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Perspective

Biophilia beyond the Building: Applying the Tools of Urban Biodiversity Planning to Create Biophilic Cities

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Abstract: In response to the widely recognized negative impacts of urbanization on biodiversity, many cities are reimagining urban design to provide better biodiversity support. Some cities have developed urban biodiversity plans, primarily focused on improving biodiversity support and ecosystem function within the built environment through habitat restoration and other types of urban greening projects. The biophilic cities movement seeks to reframe nature as essential infrastructure for cities, seamlessly integrating city and nature to provide abundant, accessible nature for all residents and corresponding health and well-being outcomes. Urban biodiversity planning and biophilic cities have significant synergies in their goals and the means necessary to achieve them. In this paper, we identify three key ways by which the urban biodiversity planning process can support biophilic cities objectives: engaging the local community; identifying science-based, quantitative goals; and setting priorities for action. Urban biodiversity planning provides evidence-based guidance, tools, and techniques needed to design locally appropriate, pragmatic habitat enhancements that support biodiversity, ecological health, and human health and well-being. Developing these multi-functional, multi-benefit strategies that increase the abundance of biodiverse nature in cities has the potential at the same time to deepen and enrich our biophilic experience in daily life.

Keywords: biophilic cities; urban biodiversity; urban biodiversity planning; human health; well-being; green infrastructure

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1. Introduction

Cities are growing rapidly, and urbanization is widely recognized to have many negative impacts on biodiversity [1]. In response, many cities are undertaking planning processes and creating programs focused on urban biodiversity conservation [2]. If successful, these efforts will lead to greener and more biodiverse urban spaces, while also helping cities achieve other ecosystem service goals for people, such as climate adaptation and stormwater management. At the same time, the incorporation of natural features and processes into the built environment to improve human experience and well-being, often referred to as biophilic design, has grown in popularity [3,4]. While biophilic design has focused particularly on building interiors, the ideas are also being applied more broadly to urban planning with the concept of biophilic cities [5].

The design of urban greenspace to support biodiversity—hereafter referred to as "urban biodiversity planning"—and biophilic design are complementary, yet they arise from different disciplines (ecological science and architecture/urban design). As both approaches expand to an increasing number of cities, evaluating the extent to which the scientific guidance, structure, and process of urban biodiversity planning can also support biophilic city goals can help inform future attempts to unite these two related efforts.

The biophilic design movement emerged in architecture in the 1990s and seeks to design buildings that increase daily contact with natural elements, views, and forms in order to transform the human experience indoors and support health and well-being [6,7].

Architects around the world are centering nature in their designs. For example, the Atlas Hotel in Hoi An, Vietnam, features planters on the façade that create cascading greenery and shading, and perforated stone walls that allow light and airflow for cooling [8]. Also in Pittsburgh, Pennsylvania, the Phipps Conservatory and Botanical Gardens designed the Center for Sustainable Landscapes to maximize human connections with nature, with a green roof and other garden spaces that feature native Pennsylvania plant species, natural lighting, and views of nature from indoor spaces [9,10]. Moving to a broader reimagining of cities, the biophilic cities movement seeks to create seamless integration with nature not only on buildings but throughout the city, resulting in abundant, accessible nature for all urban residents (Beatley 2018). The associated network of biophilic cities includes 24 members globally, as well as several hundred organizations and thousands of individuals who have taken the Biophilic Pledge [11,12]. The biophilic cities movement provides a vision of a future where citizens' ethos has shifted to embrace nature, through positive daily engagement with nature, re-establishment of social and cultural connections with nature, and participation in stewardship [13]. The biophilic cities movement also includes supporting biophilic conditions and infrastructure through the achievement of measurable improvements, such as the percentage of an urban population living within a few hundred feet of a park, and promoting pro-environmental behaviors [5]. While the vision is clear and inspiring, there is no consensus on a suite of metrics for biophilic cities [14], which would both illuminate a path to becoming a biophilic city and enable cities to measure progress.

Urban biodiversity planning has a primary focus on improving biodiversity support and ecosystem function—the collective natural processes and cycles that sustain life—within the built environment through restoring local habitat; reconnecting with physical processes; and increasing the distribution, abundance, and connectivity of urban nature. Many cities around the globe have pursued an urban biodiversity planning process (see [15–19]). Goals of these documents include ecological restoration, creation, and protection of sensitive habitat; increased tree canopy coverage; expanded open space acreage; improved habitat connectivity; increased use of native plants; and the protection of large old trees. The urban biodiversity literature highlights characteristics of habitat that are needed in every city, which can serve as the basis for goals and metrics tailored to the unique context of each city [20]. While not the focus, an important component of many plans is community engagement, e.g., through stewardship, education, and monitoring [2].

Urban biodiversity planning and biophilic city design have significant synergies in their goals and the means necessary to achieve them. In fact, some cities that have taken the biophilic city pledge also have urban biodiversity plans, like Singapore; Washington, D.C.; and Vitoria-Gasteiz, Spain. Both urban biodiversity planning and biophilic cities highlight and respond to the negative effects of a loss of nature in cities. Both envision thriving natural systems, improved environmental sustainability, and engagement of the community in the care of nature. These overlaps between biophilic city goals and urban biodiversity planning present an opportunity for collaboration to design urban landscapes that improve nature access for people while providing more functional habitat for wildlife and plants. While the broader biophilic city goals include health and human-nature connection, urban biodiversity planning provides tools and evidence-based strategies to support the ecological integrity of nature in cities, the foundation for high-quality biophilic experiences.

Here, we identify specific ways that urban biodiversity planning can inform the design of biophilic cities that support urban biodiversity, ecological health, connectedness to nature, and human health. Evidence-based guidance, both conceptual and quantitative, can help improve the functionality and longevity of natural areas within the urban landscape. We also acknowledge that the achievement of these ecological benefits may depend upon social acceptability and support from the community.

2. What Can Be Achieved by Making Cities More Biodiverse and Biophilic?

Research in the field of urban ecology has shown that while cities have many negative effects on biodiversity, they also support a broad array of plants and animals, including many native species [1,21]. Urban biodiversity, or the variety of plant and animal species found within a city, responds to the quality and quantity of available habitat. While many urban landscapes contain few species, greenspaces with higher quality habitat can support many species. Science documenting patterns of urban biodiversity can be used to guide the setting of measurable goals for biodiversity in cities. The large body of research in urban biodiversity science can be summarized into key characteristics that tend to support urban biodiversity, including patch size, connectivity, and quality of the urban matrix [20]. Actions to address any one of these characteristics are likely to yield some benefit to biodiversity, but integrated efforts aimed at most or all such characteristics are more likely to result in widespread city-scale improvements in ecological function and biodiversity support [20]. If high habitat quality is achieved, then the city may contribute to regional conservation goals [22].

Integrating insights from urban ecology with planning for biophilic cities provides an opportunity to maximize benefits for both people and urban biodiversity (Figure 1). City-wide efforts to improve biodiversity support would make cities greener through actions in both larger open spaces and smaller spaces, such as along streets and in private yards. Strategies for biodiversity, such as creating large habitat patches, creating corridors for connectivity, and increasing habitat can increase resident access and exposure to nature, and promote the meaningful coexistence with nature in cities [23]. These strategies address the so-called "extinction of experience," whereby urban residents no longer interact with nature on a regular basis [24–26]. Collectively, these actions would also have a large impact on human-focused goals for biophilia.

Increased exposure to nature imparts numerous benefits to human health, wellbeing, and community building [23,27–29], even when the exposure is virtual [30]. It fosters feelings of connectedness with nature, an important predictor of pro-environmental behavior [31], which could have wide-ranging impacts on conservation and sustainability outcomes. In their daily lives, residents of cities with greater biodiversity have more abundant access to natural spaces that can be immersive, promote awe and fascination, and support community-building and health. These natural outdoor spaces combined with a biophilic design of building interiors together create seamless and reinforcing indoor-outdoor biophilic experiences.

In the process of planning for a biodiverse city, evidence from urban biodiversity science can also support the creation of multi-functional spaces. Given limited space in cities, urban greening interventions can provide greater returns on investment and face more likely adoption when they have multiple demonstrable benefits. For example, a single greening project that can demonstrate that it will support biodiversity while providing other ecosystem services such as flood risk mitigation [32], heat risk mitigation [33,34], and physical and mental health support [28,35] may be more likely to the raise financial and community support necessary for implementation. Designing high impact, multi-benefit projects depends on the emergence of new interdisciplinary and intersectoral collaborations that bring together the necessary diversity of expertise, including landscape architecture, urban ecology, and public health.

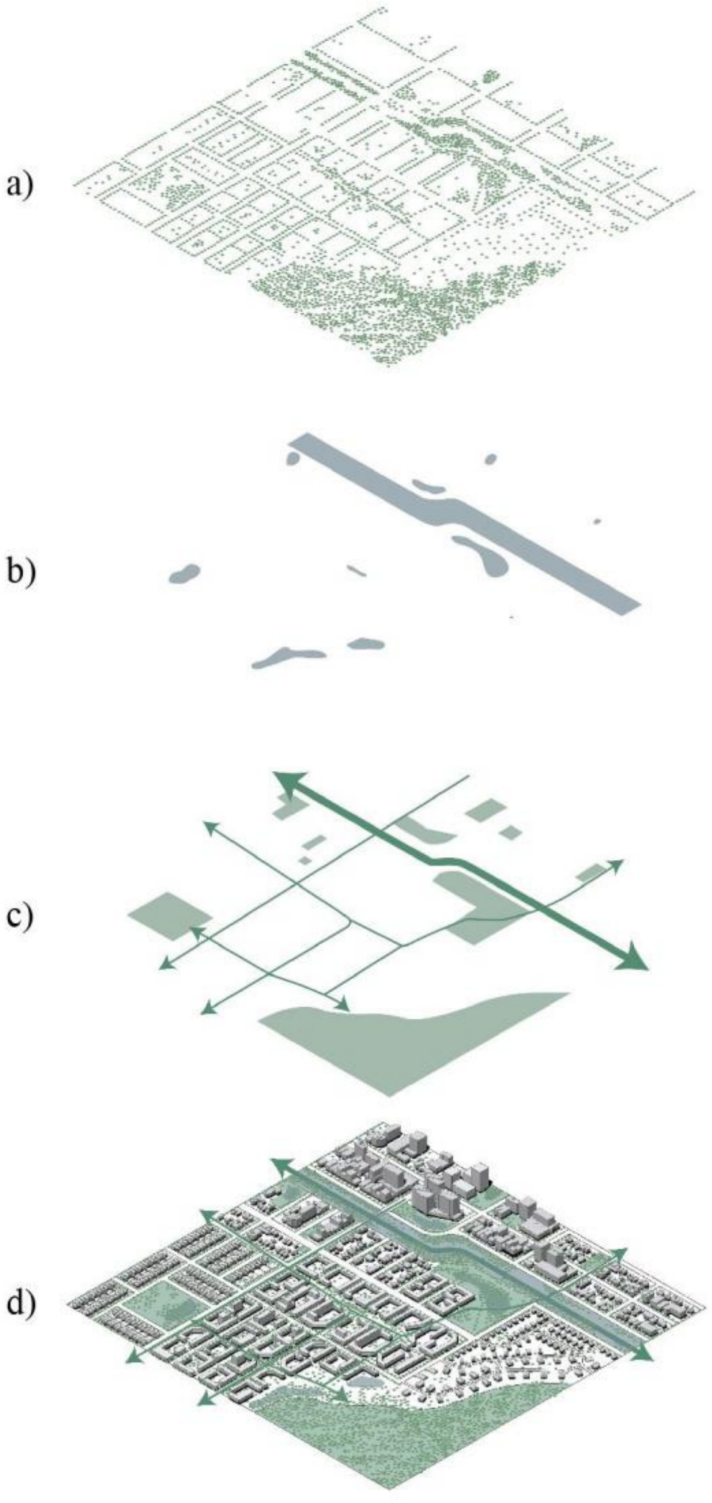

Figure 1. Biodiversity provides a foundation to achieve objectives for biophilic cities. Integrating insights from urban ecology with planning for biophilic cities provides an opportunity to maximize benefits for both people and urban biodiversity. A city's design can (**a**) provide nature that is distributed throughout the urban matrix; (**b**) include restoration and protection of special and unique resources; (**c**) enhance connectivity among greenspaces; and (**d**) in sum, support biodiversity, biophilia, and healthy and resilient communities.

3. How Can Urban Biodiversity Planning Support Biophilic Cities?

While each planning process is different, nearly all emphasize three key steps, including (1) community participation, (2) goal-setting, and (3) setting priorities for action (Figure 2) [2]. These steps are included within a resource for municipal biodiversity planning produced by the ICLEI—Local Governments for Sustainability [36]. It emphasizes a planning phase where biodiversity stakeholder groups set goals and guiding principles, develop a community engagement process, and identify a set of actions to achieve goals [36].

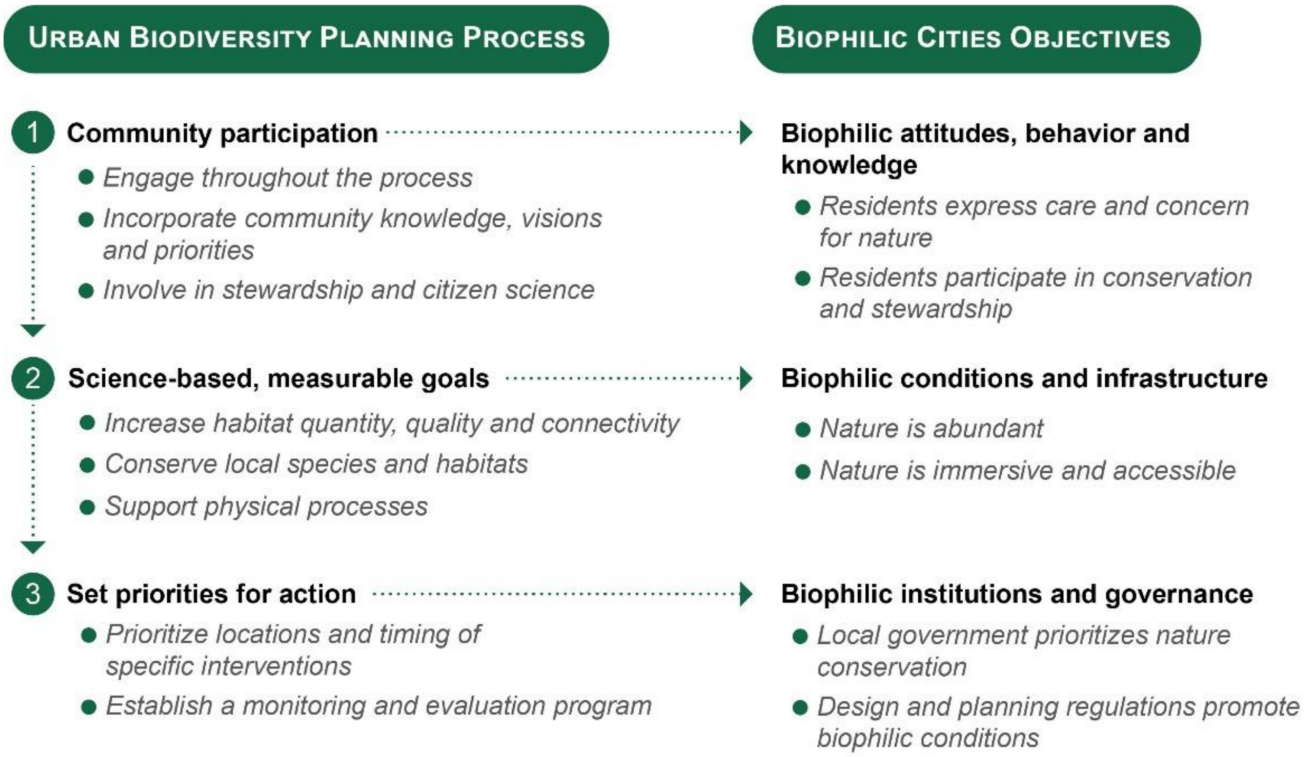

Figure 2. Urban biodiversity planning can support the creation of biophilic cities, due to numerous synergies between the two efforts.

The core components of biodiversity planning have the potential to advance biophilic design and biophilic cities objectives. Biodiversity itself is central to biophilia, and the more biodiverse our parks and greenspaces, the better the health and well-being of urban residents [37–39]. The tenets of biophilic cities include improving the quantity of greenness in cities, and increasing human contact and connectedness with nature [40]. Important dimensions of biophilic cities include creating biophilic conditions and infrastructure (e.g., nature is abundant and accessible throughout the city), supporting biophilic attitudes and behaviors (e.g., residents care for nature and participate in stewardship), and prioritizing nature conservation in governance [5]. There is significant potential for the science of urban biodiversity to inform biodiversity goal setting, though Nilon and co-authors point out that this potential is not always realized in biodiversity plans (2017). Achieving science-based goals for biodiversity would create ecological integrity in urban greenspaces, providing local opportunities for citizens to engage with nature, develop biophilic behaviors, and ultimately encourage biophilic attitudes.

Both biophilic cities and urban biodiversity require numerous and varied types of interventions, and planners must select the appropriate project type for a given location and scale. Potential intervention types at the various scales include daylit interior spaces and green walls at the building scale; green streets at the block-scale; community gardens

and pocket parks at the neighborhood scale; and open space networks at the regional scale [13]. Interventions at all scales are necessary, and as long as they are implemented in alignment with the over-arching city plan, the collection of projects eventually will operate together as a nature network and offer ecosystem services at the city-scale.

Setting priorities for action can help spur implementation and often includes identifying policies, regulations, and incentive programs that can be used to achieve biodiversity goals. These actions can help to strengthen biophilic institutions and governance. Developing and implementing a robust community participation plan can help support stewardship which in turn will support biophilic behaviors and lifestyles. Below, we identify three specific science-based goals that have synergies with biophilic planning and design, and we highlight how the core elements of biodiversity planning, including goal setting, soliciting community participation, and setting priorities for action can all be used to achieve objectives for biophilic cities.

3.1. Step 1: Solicit Community Participation

An important element in biodiversity planning is to create and implement a strategy to involve residents throughout the process. Most biodiversity planning processes include community engagement as a core component [2,36]. For example, the Nature in the City planning process in Melbourne, Australia, involved numerous stakeholder meetings, public workshops, surveys, and a Facebook campaign aimed at reaching an audience of over 45,000 people [19]. In Washington, DC, United States, the Sustainable DC Plan, which includes nature and biodiversity goals included a planning effort with working groups, public meetings, advisory groups, and a planning team that talked with 4700 people at 180 events across the city during an 18-month planning process [15]. Community visions around areas of most need, preferred modes of greening, and candidate locations can be used to guide the identification of priority actions and projects. In Melbourne, for example, community members could access design sketches of the various potential greening projects, including street trees, window boxes, vegetable gardens [19,41]. The community was also provided access to an interactive web map to suggest locations where they would like to see greening happen.

In addition, communities can share unique local knowledge and be directly involved in urban biodiversity science, as well as monitoring and stewardship. Biodiversity science is experiencing increasing engagement in and knowledge emerging from a growing number of citizen science projects [42,43], from hubs such as eBird and iNaturalist, and from organized efforts like the Christmas Bird Count and the Great Backyard Bird Count. Furthermore, community involvement in stewardship is also important for the success of greening efforts; for example, newly planted trees have a better probability of survival if local residents are invested and recruited to help with stewardship [44]. Through the urban biodiversity planning process, planners and community members can identify potential partner organizations, such as local conservation or research groups, to spearhead the creation of events and programs for stewardship and education.

Community engagement conducted through biodiversity planning presents an opportunity to understand baseline biophilic behaviors and attitudes, and to inform biophilic city-focused efforts to enhance public contact and attitudes towards urban nature. Biophilic cities strive to provide immersive nature, such that the city itself can be regarded as a park or forest [23]. Within it, residents have abundant opportunities to meaningfully engage with nature through stewardship activities and direct experience [23]. The most influential experiences that cultivate environmental sensitivity and environmentally supportive behavior include time spent outdoors, as well as work or volunteer experience with animals [45]. People who engage with nature as hunters, hikers, and birdwatchers tend to exhibit more conservation behaviors, such as making donations to conservation efforts, advocating for wildlife recreation and participating in habitat enhancement on public lands [46,47].

3.2. Step 2: Identify Science-Based Biodiversity Goals

Here, we suggest three science-based biodiversity goals that can support biophilic city planning and design. While not an exhaustive list, these goals incorporate many of the most crucial elements for supporting urban biodiversity, are well-supported by science, and if achieved, would enhance city-scale biodiversity and biophilia.

3.2.1. Goal 1: Systematically Increase the Quantity, Quality, and Connectivity of Habitat

Urban biodiversity science has found that large patches of high-quality habitat, habitat connectivity, and the quality of the urbanized matrix between greenspaces are all critical for urban biodiversity support [20,48]. Urban biodiversity goal setting for these elements can flow from an assessment of the quality and spatial arrangement of existing resources, which can guide the strategic placement of habitat enhancements to optimize support for biodiversity. A key driver of successful urban biodiversity plans is the use of measurable targets, yet too few biodiversity plans include them [2]. With wider adoption of measurable targets, urban biodiversity plans can clearly state how much additional habitat is needed and can set locally appropriate targets for the particular biophysical context of the city. For example, the city of London aims to make at least 50% of the city area green and increase tree canopy cover by 10% by the year 2050 [16], and the New York City Nature Goals 2050 includes expanding tree canopy by 5% and permeable space by 2% by the year 2050 [49].

Greening actions can be targeted to improve connectivity across the landscape, by filling gaps in existing corridors, removing barriers to movement, and creating patches of greenspace where they are lacking to serve as stepping stones of habitat [20]. The quality of habitat in greenspaces, in the urban matrix, and in habitat corridors is also important for supporting urban biodiversity [48,50]. Habitat quality can be enhanced through a variety of actions including tree planting, native plant gardens in residential yards, park master planning efforts, and other green infrastructure such as bioswales and green roofs. For instance, a non-profit organization called Nature in the City coordinates actions across public and private property to enhance matrix quality and create a corridor with stepping stones of habitat in San Francisco for the Green Hairstreak Butterfly, an endemic species whose habitat has been mostly lost in the process of development [51]. The program has documented evidence of the butterfly using and breeding within the habitat, signs of success for this species once thought to be extinct.

After drastic transformation of the landscape during urbanization, some natural features are lost or obscured in contemporary cities [52], and historical ecological research is one tool used in urban ecology that can help cities rediscover them and find opportunities to restore them [53,54]. In Chicago, Illinois, urban ecologists studied the patterns of forest conversion in relation to urbanization patterns over 200 years, and suggested the restoration of additional forest patches with native species could help restore connectivity [55]. The city then identified high quality remnant forest patches to restore and grant protected status, as well as smaller lower quality areas to restore as corridors to enhance connectivity across the landscape [56].

Key goals of biophilic cities are to increase the abundance of nature and to ensure the accessibility of nature to urban residents [23], however, there is often little available from the biophilic cities movement for designers to use as quantitative targets or measures of success [14]. Biodiversity planning efforts set clear goals that are appropriate for the local context to increase the quality, quantity, and connectivity of habitat. More abundant local nature would improve indicators of biophilic conditions and infrastructure, such as the percentage of people living within a few hundred feet of a park, the percentage of land covered by trees or other vegetation, and the number of green features on the landscape. Improved access to nature would also support biophilic behaviors and attitudes by providing easy opportunities for more residents to engage daily with nature outside their homes [5].

3.2.2. Goal 2: Create and Conserve Natural Areas That Highlight Local Species, Ecosystems, and Features

Urban biodiversity science places an emphasis on local habitat, features, and natural resources, including rare, endemic, threatened or endangered species. Urban biodiversity plans include the conservation and restoration of remnant habitat areas, which may be rare habitat types themselves and can harbor individuals of species that have been eliminated from other parts of the landscape [57]. In addition, new greenspaces can be designed with assemblages of native plants, replicating natural patterns in the proportions and spatial arrangement to create more coherent and ecologically functional urban landscapes [58–60]. Taking this approach of replicating native ecosystems can help support greater biodiversity in cities, because native insects, birds, and other wildlife often have specialized relationships with particular native plant species and are dependent on them for survival [61,62]. Incorporating native ecosystems into urban landscapes involves a process of translation and creativity to identify, design, and maintain sites with the appropriate conditions for native plant communities.

The unique ecological identity of a city can foster among its residents a sense of place, which can build support for biophilic behaviors, attitudes, and knowledge [5]. A sense of place can provide numerous health and well-being benefits to people [63]. An important tool for building an ecological identity is to build off of the local native species and habitat types [64]. Throughout human history and all around the world, local species and ecosystems are often tied to cultural identity and heritage, as evidenced by cultural representations of plants and animals in art and mythology, or as symbols of power or emotion [65,66]. For example, the city of London has embraced the hedgehog, and various groups run conservation projects organizing residents to take actions in their own backyards to extend hedgehog access to more foraging area, as well as reduce pesticide use and provide special habitat resources like brush piles [67]. An iconic ecological event can also build identity and a sense of place for local residents [68]. For example, each year, hundreds of people congregate at Chapman Elementary School in Portland, Oregon, to witness a large flock of Vaux's Swifts (Chaetura vauxi) roosting communally in the school's chimney—an event that raises awareness for local ecology and biodiversity [69].

3.2.3. Goal 3: Emphasize the Geophysical Setting and Processes

Urban biodiversity science, as well as the field of ecology more broadly, places a strong priority on understanding and building on the basic underlying geophysical conditions and processes such as hydrology, soils, and geology, as the foundation for any restoration or conservation action. Understanding the physical processes (such as the movement of water or soil) and environmental variables (such as soil type, topography, and geology) that underlie how ecosystems are assembled [70] is essential to making restoration projects successful, and restoring and reconnecting with physical processes can make the urban ecosystem more resilient to natural fluxes and disturbances over time. For example, the alteration of urban hydrology caused by excessive impermeable surfaces and limited greenspace results in higher peak stormwater flows, more delivery of contaminants to adjacent water bodies, and the lack of natural recharge to urban water tables and vegetation. The city of Melbourne, Australia, has begun to reestablish a more natural flow regime by capturing stormwater runoff in tree wells, enabling plans for large increases in tree canopy which will benefit both biodiversity and thermal comfort [71].

Biophilic cities also emphasize the role of physical processes, [6,40] as a key component of biophilic conditions and infrastructure, and connections to these underlying systems can be made at multiple scales [13]. Carefully considering physical processes and the growing conditions they create will help urban biodiversity planners choose the right action for the site, and thus also contribute to the biophilic city goal of making nature more abundant and more resilient. Drawing on local physical processes can also support biophilic knowledge by allowing local residents to experience the spatial and seasonal dynamics of ecosystems such as temporal change in river height, local geology that sup-

ports unique plant communities, or the chance to experience coastal and estuarine marsh ecosystems that change with local tides. Furthermore, biophilic cities can support nature connectedness, sense of place, and identity through local geology [72]. For instance, Reano and Ridgway [73] suggest that STEM education that employs a place-based approach and connects culture with geology would help meet community needs and attract more Native American youth to earth science disciplines. Also in an historic neighborhood of Madrid, Spain, the traditional building stones have deep cultural significance and great heritage value, and their loss would represent a loss of identity [74].

3.3. Step 3: Set Priorities for Action

A third step in biodiversity planning is to set priorities for action among the goals and targets that stem from biodiversity science and are shaped by the local community. These overarching goals and targets must be translated to spatially explicit actions. The city of Melbourne, Australia, identified roadblocks to implementation of urban greening, including potential actors not knowing where and when to start greening efforts [75]. In response, the city's strategic action plan includes an action item to examine spatial arrangement of existing resources, risks, and gaps to help prioritize locations for interventions [75]. Prioritizing precisely where and when to implement solutions may be influenced by the community's priorities, the expected return on investment, the identification of pilot projects, and the feasibility of finding financing and programmatic pathways to achieve goals. Biodiversity planning processes often identify financing and policy pathways to achieve goals, which can bolster support for biophilic institutions and governance [13]. Priorities may vary across different intervention types, such as greening vacant lots or requiring green roofs on new development. With priorities established, a city may commence executing the urban biodiversity plan.

Biophilic cities objectives include establishing indicators for tracking success over time [23]. However, there is often little available for designers to use as quantitative targets or measures of success [14]. As discussed in Step 2, the urban biodiversity planning process yields the quantitative, science-based biodiversity targets, and a strategy for tracking progress and outcomes over time make it possible for a city to monitor and evaluate short- and long-term impacts of greening projects to biodiversity. Proponents of biophilic design have suggested climate change mitigation metrics for performance analysis in addition to human health and well-being metrics, since biophilic design contributes to overall building performance, especially related to indoor air quality and thermal comfort [3,76]. With additional studies across more metrics, we can assemble a more complete accounting of the full suite of benefits for a more accurate cost-benefit analysis. Furthermore, robust and regular monitoring and evaluation will help inform better design of future projects, while providing feedback on the effectiveness of the current project. Additionally, early and ongoing monitoring can allow for course correction if the present intervention is not performing as expected.

4. Key Challenges and Considerations

The process of making cities more biodiverse and biophilic must also account for the potential implications for the environmental justice of local communities. Biophilic cities strive for abundant, accessible nature; they also aim to improve the equity in distribution of nature [23], and targeting biodiversity interventions in areas that are least green may ultimately harm efforts to make nature access more equitable. The contemporary urban forest and distribution of greenspace has been shaped by the history of social, economic, and political dynamics [77,78], and parks and canopy cover are consistently fewer in number, of lower quality, and less accessible in lower income and racial minority communities [79–82]. Proposals to target greening efforts in minority neighborhoods to achieve both biodiversity and biophilic cities goals can help redress these inequities, but can also have the unintended consequence of exacerbating displacement and gentrification [83–86]. Therefore, greening

efforts should be carried out in tandem with policies to prevent displacement, stabilize existing communities, and center the community in the planning process [87,88].

In addition, given the inevitable limitations in funding and competing priorities, the creation and maintenance of biodiverse and biophilic cities depends on collaboration and expertise from professionals across a broad variety of disciplines [50,89], such as ecology, conservation, public health, landscape architecture, city planning, engineering and urban forestry. For example, the involvement of architects and landscape architects in urban biodiversity strategies would improve their applicability to project-scale applications, where many of the actions need to take place. Similarly, site scale landscape and biophilic design can benefit from engaging urban ecologists and biodiversity strategies to identify meaningful actions that will contribute to biodiversity improvement.

We also acknowledge that the sustainability of biodiverse and biophilic cities may depend upon continued social acceptability and support from the community. A study of local governments in Chile found that key drivers of the implementation of biophilic urbanism are political will, financial resources, and citizens' commitment [90]. Some key considerations can help push on these drivers and help secure long-term success of biodiverse and biophilic cities. First, experiences with nature foster individuals' sense of connection with nature, which supports pro-environmental behaviors [31,91]. Outreach and education efforts are critical components for facilitating positive experiences with nature [92]. As cities evolve to integrate increasingly more nature, these collective experiences may produce a shift toward a culture that values nature in the city and is motivated to protect it [92,93]. Furthermore, people that have experiences with nature and that perceive nature to be beneficial to their health and well-being may be more willing to support biodiversity conservation and biophilic elements [31,91,94].

The sustainability of biodiverse and biophilic cities also depends on the creation and implementation of ongoing management plans for maintaining a nature-rich city. While funds are in short supply for the implementation of urban greening or green infrastructure projects, funds are typically even harder to come by for long-term operations and maintenance [95–98]. Innovative funding ideas are emerging, such as the Environmental Impact Bonds to fund green infrastructure projects to manage stormwater runoff and improve water quality in Washington D.C. [99]; however, these ideas are not yet being broadly developed and implemented. It is critical to educate public officials and foundations on the life cycle costs of such infrastructure and the importance of investing in operations and maintenance, such as watering new trees for a year after planting or removing dangerous tree limbs before they fall and removing trash from stormwater infrastructure [100]. In addition, there is an important need to understand how cities can keep operations and maintenance costs down through certain practices like "no-mow" zones [101,102] and the adoption of technological advances like a network of smart sensors and devices to optimize irrigation or lighting systems [103–105]. Investing in comprehensive, long-term operations and maintenance would promote safer, positive nature experiences for the community and ensure the ongoing provision of benefits to people and biodiversity.

5. Discussion

Urban biodiverse planning processes can be used to help meet the goals of other related ecosystem services priorities, including designing for biophilic cities. Urban biodiversity planning processes include goal setting, community participation, and setting of priority actions. We argue that identifying science-based goals for urban biodiversity, using community participation to guide and inform the planning process, and allowing priority actions to flow from goals and community input are all useful in meeting the objectives and tenets of biophilic cities. The biophilic cities movement has ambitious objectives that can often benefit from the specific science-based targets that urban biodiversity planning can provide. Community engagement processes that form the foundation for biodiversity planning can also be used to build biophilic attitudes, behaviors, and knowledge in local community members, particularly when engagement persists after the planning process

is complete. The setting of priority actions also often includes identification of financing mechanisms, policies, and regulations that can be used to implement urban biodiversity goals, and these policies and programs are also at the core of building biophilic institutions and governance.

The creation and maintenance of biodiverse and biophilic cities requires substantial coordination across disciplines. Commitment and action from professionals in ecology, conservation, public health, landscape architecture, urban forestry and more can help ensure that strategies provide multiple benefits and are implemented at multiple scales, ranging from establishing regional parks to planting backyard trees. Cross-pollination of ideas would promote the effective stacking of benefits for wildlife populations, ecosystem functions, and human health in urban planning decisions. Given inevitable competition for project funding, stacking benefits can enhance the return on investment and thereby the desirability of a project. This intersectoral collaboration would be the crucial first step toward an overarching multi-benefit plan for a biodiverse and biophilic city, which then can be enacted by a suite of agencies, non-governmental organizations, and individuals.

6. Conclusions

To truly achieve biophilic city objectives, our cities must embrace a nature-forward design, drawing on our understanding of how to help different forms of life to thrive in urban settings. Urban biodiversity planning provides key knowledge, tools, and techniques needed to design biophilic cities with locally appropriate, realistic biodiversity enhancements. Urban biodiversity science and historical ecology can help to identify, restore, and conserve important and unique natural features within the biophilic city through a variety of interventions at multiple scales. Developing these multi-functional, multi-benefit strategies that increase the abundance of biodiverse nature in cities has the potential at the same time to deepen and enrich our biophilic experience in daily life. In turn, re-establishing strong social and cultural connections with nature, and cultivating an ethic of nature stewardship, may help to strengthen the long-term social support for and persistence of functional, healthy urban ecosystems in our cities.

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