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Article

Biophilic Urbanism Across Scales: Enhancing Urban Nature Through Experience and Design

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Abstract: As urban density increases and cities expand, there is a decrease in urban livability, which is closely linked to social, economic, and environmental crises. To address these negative impacts, biophilic urbanism (BU) promotes human–nature interactions and their associated benefits. However, knowledge gaps remain regarding its effectiveness across different scales. This study explores how BU contributes to improving livability in the built environment and to renewing urban landscapes. Using Amsterdam as a case study, we first identified biophilic experiences by analyzing them through quantitative, qualitative, and spatial distribution metrics. We then investigated designs that foster biophilia by applying BU tools aimed at enhancing interspecies connections and leveraging ecosystem services. Our findings, in the form of maps, provide evidence-based insights to benefit everyday life using nature in settings at different scales, along with design solutions to renew urban planning, focus on human and environmental well-being, and involve citizens in spatial transformations and maintenance processes. Finally, we advocate for BU as a holistic model that uses natural capital as a key strategy for making cities more equitable, sustainable, and resilient.



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Keywords: urban nature; urban landscapes; biophilic urbanism; biophilic benefits; design tools; leftover spaces; ecosystems services; citizen science

1. Introduction

As urban density increases and cities expand, there is a decrease in urban livability, which is closely linked to social, economic, and environmental crises [1]. Modern indoor lifestyles have led to a progressive disconnect between humans and nature, with consequential adverse impacts on well-being [2], increasing the risk of diseases due to exposure to more polluted air [3], and mental disorders [4].

Comparative studies have highlighted that many cities worldwide have significant tree canopy deficits when tested against the 3-30-300 rule. This rule ensures nature is visible at three key distances: 3 feet (small plants), 30 feet (larger greenery), and 300 feet (larger green spaces) [5]. This insufficient urban canopy, driven by both anthropization and climate change, exacerbates nature inequity and negatively impacts both humans and cityscapes. In response, cities often draw on natural capital to implement cost-effective interventions—such as those associated with green gentrification—thereby perpetuating an

inequitable use of Earth's resources [6]. Alternatively, they may invest in green urbanism, which promotes a zero-emission city model focused on reducing ecological impacts, rather than prioritizing vegetation for recreation or landscape enhancement [7]. A biophilic city model, by contrast, places nature at the core of urban planning and management [8], recognizing the importance of experiencing biophilia—the inherent human affiliation with living beings [9]—in everyday life. By integrating nature into the built environment through design [10], biophilic urbanism (BU) fosters human–nature connections and their related benefits for physical health [11], mental well-being [12], society [13], the environment [14], and the economy [15]. BU is an applied research field that stems from the integration of biophilic principles into the built environment through design and planning. While it incorporates nature-based solutions as its foundational setting, BU differs from other urban approaches—such as green, blue, or brown architecture—by prioritizing prolonged and high-quality human exposure to nature, with the aim of maximizing the resulting positive effects on citizens' well-being. BU has recently gained traction as a response to the growing negative impacts of urbanization on livability and climate resilience [16]. Despite scientific evidence supporting its benefits across disciplines [16], knowledge gaps persist regarding where and how people can best access nature across urban scales.

As the extensive literature has shown, blue-green infrastructure plays a crucial role in providing ecosystem services and ensuring better living conditions for all species [16,17]. However, the current urban policies underestimate the functional value of natural capital, reducing it to an esthetic complement to urban landscapes. This limited perspective not only damages citizens' quality of life but also undermines each city's potential to develop climate resilience [18]. Urban policies struggle due to a lack of financial resources and inefficient use of natural ones, resulting in unequal management of city areas, where overdeveloped spaces driven by green gentrification alternate with leftover spaces. These latter are informal or underutilized areas, lacking a comprehensive strategy that prioritizes their function [19]. Although approached as fragmented green spaces, they contribute to promoting ecological connectivity, supporting wildlife, preserving biodiversity, and providing recreational opportunities for residents at both the local and metropolitan scales [19–21]. Most current trends in landscape design and planning blend ecological perspectives with socio-cultural dimensions [22,23]. In efforts to build climate-adapted cities, they primarily focus on bio-regions or territorial systems [18,21–23], often neglecting small-scale systems with their dynamics, such as leftover spaces. Policies supporting citizen participation in the renewal of these spaces remain limited, thereby undermining their potential as human-centered environments [24].

The esthetic marginalization of urban nature, the lack of a unifying vision of the city as a living organism, and limited community engagement in future developments represent the main gaps in the urban agenda. Within this context, BU is usually excluded or understated, despite its potential to value existing green spaces and support the creation of new ones for integrating resource-efficient and ecological cities [18]. To bridge these gaps, we advocate for a holistic approach that uses nature as a key strategy to achieve human and environmental benefits, involving citizens in processes of urban or spatial transformation. In pursuit of a paradigm shift in urban policies and practices, we promote BU principles to make cities more equitable, sustainable, and resilient. We aim to answer the following research questions (RQs):

RQ1: *How can urban nature improve livability in the built environment?*

RQ2: *How can BU renew urban landscapes, restoring human–nature interactions and enhancing ecosystem services?*

To reply to these questions through biophilic experiences across different settings, scales, times, and modalities, the paper is organized as follows. First, we outline the materials and methods in terms of the livability criteria and design tools, following the structure of a workshop that allowed us to collect firsthand data on the positive effects of biophilia in urban contexts. Second, we examine biophilic benefits through a real-time experience in a Living Lab setting at the micro scale. Third, we recall these benefits through participants' memories, identify them with specific nature-based settings at the macro scale, and spatially map them within the Amsterdam case study. Then, we explore biophilia through a co-design process by applying BU tools to enhance human–nature interactions and leverage ecosystem services in leftover urban spaces at the meso scale. Finally, we reflect on the outcomes of each approach to underline BU's potential for urban planning as a response to our RQs, thus contributing to the advancement of the field by addressing existing knowledge gaps and informing future directions.

2. Materials and Methods

2.1. Study Area

The city of Amsterdam was selected for the case study. The capital of the Netherlands spans approximately 220 km² [25] and has a rapidly growing population, which is expected to reach one million residents by 2030 [26]. Although not yet included in the Biophilic Cities network [27], Amsterdam has considerable potential to become part of it thanks to its blue-green infrastructure and urban policies. More than 61% of the public space in Amsterdam is green, with 15% of the city covered by trees and 35% by waterways. Public green spaces consist of agricultural areas (35%), natural areas (26%), neighborhood areas (23%), and recreational areas (16%) [28]. Despite these positive figures, a recent study indicated that Amsterdam falls short of the 3-30-300 rule: around half of the buildings have a view of at least three trees, 52% are within 300 m of a park, but none meet the 30% canopy cover benchmark [5]. However, a previous report by the European Environment Agency estimated the city's canopy cover at up to 14% [29]. This deficiency highlights the need for increased greening initiatives that adhere to higher quantitative and qualitative standards. In compliance with the EU Green New Deal, Amsterdam adopted a new environmental plan to become a climate-neutral city with a circular economy by 2050 [26]. With a special emphasis on natural capital, the new "Amsterdam Green Infrastructure Vision 2050" aims to make the city more livable for people, plants, and animals [30]. This biophilic-oriented plan recognizes the value of urban nature for individual health, social well-being, leisure, climate adaptation, and biodiversity. It established principles to ensure the adequate presence of green spaces, equitable distribution, fair access, and management and conservation through collective efforts. Moreover, it expands the existing green systems, providing a series of nature-based solutions to strengthen the social, spatial, and ecological connections [31]. Amsterdam city has served as a test bed to explore the positive effects of biophilia experienced at the macro, meso, and micro scales.

2.2. Research Design

This study combined different methods to structure a 5-session workshop aimed at raising awareness of nature's impact on urban livability, testing our approach in real-world settings, and collecting primary data (Figure 1). These sessions included:

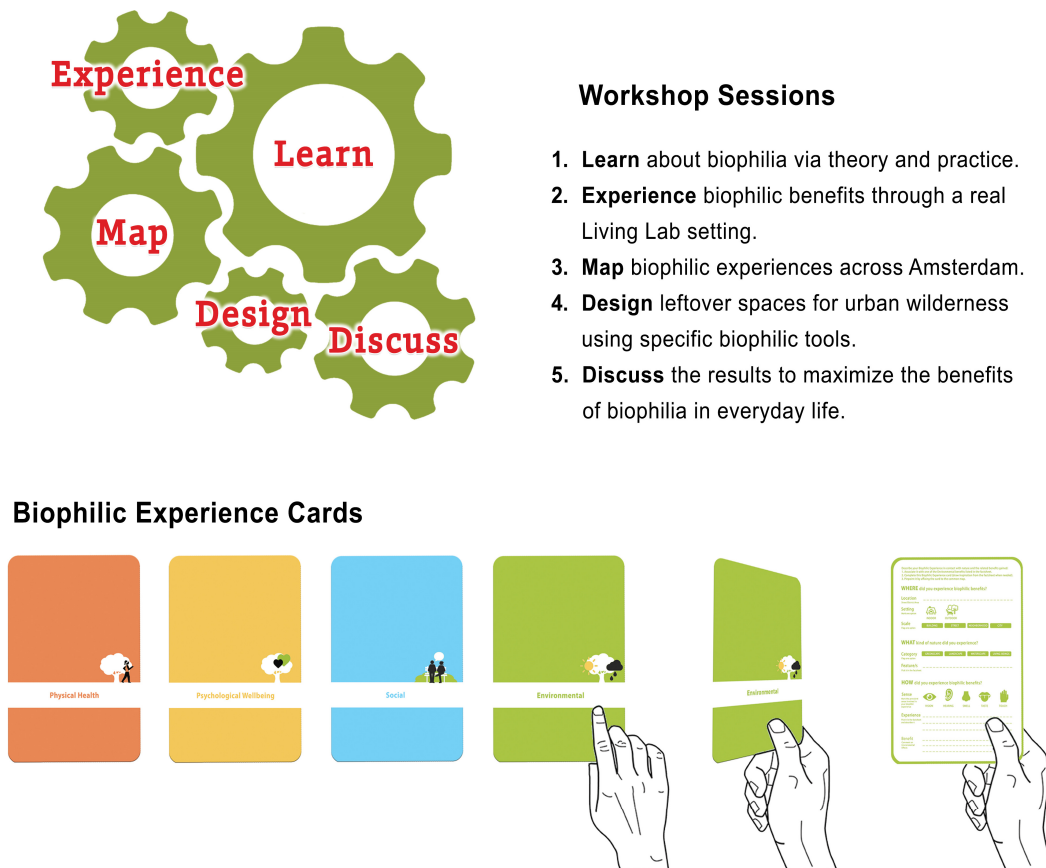


Figure 1. Workshop design, with a focus on the four Biophilic Experience Cards (BEC) used during the Map session. These cards represent the four dimensions of biophilic benefits. The back of each card is divided into three sections (Where, What, How) to be completed by participants. Further details can be found in the Supplementary Materials (Figure S1).

(1) **Learn.** The workshop integrated both theoretical and practical components. Each hands-on activity was preceded by an introduction or micro-lesson that provided essential content for completing the operative tasks. This theoretical foundation contributed to a broader learning process aimed at disseminating biophilic culture. The workshop emphasized the concept of ‘biophilic experience’ as a sense-based approach to reconnect people with nature in the built environment and to harness its multiple benefits for cities and citizens. This approach was intended to inspire participants to repeat similar experiences beyond the workshop, in the urban places they most frequently visit, either alone or with friends and family.

(2) **Experience.** To address RQ1, we adopted an empirical approach, proposing a real-time biophilic experience within a Living Lab setting. Following a brief introduction to the concept of biophilia and its benefits, along with an overview of the site, participants engaged in an on-site immersive activity. They were asked to spend up to 20 min interacting with nature using all five senses and to reflect on the positive effects they perceived on themselves, other forms of life, or the surrounding environment. To preserve participants’ freedom of action and response, only essential instructions were provided. Nonetheless, to guide reflection, we defined four key dimensions of biophilic benefits: Physical Health, Psychological Well-being, Social, and Environmental [16]. Depending on the type of activity, natural features, and senses involved, these benefits could be experienced individually or simultaneously within a single biophilic experience [16]. Furthermore, the literature suggests that the positive effects of biophilia are amplified through multisensory interactions with nature and are maximized in urban landscapes with higher biodiversity or

those that integrate multiple features within the same natural setting, such as blue-green infrastructure, varied plant species, and both wet and dry wilderness elements [16,32]. The field research was conducted at the “Leftover Green Field Lab” in Marineterrein as a testing ground to investigate biophilic benefits at the micro scale. Originally initiated by Luo’s project, this space rehabilitated a leftover green area through minimal interventions by enhancing ecosystem services and fostering interspecies exchanges [33]. Using the Living Lab methodology—which actively involves users in the design, testing, and evaluation of solutions in real-life contexts [34]—this 250 m² open-air laboratory serves as a testbed for developing new ways to incorporate wilderness into the city of Amsterdam [35]. As an outdoor biophilic setting, it stimulates engagement with blue-green infrastructure, native plants, shrubs, trees, grasses, moist soil, earthen mounds, tree trunks, sunlight, shade, and hotspots for animal restoration and feeding (Figure 2).



Figure 2. Pictures of the main workshop sessions: (a) Experience: Walking through the “Leftover Green Field Lab” (Marineterrein, Amsterdam) for a multisensory biophilic experience in a real Living Lab setting; (b) Map: Filling out the BEC; (c) Map: Preliminary results; (d) Design: Co-design process; (e) Discuss: Presentation and discussion of each team’s design project.

(3) Map. Spanning urban scales, we applied the same experiential approach used in the first workshop session, moving from the micro-scale Living Lab to the macro-scale city of Amsterdam. Biophilia was explored through cognitive-associative processes, as participants were invited to recall memories of similar biophilic experiences and associate each with a specific location in the city, the type of experience, the natural context in which it occurred, and the perceived positive effects. These detailed data were gathered using Biophilic Experience Cards (BEC), which visually represented the four dimensions of biophilic benefits through color coding and icons on the front and included structured sections for written input on the back (Figures 1 and S1). Once biophilic locations were identified according to the associated benefit dimensions, they were quantified, qualified, and spatially mapped across Amsterdam.

(4) Design. In response to RQ2, we carried out another practical session grounded in research-by-design and citizen science approaches (Figure 2). To apply BU at the meso scale, participants were introduced to the Design Toolbox, a set of guidelines used to support the cooperative Design session. The toolbox is organized into two stages (Invitation, Interaction) and encompasses six design tools (Center and Enclosure, Transition, Landmark, Diverse Habitat Conditions, Appropriation, Cue for Care). These tools were employed to revitalize leftover spaces through low-impact ecological interventions, while also strengthening human–nature interactions and boosting ecosystem services. Further details on the Design Toolbox are provided in the Supplementary Materials (Figure S2). We adopted a co-design process to overcome the limitations of traditional user-centered approaches [36], foster proactive community engagement [37], and broaden stakeholder involvement [38]. Lessons learned from the earlier theoretical and practical sessions were utilized to inform the co-design process.

(5) Discuss. The outcomes of the Design session were presented in a peer-to-peer interactive format, integrating feedback from both experts and non-experts (Figure 2). Building on the previous sessions, participants exchanged ideas on how to maximize biophilic benefits within each design project. To support continued engagement with BU, additional training resources were provided at the end of the workshop.

2.3. Data Collection and Processing

Data for this study were gathered during three workshops held on different dates (3 July, 12 July, and 20 September 2024), hosted by the Amsterdam Institute for Advanced Metropolitan Solutions (AMS) in Marineterrein. Although the workshop structure, agenda, content, timing, and duration remained unchanged, it was scheduled in either the morning or afternoon at both the beginning and end of the same season (summer) to increase participant numbers and diversify backgrounds in terms of expertise and familiarity with the research topic.

The sampling strategy targeted a broad audience of residents or individuals living in Amsterdam, including both academic participants (students, scholars, lecturers) and non-academic groups (stakeholders, community members, citizens).

The dissemination campaign, conducted from May to September 2024, combined physical and digital platforms. The call for participation was published on the AMS website and shared via the official channels of the three institutional partners supporting the research: Amsterdam Institute for Advanced Metropolitan Solutions (AMS), Delft University of Technology (TUD), and Wageningen University & Research (WUR). The research team also leveraged personal and professional networks. Paper flyers and posters were displayed at campus facilities (AMS, TUD, WUR), and personalized email invitations were sent to urban designers, ecologists, architects, environmental scientists, and City of Amsterdam representatives (Gemeente Amsterdam). Citizens were also reached through local community

platforms (e.g., Marineterrein). The call included general event details (title, dates, location, etc.), project information (structure, topic, goal, research team, participating institutions), and a QR code linking to a Google Form for online registration, which offered the option to select dates and time preferences.

The workshop was held in English. All participants were provided with a paper informed consent form, which reiterated the event information, confirmed the voluntary nature of participation, requested permission for data and image use, and described data processing, protection, and storage protocols. The form complied with official models approved by the ethical boards of TUD and WUR. The dataset was stored securely on institutional storage platforms provided by TUD.

Data collection was performed at the main workshop sessions: Experience, Map, Design, and Discuss. Feedback from the last two sessions was jointly gathered and processed as part of the same dataset.

2.3.1. Experience Dataset

Data from participants' real-time biophilic experiences in the "Leftover Green Field Lab" were collected as individual feedback. Each participant was free to explore, interact with, and connect to the nature-based setting and its living elements, using their senses to perceive the resulting benefits within a 20 min timeframe (Figure 2). At the end of the session, participants were asked to summarize their on-site experience of biophilia with a single keyword reflecting the most impactful feature or effect, and to share it during a group roundtable discussion.

The resulting experience dataset was recorded during the workshop as digital notes and later processed using an integrated quantitative-qualitative approach. First, each keyword was categorized into one of the four biophilic benefit dimensions. Then, a word frequency analysis was conducted to identify the predominant benefit dimension and its relative percentage (Table S1).

2.3.2. Biophilic Experience Cards (BEC) Dataset

To map individual biophilic experiences across Amsterdam, data were collected during a 30 min session in which participants completed Biophilic Experience Cards (BEC) (Figure 2). These cards were part of the supporting materials provided along with a brief demo prior to the Map session (Figure S1, Table 1). Different BEC were distributed to participants, with each card associated with one of four biophilic benefit dimensions and identifiable by color: Physical Health (orange), Psychological Well-being (yellow), Social (blue), and Environmental (green). Before selecting a BEC to complete, participants were asked to recall a past biophilic experience anywhere in Amsterdam, focusing on the benefit gained from it (Figures 1 and S1). Based on this self-assessment, they selected the BEC matching the benefit dimension and filled it out. To support this task, a biophilic experience framework (Table 1), grounded on benefit-oriented literature [16], was provided. The framework consists of three sub-tables: (a) biophilic benefits resulting from human–nature interactions, matched to benefit dimensions and corresponding colors; (b) biophilic categories and features of the urban scenario, sorted by cityscape types; and (c) ways to experience nature in the city, including examples of outdoor and indoor biophilic experiences involving both sensory and intangible interactions.

Table 1. The biophilic experience framework consists of three sub-tables. (a) Biophilic benefits resulting from human–nature interaction, organized by benefit dimensions and corresponding colors. (b) Biophilic features of the urban scenario, categorized into four cityscape types. (c) Ways to experience nature in the city with indoor/outdoor examples involving sensory and intangible interaction.

(a)			
Dimension	Benefit		
Physical Health	Motor function/Wayfinding/Physical wellness		
	Bodily function regulation		
	Illness recovery/Immune system support		
	Biorhythm control/Longevity		
Psychological Well-being	Mental health and recovery/Stress Reduction		
	Attention/Memory/Creativity		
	Learning and adaptive skills/Problem solving		
	Motivation/Satisfaction/Self-confidence/Fulfillment		
	Emotional recovery/Comfort and Safety/Rejuvenating potential		
	Positive mood/Enjoyment/Happiness		
	Preference/Esthetic pleasure/Fascination		
	Spiritual and Ethical values		
	Topophilia (sense of place and emotional affiliation with it)		
Social	Social interaction		
	Social cohesion/Membership		
	Proactivity/Resilient behaviors		
Environmental	Indoor Environmental Quality/Outdoor Environmental Quality		
	Mitigating temperature/Purifying water and air		
	Energy/Resource efficiency		
	Ecosystems services (provisioning, regulating, supporting)/Biodiversity		
	Carbon neutrality/Climate Resilience/Sustainability		
(b)			
Biophilic Categories and Features			
Greenscape	Landscape	Waterscape	Living Beings
Plant/Shrub/Flora	Sunlight/Daylight	Water	People
Grass/Lawn	Shadow	River/Creek	Animal/Fauna
Tree/Urban forest & canopy	Sky	Lake	
Green rooftop	Natural Air	Sea/Ocean	
Green walls/façade	Natural landscapes and ecosystems	Fountain	
Public garden/park	Field/Brownfield	Pool	
Green court/area	Earth/Ground	Waterfall	
Sidewalk garden	Rock/Stone	Floodplains	
Vegetated swale	Soil/Land/Sand	Blue infrastructure	
Edible landscaping and	Mountain/Hill		
Natural food	Natural view/panorama		
Green schools	Space/Spatial harmony		
Green corridor/infrastructure	Snow		
	Weather		
	Natural color/shape/material/pattern/texture		
	Natural images & reproductions		
	Natural process/growth/change		
	Biomimicry		

Table 1. Cont.

(c)			
Ways To Experience Nature in the City			
Outdoor		Indoor	
Physical	Psychological/ Cultural/Social	Physical	Psychological/ Cultural/Social
<ul style="list-style-type: none"> - Watching/Seeing/ Listening/Smelling/ Testing/Touching real nature - Hiking/Camping/ Spending time outdoors - Feeling wind/rain/ mist/breeze - Contemplating nature or natural view/panorama - Outdoor workout - Landscape orientation - Sensory stimuli/ Human adaptation - Engagement & immersion in nature 	<ul style="list-style-type: none"> - Training/Researching/ Studying about nature - Nature-based cognition - Participating in a nature club/organization outdoor - Nature activities (gardening, tree planting, cleaning up) - Geo-Historical/Cultural affiliation to a place - Emotional/Spiritual connection with nature or a place - Feeling/Sense of attraction, esthetic, curiosity, order, awe, safety, beauty, discovery, inspiration, etc. - Ethical/Ecological values - Enhancement of humans in interspecies relationship 	<ul style="list-style-type: none"> - Watching/Seeing/ Listening/Smelling/ Testing/Touching real nature or its reproductions - Watching nature through a window - Feeling indirect nature effects (thermal and airflow variability) - Experience nature via digital tools/ sensors/AI 	<ul style="list-style-type: none"> - Training/Researching/ Studying about nature - Scientific knowledge - Participating in a nature club/organization indoors - Nature activities indoors (gardening) - Contemplating a memory of a previous experience with nature - Feeling/Sense of attraction, esthetic, curiosity, order, awe, safety, beauty, discovery, inspiration, etc. - Ethical/Ecological values - Enhancement of humans in interspecies relationship

Each BEC was designed with a fixed layout with three sections (Where, What, How) to detail the individual biophilic experience (Figure S1). Each section was headed by a question: (a) Where did you experience biophilic benefits? (b) What kind of nature did you experience? (c) How did you experience biophilic benefits? The first section (a) required participants to specify the location (e.g., street, district, or city area) within Amsterdam, the setting (outdoor or indoor), and its relevant scale (building, street, neighborhood, or city). The second section (b) referred to cityscape categories and features. Based on the predominant component, we distinguished four types of cityscape categories: Greenscape, where vegetation is predominant; Landscape, including non-green elements of the urban environment associated with the sky; Waterscape, related to blue infrastructure and water-based elements in the city; and Living Beings, encompassing people and animals. To identify the specific cityscape feature, participants could draw inspiration from Table 1b, which lists and groups features under the four cityscape categories. This classification results from the synthesis of several biophilic literature sources [39–41]. In section (c), participants described how the biophilic experience was implemented, whether one or more senses were involved, and the way they experienced nature in the city by selecting one option from those listed in Table 1c. These options were grouped into physical activities and psychological/cultural/social activities, as mentioned in the relevant literature [10,42,43]. A final comment was required to provide additional details on the benefits gained. Each participant was asked to complete at least three BEC, preferably selecting cards related to different benefit dimensions and associating each with a single location based on the primary benefit experienced. However, completing multiple cards within the same benefit dimension was also permitted. Similarly, participants were allowed to fill out different cards referring to the same location if it evoked distinct biophilic experiences or benefits. To make the mapping activity more interactive, participants were invited to pin each completed

BEC onto a board displaying an A1 paper map of Amsterdam, offering a preliminary visual overview of the Map results by the end of the session.

In order to process the BEC dataset, we first digitized the paper-based cards and classified them by benefit dimension. The dataset was then analyzed using a 3-metric research approach that focused on quantity, quality, and spatial distribution. Following the BEC layout, we first identified and quantified the locations. Next, we screened each data point according to the three main content areas (Where, What, How). We then qualified the data by categorizing it based on the location, setting and scale (Where); cityscape category and feature (What); and sensory mode, experience type, and benefit (How). Finally, we mapped each location to visualize its spatial distribution across the city, its potential positional relationships with other locations, and the predominant benefit dimension associated with each location. Although all data were equally explored (Table S2), we only considered the locations cited at least twice on BEC as the most significant results. Nevertheless, all the locations identified by participants were geolocated across Amsterdam to develop a benefit-oriented biophilic map of the city.

2.3.3. Design and Discuss Dataset

The Design session was conducted as a 45 min co-design process. To foster co-creation and community engagement, participants were divided into small work teams of approximately three people. Although group composition was spontaneous, we ensured that each group included participants with varying levels of expertise, allowing each member to meaningfully contribute to the design outcomes according to their own pace, interests, and skills (Figure 2). During the session, we acted as advisors, providing information and practical tools to facilitate the work.

The session goal was to apply BU principals at the meso scale through a cooperative designing exercise focused on a real leftover green space. To this end, participants were asked to draw on content and insights from the previous sessions. We provided additional input, including a brief introduction to the study area, its location within the city (Bijlmermeer district, Amsterdam South), its geometric features (rectangular lot bordered by drivable roads and a bike path, covering 6400 m²), territorial characteristics (flat terrain), strengths (grass, trees, active local community), and weaknesses (long-term vacancy since 2015, partial soil contamination due to previous use as a parking lot). This study area represents a typical leftover green space affected by urban transformation. To support the co-design activity, we introduced theoretical key concepts (e.g., leftover spaces), shared practical instructions, and distributed drawing materials (maps, tracing paper, pre-filled sheets, markers), along with an essential Design Toolbox to promote meaningful human–nature interactions in urban areas. This toolbox consisted of six design tools merging landscape architecture and BU, aiming to bridge the perceptual gap between structured spaces and leftover areas, enhance place perception, and integrate wilderness into urban environments. The design tools were organized into two stages: Invitation, designed to overcome perception biases and specifically introduce people to the urban wilderness; and Interaction, aimed at encouraging creativity and deeper engagement with the space (Figure S2). Each stage encompassed three design tools. The Invitation stage utilized the following: (1) Center and Enclosure defines the space by contrasting a central focal point with clear boundaries [44], helping visitors perceive the intended meaning and unique identity of the place. (2) Transition guides users through spatial sequences, marked by gates or entry points that support the shift from familiar surroundings to new and immersive interior sites [45]. (3) Landmark identifies symbolic elements that help capture interest, stimulate curiosity, orient visitors, and connect them with the place through deeper experiences [46]. The Interaction stage contained: (4) Built on Gilles Clément’s “Third Landscape”

concept [47], Diverse Habitat Conditions emphasizes the importance of biodiversity in sustaining flora and fauna [48], refining spatial perceptions [49], and fostering learning through natural ecosystem dynamics. (5) Appropriation promotes flexible-use spaces encouraging human-place interactions, site personalization, and the development of personal connections to deepen the sense of belonging [50]. (6) Cue for Care employs visual signs to support care actions, shared stewardship, and eco-cultural values in the urban wilderness, inspiring visitors' appreciation and respect [51].

The resulting Design dataset was examined through a multi-step framework driven by qualitative research. The steps were as follows. (1) Digitalization and Organization: After digitalizing the design sheets (1–2 per group) corresponding to all team projects (Table S3), we imported them into ATLAS.ti (version 24)—a qualitative data analysis software primarily used for processing written interviews or literature research [52]. We employed ATLAS.ti to facilitate data management through coding and categorization. (2) Initial Coding: We developed a codebook based on BU principles, incorporating core aspects such as benefit dimensions, categories, features, and experiences (Table 1), along with elements from the Design Toolbox (Figure S2). (3) Code Refinement: We refined codes through iterative qualitative content analysis to align with participants' ideas, experiences, design preferences, and perceptions. (4) Thematic Coding: We organized the resulting codes into three thematic classes of BU tools: 'categories & features' that cover biophilic cityscape categories, as shown in Table 1b; 'experiences & benefits' obtained by merging Table 1a,c; and 'design tools', including the Design Toolbox elements (Figure S2). (5) Co-occurrence Analysis: This analysis identified correlations among the three BU classes, uncovering relationships between specific design interventions and their perceived benefits. It also provided insights into how participants engaged with the co-design process and translated BU principles into applied strategies. To ensure the reliability and validity of the analysis, we conducted independent coding and regular debriefing. These sessions helped address potential biases, clarify coding, and align interpretations, thus enhancing the robustness of the thematic findings (Tables S4 and S5).

After completing qualitative coding, we quantitatively analyzed the Design dataset. First, we assessed the frequency of design tool applications across team projects (Table 2). Next, we performed thematic coding of quotations related to the six design tools, measuring how frequently each design tool was cited in each team's project (Table S4). Lastly, we estimated the reciprocal correlations among the biophilic elements: 'categories & features', 'experiences & benefits', and 'design tools', using co-occurrence analysis (Tables 3 and S5).

The Discuss session followed as a post-activity report-out, in which each work team presented its design project, while we recorded feedback in the form of additional notes. These data—including project concepts, suggestions, and reflections on nature values, ecosystem services, and BU principles—complemented the Design dataset and helped establish mutual correlations among the main operative sessions (Explore, Map, Design). The Discuss dataset was processed in three steps using qualitative and associative criteria. First, the raw notes were digitized, filtered for irrelevant content, and organized by work teams. Second, the dataset was categorized according to the literature-based framework that guided the Experience and Map sessions (Table 1). Finally, the categorized data were integrated with the Design dataset and jointly analyzed via ATLAS.ti. Additionally, participants' reflections captured in the Discuss session were used to identify key factors, challenges, and practical recommendations for advancing BU, which informed the final discussion section of the study.

Table 2. Results from the Design Tool Application (ATLAS.ti): BU tools utilized during the Design session and applied in each team’s project (Identification No. + Name). Frequency of occurrence values are highlighted in gray; white cells indicate no occurrence.

		Work Teams														
		Design_1 Wilderness K-midden	Design_2 Water Garden	Design_3 Community Cafe	Design_4 Transition to Stage	Design_5 Kempering Park	Design_6 Mini-Forest	Design_7 Rainwater Garden	Design_8 Spiral Farming	Design_9 Community Kiosk	Design_10 K-buurt living room	Design_11 Inheems	Design_12 Food Garden K-buurt	Design_13 Experiencing Urban	Design_14 Summer Garden	Total
Design Tools	Appropriation															9
	Center and Enclosure															12
	Cue for Care															6
	Diverse Habitat Conditions															9
	Landmark															13
	Transition															13

Table 3. Outputs from the co-occurrence analysis, matching the thematic coding results related to the BU classes of ‘categories & features’, ‘experiences & benefits’, and ‘design tools’ implemented in each team’s project. The Psychological and Social dimensions are combined by merging Table 1a,c. Based on the groundedness of a code (Gr)—an ATLAS.ti metric indicating the frequency with which a particular code appears in the dataset—the most relevant values are highlighted in two shades of gray: darker gray indicates the highest value, and mid-gray represents the second highest for each corresponding ‘categories & features’ or ‘experiences & benefits’.

		Design Tools					
		Appropriation Gr = 14	Center and Enclosure Gr = 18	Cue for Care Gr = 8	Diverse Habitat Conditions Gr = 15	Landmark Gr = 17	Transition Gr = 21
Categories and Features	Greenscape Gr = 62	3	3	7	5	1	4
	Landscape Gr = 33	0	6	1	2	2	2
	Waterscape Gr = 9	0	3	0	1	0	0
	Living Beings Gr = 20	1	1	0	5	1	0
Experiences and Benefits	Physical Gr = 50	5	4	2	3	0	5
	Psychological/ Social Gr = 77	9	8	11	1	8	0
	Environmental Gr = 11	1	0	0	0	0	1

3. Results

3.1. Workshop Participants

Despite receiving over 80 registrations, a total of 45 participants attended the workshop across the three scheduled dates. Based on their background and expertise, participants were divided into three groups: Bachelor’s or Master’s students; professionals with knowledge in relevant disciplines (e.g., Architecture, Urban Design and Planning, Landscape Design, Urban Studies, Environmental Science, Bio-based Sciences, Plant Science, Social Science); and citizens, including local community members engaged in urban issues. This

categorization supported the formation of mixed work teams during the Design session. An overview of the participant profiles is presented in Table 4 below.

Table 4. Workshop participant data sorted by date and group.

	Workshop Participants			
	1st date	2nd date	3rd date	Total
Student	2	5	6	13
Expert	5	9	8	22
Citizen	2	6	2	10
Total	9	20	16	45

3.2. Biophilia in One Word

As shown in Figure 3, results from the biophilic experience in a real-word Living Lab setting reveal a clear predominance of Psychological Well-being (42%) among the four benefit dimensions, followed equally by Social and Environmental (22% each), and lastly by Physical Health (14%).

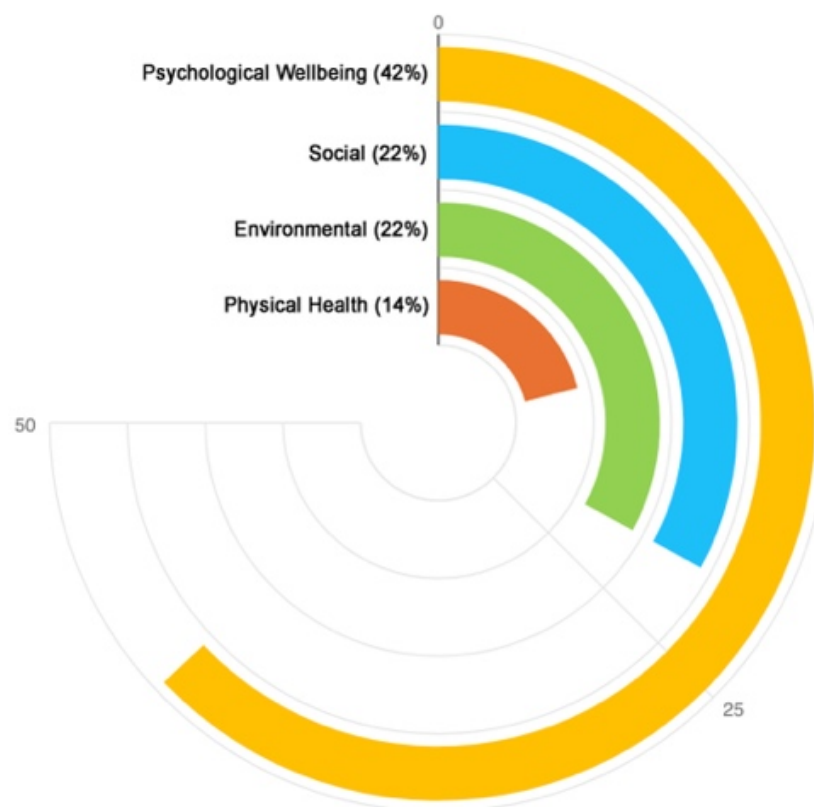


Figure 3. Radiant bar chart showing the effects of experiencing biophilia in the nature-based setting (“Leftover Green Field” Living Lab) on workshop participants, derived from Experience data processing (Table S1) and expressed as percentages across the four biophilic benefit dimensions.

Regarding specific benefits within each dimension, the experience keywords cited by participants suggest that Psychological Well-being is associated with mental restoration (rest, relax), emotional recovery inspired by positive feelings (joy, peace, freedom), and attachment to place (natural colors, connection, pride). Social benefits emerge through interpersonal interactions (caress, affection), a sense of belonging (community bonds, art as a bridge), proactivity (engagement), and civic sense (permission, social norms). Environ-

mental benefits are linked to natural elements or indicators (birds, insects, plants), natural dynamics (wild, organic, contrasting), biodiversity (vertical growth), and environmental resilience (ecological balance). Finally, Physical Health is defined in terms of bodily well-being (health), sensory interaction (tactile, touching), and spatial appreciation (big space, spaciousness). A complete list of experience keywords is provided in the Supplementary Materials (Table S1).

3.3. Biophilic Amsterdam

Before assessing how urban livability can benefit from exposure to nature, it is essential to identify which types of nature contribute to this goal and where they are located within the cityscape. These questions were addressed through the content of the BEC, which helped us answer RQ1. To this end, a total of 152 cards were collected from participants across the three workshop dates, categorized under four benefit dimensions as follows: 52 Psychological Well-being, 37 Social, 35 Physical Health, and 28 Environmental (Table S2).

To spatially localize biophilic experiences, participants identified up to 53 distinct urban settings, 17 of which were mentioned more than once, with the number of mentions ranging from 2 to 16, and the same site being associated with multiple benefits. Figure 4 displays the most frequently identified biophilic settings in Amsterdam, ranked by preference and correlated to the benefit dimensions. These included public parks, gardens, and iconic districts with city relevance. The most frequently cited location was Westerpark, which was primarily associated with the Social benefit dimension, followed by Vondelpark (Psychological Well-being), Marineterrein (Physical Health), and Hortus Botanicus (Environmental). Notably, four locations (Westerpark, Vondelpark, Marineterrein, Oosterpark) were linked to all the four biophilic experience dimensions. Only 4 out of the 152 recorded biophilic experiences were related to indoor settings. In terms of urban scale, most biophilic experiences were correlated with the city level (68%), followed by neighborhood (19%), street (7%), and building scale (6%). Regarding the type of nature involved, Greenscape was the most frequently cited cityscape category, with 112 entries, followed by Living Beings with 44 mentions. The landscape category received the lowest share (30), despite being the most widespread concept and encompassing many elements of the urban scenario, including non-green or dry landscapes and the sky, as described in Table 1b. Within each cityscape category, specific biophilic features were identified: Greenscape was primarily recognized in the form of urban forests, parks, plants, and flowers. Under the Landscape category, the most appreciated feature was the natural landscape itself and the associated views or panoramas it offers, while water was the most prevalent feature within the Waterscape category. As for interactions with Living Beings, a fundamental aspect of biophilic experiences, participants reported more frequent interactions with people than with animals. Regarding sensory engagement in experiencing biophilic benefits, participants indicated vision as the most utilized sense (144 cites), followed by touch (66), while taste was mentioned only 5 times. However, it is noteworthy that vision was almost always combined with other senses: 64% of all reported experiences were multisensory, most of which were associated with Social and Psychological Well-being benefits. Among these multisensory experiences, 87% were linked to Greenscape.

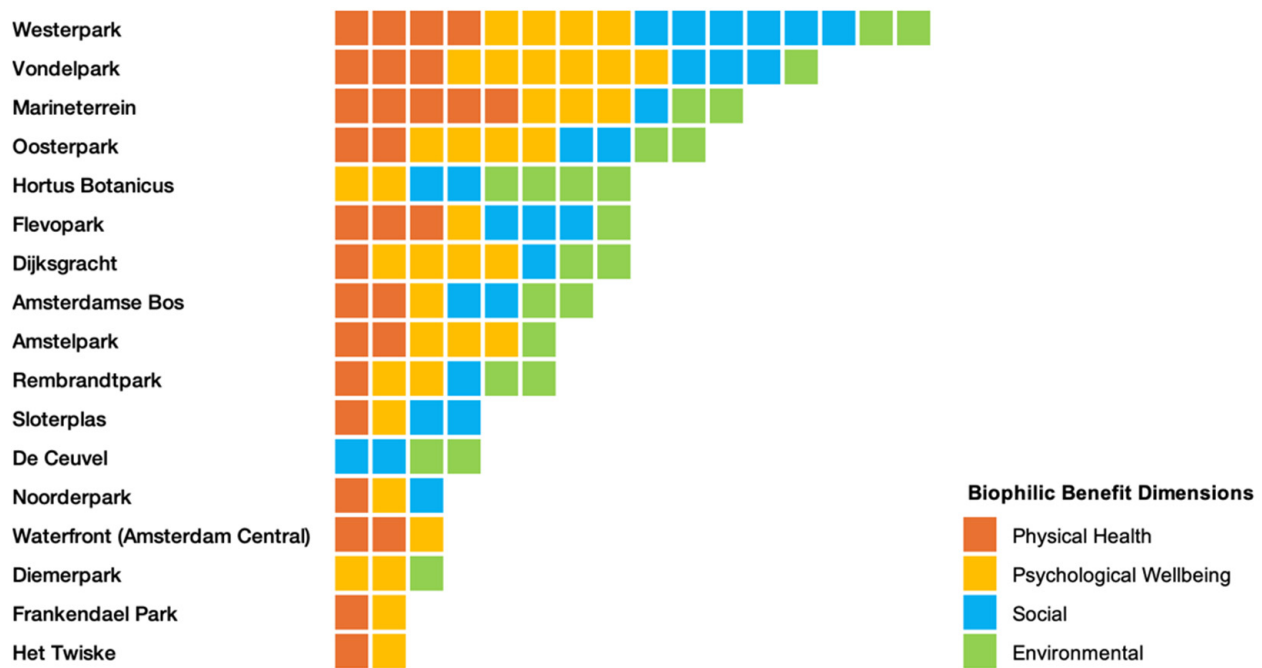


Figure 4. Biophilic locations identified across Amsterdam, ranked by preference (individual square). The top locations for each benefit were as follows: Westerpark (Social), Vondelpark (Psychological Well-being), Marineterrein (Physical Health), and Hortus Botanicus (Environmental).

Figure 5 illustrates the top ten biophilic locations across Amsterdam, ranked by participant preference. Each entry includes the associated biophilic experience and the benefit gained, as defined by the biophilic experience framework (Table 1). Among the experiences mentioned in the full sample, we identified the most frequently recurring one within each benefit dimension. This allowed us to determine key correlations between biophilic experiences, benefits, and their respective dimensions. For Physical Health, the most frequently cited benefit was physical wellness, primarily achieved through outdoor workouts. Psychological Well-being was most often associated with mental recovery, experienced through emotional connections with nature and place. Social benefit was linked to interpersonal interactions during time spent outdoors, especially in public parks. Finally, the Environmental benefit, framed as nature-based cognition, provided a dual advantage for both humans and the environment: it allowed participants to understand nature through ecosystem services and biodiversity, while also fostering ecological awareness and a sense of responsibility toward preserving these values.

Figure 6 visualizes the spatial distribution of the BEC dataset. This biophilic map of Amsterdam offers an overview of all the benefit-driven locations identified by the participants. It includes 53 sites spanning different urban scales, mostly concentrated in the city center. Each location is color-coded according to the predominant benefit dimension it represents. The map displays the biophilic locations based on frequency: Psychological Well-being emerged as the most frequently associated benefit (21), followed by Social (14), Physical Health (10), and Environmental (8). However, when considering area coverage rather than frequency, the Social benefit dimension was the most commonly reported.

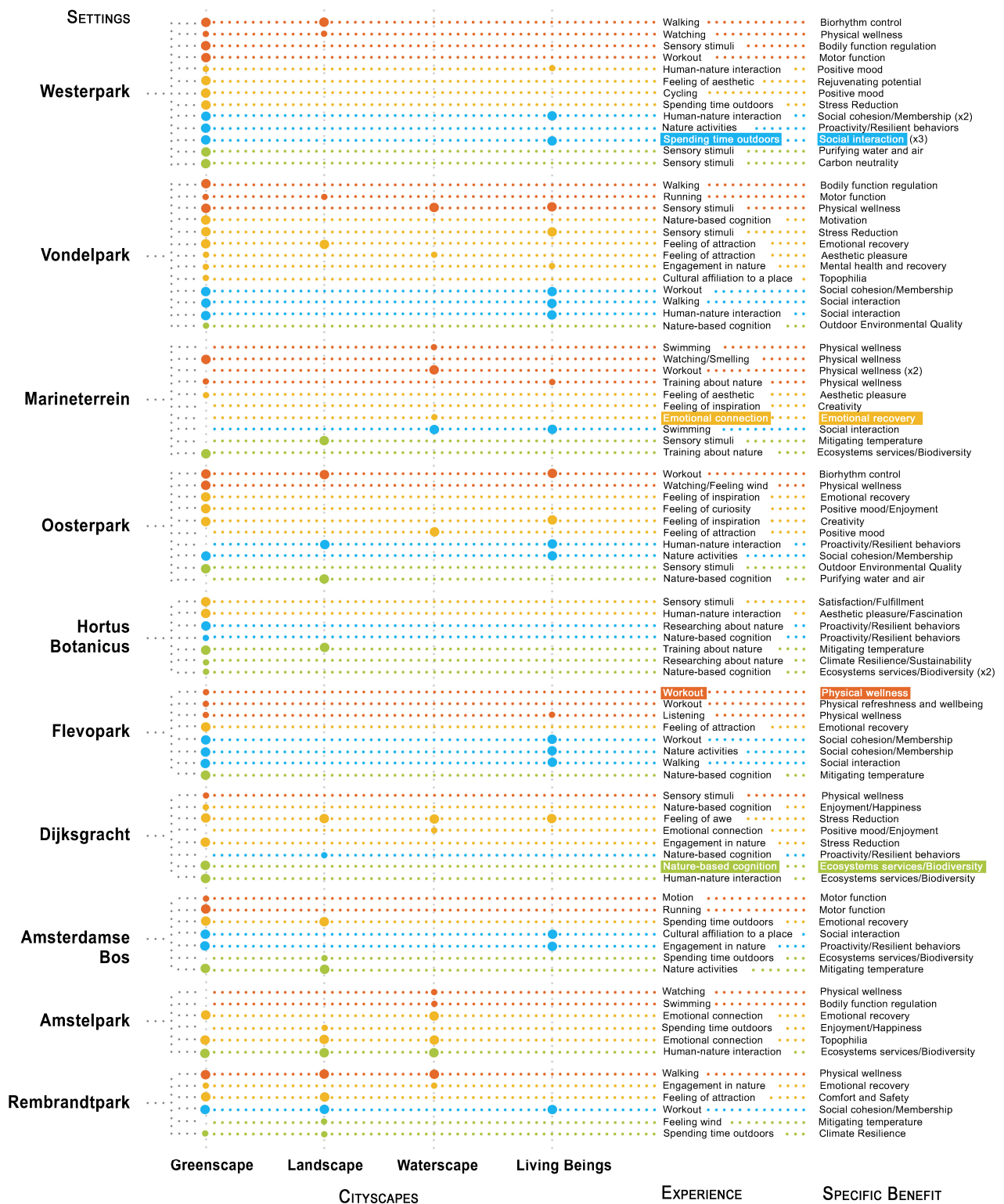


Figure 5. Top ten biophilic locations from BEC data (Figure 4). Each location (Y-axis) is linked to a cityscape category (Greenscape, Landscape, Waterscape, or Living Beings), experience, and specific benefit (X-axis). Larger dots indicate multisensory experiences, while smaller dots represent single-sense experiences. The four labeled experiences and benefits were the most frequently mentioned in the BEC dataset.



Figure 6. Spatial distribution of biophilic locations across Amsterdam, including all sites cited by workshop participants and recorded in the BEC dataset. Locations are color-coded by the predominant benefit dimension and represented in their real shapes and sizes based on neighborhood- or city-scale relevance. Triangles indicate sites at the street or building scale.

3.4. BU Tools: Application and Correlation

Based on the total number of participants and work teams, the Design and Discuss sessions yielded 14 entries. All team projects are summarized in the Supplementary Materials (Table S3), including the project identification number, name, main concept, short description, and their correlation with the benefit dimensions defined in the biophilic experience framework (Table 1).

Our results were organized into three groups, each highlighting BU elements or strategies employed by the work teams to foster human–nature interactions and enhance ecological values. These result groups emerged from a 3-stage qualitative analysis conducted using ATLAS.ti. First, we examined the application of design tools in the team projects, as part of a theory-to-practice learning process aimed at demonstrating the impact of the newly delivered content, regardless of participants' backgrounds (Design Tool Application). Second, we presented the thematic coding results, expressed as the frequency of quotations related to three BU classes: 'categories & features', 'experiences & benefits', and 'design

tools' (Thematic Coding). In this analysis, the Psychological and Social benefit dimensions were merged, as they were treated as a single dimension within the framework of the ways to experience nature in the city (Table 1). Finally, we explored the co-occurrence of codes among the three BU classes to identify patterns of interrelation (Co-occurrence Analysis).

- **Design Tool Application.** On average, each team project incorporated most of the design tools provided (Figure S2), though only 4 out of 14 projects utilized all six design tools. Transition was the most frequently used tool, appearing in 13 out of 14 project entries, followed by Center and Enclosure and Diverse Habitat Conditions, each used in four entries. Cue for Care was the least applied, absent in 7 out of 14 projects (Table 2). The analysis of the projects highlights how these design tools can enhance biophilic experiences in urban green spaces. While all six design tools were applied across the projects, some—particularly Appropriation, Cue for Care, and Diverse Habitat Conditions—were only partially implemented. Diverse Habitat Conditions aimed to support non-human life, whereas Appropriation and Cue for Care were intended to serve diverse social groups. Their limited application suggests a misalignment between the goals of supporting non-human life and accommodating human use when applying BU to renew leftover green spaces.
- **Thematic Coding.** The coding results reveal variations in the application of the six design tools across the 14 team projects. Among these, Transition was the most frequently applied tool, with 21 quotations, followed by Center and Enclosure (18), and Landmark (17). Diverse Habitat Conditions (15) and Appropriation (14) were also commonly cited, while Cue for Care was the least referenced, with only 8 quotations (Tables 3 and S4). Thematic coding applied to 'categories & features' shows that Greenspace was the most frequently addressed, with 62 quotations, followed by Landscape (33) and Living Beings (20). Waterscape was the least mentioned, with only 9 quotations. Regarding 'experiences & benefits', the merged Psychological and Social dimension was the most prominent, with 77 quotations, followed by Physical (50), and Environmental, which was cited only 11 times (Table 3).
- **Co-occurrence Analysis.** Table 3 summarizes and correlates the results of the thematic coding related to 'categories & features' (Table S5), 'experiences & benefits' (Table S5), and 'design tools' (Table S4). Revealing strong correlations among these BU classes, it demonstrates how participants internalized key BU concepts by associating elements of the biophilic experience framework (Table 1) with the Design Toolbox (Figure S2), thus reinforcing their integration in the project designs. These connections are supported by both the frequency-based co-occurrence analysis (Table 3) and the design project concepts (Table S3). Greenspace frequently co-occurred with design tools such as Cue for Care, Diverse Habitat Conditions, and Transition. For example, one project combined wild vegetation zones (Greenspace) with signage to encourage community engagement (Cue for Care) and diverse planting schemes to support biodiversity (Diverse Habitat Conditions). These interventions were associated with Psychological and Social benefits, particularly in leftover spaces (Greenspace). The co-occurrence of Greenspace and Cue for Care was also evident in another project focused on elderly friendly parks, where nature-based pathways enhanced accessibility and safety. Similarly, Landscape and Waterscape were frequently paired with Center and Enclosure tool, as seen in an urban plaza project where water features and landscape elements were employed to create focal points and a sense of shelter. Living Beings showed a notable co-correspondence only with Diverse Habitat Conditions, especially in projects introducing pollinator-friendly plants to support local biodiversity. In terms of 'experiences & benefits', Physical benefits were equally associated with Appropriation and Transition, as illustrated by projects combining active-use areas

alongside quieter, contemplative spaces. Meanwhile, Psychological and Social benefits showed higher co-occurrence with four design tools: Appropriation, Center and Enclosure, Cue for Care, and Landmark. This correlation was clearly reflected in community-oriented design projects that promoted mental well-being and social interaction, using accessible landmarks and enclosed seating arrangements to foster comfort and identity.

4. Discussion

This study explores the role of BU in renewing urban planning by positioning nature as an ecological, economic, and sustainable strategy. While scientific literature offers substantial evidence of the many benefits of integrating nature into the built environment [10,16], we critically examine the actual potential of BU to positively impact livability across scales and its applicability in regenerating urban landscapes by ensuring both human and ecological well-being. The following discussion is structured around previous research, the knowledge gaps identified, and our research questions (RQs). Throughout the paper, we reflect on the results of biophilic experiences across time (real-time, past, and future) and space (micro, meso, and macro scales).

As prior studies have shown, experiencing nature in the city brings benefits across various domains [16]. Through an experience-based approach, this study demonstrates that BU offers clear pathways to enhance urban livability. Specifically, the knowledge and graphic tools help identify where and how to achieve biophilic benefits in everyday life. Our spatial findings indicate that most biophilic experiences occur in large-scale outdoor settings, primarily in well-known locations such as public parks or gardens. Conversely, domestic and building-scale environments are rarely recognized as effective or accessible settings for enjoying nature, either directly or indirectly. This emphasizes the importance of public green spaces as primary locations for fostering human–nature interactions. The underrepresentation of indoor and street-scale biophilic settings further reflects limitations in public perception. Our biophilic map of Amsterdam also reveals a strong dominance of Greenscape, despite the cityscape being extensively featured by water bodies. This suggests that biophilic culture is not yet fully embedded in everyday life and points to a lack or limited presence of nature-based solutions in smaller living spaces, such as homes and streetscapes. Our benefit-driven map displays up to 53 biophilic locations across Amsterdam. This helps overcome nature inequity and its associated negative impacts by encouraging residents to explore new mobility pathways towards greater benefits, even beyond their own neighborhoods when local opportunities are lacking [5]. Although previous studies stress insufficient urban canopy coverage in Amsterdam [5], our biophilic map shows that parks and urban forests within the Greenscape category are perceived as the most positively impactful green features. These areas are most commonly associated with Psychological Well-being, followed by Physical and Social benefits, and less so with Environmental benefits. Our quantitative, qualitative, and spatial results demonstrate that Amsterdam is a biophilic city. This is validated by the ‘site-experience-benefit’ perspective introduced in the workshop methodology to guide participants in systematically identifying and experiencing biophilic environments. Moreover, the city’s natural assets and ongoing climate neutrality initiatives make Amsterdam a viable candidate for inclusion in the Biophilic Cities network [27].

The biophilic experience framework proposed here provides a wide range of nature-based solutions, features, experiences, and four-dimensional benefits at different scales, all aimed at improving urban quality of life. Regarding the site-benefit pairing, our findings reveal a strong correlation between public green spaces—the highest-ranked biophilic locations—and benefits related to Psychological Well-being, Physical Health, and Social

connection, as these are short-term, easily perceivable and measurable. In contrast, Environmental benefits tend to be indirect, space-related, and longer-term, requiring more time to be fully appreciated. This may limit BU's integration into urban planning, as stakeholders often prioritize outcomes that are immediate and quantifiable [16].

During the workshop, three cross-scale biophilic experiences were proposed, each highlighting the positive impact of BU across different locations and modes of engagement. At the micro scale, a real-time field experience in a Living Lab revealed positive effects on Psychological Well-being, reported as one-word immediate feedback. At the macro scale, the BEC results broadened the scope: 'contemplating a memory of a previous experience with nature' also served as a biophilic experience itself, generating specific benefits such as emotional recovery, stress reduction, or positive mood, all aligned with the Psychological Well-being dimension in the biophilic experience framework. At the meso scale, design projects reinforced this trend with participants anticipating primarily Psychological and Social benefits from applying BU tools in urban landscape renewal. Through the co-design process, participants had the opportunity to indirectly experience the positive effects of BU by assuming roles as urban planners or city-makers. This is just one of the biophilic activities outlined in our theoretical framework and integrated into various design projects, including nature-based cognition, engagement and immersion in nature, and emotional connection. Findings from each session confirm BU's effectiveness across scales in enhancing urban livability, building a cohesive narrative that links macro-scale urban planning with meso-scale design interventions, macro-scale experiential memories with lived micro-scale experiences. This supports the integration of BU into urban planning, addressing the current mismatch between policy frameworks and biophilic principles.

While traditional approaches in urban planning reveal significant limitations in valuing nature [7], our Design results prove that such a gap can be effectively addressed through BU. Specifically, the application of design tools demonstrates their easy implementation. Although participants initially struggled to identify Environmental benefits during the Experience and Map sessions, they actively engaged with this benefit dimension and explored ways to enhance it by integrating appropriate features into their projects. Greenscape emerges as a key element across all workshop sessions. It was the highest-ranked biophilic category in terms of locations, experiences, and benefits, and also the most frequently applied design tool, even when designing green spaces with an inherently high degree of wildness. This proves that nature, particularly vegetation and urban forests, is not antithetical to urban development but essential to it, as BU advocates.

Even though the high co-occurrence between Greenscape and design tools such as Cue for Care and Diverse Habitat Conditions was expected, the lack of a similar correlation with the Environmental benefits reveals a critical limitation. Most projects emphasized Psychological and Social benefits through restoration, community bonding, visual care, and ecological variety. Although these design interventions often integrate wild vegetation and habitat zones (Greenscape) with community-oriented features, they not explicitly address ecological processes tied to Environmental benefits. This predominance of Psychological and Social aspects may reflect their more immediate and observable implications. However, the strong co-occurrence between design tools and Psychological and Social benefits suggests that urban planning can meaningfully enhance the social and cultural facets of biophilic experiences, potentially triggering a virtuous ripple effect in how nature is valued and integrated into urban contexts.

Unlike most research focused on large-scale urban projects, this study centered on leftover spaces to highlight their multiple values, despite their limited size. This approach enabled participants to recognize the significance of natural capital in underutilized and neglected areas and to foster biophilic experiences by applying our Design Toolbox. Built

on BU principles, this toolkit supports meaningful human–nature interactions, promotes community engagement, and leverages ecosystem services. Focusing on leftover spaces, we also challenged the esthetic marginalization and the partial or profit-driven exploitation of nature [7], positioning it as a functional component in urban planning.

As a relatively recent research field, BU still presents both knowledge and application gaps [8]. While the results of the Map session suggest that biophilic know-how requires broader dissemination, insights from the Discuss session reveal a strong interest in raising public awareness of nature and its multiple benefits for urban life. Through a combination of empirical, theoretical, and practical methods, workshop participants were able to both learn and apply biophilic principles. Moreover, the interrelation among the workshop sessions, as reflected in the Design and Discuss results, demonstrates that combining theory with hands-on activities fosters an ongoing learning process, essential for promoting biophilic culture and encouraging nature-integrated lifestyles.

Despite its contributions to advancing the research field, this study presents certain limitations. The number of workshop participants and the uneven distribution of their expertise may have influenced the results. To optimize the time and outputs during the co-design process, participants were divided into small groups. While ensuring a mix of different backgrounds in each work team, this may have further affected the outcomes. Given the empirical nature of the study, sample size played a critical role. While the total number of feedback entries was consistent, the number of unique biophilic locations identified across Amsterdam was relatively low—considering the extent of its blue-green infrastructure [28], primarily due to data repetition and overlap. Additionally, there were very few entries related to indoor settings or to biophilic experiences at the building and street scales. External factors such as workshop timing, weather, and seasonal changes may also have affected data collection. In particular, the real-time Experience session was likely influenced by the time of day, differences in light, or the growth stages of nature across the workshop dates. Nevertheless, these dynamics are inherent to the biophilic experience, which is rooted in natural, life-like processes. As our approach focused on the positive aspects of biophilia, we did not explore the negative aspects resulting from human–nature interaction, such as biophobia. However, no negative outcomes emerged from the data processing. In the Design session, the identification of benefits from BU tools relied on subjective judgment, reflecting the author’s expertise in the field. This introduces the possibility that some benefits were misjudged or overestimated. Including a focused group discussion with participants on the perceived benefits of BU tools could have enhanced the validity of the analysis.

5. Conclusions

In an increasingly urbanized world, this study addresses the challenge of improving urban livability. We explore the potential of BU to provide physical, psychological, social, and environmental benefits across scales, using nature’s functions as an essential strategy for sustainability. Through experience and design, we demonstrate nature’s capacity to renew urban landscapes, reconnect humans with other forms of life, and leverage ecosystem services.

Beyond addressing the RQs and bridging gaps identified in prior literature, this study contributes to the fields of biophilia and its applied subject areas (biophilic design, biophilic urbanism) through both theoretical and methodological advancements. Theoretically, it explores the concepts of ‘biophilic experience’ and ‘biophilic benefit’, using quantitative, qualitative, and spatial perspectives to enhance our understanding and facilitate human–nature connections in the built environment, thereby maximizing the benefits for livability. The combined use of the biophilic experience framework, rooted in biophilia-related dis-

ciplines, and the Design Toolbox, derived from landscape design and planning, advance both fields through reciprocal interactions while setting the stage for new interchanging explorations. Methodologically, we integrate approaches that combine empirical research with research-by-design. The study is also inter-scalar, investigating different urban scales, and inter-disciplinary, merging knowledge from design, planning, psychology, and environmental science, thus crossing the traditional borders of BU as an applied science for shaping anthropic habitats. We propose targeted strategies for urban planning: a benefit-driven approach that directs policies towards enhancing individual, social, and environmental well-being, and evidence-based tools that support city-makers in implementing strategies validated by science. Lastly, we couple biophilia with citizen science to place citizens in active roles throughout the participatory process, thereby amplifying the impact of BU, as proven by our co-design findings.

As an emerging research field, BU warrants further investigation. The low proportion of biophilic experiences within the Environmental benefit dimension highlights the need for longitudinal studies to assess the short-, medium-, and long-term impacts of BU on urban natural systems. In light of the current climate crisis, this represents a pressing research priority. Positive feedback from the application of design tools confirmed that our Design Toolbox could pave the way for integrating BU into urban planning. However, its full potential could be realized through upscaling and the development of guidelines applicable across urban scales. Additionally, the limited application of water-based solutions underscores the need for specific guidelines on incorporating blue-green infrastructure into regenerative design processes to further strengthen ecological and social value. Given the transferability and replicability of our integrated, cross-scale methods, they may be applied in other cities to validate and refine biophilic design tools, or to inspire international cooperative research.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/land14051112/s1>, Figure S1: Biophilic Experience Cards (BEC); Figure S2: Design Toolbox; Table S1: Experience data processing; Table S2: BEC data processing; Table S3: Team project descriptions; Table S4: Thematic coding of Design Tools; Table S5: Thematic coding.

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Informed Consent Statement: The informed consent procedure followed the official form issued by the HREC of TU Delft. Informed consent was obtained from all subjects involved in the study.

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References

1. Hee, L. Can Dense Cities Really Be Liveable? In *Future City Architecture for Optimal Living*; Rassia, S.T., Pardalos, P.M., Eds.; Springer International Publishing: Cham, Switzerland, 2015; pp. 81–104. [\[CrossRef\]](#)
2. Beery, T.; Jönsson, K.; Elmberg, J. From Environmental Connectedness to Sustainable Futures: Topophilia and Human Affiliation with Nature. *Sustainability* **2015**, *7*, 8837–8854. [\[CrossRef\]](#)
3. Yasmin, A.; Ahmed, I.; Haider, M.; Hossain, M.K.; Motalib, M.A.; Hossain, M.S. Characterizing indoor air quality and identifying factors influencing air quality at home microenvironment in Dhaka city. *Indoor Environ.* **2024**, *1*, 100056. [\[CrossRef\]](#)
4. Saheer, T.B.; Lien, L.; Hauff, E.; Kumar, B.N. Ethnic differences in seasonal affective disorder and associated factors among five immigrant groups in Norway. *J. Affect. Disord.* **2013**, *151*, 237–242. [\[CrossRef\]](#)
5. Croeser, T.; Sharma, R.; Weisser, W.W.; Bekessy, S.A. Acute canopy deficits in global cities exposed by the 3-30-300 benchmark for urban nature. *Nat. Commun.* **2024**, *15*, 9333. [\[CrossRef\]](#)
6. Beatley, T. *Canopy Cities: Protecting and Expanding Urban Forests*; Routledge: New York, NY, USA, 2023.
7. Lehmann, S. Green Urbanism: Formulating a Series of Holistic Principles. *SAPIENS* **2010**, *3*.
8. Beatley, T. Biophilic Urbanism: Inviting Nature Back to Our Communities and Into Our Lives. *William Mary Environ. Law Policy Rev.* **2009**, *34*, 209.
9. Wilson, E. *Biophilia. The Human Bond with Other Species*; Harvard University Press: Cambridge, MA, USA, 1984.
10. Beatley, T. *Handbook of Biophilic City Planning and Design*; Island Press: Washington DC, USA, 2016.
11. White, M.; Alcock, I.; Grellier, J.; Wheeler, B.; Hartig, T. Spending at least 120 minutes a week in nature is associated with good health and wellbeing. *Sci. Rep.* **2019**, *9*, 7730. [\[CrossRef\]](#)
12. Sudimac, S.; Sale, V.; Kühn, S. How nature nurtures: Amygdala activity decreases as the result of a one-hour walk in nature. *Mol. Psychiatry* **2022**, *27*, 4446–4452. [\[CrossRef\]](#)
13. Soga, M.; Gaston, K.; Yamaura, Y.; Kurisu, K.; Hanaki, K. Both Direct and Vicarious Experiences of Nature Affect Children’s Willingness to Conserve Biodiversity. *Int. J. Environ. Res. Public Health* **2016**, *13*, 529. [\[CrossRef\]](#)
14. El-Baghdadi, O.; Desha, C. Conceptualising a biophilic services model for urban areas. *Urban For. Urban Green.* **2017**, *27*, 399–408. [\[CrossRef\]](#)
15. Browning, B.; Garvin, C.; Fox, B.; Cook, R. *The Economics of Biophilia Why Designing with Nature in Mind Makes Financial Sense*; Terrapin Bright Green: New York, NY, USA, 2012.
16. Lefosse, D.; van Timmeren, A.; Ratti, C. Biophilia Upscaling: A Systematic Literature Review Based on a Three-Metric Approach. *Sustainability* **2023**, *15*, 15702. [\[CrossRef\]](#)
17. Andersson, E.; Barthel, S.; Borgström, S. Reconnecting cities to the biosphere: Stewardship of green infrastructure and urban ecosystem services. *Ambio* **2014**, *43*, 445–453. [\[CrossRef\]](#)
18. Thomson, G.; Newman, P. Green infrastructure and biophilic urbanism as tools for integrating resource efficient and ecological cities. *Urban Plan.* **2021**, *6*, 75–88. [\[CrossRef\]](#)
19. Naghibi, M.; Faizi, M. Temporary reuse in leftover spaces through the preferences of the elderly. *Cities* **2022**, *127*, 103769. [\[CrossRef\]](#)

20. Beery, T.; Olagsson, A.S.; Gentin, S.; Maurer, M.; Stålhammar, S.; Albert, C. Disconnection from nature: Expanding our understanding of human–nature relations. *People Nat.* **2023**, *5*, 470–488. [CrossRef]
21. Fang, X.; Li, J.; Ma, Q. Integrating green infrastructure, ecosystem services and nature-based solutions for urban sustainability: A comprehensive literature review. *Sustain. Cities Soc.* **2023**, *98*, 104843. [CrossRef]
22. Wang, D.; Xu, P.-Y.; An, B.-W.; Guo, Q.-P. Urban green infrastructure: Bridging biodiversity conservation and sustainable urban development through adaptive management approach. *Front. Ecol. Evol.* **2024**, *12*, 1440477. [CrossRef]
23. Whitten, M. Engaging Resilience: Integrating Sociocultural Dimensions into Green Infrastructure Planning. In *Planning with Landscape: Green Infrastructure to Build Climate-Adapted Cities*; Sant’Anna, C.G., Mell, I., Schenk, L.B.M., Eds.; Springer International Publishing: Cham, Switzerland, 2023; pp. 15–33. [CrossRef]
24. Kim, G.; Newman, G.; Jiang, B. Urban regeneration: Community engagement process for vacant land in declining cities. *Cities* **2020**, *102*, 102730. [CrossRef]
25. *Kerncijfers Amsterdam*; Dienst Onderzoek en Statistiek: Amsterdam, The Netherlands, 2007.
26. *New Amsterdam Climate. Amsterdam Climate Neutral Roadmap 2050*; Space and Sustainability Cluster: Amsterdam, The Netherlands, 2020.
27. Beatley, T. Biophilic Cities Network. In *Encyclopedia of Sustainability Science and Technology*; Springer: Berlin/Heidelberg, Germany, 2020; p. 284.
28. *Monitor Groen 2022*; Onderzoek en Statistiek: Amsterdam, The Netherlands, 2023.
29. EEA. Percentage of Total Green Infrastructure, Urban Green Space, and Urban Tree Cover in the Area of EEA-38 Capital Cities (Excluding Liechtenstein). 2022. Available online: <https://www.eea.europa.eu/en/analysis/maps-and-charts/percentage-of-total-green-infrastructure> (accessed on 20 November 2024).
30. *Amsterdam Green Infrastructure Vision 2050. A Liveable City for People, Plants, and Animals*; Department of Planning and Sustainability: Amsterdam, The Netherlands, 2020.
31. Paulin, M.; Remme, R.; de Nijs, T. *Amsterdam’s Green Infrastructure: Valuing Nature’s Contributions to People*; National Institute for Public Health and the Environment (RIVM): Bilthoven, The Netherlands, 2019.
32. Methorst, J.; Bonn, A.; Marselle, M.; Böhning-Gaese, K.; Rehdanz, K. Species richness is positively related to mental health—A study for Germany. *Landsc. Urban Plan.* **2021**, *211*, 104084. [CrossRef]
33. Luo, S. Ontwerpen aan groene reestruimte in steden. *Stadswerk* **2023**, *7*, 38–41.
34. Van Leeuwen, C.; Clavijo, J.D.; Mariën, I.; Jacobs, A. Invisible in the smart city: Using participatory design methods for age-friendly solutions. *Front. Sustain. Cities* **2022**, *4*, 956787. [CrossRef]
35. Luo, S. Leftover Green Field Lab. Available online: <https://www.ams-institute.org/urban-challenges/resilient-cities/Leftover-Green-Field-Lab/> (accessed on 19 November 2024).
36. Sanders, E.B.-N.; Stappers, P.J. Co-creation and the new landscapes of design. *CoDesign* **2008**, *4*, 5–18. [CrossRef]
37. Fors, H.; Hagemann, F.A.; Sang, Å.O.; Randrup, T.B. Striving for Inclusion—A Systematic Review of Long-Term Participation in Strategic Management of Urban Green Spaces. *Front. Sustain. Cities* **2021**, *3*, 572423. [CrossRef]
38. Reed, M.S.; Graves, A.; Dandy, N.; Posthumus, H.; Hubacek, K.; Morris, J.; Prell, C.; Quinn, C.H.; Stringer, L.C. Who’s in and why? A typology of stakeholder analysis methods for natural resource management. *J. Environ. Manag.* **2009**, *90*, 1933–1949. [CrossRef]
39. Beatley, T. *Biophilic Cities: Integrating Nature into Urban Design and Planning*; Island Press: Washington, DC, USA, 2011.
40. Kellert, S.; Calabrese, E. *The Practice of Biophilic Design*; Terrapin Bright LLC: London, UK, 2015.
41. Kellert, S.R. *Nature by Design: The Practice of Biophilic Design*; Yale University Press: New Haven, CT, USA, 2018.
42. Kellert, S.; Heerwagen, J.; Mador, M. *Biophilic Design: The Theory, Science and Practice of Bringing Buildings to Life*; Wiley: Hoboken, NJ, USA, 2008.
43. Browning, W.; Ryan, C.; Clancy, J. *14 Patterns of Biophilic Design*; Terrapin Bright Green: New York, NY, USA, 2014.
44. De Wit, S. *Hidden Landscapes the Metropolitan Garden and the Genius Loci*; Delft University of Technology: Delft, The Netherlands, 2014.
45. Diedrich, L.B. Translating Harbourscapes: Site-Specific Design Approaches in Contemporary European Harbour Transformation. Ph.D. Thesis, Department of Geosciences and Natural Resource Management, Faculty of Science, University of Copenhagen, Copenhagen, Denmark, 2013.
46. Kowarik, I. Urban wilderness: Supply, demand, and access. *Urban For. Urban Green.* **2018**, *29*, 336–347. [CrossRef]
47. Clément, G. *Manifeste du Tiers Paysage Sujet/Objet*; Genève, Switzerland, 2004; p. 6. Available online: https://www.caue-nord.com/SPASSDATA/attachments/2006_10/06/5f7f3d9a6fac7-d43183.pdf (accessed on 20 November 2024).
48. Dallimer, M.; Irvine, K.N.; Skinner, A.M.J.; Davies, Z.G.; Rouquette, J.R.; Maltby, L.L.; Warren, P.H.; Armsworth, P.R.; Gaston, K.J. Biodiversity and the Feel-Good Factor: Understanding Associations between Self-Reported Human Well-being and Species Richness. *BioScience* **2012**, *62*, 47–55. [CrossRef]
49. Bonthoux, S.; Chollet, S.; Balat, I.; Legay, N.; Voisin, L. Improving nature experience in cities: What are people’s preferences for vegetated streets? *J. Environ. Manag.* **2019**, *230*, 335–344. [CrossRef]

50. Wagner, A. Permitted Exceptions: Authorised Temporary Urban Spaces Between Vision and Everyday. Ph.D. Thesis, Department of Geosciences and Natural Resource Management, Faculty of Science, University of Copenhagen, Copenhagen, Denmark, 2016.
51. Nassauer, J.I. Care and stewardship: From home to planet. *Landsc. Urban Plan.* **2011**, *100*, 321–323. [[CrossRef](#)]
52. Smit, B.; Scherman, V. Computer-Assisted Qualitative Data Analysis Software for Scoping Reviews: A Case of ATLAS.ti. *Int. J. Qual. Methods* **2021**, *20*, 160940692110191. [[CrossRef](#)]

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