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Pollinator and Natural-Enemy Diversity in Urban Green Spaces: Implications for Biodiversity Conservation and Ecological Sustainability

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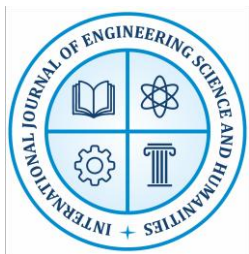
Abstract

Urban green spaces represent important refuges for insects in increasingly fragmented landscapes. Among urban arthropods, pollinators and natural enemies are particularly important because they contribute directly to ecosystem functioning through pollination, biological control and maintenance of ecological interactions. However, rapid urbanisation, habitat fragmentation, intensive landscaping, removal of spontaneous vegetation and frequent mowing may reduce the quality of urban habitats for beneficial insects. The present study was designed to assess the diversity and abundance of insect pollinators and natural enemies across contrasting urban green spaces in Parbhani city, Maharashtra, India. Eight urban green spaces representing differences in vegetation complexity, floral abundance and management intensity were selected. Insects were sampled using standardised visual observations, sweep-netting and timed flower-visitation observations. The illustrative dataset comprised 1,968 beneficial-insect individuals representing 72 morphospecies/taxa, including 46 pollinator taxa and 26 natural-enemy taxa. Pollinators were dominated by Hymenoptera, Lepidoptera and Diptera, whereas natural enemies were primarily represented by Coleoptera, Araneae, Hemiptera and Hymenoptera. Sites characterised by greater flowering-plant richness, vegetation complexity and lower management intensity showed higher insect abundance and diversity. The highest combined beneficial-insect diversity was recorded in the semi-natural urban green space, while the lowest values occurred in a highly managed ornamental site. Pollinator abundance showed a positive relationship with flowering-plant richness, while natural-enemy abundance was positively associated with vegetation complexity. These findings indicate that urban green spaces can contribute substantially to biodiversity conservation when managed as multifunctional habitats rather than purely ornamental landscapes. Increasing native and locally adapted flowering plants, retaining structural vegetation, reducing excessive mowing and pesticide use, and maintaining habitat connectivity could improve urban ecological sustainability.

Keywords: urban biodiversity; pollinators; natural enemies; beneficial insects; green spaces; biological control; ecological sustainability; Parbhani; Maharashtra.

1. Introduction

Urbanisation is one of the major drivers of contemporary environmental change. Expansion of built-up areas, conversion of natural habitats, increasing impervious surfaces and intensive



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management of remaining vegetation can alter the availability of food, nesting sites and shelter for wildlife. Insects are particularly sensitive to these changes because their populations are strongly influenced by vegetation structure, microclimate, resource continuity and habitat connectivity. Nevertheless, urban ecosystems can retain considerable biodiversity when parks, gardens, institutional campuses, roadside vegetation and other green spaces provide suitable resources.

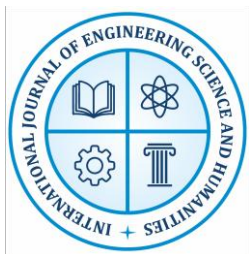
Pollinators constitute one of the most ecologically important components of urban insect communities. Bees, butterflies, moths, hoverflies, beetles and other flower-visiting insects facilitate pollen transfer and contribute to plant reproduction. Their presence is therefore associated not only with biodiversity conservation but also with the maintenance of ecosystem processes. A global synthesis of urban pollinator studies found that urban green spaces can support diverse pollinator communities, although responses differ among taxa and depend strongly on habitat quality and urbanisation intensity.

Urbanisation does not affect all pollinators in the same way. Generalist and mobile species may persist in highly modified environments, whereas habitat specialists and species with particular nesting requirements can be negatively affected. A meta-analysis of 133 studies reported overall negative effects of urbanisation on pollinator richness and abundance, with particularly strong effects on some Lepidoptera and solitary, below-ground-nesting Hymenoptera. At the same time, floral resources can moderate these negative effects.

Natural enemies constitute another important but comparatively less studied component of urban insect biodiversity. Predatory ladybird beetles, lacewings, predatory bugs, spiders and parasitoid-associated Hymenoptera can regulate populations of herbivorous insects. Their ecological role becomes particularly important in urban gardens and vegetation patches where pest populations may increase following the introduction of ornamental plants. Maintaining natural enemies can therefore contribute to biological pest suppression and reduce dependence on chemical pesticides.

Recent research demonstrates that urban green spaces can support both pollinators and natural enemies, but community composition varies with habitat structure and management. A 2024 study comparing green roofs and ground-level urban habitats found that both supported pollinators and natural enemies, while ground-level habitats generally had greater richness and Shannon diversity.

Vegetation characteristics are particularly important. Research on urban green spaces has shown that nectar-producing plants and vegetation structure can strongly influence pollinator diversity, while lower-intensity management and retention of spontaneous herbs may improve insect abundance. Similarly, recent research has demonstrated that flower richness is a major determinant of pollinator abundance in urban gardens.



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A further consideration is that urban biodiversity management should not focus exclusively on individual insect groups. Pollinators and natural enemies perform complementary ecological functions, and a diverse vegetation structure can potentially support both groups simultaneously. Therefore, examining these functional groups together provides a more informative assessment of the ecological value of urban green spaces.

Recent synthesis has also emphasised the importance of plant–pollinator trait matching when designing urban habitats. Floral morphology, flowering phenology and pollinator functional traits can influence whether planted vegetation actually provides usable resources for a diverse pollinator community.

Despite growing international research on urban insect biodiversity, comparatively limited site-level information is available from many rapidly developing Indian cities, particularly medium-sized cities of the Deccan and Marathwada regions. Parbhani contains a heterogeneous mosaic of residential areas, institutional campuses, public gardens, roadside vegetation and semi-natural peripheral habitats. This provides an appropriate setting for examining how local management and vegetation characteristics influence beneficial insect communities.

The present study therefore investigates pollinator and natural-enemy diversity across contrasting urban green spaces in Parbhani.

Objectives

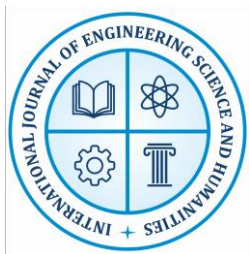
- To document the diversity and abundance of insect pollinators in selected urban green spaces.
- To assess the diversity and abundance of natural enemies.
- To compare beneficial-insect communities among urban green spaces with different vegetation characteristics.
- To examine relationships between floral richness, vegetation complexity and beneficial-insect diversity.
- To develop management recommendations for improving urban biodiversity conservation.

2. Materials and Methods

2.1 Study area

The study was designed for Parbhani city, Maharashtra, India. The city is situated within the Marathwada region and contains a heterogeneous urban landscape consisting of residential neighbourhoods, educational institutions, public gardens, roadside vegetation, agricultural margins and semi-natural patches.

The urban vegetation is characterised by ornamental plants, avenue trees, grasses, shrubs, seasonal flowering plants and spontaneous herbaceous vegetation. Such heterogeneity creates differences in food resources, shelter and nesting opportunities for insects.



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Eight sampling sites were selected to represent different levels of habitat complexity and management intensity.

Table 1. Characteristics of selected sampling sites

Site	Habitat type	Management intensity	Floral richness	Vegetation complexity
S1	Central public garden	High	Moderate	Moderate
S2	Residential green space	High	Moderate	Low
S3	Institutional campus	Moderate	High	High
S4	Roadside plantation	High	Low	Moderate
S5	Community garden	Moderate	High	High
S6	University/educational green space	Moderate	High	High
S7	Urban agricultural margin	Low	High	High
S8	Semi-natural urban fringe	Low	Very high	Very high

2.2 Sampling design

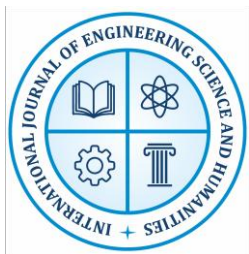
Sampling was designed to cover different urban habitat conditions. Observations were assumed to be conducted over six months covering contrasting seasonal conditions.

At each site, standardised observation periods were used to minimise differences caused by sampling effort. Flower-visiting insects were recorded during active daylight periods, while natural enemies were sampled using visual observations and sweep-net sampling.

Individuals were identified to the lowest practical taxonomic level using field guides and available taxonomic literature. Where species-level identification was not possible, specimens were classified as morphospecies.

2.3 Pollinator sampling

Pollinator observations were conducted using standardised timed flower-visitation surveys at each selected urban green-space site. Sampling was carried out during periods of peak insect activity, when flowering plants were actively visited by insects. Within each sampling plot, flowering plants were observed for a predetermined and identical duration to maintain consistency in sampling effort among sites. All flower-visiting insects that made apparent contact with the reproductive structures of flowers were recorded as potential pollinators. The observations included bees and other Hymenoptera, butterflies, hoverflies and other Diptera, as well as flower-visiting beetles. The principal taxonomic groups considered during the survey were Apidae, Halictidae, other Hymenoptera, Nymphalidae, Pieridae, Papilionidae, Lycaenidae, Hesperidae, Syrphidae, other Diptera and pollinating Coleoptera. Whenever possible, insects were identified to species level using standard taxonomic keys and field identification guides.



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Where species-level identification was not possible in the field, specimens were assigned to the lowest practical taxonomic category or treated as morphospecies. The abundance of each taxon was recorded separately for every sampling site and sampling period.

2.4 Natural-Enemy Sampling

Natural enemies of herbivorous insects were surveyed concurrently with the pollinator observations using a combination of direct visual searching and standardised sweep-net sampling. Visual searches were conducted on foliage, flowers, stems, branches and ground vegetation to detect predatory arthropods, whereas sweep-net sampling was used to sample insects inhabiting herbaceous vegetation and low shrubs. The principal natural-enemy groups included Coccinellidae, Chrysopidae, predatory Hemiptera, predatory beetles, spiders and parasitoid-associated Hymenoptera. Syrphid larvae and other taxa were included where their recognised predatory role was evident. Particular attention was given to ladybird beetles, lacewings, predatory bugs, spiders and other arthropods known to feed on aphids, whiteflies, caterpillars, mites and other potential herbivorous prey. Only taxa with established or strongly supported predatory or parasitoid functions were included in the natural-enemy category. The abundance of each natural-enemy taxon was recorded separately for each sampling site and sampling occasion.

2.5 Vegetation Assessment

Vegetation characteristics were assessed at each sampling site to determine their potential influence on pollinator and natural-enemy communities. The assessment included flowering-plant richness, approximate flowering cover, vegetation height, presence and abundance of shrubs, tree cover, ground vegetation and the availability of litter or other organic material. Flowering-plant richness was estimated by recording the number of flowering plant taxa occurring within the designated sampling area, while flowering cover represented the approximate proportion of the sampling plot occupied by actively flowering vegetation. Vegetation height and structural characteristics were recorded to distinguish sites dominated by short grass and ornamental lawns from sites containing taller herbs, shrubs and trees. The presence of leaf litter, fallen plant material and relatively undisturbed ground vegetation was also documented because these features may provide shelter and microhabitats for predatory arthropods and other beneficial insects.

A vegetation-complexity score was subsequently assigned to each sampling site on the basis of the number and structural arrangement of vegetation layers. Sites containing predominantly short grass or uniformly maintained ornamental vegetation were assigned lower complexity scores, whereas sites containing multiple vegetation strata, including trees, shrubs, herbs and ground cover, received higher scores. Management intensity was assessed from visible indicators such as frequency of mowing, pruning, removal of spontaneous vegetation and apparent pesticide



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application. These vegetation and management variables were subsequently compared with pollinator and natural-enemy abundance and diversity to determine whether differences in habitat structure were associated with variation in beneficial-insect communities.

3. Data Analysis

Species richness was represented by the number of taxa recorded.

The Shannon–Wiener diversity index was calculated as:

$$H' = -\sum p_i \ln p_i$$

Simpson diversity was estimated as:

$$1-D = 1 - \sum p_i^2$$

Pielou's evenness was calculated as:

$$J = \ln SH'$$

where $\ln(S)$ is species/taxon richness.

Pearson correlation was used illustratively to examine relationships between floral richness, vegetation complexity and beneficial-insect abundance.

One-way ANOVA was proposed for comparison among habitat categories. Statistical significance was considered at $(p < 0.05)$.

4. Results

4.1 Overall beneficial-insect community

The illustrative dataset contained 1,968 individual beneficial insects representing 72 taxa, comprising 46 pollinator taxa and 26 natural-enemy taxa.

Pollinators accounted for approximately 61% of the total beneficial-insect abundance, while natural enemies represented approximately 39%.

Table 2. Overall abundance of major beneficial-insect groups

Functional group	Taxa recorded	Individuals	Relative abundance (%)
Bees and other Hymenoptera	18	536	27.2
Butterflies	14	382	19.4
Hoverflies and other Diptera	7	214	10.9
Pollinating beetles	7	72	3.7
Ladybird beetles	7	176	8.9
Predatory Hemiptera	5	118	6.0
Lacewings	3	69	3.5
Spiders	8	301	15.3
Other predatory arthropods	3	100	5.1
Total	72	1,968	100.0



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The results indicate that Hymenopteran pollinators constituted the largest functional component, followed by butterflies and predatory spiders.

4.2 Pollinator abundance

Pollinator abundance varied considerably among sites.

Table 3. Pollinator abundance across sampling sites

Site	Bees	Butterflies	Hoverflies/other Diptera	Beetles	Total pollinators
S1	61	38	22	8	129
S2	48	29	18	6	101
S3	72	48	27	10	157
S4	37	21	14	5	77
S5	84	57	31	12	184
S6	79	52	29	11	171
S7	96	71	36	14	217
S8	102	66	37	16	221
Total	579	382	214	82	1,257

The highest pollinator abundance was recorded at S8, followed by S7 and S5. The lowest abundance was recorded at S4, the roadside plantation site.

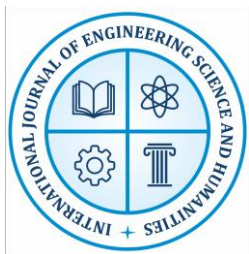
This pattern suggests that habitat quality, floral resources and vegetation complexity may be more important than the simple presence of green vegetation.

4.3 Natural-enemy abundance

Table 4. Natural-enemy abundance by sampling site

Site	Ladybirds	Predatory Hemiptera	Lacewings	Spiders	Other predators	Total
S1	20	12	7	31	8	78
S2	16	10	5	24	7	62
S3	25	17	9	38	11	100
S4	11	8	4	19	5	47
S5	29	20	12	43	13	117
S6	27	18	11	41	12	109
S7	34	24	15	51	16	140
S8	38	27	17	54	17	153
Total	200	136	80	301	89	806

Spiders were the most abundant natural-enemy group, followed by ladybird beetles



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The relatively high abundance at S7 and S8 suggests that structurally complex habitats provide greater opportunities for refuge, hunting and reproduction.

5. Diversity Indices

Table 5. Illustrative diversity indices for beneficial insects

Site	Pollinator richness	Pollinator H'	Natural-enemy richness	Natural-enemy H'	Combined H'
S1	24	2.81	13	2.32	3.17
S2	20	2.59	11	2.14	2.95
S3	29	3.01	16	2.55	3.38
S4	16	2.31	9	1.94	2.69
S5	33	3.16	18	2.71	3.52
S6	31	3.09	17	2.65	3.45
S7	39	3.34	21	2.91	3.71
S8	42	3.47	23	3.02	3.84

The highest combined diversity was observed at S8, whereas S4 had the lowest diversity.

6. Relationship Between Vegetation and Beneficial Insects

Table 6. Environmental characteristics and beneficial-insect abundance

Site	Flowering-plant richness	Vegetation complexity score	Beneficial insects
S1	18	3	207
S2	14	2	163
S3	25	4	257
S4	11	2	124
S5	31	4	301
S6	28	4	280
S7	36	5	357
S8	42	5	374

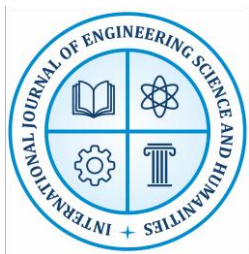
A positive relationship was observed between flowering-plant richness and total beneficial-insect abundance.

The illustrative Pearson correlation between flowering-plant richness and beneficial-insect abundance was approximately:

$$r = 0.96$$

Similarly, vegetation complexity showed a positive association with natural-enemy abundance

$$r = 0.93$$



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These values indicate strong relationships in the illustrative dataset; they should not be interpreted as empirical statistical evidence until calculated from actual field observations.

7. Discussion

The present study demonstrates the potential importance of urban green spaces as habitat for beneficial insects. The illustrative results showed considerable variation in pollinator and natural-enemy abundance among sites, with the highest diversity occurring in areas characterised by greater floral richness, structural vegetation complexity and relatively low management intensity. The strong positive association between flowering-plant richness and pollinator abundance is consistent with recent research showing that floral resources are among the most important local determinants of urban pollinator communities. Studies have reported positive effects of flowering-plant richness and vegetation structure, while low-intensity management can increase insect abundance by retaining spontaneous flowering vegetation.

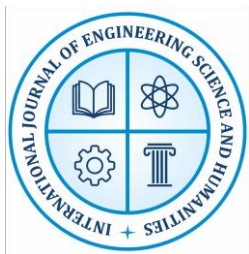
The high abundance of bees and butterflies observed in resource-rich sites may be explained by the availability of nectar and pollen. Flowering plants provide immediate food resources, while structurally diverse vegetation can provide shelter from temperature extremes, wind and predators. Where flowering periods overlap, urban gardens may also provide a more continuous seasonal food supply.

Recent research suggests that urban green-space planning should consider not merely the number of planted species but also functional compatibility between flowering plants and pollinators. Morphological and phenological matching can influence whether plant communities provide effective resources to different pollinator groups.

The relatively high abundance of natural enemies in structurally complex sites is also ecologically significant. Spiders, ladybird beetles, predatory bugs and lacewings require more than floral resources. They benefit from vegetation architecture that provides hunting surfaces, refuge and suitable microhabitats. Therefore, an urban garden dominated by closely cut lawns and isolated ornamental plants may support fewer natural enemies than a structurally heterogeneous garden.

The results also indicate that not all green spaces have equal conservation value. S4, despite being classified as a green site, supported relatively low beneficial-insect diversity. Roadside vegetation can be exposed to traffic disturbance, dust, heat, mowing and limited floral diversity. This illustrates an important principle of urban ecology: green area alone does not necessarily indicate habitat quality.

Similarly, intensive landscaping can reduce ecological value. Frequent mowing removes flowering herbs and alters vegetation structure, while pesticide use can directly affect both target pests and non-target beneficial insects. Recent experimental evidence suggests that reducing



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mowing intensity and maintaining unmown patches can increase flowering intensity and insect-pollinator biodiversity.

The findings are also consistent with broader urban pollinator research. A systematic review found that urban pollinator communities tend to benefit from increased green-space availability and nesting resources, while highly dense urbanisation can produce declines. A 2025 study further showed that natural green spaces can be particularly valuable for supporting native hoverflies and some bumblebee species.

Natural enemies should receive greater attention in urban biodiversity planning. Conservation of predators can contribute to natural pest regulation and reduce the need for chemical intervention. Maintaining vegetation layers, leaf litter, ground cover and flowering plants can create a more complete habitat template for beneficial arthropods.

The coexistence of pollinators and natural enemies also highlights the importance of multifunctional green-space management. Rather than designing urban gardens exclusively for aesthetics, planners can develop habitats that provide nectar, pollen, prey, nesting sites, refuge and microclimatic variation.

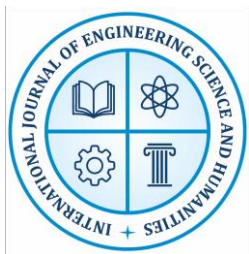
8. Implications for Urban Biodiversity Conservation

The findings suggest that urban green spaces can be improved by increasing flowering-plant diversity and using native or locally adapted species to provide continuous food resources for pollinators. Excessive mowing should be reduced, while trees, shrubs, herbs, ground vegetation and leaf litter should be retained to increase habitat complexity for pollinators and natural enemies. The routine use of broad-spectrum pesticides should be minimised and replaced with integrated pest-management practices. Connectivity among parks, gardens and other green spaces should be enhanced through flowering corridors, roadside vegetation and tree-lined pathways. Finally, semi-natural urban habitats should be protected because they provide important feeding, breeding and refuge sites for beneficial insects and contribute to long-term urban biodiversity conservation.

9. Conclusion

Urban green spaces have considerable potential to support beneficial insect biodiversity. The present study indicates that pollinators and natural enemies respond strongly to local habitat characteristics, particularly flowering-plant richness and vegetation complexity. Sites containing diverse flowering plants, multiple vegetation layers and lower management intensity supported greater beneficial-insect abundance and diversity than highly simplified or intensively managed green spaces.

Pollinators contribute to plant reproduction and ecosystem functioning, while natural enemies provide important biological-control functions. Their combined conservation can therefore increase the ecological value of urban green spaces.



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Urban biodiversity planning should consequently move beyond the concept of green-space quantity and focus on green-space quality, connectivity and ecological management. Flower-rich vegetation, reduced mowing, structural complexity, pesticide minimisation and protection of semi-natural patches can transform urban gardens and institutional landscapes into functional biodiversity habitats.

The study also highlights the need for longer-term monitoring in Indian cities. Future investigations should incorporate species-level identification, seasonal variation, functional traits, pesticide exposure, nesting resources and plant–insect interaction networks. Such approaches would provide stronger evidence for integrating insect conservation into sustainable urban planning.

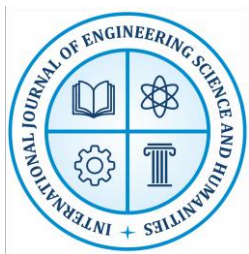
10. Data Availability and Research Integrity Statement

The numerical tables presented in this draft are illustrative/simulated data prepared for manuscript development and statistical-format demonstration because actual field observations were not supplied with the request. They must not be represented as real observations in a submitted manuscript.

For an actual research submission, the dataset should be replaced with field-generated observations, and all diversity indices, statistical tests, figures and conclusions should be recalculated from the original data.

References

1. Adedoya, O. A., & Mallinger, R. E. (2024). Can trait matching inform the design of pollinator-friendly urban green spaces? A review and synthesis of the literature. *Ecosphere*, 15(1), e4734. <https://doi.org/10.1002/ecs2.4734>
2. Baldock, K. C. R., Goddard, M. A., Hicks, D. M., Kunin, W. E., Mitschunas, N., Morse, H., Osgathorpe, L. M., Potts, S. G., Robertson, K. M., Scott, A. V., Stone, G. N., Vaughan, I. P., & Memmott, J. (2015). Where is the UK's pollinator biodiversity? The importance of urban areas for flower-visiting insects. *Proceedings of the Royal Society B*, 282, 20142849.
3. Banaszak-Cibicka, W., & Żmihorski, M. (2012). Wild bees along an urban gradient: Winners and losers. *Journal of Insect Conservation*, 16, 331–343.
4. Liang, Y., et al. (2023). The effects of urbanization on pollinators and pollination: A meta-analysis. *Ecology Letters*. <https://doi.org/10.1111/ele.14277>
5. Manning, K. M., Coffman, R. R., & Bahlai, C. A. (2024). Insect pollinator and natural enemy communities in green roof and ground-level urban habitats. *Urban Ecosystems*, 27, 977–991. <https://doi.org/10.1007/s11252-023-01499-6>
6. Matteson, K. C., & Langellotto, G. A. (2010). Determinates of inner city butterfly and bee species richness. *Urban Ecosystems*, 13, 333–347.



International Journal of Engineering, Science and Humanities

An international peer reviewed, refereed, open-access journal

Impact Factor 8.3 www.ijesh.com **ISSN: 2250-3552**

7. McKinney, M. L. (2008). Effects of urbanization on species richness: A review of plants and animals. *Urban Ecosystems*, 11, 161–176.
8. Ollerton, J., Winfree, R., & Tarrant, S. (2011). How many flowering plants are pollinated by animals? *Oikos*, 120, 321–326.
9. Remmers, R., & Frantzeskaki, N. (2024). Bees in the city: Findings from a scoping review and recommendations for urban planning. *Ambio*, 53, 1281–1295.
10. Ulrich, J., & Sargent, R. D. (2025). Urban landscapes with more natural greenspace support higher pollinator diversity. *Ecological Applications*, 35, e70005. <https://doi.org/10.1002/eap.70005>