

Review

A Review on Landscape Factors for Biodiversity Performance Enhancement in Urban Parks

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Abstract: Urbanization significantly reduced natural habitats and biodiversity, creating challenges for sustainable urban development. Urban parks, as essential green spaces, help mitigate these impacts by promoting biodiversity and enhancing urban resilience. This review synthesizes current knowledge on landscape factors that influence biodiversity in urban parks, emphasizing how these parks contribute to biodiversity conservation and urban sustainable development. A comprehensive literature search identified key landscape factors that affect biodiversity, categorized into five groups: park size and shape, vegetation composition, artificial components, landscape patterns, and surrounding land use. The findings reveal that larger park areas, simplified boundaries, diverse vegetation structures, reduced human interference, and improved habitat connectivity are crucial for boosting biodiversity. The review also suggests practical design strategies, such as enhancing green space networks and preserving old trees, to foster biodiversity in urban parks. Overall, this review provides valuable insights for urban planners and landscape designers aiming to create resilient, biodiversity-rich urban spaces that support sustainable development.

Keywords: biodiversity; landscape factors; urban parks; habitat



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1. Introduction

Urban areas rapidly expand due to urbanization and population growth [1]. This trend led to residential areas and roads replacing many natural habitats [2]. This resulted in significant landscape modification, including biotic and abiotic changes [3,4]. Remnant natural areas within or near urban environments often become isolated or are destroyed, posing challenges for species survival and leading to biodiversity loss [5–7]. Biodiversity loss in urban areas has significant implications for human health, ecosystem services, and overall urban resilience. Urban biodiversity contributes to climate regulation, air purification, and psychological well-being for urban residents [8,9], making it essential for enhancing the quality of urban life [10–12].

There are various definitions of “urban green space”. In this review, urban green space refers to open spaces dominated by vegetation, valued for aesthetic enjoyment, ecological improvement, and recreational use, regardless of ownership [13]. Urban parks are a typical type of urban green space, defined as delineated open areas primarily covered by vegetation

and water, and generally reserved for public use, providing recreational, aesthetic, and ecological functions [14].

The construction of urban parks is one of the solutions used to mitigate the negative impacts of urban environments on both humans and biodiversity. Urban parks are often the most species-rich land use among various urban green spaces [15], serving as biodiversity oases within the urban ecosystem. As essential components of urban ecosystems, urban parks are considered the most heterogeneous green spaces in cities, they also have the highest vegetation diversity [16,17]. They play a vital ecological role in maintaining biodiversity by acting as physical barriers that reduce the adverse effects of nearby urban disturbances [8,18]. Urban parks not only provide food resources and nesting sites for wildlife, but also serve as critical nodes in the urban ecosystem, offering stepping stones for biological migration [19–21]. These services make urban parks important refuges for remnant biodiversity, especially in the context of urbanization and habitat fragmentation.

Integrating biodiversity conservation into urban planning and construction became a key trend in sustainable development. However, current guidelines for landscape designers and civil engineers on designing urban parks that promote biodiversity are insufficient. For instance, variations in landscape factors of urban parks can lead to uncertainty in the effectiveness of biodiversity conservation [15]. Garrard et al. [22] highlighted that urban design often lacks sufficient ecological knowledge, leading to inconsistent or insufficient implementation of biodiversity-sensitive practices. There is limited understanding of how specific landscape features contribute to biodiversity outcomes, and conflicting findings in the literature make it challenging for practitioners to apply consistent design principles.

The recent review studies on urban parks primarily focused on human-centered aspects, such as sensory experiences [23], well-being benefits [24], or the psychological and physical effects of landscape characteristics [25,26]. While some research acknowledged the role of urban parks in biodiversity conservation and ecosystem functioning, these studies examined specific factors, such as park shape and size [27], or their impact on human well-being [28,29], without a comprehensive exploration of integrated landscape design strategies for biodiversity enhancement. This review addresses this gap by systematically identifying key landscape factors that influence biodiversity performance in urban parks, aiming to establish a holistic design framework that not only enhances biodiversity, but also supports broader ecological and social benefits.

Therefore, understanding the mechanisms through which urban parks support biodiversity conservation is crucial. This review aims to integrate the landscape factors that positively or negatively affect biodiversity establishment during the design and management phases of urban parks. Specifically, the objectives of this review are:

1. To review landscape factors that have been shown to impact biodiversity performance in urban parks.
2. To provide scientific evidence for assessing urban parks from the perspective of biodiversity conservation during design and management periods.

2. Review Methods

The review methods partly followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines for conducting systematic reviews [30], consisting of stages including literature search, screening, as well as extraction and categorizing the findings of previous research (Figure 1).

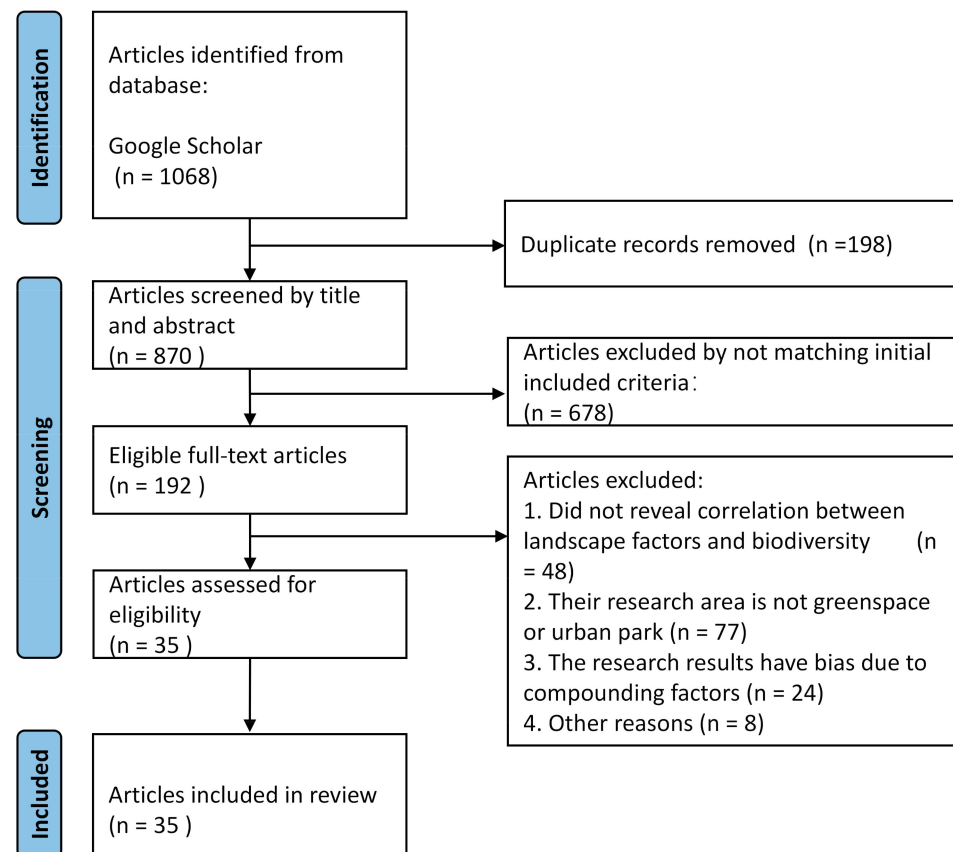


Figure 1. The PRISMA flow chart.

2.1. Literature Search

In the first stage, a comprehensive search of the academic database Google Scholar was conducted to identify relevant studies published from 2000 to 2024. Within the scope of “urban park”, “urban green space”, “habitat patch”, “woodland”, and “forest”, the keywords used included “biodiversity”, “habitat attractiveness”, “habitat quality”, “bird richness”, and “species diversity”. Only peer-reviewed articles were included. Scientific papers were selected using these keywords under a defined scope of spatial scale (Figure 1). The purpose of this stage was to identify possible landscape factors at both local and regional scales that have been proven to impact the biodiversity of urban parks based on empirical findings. In this stage, 1068 articles were searched, and 870 remained after removing duplicates.

2.2. Reference Screening

In the second stage, the articles identified during the literature search were screened based on their titles, abstracts, and full texts to determine their relevance to the objectives of this review. Articles were selected if they elucidated the mechanisms of landscape factors and biodiversity performance relationships (Figure 1). In total, 192 articles were selected for the next step, screening. Studies focusing on biodiversity performance, landscape factors, and urban park design were prioritized, while those conducted outside urban green spaces were excluded. It is worth noting that our selection criteria specify the removal of articles that do not reveal the correlation between landscape factors and biodiversity because our review focuses specifically on landscape factors and to avoid introducing uncertainty into the analysis. However, we acknowledge that studies reporting no correlation may be limited in scope or could reflect a more complex underlying relationship that merits

further exploration in future research. A total of 35 articles thus remained and were further reviewed in the next stage of this study.

2.3. Organizing the Key References

The third stage, organizing the references, involved consolidating and categorizing all the landscape factors that could potentially influence the biodiversity of urban parks to generate solid conclusions (Figure 1). The selected studies were categorized according to key landscape factors affecting biodiversity in urban parks, such as park size, vegetation structure, connectivity, and management practices. Each of these factors is discussed in detail to provide a comprehensive understanding of their role in enhancing biodiversity in urban parks. Meanwhile, research results from the studies were systematically extracted to compile relationships between landscape factors and biodiversity indicators. The empirical findings of this review provide insights into the overall evaluation indicator systems and suggestions for landscape designers to build urban parks with relatively high biodiversity performance.

3. Biodiversity in Urban Parks

3.1. Common Methods to Assess Biodiversity in Urban Parks

In most of the reviewed studies, birds are the most commonly used indicators to characterize the biodiversity performance of urban green spaces and the quality of the habitat [31–35]. Indices such as the Shannon index and species number are commonly used to reflect species richness and evenness [19,21,32,36–39]. Birds are a significant component of urban fauna, with 20% of global bird species found in urban areas [40]. Birds are also relatively easy to observe and count, and they have broad public appeal [41]. Additionally, birds are sensitive to the availability of habitat structures, which makes them good indicators of habitat quality [42]. Apart from birds, bats [32], insects [43,44], amphibians and reptiles [45], and even plants [46] are also commonly used as biodiversity indicators.

3.2. Relations Between Landscape Factors and Biodiversity

It is noticed that some research results are not always consistent with the mainstream of conclusions because of some confounding factors (i.e., human intervention, threshold value, and weather of research area). To better explain the classification of various landscape factors as well as the determination of the effects (either positive and negative) on biodiversity in urban parks, the relationships of landscape factors and biodiversity implications are concluded based on the major finding of the research results. These results which are different from the mainstream of conclusions have also been reviewed and mentioned to obtain a more objective view between impact factors and biodiversity performance. In this review, 17 landscape factors, which were classified into five categories based on their biophysical and spatial characteristics, were identified as being related to the biodiversity performance of urban parks. These categories include (1) size and shape of the habitat, (2) vegetation composition and coverage, (3) artificial components and human interference, (4) landscape and habitat pattern, and (5) surrounding land use and connectivity of the habitat.

3.2.1. Shape and Size of Urban Parks

The size of an urban park is considered to be one of the most critical factors impacting bird diversity, as explained by the island biogeography theory [47]. Small green spaces tend to be less attractive to birds because they have more edge effects, which make them more vulnerable to human activities and environmental changes. Consequently, smaller parks offer less cover and protection against predators and human disturbances compared

to larger urban parks [48–52]. Larger parks are also expected to provide more food and nesting resources for diverse bird species [36,53]. A similar phenomenon is observed in plant communities and among amphibian and reptile populations. The extent of the park area exhibits a positive correlation with species richness for both flora and fauna. Larger parks provide more extensive habitats, thereby supporting a broader spectrum of species diversity [45,46], particularly uncommon species that tend to thrive in larger urban parks [45] (Table 1). Moreover, for the impact driven from the size of an urban park, the positive impact of urban parks has been well illustrated in terms of availability of food sources, habitat diversity, protection cover, and decreased human disturbance [52,54].

However, among the collected references, the positive contribution of size of the urban park to the bird species richness cannot be found only once. This may be explained by the sizes of studied parks ranging from 11.73 to 71.71 ha, larger than 10 ha [55]. Referring to the research of Chamberlain et al. [56], species richness was strongly related to the size of green space. However, the correlation rate differs among different size classifications. There is an especially strong correlation observed in the green spaces ranging from 1 to 5 ha. Additionally, 10 ha is regarded as a threshold value that can maximally contribute to species richness. Thus, it is reasonable that positive correlation cannot be observed from the park size ranging from 11.73 to 71.71 ha.

The shape of an urban park can be quantified by edge indices, such as the FRAC, PARA, and edge density metrics [57]. More complex shapes have larger edge areas, making them more susceptible to human disturbances from outside the park [58]. The higher predation rates originating from outside habitat patches or edge habitats make these areas less attractive to breeding birds [52]. Moreover, abiotic flows at the edges, such as temperature and humidity fluctuations, create unstable conditions that may be undesirable for some species [54] (Table 1).

Table 1. Literature review for the landscape factors in “shape and size” category.

Category	Landscape Factors	Summary of Findings	Study Sites	References
Shape and size	Size of the urban park (+) *	Park area best predicted breeding bird richness (38.8% variance explained), with smaller parks showing food limitation effects.	A total of 54 urban parks in the city of Oulu in northern Finland and their surrounding 9 ha areas.	[33]
		Urban park area significantly predicts species diversity and occupancy probabilities, demonstrating critical habitat size effects.	Review articles	[47]
		Higher nest predation in small patches predicts greater open-nester abundance in large, magpie-free habitats, highlighting patch-size effects.	A total of 48 woodland patches within a 15 km ² farmland area around the village of Kraghede, Denmark.	[52]
		Urban green space size positively correlates with insectivore guild richness seasonally, driven by food resource availability.	A 250 m buffer around 18 urban green spaces in Dehradun city, Uttarakhand, India.	[36]
		Patch area predominantly predicts bird functional group abundances and species richness, demonstrating area-sensitive responses.	A total of 44 small forest patches (0.5–20.0 ha) embedded in an urbanized landscape in Seoul.	[49]
		Small green spaces’ edge-dominated, resource-poor conditions drive avian population decline through exposure risks and reduced carrying capacity.	A total of 12 green projects in Boston, USA.	[59]

Table 1. Cont.

Category	Landscape Factors	Summary of Findings	Study Sites	References
Shape and size	Size of the urban park (+) *	Urban park area and perimeter positively correlate with plant richness, peaking at 30 ha.	A total of 33 typical urban parks in Changchun, China.	[46]
		Woodland size emerged as the primary driver of avian species richness, demonstrating area-dependent biodiversity thresholds.	A total of 32 woodlands in Springfield, MA, USA.	[48]
		Urban park size positively predicts herpetofauna richness, with larger areas disproportionately supporting rare species.	A total of 10 urban areas and 165 urban parks in the eastern United States.	[45]
	The shape of park (−) *	Park shape complexity nonlinearly reduces plant richness, demonstrating edge-driven diversity constraints.	A total of 33 typical urban parks in Changchun, China.	[46]
		Compact-shaped woodlands in xeric conditions drove avian diversity metrics, not species counts, revealing habitat-metric dependencies.	A total of 32 woodlands in Springfield, MA, USA.	[48]
		Park geometries minimizing edge-to-core ratios enhance biodiversity through micro-climate stabilization and pathogen resistance, prioritizing compact spatial designs.	A large-scale replicated habitat corridor experiment located at the Savannah River Site, a National Environmental Research Park south of New Ellenton, SC, USA.	[60]

Remark: the “+” and “−” represent the positive or negative relationship between the factor and biodiversity, respectively. “*” indicates the intrinsic landscape factor that is controllable for landscape designers.

3.2.2. Vegetation Composition in Urban Parks

Vegetation characteristics, including vegetation composition, diversity, shrub coverage, and vertical structure, are essential factors influencing the habitat quality of urban parks [21,61,62] (Table 2). Trees and shrubs are treated as the major habitat components due to their branches, flowers, fruits, and nourished microbial community, which provide protective shelters and food sources [42,63]. Tree and shrub coverage has been shown to correlate positively with bird species richness [15,64,65]. Additionally, the benefits of dense and rich vertical vegetation layers for birds have been well documented [21,62]. Complex vegetation structures can form different height layers within the habitat, providing cover for different bird species with varied body shapes [21,36]. Vegetation diversity also contributes positively to bird richness by providing a variety of food sources for insects, which in turn serve as food for birds [66]. Furthermore, diverse vegetation types provide different forms of shelter sites for bird species of varying body shapes [21]. Research conducted in 100 randomly selected urban areas in Britain found that tree species richness can effectively increase foliage height diversity, providing diverse food resources and protection from predators [42]. However, in Beijing’s urban parks, vegetation is selected, planted, and trimmed by humans for aesthetic reasons, which does not effectively increase foliage height diversity or the availability of food resources [19].

Table 2. Literature review for the landscape factors in the “vegetation composition” category.

Category	Landscape Factors	Summary of Findings	Study Sites	References
Vegetation composition	Vegetation coverage (+) *	Larger green spaces in parks significantly affect bird presence positively.	A total of 26 urban parks within Beijing city, China.	[19]
		Nest predation rates are similar or higher in artificial habitats rather than in habitats with a high vegetation coverage rate.	A total of 100 randomly selected urban 1 km squares in a British urban area.	[42]
	Tree coverage (+) *	Tree coverage is positively correlated with bird species richness due to increased resource availability and tree diversity, which enhance food and micro-habitat diversity.	Four kinds of urban green space in Local Government Areas (LGAs) of south-east Queensland, Australia.	[64]
		Increased forest cover in parks is linked to higher amphibian species richness.	A total of 10 urban areas and 165 urban parks in the eastern United States.	[45]
		Increasing tree cover in the urban matrix is the most promising and efficient measure to enhance bird species richness and diversity.	A total of 96 sample sites (urban green space) in three cities in Swiss.	[65]
	Shrub coverage (+) *	Shrub cover is especially important, with areas containing dense shrubs attracting more birds.	Four small community parks in Beijing: Nanguan Park, Dongdan Park, Shuangxiu Park, and Madian Park in China.	[21]
		Well-developed shrub layers promote higher bird species richness and diversity.	A total of 32 woodlands in Springfield, MA, USA.	[48]
		Natural, unmanaged shrubbed woodland patches are preferred by small mammals.	A total of 11 cells in Milan, 18 in Florence, and 12 in Rome in Italy	[67]
	Grass coverage (−) *	Over-managed lawns reduce the biodiversity value of park grasslands compared with that of meadows.	Review article	[68]
		Newly established habitat patches where human activities take place affect the distribution of ground-feeding species.	Seoul and surrounding cities in Gyeonggi Province, South Korea.	[49]
	Coverage of habitat with two or more layers (+) *	Vertical vegetation diversity has a slight positive impact on bird species richness during breeding.	A 250 m buffer around 18 urban green spaces in Dehradun city, Uttarakhand, India.	[36]
		More vegetation layers and vertical structures attract a wider range of bird species.	Four small community parks in Beijing: Nanguan Park, Dongdan Park, Shuangxiu Park, and Madian Park in China	[21]
		More complex vegetation structures increase bird species richness and abundance, particularly for migrants and ground nesters.	Seoul and surrounding cities in Gyeonggi Province, South Korea.	[49]
	Vegetation diversity (+) *	Complex vegetation structures are linked to higher bird diversity.	A total of 12 shrines and temples, 9 urban parks, and 3 historic parks from among the green spaces in Bunkyo ward, Tokyo, Japan.	[69]

Table 2. Cont.

Category	Landscape Factors	Summary of Findings	Study Sites	References
Vegetation composition	Vegetation diversity (+) *	Greater plant diversity, particularly trees and flowers, boosts bee populations and diversity.	A total of 16 sites (areas from 200 m ² to 8.0 km ²) in urban and suburban green spaces (parks, preserves, and other natural areas) in the Fox Cities region of northeastern Wisconsin, USA.	[43]
		Enhancing vegetation diversity and structure in urban areas supports greater bird species richness.	A total of 100 randomly selected urban 1 km squares in British urban.	[42]
		Larger urban green spaces with rich plant communities increase bird richness via structural diversity.	A 250 m buffer around 18 urban green spaces in Dehradun city, Uttarakhand, India.	[36]
		Invertebrates benefit from rough vegetation and floral diversity, and bird species richness responds positively to increased woody plant species.	Review article	[15]
		Omnivorous and tree-nesting birds thrive with increased plant species richness, both herbaceous and woody.	A total of 26 urban parks within Beijing city, China.	[19]
		A higher diversity of tree species enhances the capacity of small urban green spaces (SPUGSs) to harbor diverse bird populations.	A total of 28 SPUGSs in an urban area, Tio Claro, Brazil.	[70]
		Diverse vegetation provides food and shelter for different bird species.	Four small community parks in Beijing: Nanguan Park, Dongdan Park, Shuangxiu Park, and Madian Park in China.	[21]

Remark: the “+” and “−” represent the positive or negative relationship between the factor and biodiversity, respectively. “*” indicates the intrinsic landscape factor that is controllable for landscape designers.

3.2.3. Artificial Components in Urban Parks

Artificial surfaces, including impermeable surfaces and pathways, are used as indicators of the intensity of human disruption [48,49]. Impervious surface covers, such as playgrounds, buildings, roads, and footpaths, has strong, consistently negative effects on bat assemblages [32]. These artificial materials can disrupt the growth of microbial communities in the soil, limiting vegetation growth and reducing soil-dwelling insects that serve as food sources for birds and other small animals [7,71,72]. Consequently, impervious surfaces are barriers that impact bird communities in urban parks by altering their habitats and food resources [73,74] (Table 3). In addition, artificial surfaces often attract more visitors, leading to increased visitor disturbance, which has been shown to decrease temporal and spatial resources available for breeding birds [49,75]. On the positive side, water bodies, such as ponds, lakes, or water channels, provide valuable resources for birds, particularly wading species. Some studies found a positive relationship between water area and bird diversity index due to the provision of drinking water and food resources [21,35] (Table 3).

Table 3. Literature review for the landscape factors in “artificial components” category.

Category	Landscape Factors	Summary of Findings	Study Sites	References
Artificial components	Impermeable surface (−) *	An impervious surface cover negatively impacts bird and bat populations across various metrics.	Three types of urban green spaces in south-east Melbourne, including (1) golf courses, (2) public parks, and (3) residential neighborhoods.	[32]
		An impervious surfaces reduce overall bird richness and the richness of functional groups.	Campo Grande municipality (20°27′53″ S; 54°36′58″ W), central-west Brazil	[7]
		Landscapes with less impervious surface areas tend to have greater biodiversity than urbanized areas with limited green spaces.	A total of 16 sites (areas from 200 m ² to 8.0 km ²) in urban and suburban green spaces (parks, preserves, and other natural areas) in the Fox Cities region of northeastern Wisconsin, USA.	[43]
		More impervious surfaces in urban parks are linked to lower species richness.	A total of 10 urban areas and 165 urban parks in the eastern USA.	[45]
		An impervious surface is one of the main drivers that reduce species abundance and richness through direct changes in resources and habitats.	Review article	[73]
	Water body (+) *	Various wetland types in urban parks increase amphibian species richness.	A total of 10 urban areas and 165 urban parks in the eastern USA.	[45]
		Higher water surface ratios are positively correlated with greater bird species richness.	Four small community parks in Beijing: Nanguan Park, Dongdan Park, Shuangxiu Park, and Madian Park in China.	[21]
		Ground-nesting and other bird species are significantly more likely to be found near water, emphasizing the importance of water for bird diversity.	In four parks in Vancouver and Burnaby, Canada.	[35]
	Pathway (−) *	Higher pedestrian traffic is associated with lower species richness and reduced habitat occupation for 16 species during breeding seasons.	In three large parks of Madrid: Moro (18 ha), Oeste (98 ha), and Retiro (110 ha), in Spain.	[76]
		Bird species diversity and abundance decrease near trails.	A total of 32 woodlands in Springfield, MA, USA.	[48]
	Artificial surface edge (−) *	The shape of the curving trails limits the variety and number of birds.	A total of 32 woodlands in Springfield, MA, USA	[48]

Remark: the “+” and “−” represent the positive or negative relationship between the factor and biodiversity, respectively. “*” indicates the intrinsic landscape factor that is controllable for landscape designers.

3.2.4. Landscape Patterns in Urban Parks

Landscape patterns also play a crucial role in affecting habitat quality. Urban park habitats with more edges may be subject to increased predation and interference [52]. The quantification of landscape indices, including spatial arrangement and the shape of patches, is often conducted using software such as Fragstats. Edge effects can be quantified using metrics such as perimeter-area fractal dimension (PAFRAC) and fractal dimension index (FRAC) [21]. The aggregation of patches can be quantified using the aggregation index [77]. Pathway edges may indicate visitor disturbance, negatively impacting the stability of habitat patches [49] (Table 4). The spatial arrangement of habitat patches is crucial in the design

phase. Studies have shown that habitat patch aggregation can increase the probability of propagules landing in suitable habitats, thus promoting successful breeding [78,79]. Birds prefer avoiding flying across open matrices without continuous protection, which makes isolated and dispersed habitat patches less favorable for colonization [36,80–83] (Table 4).

Table 4. Literature review for the landscape factors in “landscape pattern” category.

Category	Landscape Factors	Summary of Findings	Study Sites	References
Landscape pattern	Habitat patch edge (+) *	Habitat fragmentation drives predation surges via edge-mediated effects and matrix-derived predator incursions.	A total of 48 woodland patches within a 15 km ² farmland area around the village of Kraghede, Denmark.	[52]
		Edge-mediated abiotic fluxes drive micro-climate fluctuations in fragmented habitats, demonstrating edge-driven ecological instability.	Review article	[54]
		Edge effects amplify predation in small habitat islands through edge-dominated configurations and matrix-forced predator spillover.	A total of 10 forest tracts in central Maryland (3.8–905 ha) and one in southeastern Tennessee, USA.	[84]
	Aggregation of the habitat patch (+) *	Habitat aggregation enhances propagule establishment in suitable patches yet only partially offsets habitat deficits through spatial configuration.	Review article	[80]
		High-quality habitat aggregation enhances metapopulation stability in fragmented landscapes by sustaining source habitats where quality surpasses size/isolation effects.	All the potential habitat patches in central southern England.	[78]
		Habitat aggregation moderately enhances butterfly (less so plant) diversity in fragmented grasslands, though area effects dominate.	A total of 62 calcareous grasslands were selected as study sites in ‘Fränkische Schweiz’, located in the vicinity of the town Bayreuth in southern Germany.	[79]
		Multi-scale habitat aggregation enhances avian biodiversity through broadleaf–conifer gradients and connectivity, mitigating fragmentation while optimizing structural habitat quality.	A total of 126 1 ha plots in the forest landscape of the Black Forest, southwest Germany.	[85]

Remark: the “+” represent the positive relationship between the factor and biodiversity. “*” indicates the intrinsic landscape factor that is controllable for landscape designers.

3.2.5. Surrounding Land Use of Urban Parks

Urban parks are often surrounded by residential buildings, which is a typical characteristic of these green spaces. Tall buildings may cause bird collisions or block migration routes, negatively affecting biological connections among urban green spaces [42,48,86] (Table 5). Isolated urban parks are generally less attractive, whereas surrounding green spaces can improve the likelihood of bird occurrence by providing breeding resources or stepping stones within a certain range of the park [19,33,35,71]. Connectivity among urban green spaces provides habitats and corridors that help conserve biodiversity [20]. However, adjacent traffic lines can reduce habitat quality by introducing traffic noise, which disrupts birds’ ability to detect conspecific songs, further impacting their habitat use [33,87,88]

(Table 5). Furthermore, regarding the impact derived from road traffic, the negative effects in terms of collisions, noise, and air pollution were well revealed [33,89].

Table 5. Literature review for the landscape factors in “surrounding land use” category.

Category	Landscape Factors	Summary of Findings	Study Sites	References
Surrounding land use	Building (−)	Adjacent building density and proximity significantly suppress avian species richness (S) and diversity (H') through edge-driven disturbance.	A total of 32 woodlands in Springfield, MA, USA.	[48]
		Avian attraction to urban parks elevates collision risks from adjacent buildings through edge-mediated structural hazards.	Bryant Park located in the Midtown neighborhood of Manhattan, NJ, USA.	[86]
		Building density inversely predicts avian species richness and densities, demonstrating urban infrastructure's biodiversity suppression.	A total of 100 randomly selected urban 1 km squares in British urban.	[42]
	Traffic lines (−)	Road zones exhibited 40% reduced male productivity per hectare due to noise-driven habitat degradation suppressing reproductive success.	A nature reserve, 'Bolgerijen-Autena', is located in the center of the Netherlands.	[89]
		Road density suppresses spotted flycatcher distribution, while close park proximity enhances it, revealing urban spatial thresholds.	A total of 54 urban parks in the city of Oulu in northern Finland and their surrounding 9 ha areas.	[33]
	Green space (+)	Contiguous urban green spaces enhance bee communities through area-dependent habitat benefits.	A total of 16 sites (areas from 200 m ² to 8.0 km ²) in urban and suburban green spaces (parks, preserves, and other natural areas) in the Fox Cities region of northeastern Wisconsin, USA.	[43]
		Proximal green spaces (≤200 m) enhance avian richness by breeding resource provisioning around urban parks.	A total of 26 urban parks within Beijing city, China.	[19]
		Landscape metrics (500 m forest cover and park area) enhance avian occurrence predictions by amplifying local habitat feature efficacy.	Four parks in Vancouver and Burnaby, Canada.	[35]
		Park area and vegetation complexity drive avian richness, with nest boxes offsetting small-park (<0.75 ha) limitations under urban matrix pressures.	In the city of Oulu in northern Finland.	[33]
		Connected parks and forested habitats sustain greater unique species richness than isolated counterparts through enhanced habitat connectivity.	A total of 10 parks in the urban area of the city of Rio de Janeiro, Brazil.	[71]

Remark: the “+” and “−” represent the positive or negative relationship between the factor and biodiversity, respectively.

4. Additional Landscape Strategies to Enhance Biodiversity of Urban Parks

Overall, the relationships between various landscape factors and biodiversity performance, particularly bird species richness, are complex and influenced by multiple

confounding factors. Enhancing biodiversity in urban parks requires the consideration of factors such as landscape pattern, vegetation composition, visitor interference, and surrounding land use. In addition, several strategies can further enhance biodiversity from a landscape perspective.

4.1. Enhance the Networking of the Urban Green Spaces and Parks

Establishing an interconnected urban green space network has been demonstrated to have a positive effect on the biodiversity of urban parks [19,33,35]. Connecting urban green spaces into an integrated green infrastructure is particularly important in contexts where space for urban parks is limited. It is recommended to increase the density and length of urban green spaces by strategically planning plazas, pocket parks, and roadside green spaces [20]. Assessing the connectivity of urban green space networks can be achieved using least-cost path analysis and gravity model analysis, which help identify potential ecological corridors for guiding urban green space planning [20,90–92]. Based on the results of gravity modeling, urban planners, landscape designers, and park managers should develop configurations that improve connectivity between green space patches, while enhancing the quality of habitats within corridors to serve as stepping stones for wildlife movement.

4.2. Preserve Old Trees in Urban Park

Old trees play a critical role as keystone structures in urban parks, as they provide a disproportionately high amount of nesting resources and food [64]. In addition, old trees contribute to increased structural complexity, which further improves the protection of birds from predation [36,93]. Therefore, preserving remnant trees during the construction and planning phases of urban parks is essential. Older parks, which retain more mature trees, tend to exhibit higher biodiversity, underscoring the importance of preserving these keystone features in urban landscapes.

4.3. Enhance Vertical Structure Complexity of Habitat Patches

The vertical complexity of vegetation layers is crucial for providing continuous shelter for various species, thus offering greater protection for birds. To achieve a higher density of vertical structures, it is advisable to plant native vegetation periodically and support the natural regeneration of vegetation. This practice enhances both vertical and horizontal heterogeneity, which ultimately promotes the maintenance of a greater diversity of bird species [36]. Apart from the design and construction phases of urban parks, continual management is vital for maintaining the vertical structural complexity of habitat patches. Through thinning, pruning, and modifying vegetation structure, vegetation patches can be maintained at varying heights, further enhancing habitat diversity and influencing bird taxonomic and functional diversity in urban parks [94,95].

4.4. Enhance the Habitat Spatial Arrangement

Many bird species inherently avoid crossing open matrices without protective cover [81]. Moreover, the “abiotic flow” at habitat edges can lead to environmental fluctuations that negatively impact breeding birds [54,96]. To develop an ecologically friendly park, habitat patches should be compact with fewer edge zones to facilitate bird movement and reduce habitat fragmentation. By reducing edge effects and creating more contiguous habitat patches, landscape fragmentation can be mitigated, enhancing the quality of the habitat for avian species and other wildlife.

5. Challenges and Future Directions

This review primarily focused on the horizontal structure of landscapes, with only limited consideration of vertical habitat heterogeneity. However, vertical landscape elements also play a significant role in shaping urban park biodiversity. While existing studies attempted to quantify vertical structure using methods such as coefficient of variation (CV) in tree heights [36], foliage height diversity (FHD) [21,33], and classification of habitat patches based on vertical layers [62,97], these approaches primarily measure the number of vertical layers rather than the continuity of these layers. Yet, vertical continuity is crucial for understanding animal movement, habitat accessibility, and species interactions within urban ecosystems. Therefore, more refined quantification methods are needed to accurately capture the complexity of vertical structures in urban green spaces.

Additionally, this review specifically examined landscape factors affecting urban park biodiversity, while other anthropogenic influences, such as nightlight, noise pollution, and human activities, were not included [98–100]. Furthermore, each landscape factor was analyzed independently, yet biodiversity outcomes are rarely driven by single variables in isolation. Instead, offset effects, enhancement effects, and mixed effects among multiple factors should be considered to better understand their interactive influences on biodiversity performance [101,102]. Future research should focus on developing multifactor models that integrate these complex relationships rather than treating each variable in isolation.

To address these limitations, future studies should leverage advanced remote sensing technologies, such as unmanned aerial vehicles (UAVs) equipped with 3D LiDAR, to improve the quantification of vertical landscape structures [103,104]. Such technologies would allow for high-resolution, three-dimensional assessments of vegetation and habitat complexity.

Moreover, current studies commonly use indicator taxa, species counts, and species richness to evaluate biodiversity performance in urban green spaces [36,48,49,73,79,86]. However, such assessments can only be conducted in the post-construction phase. Therefore, it is desirable to develop an evaluation system that focuses on the landscape factors identified in this review, which fall into five categories. This landscape factor-derived evaluation system could serve as a pre-construction tool, providing effective guidance during the design phase. Moreover, it could be applied to existing urban parks to assess their biodiversity conservation function, supporting ongoing management and future updates.

6. Conclusions

This review primarily discussed how landscape factors influence the biodiversity performance of urban parks. A series of landscape factors in five categories that have been empirically proven to impact biodiversity conservation were compiled, using bird biodiversity as the major indicator. In summary, urban parks' biodiversity conservation functions are significantly influenced by their shape and size, vegetation composition, artificial components, landscape patterns, and surrounding land use. These factors should be thoroughly considered during the design and management of urban parks to optimize biodiversity outcomes.

Urban parks with larger areas and simpler boundary shapes generally exhibit better biodiversity conservation performance. Regarding vegetation composition, larger coverage—particularly of trees and shrubs—and complex vertical structures are more likely to provide desirable habitats for a wide range of species. For artificial components, the presence of larger water bodies and minimizing human interference, including reducing edge effects, can benefit the biodiversity performance of parks. In terms of landscape pattern, compact and large habitat patches with fewer edges can enhance the overall attractiveness of urban parks for bird species.

On a broader scale, urbanization patterns, including the surrounding buildings and traffic lines, influence the connectivity of urban green space networks. Reducing such urbanization patterns can drive the connectivity of these networks, thereby enhancing the biodiversity performance of urban parks. Several practical conservation implications have also been outlined, such as enhancing urban green space networks, improving the vertical structure of vegetation, and preserving remnant trees.

Besides supporting ecological resilience and directly contributing to SDG 15 (Life on Land) through biodiversity conservation, biodiversity-favorable urban parks also enhance human well-being and contribute to multiple sustainable development goals (SDGs). They provide restorative spaces that improve mental health (SDG 3: Good Health and Well-being), promote eco-tourism and green jobs (SDG 8: Decent Work and Economic Growth), and strengthen community interactions (SDG 11: Sustainable Cities and Communities). Therefore, integrating biodiversity-driven design in urban parks serves as a crucial strategy for sustainable urban development.

The empirical conclusions drawn from this review provide valuable insights for urban planners, landscape designers, and other stakeholders to create urban parks with enhanced biodiversity performance. By focusing on the key landscape factors discussed, urban parks can be better designed and managed to serve as important contributors to biodiversity conservation, ultimately supporting broader sustainable development goals.

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Abbreviations

The following abbreviations are used in this manuscript:

SDGs	Sustainable Development Goals
FRAC	Fractal Dimension Index
PARA	Mean Perimeter Area Ratio
PAFRAC	Perimeter-Area Fractal Dimension
CV	coefficient of variation
FHD	foliage height diversity

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