 13: 131-44. https://doi.org/10.1016/0022-5193(66)90013-0.

Potgieter, Luke J., Mirijam Gaertner, Christoph Kueffer, Brendon M.H. Larson, Stuart W. Livingstone, Patrick J. O'Farrell, e David M. Richardson. 2017. "Alien plants as mediators of ecosystem services and disservices in urban systems: A global review." *Biological Invasions* 19, 12: 3571-88. https://doi.org/10.1007/s10530-017-1589-8.

Puppim de Oliveira, Jose Antonio, Christopher N.H. Doll, Raquel Moreno-Peñaranda, e Osman Balaban. 2014. "Urban biodiversity and climate change." In *Global Environmental Change*, 461-68. Springer.

Rendon, Paola, Natalie Love, Camille Pawlak, Jenn Yost, Matthew Ritter, e Jacqueline Doremus. 2024. "Street tree diversity and urban heat." *Urban Forestry & Urban Greening* 91: 128180. https://doi.org/10.1016/j.ufug.2023.128180.

Robinson, Jake M., Andrew C. Breed, Araceli Camargo, Nicole Redvers, e Martin F. Breed. 2024. "Biodiversity and human health: A scoping review and examples of underrepresented linkages." *Environmental Research* 246: 118115. https://doi.org/10.1016/j.envres.2024.118115.

Santamour, Frank S. 1990. "Trees for urban planting: Diversity, uniformity, and common sense." *Journal of Arboriculture* 7, 7: 57-66.

Scherber, Christoph, Elke A. Vockenhuber, Andreas Stark, Hans Meyer, e Teja Tscharntke. 2014. "Effects of tree and herb biodiversity on Diptera, a hyperdiverse insect order." *Oecologia* 174, 4: 1387-400. https://doi.org/10.1007/s00442-013-2865-7.

Simpson, E.H. 1949. "Measurement of diversity." *Nature* 163, 4148: 688. https://doi.org/10.1038/163688a0.

Vigevani, Irene, Denise Corsini, Jacopo Mori, Alice Pasquinelli, Marco Gibin, Sebastien Comin, Przemysław Szwałko, Edoardo Cagnolati, Francesco Ferrini, e Alessio Fini. 2022.

"Particulate pollution capture by seventeen woody species growing in parks or along roads in two European cities." *Sustainability* 14, 3: 1113. https://doi.org/10.3390/su14031113.

Wania, Annett, Ingolf Kühn, e Stefan Klotz. 2006. "Plant richness patterns in agricultural and urban landscapes in central Germany—spatial gradients of species richness." *Landscape and Urban Planning* 75, 1-2: 97-110. https://doi.org/10.1016/j.landurbplan.2004.12.006.

Werner, Peter, e Rudolf Zahner. 2010. "Urban patterns and biological diversity: A review." In *Urban Biodiversity and Design*, 145-73.

Williams, Nicholas S.G., Mark W. Schwartz, Peter A. Vesk, Michael A. McCarthy, Amy K. Hahs, Steven E. Clemants, Richard T. Corlett, Richard P. Duncan, Briony A. Norton, Ken Thompson, e Mark J. McDonnell. 2009. "A conceptual framework for predicting the effects of urban environments on floras." *Journal of Ecology* 97, 1: 4-9. https://doi.org/10.1111/j.1365-2745.2008.01460.x.

Xiao, Qingfu, E. Gregory McPherson, Susan L. Ustin, Mark E. Grismer, e James R. Simpson. 2000. "Winter rainfall interception by two mature open-grown trees in Davis, California." *Hydrological Processes* 14, 4: 763-84. https://doi.org/10.1002/(SICI)1099-1085(200003)14:4<763::AID-HYP971>3.0.CO;2-7.

Xie, Chunping, Shuifei Chen, Dawei Liu, e Chi Yung Jim. 2024. "Unveiling the complex networks of urban tree diversity research: A global perspective." *Ecology and Evolution* 14, 6: e11630. https://doi.org/10.1002/ece3.11630.

Zavaleta, Erika S., Jae R. Pasari, Kristin B. Hulvey, e G. David Tilman. 2010. "Sustaining multiple ecosystem functions in grassland communities requires higher biodiversity." *Proceedings of the National Academy of Sciences* 107, 4: 1443-46. https://doi.org/10.1073/pnas.0906829107.