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Managing urban development for biodiversity: a cross-country analysis of local planning practices

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ABSTRACT

Biodiversity conservation is gaining prominence in urban and regional planning, yet limited attention has been paid to how local authorities translate high-level biodiversity policies into effective practices. This paper examines how urban development is managed to prevent biodiversity loss and enhance ecosystem services through a comparative analysis of planning practices in Manchester (England), Bologna (Italy), Calgary (Canada), Frankfurt (Germany), and Ghent (Belgium). The study explores how biodiversity is integrated into planning across three governance levels: national/regional, city, and project. It reveals that while all five cities demonstrate a commitment to biodiversity, their strategies differ according to governance structures, planning cultures, and legal frameworks. Regulatory systems, such as those in Germany and Italy, provide prescriptive, plan-led approaches, whereas discretionary systems, like England's, allow for more flexibility during project appraisal. However, these distinctions are not always clear-cut. Ghent, despite operating in a regulatory framework, adopts discretionary practices at the project level, resembling Manchester's approach. Conversely, Frankfurt, Bologna, and Calgary emphasise early-stage integration of biodiversity through zoning and city planning. The findings offer insights into the advantages and limitations of both regulatory and discretionary approaches and highlight the importance of aligning biodiversity strategies across governance levels to improve ecological outcomes in urban development.

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Biodiversity; development management; environmental planning; biodiversity net gain; ecosystem services

1. Introduction

Urbanisation is one of the significant global trends of the twenty-first century, with profound implications for biodiversity and ecosystem services and land use change is identified as one of the direct drivers of biodiversity loss (IPBES, 2019). Currently, over half of the global population resides in cities, and the United Nations predicts this figure will rise to 68% by 2050 (United Nations, 2018). Urban land is expanding at rates far exceeding population growth, sometimes by two to four times (Angel et al., 2011; Seto et al., 2011). Studies predict that over half of the urban land in existence by 2030 will have been developed in the first 30 years of the twenty-first century (Seto et al., 2012). Biodiversity is in decline globally, primarily due to the conversion of natural

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habitats for agriculture, commercial forestry, resource extraction, and urban development (IPBES, 2019). Urban growth disrupts habitat configuration and connectivity, threatening species dispersal and increasing the risk to endemic species through the introduction of non-native species (Beninde et al., 2015; La Sorte et al., 2018; Lososová et al., 2016; McKinney, 2006; Miles et al., 2019). Additionally, urban expansion frequently results in habitat fragmentation and genetic and demographic isolation (Alberti, 2005; Ricketts, 2001; Tratalos et al., 2007).

Having recognised the adverse effects of urban growth on biodiversity and ecosystem services, biodiversity conservation and enhancement have become increasingly central themes in urban and regional planning (Aronson et al., 2017; Slaev & Shahab, 2026). In the absence of policy intervention, urban development often results in the loss or degradation of biodiversity by diminishing the availability of habitats for species and disrupting key ecological processes. Recognising the critical role of biodiversity in sustaining essential ecosystem services, as well as its socio-economic and recreational value, international policy frameworks such as Sustainable Development Goal (SDG) 15 of the 2030 Agenda for Sustainable Development and the EU Biodiversity Strategy for 2030 have called for urgent action to halt biodiversity loss. In response, many countries have introduced a range of measures aimed at safeguarding biodiversity, including policies designed to reconcile development and conservation goals (Zarei & Shahab, 2025). Notably, some of these measures require that biodiversity losses resulting from development be offset by equivalent gains, either on-site or off-site, despite the persistent challenges associated with quantifying habitat biodiversity value (Bull & Strange, 2018; Milner-Gulland et al., 2021; Shahab & Allam, 2020).

While extensive research exists on the ecological dimensions of biodiversity conservation and offset policies, there is a noticeable gap in studies focusing on the planning and development management aspects of biodiversity conservation at the urban level. In particular, there is limited understanding of how local planning authorities strategically navigate the complexities of urban development to prevent or mitigate biodiversity loss. This lack of knowledge highlights the need for further investigation into the strategies and practices employed by city-level planners to integrate biodiversity considerations into development management processes.

This paper seeks to address this gap by examining planning practices through a series of case studies in five countries: England, Italy, Canada, Germany, and Belgium. The case studies represent pioneering efforts within their respective regional and national contexts, offering valuable insights into innovative approaches to integrating biodiversity conservation into development management. By employing a multiple case study methodology, the paper facilitates a comparative analysis across diverse jurisdictions, enabling the identification of best practices. The research involves a document analysis of planning policies that target the intersection of development management and biodiversity conservation. This paper examines planning policies and practices across three governance levels: the high level (i.e. national and regional policies), city level (e.g. urban development plans or master plans), and project level (i.e. planning application and consent). This multi-level perspective allows for a nuanced understanding of how biodiversity considerations are integrated into urban planning processes. Additionally, it investigates how high-level policies are translated and implemented at the city and project levels in different cities.

To achieve this, the paper begins with a brief review of the literature at the intersection of biodiversity conservation and development management. It then outlines the methodological steps undertaken to identify and analyse relevant policy documents. The analysis explores how biodiversity is integrated into planning frameworks and decision-making processes across national, regional, city, and project levels. Particular attention is paid to the instruments and institutional arrangements that shape how urban development is managed in relation to biodiversity goals.

The paper concludes with a summary of the research findings and their implications for planning practice and biodiversity governance.

2. Biodiversity considerations in planning and development management

Balancing the competing demands of urban development and biodiversity conservation presents a significant challenge for planners. Infrastructure is vital for meeting society's fundamental needs, including housing, transportation, energy, and industrial production. However, excessive or poorly regulated urban growth can undermine both human well-being and the integrity of natural ecosystems (Brand-Correa et al., 2020; Fanning et al., 2021; O'Neill et al., 2018).

Efforts to address biodiversity loss in urban areas have increasingly focused on the integration of ecological considerations into planning and development management processes. Green infrastructure, defined as interconnected networks of natural spaces and corridors, has emerged as a cornerstone of biodiversity conservation in urban contexts (Hostetler et al., 2011). Studies have demonstrated that well-designed and accessible green infrastructure not only mitigates environmental pressures associated with urbanisation but also enhances citizens' quality of life by strengthening ecological resilience, improving environmental perceptions, and supporting social interaction within urban settings (Aram et al., 2022). However, the effectiveness of green infrastructure depends significantly on its connectivity, maintenance, and the ecological compatibility of surrounding urban areas (Ahmadpoor & Shahab, 2021; Bruno et al., 2023; Norton et al., 2016).

One area of particular focus in the literature is biodiversity offsetting, which has been widely implemented to compensate for the ecological impacts of development projects. Offset policies, such as those aimed at achieving 'no net loss' or 'net gain' of biodiversity, are often promoted as mechanisms to reconcile conservation and development objectives (Ermgassen et al., 2021; Weissgerber et al., 2019). However, these policies have faced criticism for their uncertain ecological outcomes and challenges in achieving equivalence between biodiversity losses and gains. Research indicates that offset sites frequently fail to replicate the ecological functions of impacted habitats, raising questions about the long-term effectiveness of such measures (Weissgerber et al., 2019). Furthermore, the governance and enforcement of offsetting measures remain significant challenges, as demonstrated by experiences in England, where mandatory biodiversity net gain policies are often undermined by shortcomings in implementation and monitoring (Ermgassen et al., 2021).

Moreover, the incorporation of ecosystem services into urban planning frameworks represents an important approach to linking biodiversity conservation with human well-being. Ecosystem services mapping has been shown to support integrated planning approaches by quantifying the benefits provided by natural systems, such as climate regulation, air purification, and recreational opportunities (González-García et al., 2022). Although the use of ecosystem services mapping has gained traction in cities such as Stockholm, Berlin, and New York, its broader implementation has been constrained by institutional silos and the lack of standardised methodologies for integrating ecosystem services into local planning processes (Nilon et al., 2017).

Despite growing interest in ecosystem services within urban planning, the integration of biodiversity conservation objectives into planning and development management remains understudied. While extensive research has addressed the ecological and technical dimensions of biodiversity conservation and offsetting, there is a lack of focus on the institutional, strategic, and procedural aspects of biodiversity integration at the urban level. For instance, tools such as biotope mapping and spatial prioritisation have been proposed to identify and protect ecologically valuable areas, yet

their application in urban planning remains inconsistent and poorly understood (González-García et al., 2022; Löfvenhaft et al., 2002). Similarly, limited attention has been paid to how local planning authorities navigate the complexities of competing development pressures to prevent or mitigate biodiversity loss. These gaps underscore the need for further investigation into the strategies, decision-making processes, and governance mechanisms employed by city-level planners to more effectively integrate biodiversity considerations into urban development.

3. Methodology

This study employs a multiple case study approach to investigate the integration of biodiversity conservation into development management practices across five cities in different countries: Manchester (England), Bologna (Italy), Calgary (Canada), Frankfurt am Main (Germany), and Ghent (Belgium). The selected case studies represent pioneering actions within their regional and national contexts, providing a diverse set of examples for comparative analysis.

- Manchester was selected for its initiative in developing a city-level biodiversity strategy and as the first city in England to sign the Edinburgh Declaration, a global commitment to addressing biodiversity loss and the interconnected challenges of biodiversity and climate change.
- Bologna was chosen for its leading role in Italy, being among the first cities to incorporate the concept and mapping of ecosystem services into its planning documents. By using these principles to guide urban planning decisions, Bologna has made significant efforts to protect biodiversity and ecosystems.
- Calgary was included for its involvement in the Local Action for Biodiversity (LAB) programme since 2010, which resulted in the mayor signing the Durban Commitment on Biodiversity. In 2021, the city completed a Natural Asset Inventory and Valuation, reinforcing its commitment to biodiversity. Calgary is also currently developing a new municipal plan, zoning bylaw, and biodiversity strategy to further integrate nature conservation into its urban planning.
- Frankfurt am Main was likewise selected for its pioneering role in Germany, coming third in a national 'Capital of Biodiversity' competition in 2011, co-organised by Environmental Action Germany. It was also one of the founding members of the 400-member alliance 'Municipalities for Biodiversity' and has recently published a detailed biodiversity strategy.
- Ghent was chosen for its leadership in Belgium, integrating nature conservation into planning through strategic frameworks and regulations. The city's strong environmental policies are supported by the elected Green Party and active citizen involvement in local environmental issues.

The case studies exhibit diverse characteristics, reflecting their operation within different legal systems and government structures across five countries. They include various forms of city governance and leadership, such as directly elected mayors overseeing multiple local authorities, as well as conventional political councils. Additionally, these cities vary in their levels of autonomy from regional and national governments, providing a broad spectrum of governance contexts for the comparative analysis.

This study conducts a thematic document analysis of city-level planning policies that address the intersection of development management and biodiversity conservation. The analysis was conducted in three stages. In the first stage, the researchers identified the relevant official planning documents, policies, and regulatory frameworks within each case study jurisdiction. For policy documents to be included in this study, they needed to meet two main criteria: (a) to include

policies implemented at a city level, (b) to cover policies, strategies, and recommendations targeting the intersection of development management and biodiversity conservation. A total of 17 policy documents from the five case-study cities were identified and selected for analysis. These documents were publicly accessible and deemed credible, as they were prepared by or in collaboration with city authorities, often endorsed by a leading politician in their introductions. Some also carry legal weight, either having the force of law or being formally endorsed through legal or statutory procedures. An overview of the selected policy documents is provided in Table 1.

In the second stage, the selected policy documents were reviewed through a combination of skimming (i.e. superficial examination) and detailed reading, following the approach outlined by Bowen (2009). In the third stage, a thematic analysis was conducted, guided by the study's research objectives. This analysis adhered to the Thematic Coding Approach described by Robson and McCartan (2016). During this process, the documents were examined and classified into analytical categories to identify content of potential interest, particularly in relation to the three governance levels. Material grouped under similar categories was then consolidated into broader themes, which then formed the basis for further data analysis and interpretation, allowing for comparisons across various aspects of the collected data. It should be noted that the study focused exclusively on written and official policy documents; unwritten plans and the perspectives of decision-makers were not explored.

4. Comparing biodiversity integration into planning practices across different governance levels

The results are structured according to a three-tiered framework that examines biodiversity conservation policies and their integration into planning practices across different levels of governance. These tiers include: the high level, focusing on national and regional policies; the city level, which considers urban development plans, zoning, and master plans; and the project level, addressing planning application and consent processes.

4.1. The high level: national and regional policies

At the national and regional levels, biodiversity policies often set the foundational principles that local planning authorities translate into actionable measures. Across the case studies, significant variations are evident in governance frameworks shaping urban development for biodiversity. England's Biodiversity Net Gain (BNG) requirement exemplifies a highly prescriptive approach, mandating that new developments deliver a measurable increase in biodiversity relative to baseline conditions. This requirement is articulated in the national BNG framework and reinforced in documents such as the GMCA Biodiversity Net Gain Guidance (2021), which operationalises the policy for Greater Manchester. This directive is operationalised using tools such as the Biodiversity Metric 2.0, which quantifies the biodiversity value of a site before and after development. The metric evaluates habitat types, ecological conditions, spatial connectivity, and alignment with biodiversity priorities, providing a detailed framework for developers to assess and enhance biodiversity impacts. This top-down approach aims to ensure a consistent national baseline for biodiversity integration, yet it also places significant demands on local authorities and developers to effectively implement the policy. The rigidity of the BNG framework serves as both a strength, in standardising biodiversity considerations across the country, and a limitation, as it may not fully account for specific local ecological and socioeconomic conditions.

Table 1. The description of the policy documents investigated in this study.

City	Document Name	No. of pages	Date of publication	Description
Manchester	Biodiversity Strategy 2022–2030	42	Oct 2022	Co-produced by the Wildlife Trust for Lancashire, Manchester and North Merseyside and Manchester City Council with the support of the Manchester Biodiversity Action Group.
	GMCA Biodiversity Net Gain	61	Feb 2021	Greater Manchester Combined Authority (GMCA) and funded by Resilient Greater Manchester. It was authored by WSP and Footprint Ecology.
	Manchester Local Plan – Core Strategy 2012–2027	250	Jul 2012	Prepared by Manchester City Council. The Core Strategy is the key document in the Manchester Local Plan.
	Places For Everyone Joint Development Plan 2022 to 2039	561	Mar 2024	Prepared by the Greater Manchester Combined Authority (GMCA). It has partially replaced some of the policies of Manchester's Core Strategy.
Bologna	Piano urbanistico Generale – Disciplina (General Urban Plan – Regulatory Framework)	294	Sep 2021	Prepared by the Bologna city planning department. It is the main document of the Bologna city plan.
	Piano urbanistico Generale – Regolamento del verde pubblico e privato (General Urban Plan – Regulation of Public and Private Green Spaces)	46	Sep 2021	Prepared by the city administration and sets out key regulations governing both private and public green spaces.
	Regolamento edilizio (Building Code)	192	Sep 2021	Prepared by the city administration and outlines the regulatory framework for construction activities and building standards.
	Schede Tecniche (Technical Guidelines)	21	Sep 2021	Prepared by the city, outlining provisions on topics such as resilience.
Calgary	Municipal Development Plan (Final Draft)	43	Nov 2024	Prepared by the City of Calgary; city-wide plan guiding land use and growth.
	Ecological Inventory Framework: Area Structure Plans	37	Mar 2016	Prepared by the City of Calgary; guidance for integrating ecological data into development planning.
	Alberta Wetland Policy	26	Mar 2015	Prepared by the Government of Alberta; framework for wetland conservation in land-use planning.
	Our BiodiverCity: Calgary's 10-year biodiversity strategic plan	48	Sep 2014	Prepared by the City of Calgary; outlines biodiversity goals and actions.
Frankfurt am Main	Arten- und Biotopschutzkonzept für Frankfurt am Main (Species and Habitat Protection Concept for Frankfurt am Main)	1338 (long version), 72 (short version)	May 2021	Biodiversity Strategy prepared by the Environmental Department of the City of Frankfurt am Main. Adopted by the City Council.
	Frankfurt 2030 + . Integriertes Stadtentwicllungskonzept (Frankfurt 2030 +: Integrated Urban Development Concept)	72	Jun 2019	Integrated Urban Development strategy prepared by the Department for Planning and Housing of the City of Frankfurt am Main. Adopted by the City Council.

(*Continued*)

Table 1. Continued.

City	Document Name	No. of pages	Date of publication	Description
Ghent	Ruimte voor Gent (Local Strategic Plan)	296	May 2018	Approved by Ghent City Council, prepared by the City Planning Department.
	Groenstructuurplan (Green Structure Plan)	183	Jan 2012	Approved by Ghent City Council, prepared by planning consultant Omgeving and the Urban Green Department.
	Thematisch RUP 169 Groen en Onteigeningsplan (Thematic Land-Use-Plan 169 and Expropriation Plan)	107	Sep 2021	Approved by Ghent City Council, prepared by the City Planning Department and Urban Green Department.
	Algemeen Bouwreglement (Local Building Code)	118	May 2024	Approved by Ghent City Council, prepared by the City Planning Department, in successive versions.

In contrast, Bologna operates within the framework of the European Union's biodiversity directives, the Italian Constitution, which establishes the general principle of protecting biodiversity and ecosystems, and a national law on tree protection and urban afforestation. The city's planning instruments, particularly the *Piano Urbanistico Generale – Disciplina* (2021) and the *Regolamento del Verde Pubblico e Privato* (2021), translate these national principles into locally applicable ecological performance requirements. These instruments set broad regulatory goals while allowing substantial flexibility for regional and municipal adaptation. At the regional level, the planning law mandates that the strategy for urban and ecological quality should aim to increase environmental quality, define ecological and environmental performance standards, restore natural habitats and soil biodiversity, and create ecological networks. This decentralised system enables Bologna to align biodiversity strategies with local priorities, such as enhancing ecological connectivity and integrating ecosystem services into urban plans. However, the combination of flexibility and vague national guidance can result in inconsistencies in implementation across regions.

Calgary's governance reflects Canada's federal system, in which provincial legislation plays a significant role in shaping biodiversity policy. In Alberta, where Calgary is located, regional priorities inform initiatives such as ecological inventories, green infrastructure planning, and wetland conservation. These priorities are outlined in documents including the Ecological Inventory Framework (The City of Calgary, 2016) and Calgary's Our BiodiverCity strategy (The City of Calgary, 2015), which set expectations for integrating ecological data into planning processes. While this decentralised approach allows for policy adaptation to local contexts, it often results in uneven implementation of biodiversity principles across the province. One notable exception is wetland protection, which is governed by a binding provincial framework, the Alberta Wetland Policy. This policy mandates that any permanent loss of wetland area must be compensated through restoration or offsetting, typically at a default ratio of 3:1. This legal requirement ensures a more consistent application of biodiversity safeguards in relation to wetlands, though its effectiveness depends on rigorous enforcement and the availability of suitable sites for restoration.

Frankfurt's approach is shaped by Germany's federal system, which balances national environmental mandates with considerable autonomy at the municipal level. Germany's biodiversity policy framework is characterised by a robust federal structure in which both the federal government and the Länder (states) establish overarching conservation principles and implement EU legislation, while municipalities bear primary responsibility for on-the-ground implementation. Naturschutz

(conservation) laws provide the legal foundation for mandatorily integrating biodiversity considerations into infrastructure planning, most notably through the requirement of compensation measures for environmental impacts. Frankfurt's Arten – und Biotopschutzkonzept (Stadt Frankfurt am Main, 2021) demonstrates how these requirements are translated into locally specific assessments and compensation principles. In the context of urban planning, however, such measures are comparatively weaker, forming part of the broader balancing of public and private interests during the plan-making process. Ultimately, the effectiveness of this framework depends significantly on the administrative capacity and political commitment of individual municipalities.

Similarly, Ghent operates within Belgium's complex multilevel governance system, where overlapping responsibilities among regional, provincial, and local authorities demand strong coordination to realise biodiversity objectives. In the Flemish planning context, zoning designations do not impose implementation obligations on landowners, which limits the proactive role of public authorities in biodiversity conservation (Shahab et al., 2021). Instead, mitigation and compensatory measures are typically undertaken by developers in response to permitted development activities. The city's approach is documented in the Groenstructuurplan (Stad Gent, 2012) and the thematic RUP 169 (Stad Gent, 2021), which outline ecological priorities and designate strategic green and blue networks. Unlike the system in England, Flanders does not employ a weighting metric to assess the ecological value lost through development and to guide compensation efforts. As a result, ecological compensation tends to be primarily quantitative, often failing to prevent a net loss of ecological value.

These variations underscore a tension in biodiversity governance between regulatory rigidity and flexibility. England's BNG requirement illustrates how a highly prescriptive national mandate can establish clear expectations and promote standardised outcomes. However, it also reveals the practical challenges of implementation, particularly where local authorities face limited capacity or technical expertise. In contrast, the more adaptable frameworks in Bologna, Frankfurt, and Ghent afford cities the ability to tailor biodiversity strategies to local ecological and spatial contexts. This flexibility can foster context-sensitive planning but often results in fragmented implementation, especially in the absence of strong coordinating mechanisms or clearly defined performance metrics. Calgary, Ghent, and Frankfurt exemplify the dynamics of federal systems, where provincial or state-level leadership shapes biodiversity policy and municipal action is influenced by regional priorities. While this decentralised model allows for policy innovation and responsiveness to local conditions, as seen in Alberta's binding wetland offsetting requirements, it can also lead to uneven application of biodiversity principles across jurisdictions. Arguably, neither centralisation nor decentralisation alone guarantees effective integration of biodiversity into planning. Rather, the success of national and regional policies depends on the clarity of mandates, the alignment of institutional responsibilities, and the strength of enforcement and coordination mechanisms across governance levels.

4.2. City level: urban development plans, master plans, and zoning

City-level frameworks act as a bridge between national policies and site-specific implementation, typically through urban development plans, master plans, or zoning and building ordinances. These frameworks translate high-level policies into actionable strategies, and their effectiveness depends on how well biodiversity considerations are embedded within urban planning processes. The case studies reveal notable variations in this regard, reflecting differences in local governance structures and urban priorities.

In Manchester, biodiversity integration into planning processes is shaped by both local strategies and the overarching national BNG requirement. The city's Biodiversity Strategy 2022–2030 sets out these priorities, outlining local priorities such as habitat enhancement, ecological connectivity, and community engagement. These objectives are reflected in planning guidance and supplementary documents used to inform development management. However, unlike some neighbouring authorities in Greater Manchester, the City of Manchester does not have a dedicated biodiversity policy embedded in its core spatial strategy. Biodiversity considerations are typically addressed through the development management process on a case-by-case basis, often relying on ecological assessments submitted by applicants. Although there is growing institutional awareness, the absence of binding local targets or enforceable development management policies limits more consistent integration. Consequently, biodiversity goals tend to be operationalised in a reactive rather than strategic manner, and their implementation is constrained by resource pressures and competing urban development priorities.

In Bologna, biodiversity is embedded in city-level planning through a coordinated set of instruments, including the Urban Green Regulation, and associated technical guidelines. The PUG – Disciplina (Comune di Bologna, 2022) and Regulations for Public and Private Green Areas (Comune di Bologna, 2021) explicitly incorporate biodiversity goals within broader objectives of environmental resilience and soil de-sealing, supported by ecosystem service assessments and spatial analysis. Specific measures, such as mandatory green roofs for new industrial and commercial buildings, net-positive compensation for sealed surfaces through de-sealing interventions, and requirements to maintain or enhance vegetation cover, reflect the city's commitment to ecological quality. These measures are embedded in both planning and building regulations and are reinforced through performance-based standards outlined in the Technical Guidelines. Moreover, the Regulation for Public and Private Green Spaces provides detailed rules for the protection of existing vegetation, including tree preservation, species selection for replanting, and obligations for ecological compensation in development projects.

In Calgary, biodiversity integration at the city level is shaped by a combination of strategic planning instruments, technical frameworks, and policy guidance. The Climate Implementation Plan (The City of Calgary, 2024), the Ecological Inventory Framework (The City of Calgary, 2016), and the BiodiverCity Strategy (The City of Calgary, 2015) all articulate the city's ambition to safeguard ecological assets. However, integration into land-use planning remains uneven. Zoning and planning approvals are largely governed by Area Structure Plans, which require ecological inventories and biophysical impact assessments, yet decisions often depend on developer-led submissions and vary by project. Instruments such as the Ecological Inventory Framework and Natural Asset Valuation provide technical guidance, but they are not always binding. Calgary's open space policies encourage the preservation and restoration of ecologically valuable land, but many biodiversity measures rely on voluntary uptake or are limited to city-owned land. While habitat restoration frameworks and species protection guidelines exist, the absence of strong legal mandates in zoning practices limits the enforceability of biodiversity targets. As a result, despite growing institutional recognition of biodiversity's importance, the city's planning system lacks consistent mechanisms to ensure biodiversity outcomes across all forms of development.

Frankfurt exemplifies the integration of ecological considerations into urban planning, employing a range of instruments to systematically assess habitats and species and to embed environmental concerns within zoning decisions. The city's Arten- und Biotopschutzkonzept (Stadt Frankfurt am Main, 2021), together with the Frankfurt 2030+ Integrated Urban Development Concept, provides a comprehensive basis for ensuring biodiversity considerations are incorporated into planning

decisions. As in other German municipalities, the preparation of a new land-use plan exceeding a certain threshold mandatorily requires a detailed environmental assessment. This assessment covers a range of 'protected goods' (*Schutzgüter*), including humans, animals and plants, soil, water, climate, air quality, landscape appearance, cultural heritage, and the interactions among these elements. The city's comprehensive Species and Habitat Protection Concept is designed to inform and guide conservation-related decisions within the land-use planning process. This approach is underpinned by strong political commitment and a long-established tradition of environmental planning. Ecological compensation measures, such as requiring developers to offset biodiversity losses through restoration or enhancement projects, are routinely implemented by municipalities across Germany, aiming to ensure that urban development is balanced with ecological preservation.

Similarly, Ghent integrates biodiversity into city planning with a particular emphasis on green and blue infrastructure. The Groenstructuurplan (Stad Gent, 2012) and the strategic plan Ruimte voor Gent (Stad Gent, 2018) prioritise habitat connectivity and the multifunctionality of green spaces, aligning biodiversity objectives with broader aims such as climate resilience, flood management, and public health. Following a lengthy approval process, a thematic zoning plan, i.e. RUP 169 2021, was adopted to rezone and protect more than 100 sites. However, the full realisation of the planned green infrastructure is not yet assured, as the city government excluded the most contested sites from the final plan, particularly those located along the proposed radial 'climate axes', which are corridors intended to channel cool air and enhance ecological connectivity from the urban periphery into the city centre. These areas often intersect with high-value real estate, creating tensions between environmental goals and development interests.

The case studies highlight substantial variation in how biodiversity is integrated into city-level planning frameworks, reflecting differences in institutional capacity, legal mandates, and political priorities. Frankfurt and Ghent represent comparatively advanced cases, where biodiversity is systematically embedded in zoning and land-use planning through clearly defined instruments and strong political support. In Frankfurt, ecological compensation is integral to planning practice and enforced through land-use regulations, while Ghent has institutionalised green and blue infrastructure through dedicated strategies and thematic zoning, despite delays and compromises in implementation. Bologna also demonstrates a structured and technically sophisticated approach, embedding biodiversity goals into its City Plan, Urban Green Regulation, and Technical Guidelines. Measures such as mandatory green roofs for new industrial and commercial buildings and compensation for sealed surfaces through de-sealing requirements reflect the city's proactive regulatory framework. In contrast, Manchester and Calgary illustrate more constrained models at a city level. In Manchester, biodiversity objectives are largely shaped by national mandates and remain unevenly integrated across planning instruments, with implementation relying on discretionary assessment. Calgary's strategic documents articulate strong commitments, but the absence of binding requirements within planning approvals and the reliance on voluntary measures limit their enforceability. Across all cases, the extent to which biodiversity is prioritised in city-level planning is closely linked to the legal status of relevant instruments, the strength of enforcement mechanisms, and the degree of alignment with broader development goals.

4.3. Project level: planning application and consent

The project level represents the practical interface between policy and action, where biodiversity objectives are translated into concrete outcomes through planning applications and consent processes. The degree of discretion granted to planners in integrating biodiversity considerations at

the project level varies widely across the case studies, shaping both opportunities and challenges in achieving biodiversity goals.

In Manchester, planners operate within a discretionary development management system, understood here as one that allows case-by-case interpretation within statutory and policy constraints, in which biodiversity is treated as a 'material consideration', i.e. a relevant factor that must be taken into account when determining planning applications under English planning law. The introduction of the BNG policy has formalised expectations at the project level, requiring developers to assess pre – and post-development biodiversity values using standardised metrics. This has enhanced the ability of planning officers to request ecological surveys, negotiate on-site mitigation, or require off-site compensation. However, the effectiveness of this policy is contingent on the capacity of local authorities to enforce compliance and monitor outcomes (Rampling et al., 2023). In practice, limited ecological expertise within planning departments continues to constrain meaningful implementation, as planners may lack the knowledge or confidence to challenge developers' biodiversity assessments or apply the metrics rigorously. This reflects a broader pattern observed in urban contexts, where planning institutions often lack the ecological knowledge and data required to fully integrate biodiversity into decision-making (Niemelä, 1999; Steiner et al., 2013).

In contrast, project-level discretion in Bologna is relatively limited. Biodiversity considerations are primarily addressed through environmental impact assessments (EIAs), which evaluate ecological effects based on predetermined criteria embedded in the city's urban plans and regulatory instruments. These criteria are set out in the PUG – Disciplina (Comune di Bologna, 2022), the Regolamento Edilizio (Comune di Bologna, 2021), and the Technical Guidelines, which provide scoring systems for factors such as the permeability of surfaces, the extent of vegetative cover, and the management of water run-off. While this system offers a regulatory foundation for integrating biodiversity and soil health into development assessments, it limits the scope for planners to request project modifications beyond compliance with established standards. As long as proposals meet the technical and design-based thresholds set out in the planning framework, municipal authorities have limited legal grounds to require additional ecological enhancements. As such, Bologna's model ensures a baseline level of biodiversity consideration, but offers less flexibility for case-specific negotiation or discretionary intervention at the project level.

In Calgary, biodiversity considerations at the project level are largely determined during earlier planning stages, particularly through the preparation of Area Structure Plans. These statutory plans, guided by the Ecological Inventory Framework (The City of Calgary, 2016), require ecological inventories and biophysical impact assessments that inform the designation of environmental reserves and outline mitigation strategies for new communities. Once an Area Structure Plan is approved, project-level applications are primarily assessed for conformity with its provisions, which leaves planners with limited scope to introduce additional biodiversity measures during the development management process. Project-level discretion is further constrained by the absence of binding biodiversity requirements within zoning or building regulations and the reliance on developer-led submissions. As a result, while biodiversity is acknowledged in principle, its consistent integration into site-specific decisions depends on voluntary measures, negotiated outcomes, and the willingness of individual actors to prioritise ecological concerns. This contributes to uneven implementation and limits the capacity of the planning system to deliver reliable biodiversity outcomes across projects.

In Frankfurt, planners have limited discretion at the project level, as biodiversity requirements are largely determined during earlier stages of the planning process. Ecological considerations, such

as compensation for habitat loss, restoration measures, and compliance with green certification schemes, are embedded in city-level land-use and master plans. These measures are typically negotiated and formalised prior to project-level review, leaving little scope for planners to require further biodiversity enhancements during individual application assessments. While this approach provides a clear and consistent framework for developers, it also restricts planners' ability to respond to site-specific ecological concerns. Moreover, the system has been criticised for relying on temporary or short-term compensation measures and for lacking robust mechanisms for monitoring and enforcement. These limitations point to the need for improved oversight and longer-term accountability to ensure that biodiversity outcomes are not only planned for but sustained over time.

Like Manchester, planners in Ghent exercise considerable discretion in the planning consent process, particularly through the application of cumulative environmental decrees and EIAs. These tools ensure that biodiversity considerations are embedded in project evaluation, with a strong emphasis on preserving green infrastructure and maintaining habitat connectivity. A key legal instrument is the 'stand-still' principle embedded in Flemish nature legislation, which prohibits the deterioration of ecologically valuable areas and provides planners with a legal basis to enforce biodiversity protection. Where on-site ('in natura') compensation is not feasible, developers are required to make financial contributions, which are then used by the city to implement compensation measures elsewhere within its jurisdiction. However, the effectiveness of this mechanism is limited by a chronic shortage of available land for ecological restoration. Weaknesses in the city's land acquisition policy have contributed to long-standing delays in the expansion of planned nature reserves and green corridors around the urban periphery. This is an issue also observed in other urban contexts, where a lack of effective planning instruments hampers biodiversity protection at the urban fringe (Bekessy et al., 2012).

These variations illustrate how the degree of discretion afforded to planners at the project level shapes the ways in which biodiversity considerations are incorporated into development management processes. In Manchester and Ghent, discretionary planning systems provide planners with opportunities to negotiate ecological enhancements and respond to site-specific conditions, particularly where biodiversity is recognised through legal instruments such as material considerations or environmental decrees. While this flexibility allows for context-sensitive decision-making, it also introduces variability, as the extent and consistency of biodiversity integration may depend on institutional capacity, technical expertise, and local priorities. In contrast, Frankfurt, Bologna, and Calgary adopt more standardised approaches, where biodiversity requirements are largely determined at earlier planning stages and formalised through regulatory instruments such as master plans, technical indices, or area structure plans. These frameworks can promote consistency and legal clarity, but they may limit planners' ability to respond to unforeseen ecological issues during project appraisal. Across the cases, the role of discretion at the project level reflects broader planning cultures and governance structures, highlighting the importance of aligning procedural tools, regulatory mandates, and institutional resources to support the effective consideration of biodiversity in development management.

5. Discussion and conclusion

This paper has examined how biodiversity conservation is integrated into urban planning and development management across five cities (Manchester, Bologna, Calgary, Frankfurt, and Ghent) by analysing planning practices at the national, regional, city, and project levels. While

all five cases demonstrate formal commitments to biodiversity, the ways in which these objectives are incorporated into planning practice vary significantly, shaped by the structure of planning systems, the distribution of planning authority, and institutional capacity.

A key insight is that the structure of the planning system, whether regulatory or discretionary, shapes but does not determine how biodiversity is addressed. Regulatory systems, as seen in Frankfurt, Bologna, and Calgary, typically embed biodiversity into formal planning instruments such as zoning plans, technical codes, or area structure plans. This can support policy clarity and consistency, offering developers a predictable framework within which ecological requirements are established in advance. However, such systems may leave limited room for planners to adjust requirements at the project level, potentially constraining site-specific adaptation.

Manchester, operating within a discretionary planning system, provides planners with greater flexibility to negotiate biodiversity measures during the development management process. The introduction of mandatory BNG has given planners stronger tools to assess and influence project-level impacts, but the success of such tools depends heavily on local capacity, expertise, and institutional follow-through. By contrast, Ghent, while situated within a regulatory planning tradition, grants planners significant discretion in biodiversity-related decisions at the project level, particularly through the application of environmental assessments and the enforcement of the 'stand-still' principle under Flemish nature legislation. This highlights the importance of examining not only planning system types but also how biodiversity is treated within specific legal and procedural domains.

Another important finding concerns the degree of vertical coordination across governance levels. Cities with more structured and coherent linkages between national, regional, and local planning, such as Frankfurt and Bologna, are better positioned to translate biodiversity commitments into operational tools and regulatory frameworks. In contrast, Calgary and Manchester exhibit weaker vertical integration in the sense that project-level planning is primarily shaped by national or provincial mandates, rather than being clearly guided by coherent city-level biodiversity strategies. This can result in fragmented implementation, where local or city-level ambitions are not fully articulated in planning processes or translated into enforceable mechanisms at the site level.

The analysis also draws attention to cross-cutting challenges that affect all five cities. These include tensions between ecological goals and competing development priorities, limitations in institutional capacity, and uneven levels of stakeholder engagement. While biodiversity strategies are increasingly formalised in local plans and policies, their implementation often remains secondary to more immediate planning objectives, such as housing delivery or economic growth. Urban planning frameworks still frequently treat biodiversity as a constraint on development rather than as a public good to be protected and enhanced, a framing that narrows the scope for more proactive and integrated ecological planning (Bekessy et al., 2012). Moreover, instruments such as biodiversity offsetting and net gain are often deployed in ways that emphasise procedural compliance over ecological effectiveness, reinforcing a development-led logic within planning systems (Jones et al., 2019). Addressing these challenges requires not only technical capacity and clear regulation, but also a shift in how biodiversity is positioned within planning cultures and institutional priorities.

Three key lessons emerge. First, integrating biodiversity considerations into statutory planning instruments from the outset can provide a strong and consistent foundation for long-term ecological protection. This may include establishing clear ecological performance standards within zoning or building regulations, embedding biodiversity mapping and habitat data directly into statutory plans, and defining unambiguous rules for ecological compensation to ensure predictable and enforceable outcomes.

Second, enabling targeted discretion at the project level, supported by clear guidance and technical capacity, can enhance responsiveness to local ecological conditions. In practical terms, this entails giving planners access to ecological expertise and standardised assessment tools, alongside explicit criteria that help determine when negotiated or site-specific biodiversity measures are appropriate. Such support can ensure that discretion is used consistently and transparently.

Third, improving vertical alignment between national, regional, and local governance levels is essential for translating biodiversity ambitions into implementation. This can be strengthened by enhancing data-sharing across governance tiers, aligning national or regional biodiversity strategies with local planning tools, and establishing coordinated monitoring systems that ensure continuity from high-level policy commitments to project-level delivery. Additionally, collaboration between planners, ecologists, developers, and communities can help ensure that biodiversity strategies are grounded in practical and place-based knowledge.

In conclusion, this study underscores the value of a multi-level and context-sensitive approach to biodiversity planning. Cities are likely to be most effective when they combine the stability of regulatory frameworks with the adaptability of discretionary tools, and when biodiversity is integrated not only into planning documents but also into the institutional practices that govern urban development. As pressures on urban land continue to grow, embedding biodiversity meaningfully across all levels of planning will be essential for ensuring more ecologically resilient urban futures.

Future research could build on these findings by assessing the effectiveness of different planning approaches in achieving biodiversity goals across urban contexts. While this study focused on governance structures and planning instruments, further work is needed to evaluate how various regulatory, discretionary, and hybrid models influence biodiversity outcomes in practice. Comparative studies that link specific interventions, such as biodiversity compensation schemes, ecosystem service assessments, or green infrastructure plans, to measurable ecological or spatial outcomes would help clarify what kinds of planning practices are most effective under different institutional conditions. In addition, research into how planners, ecologists, and other actors manage trade-offs between biodiversity and development could shed light on the informal and negotiated aspects of biodiversity governance. Such work would enhance understanding of how formal planning frameworks interact with everyday planning practice and contribute to more context-sensitive and outcome-oriented biodiversity strategies.

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References

Ahmadpoor, N., & Shahab, S. (2021). Realising the value of green space: A planners' perspective on the COVID-19 pandemic. *Town Planning Review*, *92*, 49–55. https://doi.org/10.3828/tpr.2020.37

Alberti, M. (2005). The effects of urban patterns on ecosystem function. *International Regional Science Review*, *28*(2), 168–192. https://doi.org/10.1177/0160017605275160

Angel, S., Parent, J., Civco, D. L., Blei, A., & Potere, D. (2011). The dimensions of global urban expansion: Estimates and projections for all countries, 2000–2050. *Progress in Planning*, *75*(2), 53–107. https://doi.org/10.1016/j.progress.2011.04.001

Aram, F., Shahab, S., & Solgi, E. (2022). Editorial: Impacts of urban green spaces on environmental perceptions andsocial life. *Frontiers in Environmental Science*, *10*, 1050597. https://doi.org/10.3389/fenvs.2022.1050597

Aronson, M., Lepczyk, C., Evans, K., Goddard, M., Lerman, S., Macivor, J., Nilon, C., & Vargo, T. (2017). Biodiversity in the city: Key challenges for urban green space management. *Frontiers in Ecology and the Environment*, *15*, 189–196. https://doi.org/10.1002/FEE.1480

Bekessy, S. A., White, M., Gordon, A., Moilanen, A., McCarthy, M. A., & Wintle, B. A. (2012). Transparent planning for biodiversity and development in the urban fringe. *Landscape and Urban Planning*, *108*(2), 140–149. https://doi.org/10.1016/j.landurbplan.2012.09.001

Beninde, J., Veith, M., & Hochkirch, A. (2015). Biodiversity in cities needs space: A meta-analysis of factors determining intra-urban biodiversity variation. *Ecology Letters*, *18*, 581–592.

Bowen, G. A. (2009). Document analysis as a qualitative research method. *Qualitative Research Journal*, *9*, 27–40.

Brand-Correa, L. I., Mattioli, G., Lamb, W. F., & Steinberger, J. K. (2020). Understanding (and tackling) need satisfier escalation. *Sustainability: Science, Practice and Policy*, *16*, 309–325.

Bruno, E., Falco, E., Shahab, S., & Geneletti, D. (2023). Integrating ecosystem services in transfer of development rights: A literature review. *Land Use Policy*, *131*, 106694. https://doi.org/10.1016/j.landusepol.2023.106694

Bull, J. W., & Strange, N. (2018). The global extent of biodiversity offset implementation under no net loss policies. *Nature Sustainability*, *1*(12), 790–798.

Comune di Bologna. (2021). *Regulations for public and private green areas: Annex to the building code of the General Urban Plan (PUG)*. Comune di Bologna, Environment and Energy Department.

Comune di Bologna. (2022). *Disciplina del Piano: Piano Urbanistico Generale (PUG)* [Planning Regulations: General Urban Plan]. Comune di Bologna, Department of Urban Planning, Housing and Environment.

Ermgassen, S. O. S. E., Marsh, S., Ryland, K., Church, E., Marsh, R., & Bull, J. W. (2021). Exploring the ecological outcomes of mandatory biodiversity net gain using evidence from early-adopter jurisdictions in England. *Conservation Letters*, *14*(6), e12820. https://doi.org/10.1111/conl.12820

Fanning, A. L., O'Neill, D. W., Hickel, J., & Roux, N. (2021). The social shortfall and ecological overshoot of nations. *Nature Sustainability*, 1–11.

GMCA. (2021). *Greater Manchester Combined Authority biodiversity net gain: Guidance for Greater Manchester*. Greater Manchester Combined Authority (GMCA).

González-García, A., Palomo, I., González, J. A., García-Díez, V., García-Llorente, M., & Montes, C. (2022). Biodiversity and ecosystem services mapping: Can it reconcile urban and protected area planning? *Science of The Total Environment*, *803*, 150048. https://doi.org/10.1016/j.scitotenv.2021.150048

Hostetler, M., Allen, W., & Meurk, C. (2011). Conserving urban biodiversity? Creating green infrastructure is only the first step. *Landscape and Urban Planning*, *100*(4), 369–371. https://doi.org/10.1016/j.landurbplan.2011.01.011

IPBES. (2019). Global assessment report on biodiversity and ecosystem services of the intergovernmental science-policy platform on biodiversity and ecosystem services. Brondizio ES, Settele J, Díaz S, Ngo HT, eds.

Jones, J. P. G., Bull, J. W., Roe, D., Baker, J., Griffiths, V. F., Starkey, M., Sonter, L. J., & Milner-Gulland, E. J. (2019). Net gain: Seeking better outcomes for local people when mitigating biodiversity loss from development. *One Earth*, *1*(2), 195–201. https://doi.org/10.1016/j.oneear.2019.09.007

La Sorte, F. A., Lepczyk, C. A., Aronson, M. F., Goddard, M. A., Hedblom, M., Katti, M., MacGregor-Fors, I., Mörtberg, U., Nilon, C. H., Warren, P. S., & Williams, N. S. (2018). The phylogenetic and functional diversity of regional breeding bird assemblages is reduced and constricted through urbanization. *Diversity and Distributions*, *24*, 928–938.

Löfvenhaft, K., Björn, C., & Ihse, M. (2002). Biotope patterns in urban areas: A conceptual model integrating biodiversity issues in spatial planning. *Landscape and Urban Planning*, *58*(2), 223–240. https://doi.org/10.1016/S0169-2046(01)00223-7

Lososová, Z., Čeplová, N., Chytr, M., Tich, L., Danihelka, J., Fajmon, K., Láníková, D., Preislerová, Z., & Řehořek, V. (2016). Is phylogenetic diversity a good proxy for functional diversity of plant communities? A case study from urban habitats. *Journal of Vegetation Science*, *27*, 1036–1046.

McKinney, M. L. (2006). Urbanization as a major cause of biotic homogenization. *Biological Conservation*, *127*(3), 247–260.

Miles, L. S., Rivkin, L. R., Johnson, M. T. J., Munshi-South, J., & Verrelli, B. C. (2019). Gene flow and genetic drift in urban environments. *Molecular Ecology*, *28*, 4138–4151.

Milner-Gulland, E. J., Addison, P., Arlidge, W. N., Baker, J., Booth, H., Brooks, T., Bull, J. W., Burgass, M. J., Ekstrom, J., Zu Ermgassen, S. O., & Fleming, L. V. (2021). Four steps for the Earth: Mainstreaming the post-2020 global biodiversity framework. *One Earth*, *4*(1), 75–87.

Niemelä, J. (1999). Ecology and urban planning. *Biodiversity & Conservation*, *8*(1), 119–131. https://doi.org/10.1023/A:1008817325994

Nilon, C. H., Aronson, M. F. J., Cilliers, S. S., Dobbs, C., Frazee, L. J., Goddard, M. A., O'Neill, K. M., Roberts, D., Stander, E. K., Werner, P., Winter, M., & Yocom, K. P. (2017). Planning for the future of urban biodiversity: A global review of city-scale initiatives. *BioScience*, *67*(4), 332–342. https://doi.org/10.1093/biosci/bix012

Norton, B. A., Evans, K. L., & Warren, P. H. (2016). Urban Biodiversity and Landscape Ecology: Patterns, Processes and Planning. *Current Landscape Ecology Reports*, *1*(4), 178–192. https://doi.org/10.1007/s40823-016-0018-5

O'Neill, D. W., Fanning, A. L., Lamb, W. F., & Steinberger, J. K. (2018). A good life for all within planetary boundaries. *Nature Sustainability*, *1*, 88–95.

Rampling, E. E., Zu Ermgassen, S. O., Hawkins, I., & Bull, J. W. (2023). Achieving biodiversity net gain by addressing governance gaps underpinning ecological compensation policies. *Conservation Biology*, *38*(2), e14198. https://doi.org/10.1111/cobi.14198

Ricketts, T. H. (2001). The matrix matters: Effective isolation in fragmented landscapes. *The American Naturalist*, *158*(1), 87–99. https://doi.org/10.1086/320863

Robson, C., & McCartan, K. (2016). *Real world research: A resource for users of social research methods in applied settings*. Wiley.

Seto, K. C., Fragkias, M., Guneralp, B., & Reilly, M. K. (2011). A meta-analysis of global urban land expansion. *PLoS One*, *6*(8), e23777. https://doi.org/10.1371/journal.pone.0023777

Seto, K. C., Guneralp, B., & Hutyra, L. R. (2012). Global forecasts of urban expansion to 2030 and direct impacts on biodiversity and carbon pools. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(40), 16083–16088. https://doi.org/10.1073/pnas.1211658109

Shahab, S., & Allam, Z. (2020). Reducing transaction costs of tradable permit schemes using Blockchain smart contracts. *Growth and Change*, *51*, 302–308. https://doi.org/10.1111/grow.12342

Shahab, S., Hartmann, T., & Jonkman, A. (2021). Strategies of municipal land policies: Housing development in Germany, Belgium, and Netherlands. *European Planning Studies*, *29*(6), 1132–1150. https://doi.org/10.1080/09654313.2020.1817867

Slaev, A. D., & Shahab, S. (2026). *A theory of complex property rights: Institutions for governing natural and built environments*. Edward Elgar.

Stad Gent. (2012). *Groenstructuurplan Gent* [Green Structure Plan Ghent]. Dienst Stedenbouw en Ruimtelijke Planning, Stad Gent.

Stad Gent. (2018). *Ruimte voor Gent: Structuurvisie 2030*. Dienst Stedenbouw en Ruimtelijke Planning, Stad Gent.

Stad Gent. (2021). *Overzicht Thematisch RUP Groen* [Overview of Thematic Green Land-Use Plan]. Department of Urban Planning, City of Ghent.

Stadt Frankfurt am Main. (2021). *Arten- und Biotopschutzkonzept der Stadt Frankfurt am Main* (Edited by Umweltamt Frankfurt am Main, Prepared by PAN Planungsbüro für angewandten Naturschutz GmbH). Umweltamt, Magistrat der Stadt Frankfurt am Main.

Steiner, F., Simmons, M., Gallagher, M., Ranganathan, J., & Robertson, C. (2013). The ecological imperative for environmental design and planning. *Frontiers in Ecology and the Environment*, *11*, 355–361. https://doi.org/10.1890/130052

The City of Calgary. (2015). *Our BiodiverCity: Calgary's 10-year biodiversity strategic plan*. The City of Calgary, Parks Department. https://www.calgary.ca

The City of Calgary. (2016). *Ecological inventory framework: Area structure plans* (Version 1.1/Q1 2016). The City of Calgary, Calgary Parks. www.calgary.ca

The City of Calgary. (2024). *2023–2026 Climate implementation plan*. City of Calgary, Climate andEnvironmental Management.

Tratalos, J., Fuller, R. A., Warren, P. H., Davies, R. G., & Gaston, K. J. (2007). Urban form, biodiversity potential and ecosystem services. *Landscape and Urban Planning*, *83*(4), 308–317. https://doi.org/10.1016/j.landurbplan.2007.05.003

United Nations. (2018). *Revision of world urbanization prospects*. https://population.un.org/wup/Publications/Files/WUP2018-Report.pdf

Weissgerber, M., Roturier, S., Julliard, R., & Guillet, F. (2019). Biodiversity offsetting: Certainty of the net loss but uncertainty of the net gain. *Biological Conservation*, *237*, 200–208. https://doi.org/10.1016/j.biocon.2019.06.036

Zarei, M., & Shahab, S. (2025). Nature-Based solutions in urban green infrastructure: A systematic review of success factors and implementation challenges. *Land*, *14*(4), 818. https://doi.org/10.3390/land14040818