Biodiversity, resilience and well-being in urban projects: critical analysis on three case studies

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Abstract: The contribution investigates the systemic relationships between biodiversity, urban resilience, and human well-being within processes of territorial and environmental regeneration, through a comparative analysis of three European case studies: the Emscher Restoration Project (Germany), Lyon Confluence (France), and the North–South Green Corridor in Berlin, including *Park am Gleisdreieck* and *Natur Park Südgelände*. The main objective is to assess how biodiversity can serve as an operational parameter for the adaptive design of urban ecosystems, contributing to climate mitigation and the enhancement of urban liveability. The research adopts a critical and interdisciplinary methodology, combining morphological and environmental analysis with the examination of strategies for integrating green infrastructures, ecological networks, and public space systems. Three key analytical axes are identified: (1) the interactions between biodiversity, resilience, and well-being in urban projects; (2) the capacity of green infrastructures to generate multiple ecosystem services; and (3) the design awareness involved in creating shared habitats for human and non-human species. Findings highlight that the most effective strategies operate according to a systemic and multiscalar logic, integrating ecological, social, and climatic dimensions. The Emscher Restoration stands as a model of integrated ecological regeneration, where river restoration and landscape reconnection produce measurable effects on territorial resilience. Lyon Confluence demonstrates the potential of climate-oriented design for urban liveability, albeit showing limitations in ecological monitoring. The Berlin park system represents a paradigm of multi-species cohabitation, where spontaneous natural processes and deliberate planning coexist in a dynamic balance. The study concludes that urban sustainability should not be assessed through isolated performance indicators but through the ecosystemic integration capacity that defines the city as a complex adaptive system. This perspective opens new research directions on biodiversity as a strategic ecological infrastructure, capable of steering urban design towards socio-ecological resilience and widespread environmental well-being.

Keywords: Urban Biodiversity, Urban Resilience, Health and well-being, Integrated design.

1. Nature-based Thinking: a holistic approach to biodiversity, resilience and well-being in urban environments

Today, urban ecosystems face epochal challenges induced by climatic, economic, and social changes. Among these, first and foremost, is the attempt to moderate and reverse the trajectory that, over the last two centuries, has led to a clear and evident loss of biodiversity. In our times, this has compromised or risks compromising the very ability of ecosystems to reiterate and reproduce those functions necessary for the survival of living communities, including climate regulation, water and air quality, and food supply (IPBES 2019).

Concurrently, the impacts of climate change are manifesting with increasing severity, and ecosystems characterized by high levels of diversity show greater resilience to these impacts, enabling more effective adaptation and mitigation processes (Knapp et

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al. 2019; IPCC 2023). In this scenario, urban natures assume a pivotal role not only in maintaining climatic and environmental balances but also in directly influencing human health and well-being (EC 2021a; UN-Habitat 2022).

Human health is fundamentally dependent on healthy and diversified ecosystems, which support the essential conditions for life while offering protection against extreme climatic events and disease risks (WHO 2021). Faced with these challenges, the temptation is often to seek technological or "green" ready-to-use solutions, almost as if consulting a catalogue. However, when discussing Nature-based Solutions (NbS), it must be premised that a single solution, taken in isolation, is not sufficiently articulated to solve problems that are, by their nature, extremely complex. One cannot assume that installing a single green roof can solve the urban heat island problem, just as a single water retention area cannot manage the flood risk of an entire basin on its own.

As the case studies observed in this chapter suggest, the most effective responses do not stem from the application of a single NbS, but from an integrated strategy that considers the multiple interactions between ecological, social, and economic components. Precisely, it is essential to make a conceptual shift: moving from reductionist and mechanistic thinking - based on applying a linear cause-effect response model to complex problems - to thinking based on complexity, which is systemic and recursive: a Nature-based Thinking (NbThinking) (Randrup et al. 2020). While a reductionist view might lead to applying "green solutions" as mere technological artifices, a nature-based approach implies considering multifunctionality, ecological connectivity, and specific biodiversity, relating them to the place and the living community that inhabits it. The approach, therefore, defines the solution, and not vice versa. This "thinking" represents the true interpretive key for NbS; indeed, from this perspective, NbS are not the starting point, but the result of a design process that centers ecological processes. This is a mode of city planning and design that should, by its very nature, be truly integrated into the local system of habitats and ecosystems it addresses; multidisciplinary because it is complex and systemic; and participatory because it is capable of activating cultural and social processes.

An integrated project is one that considers the interdependencies between different objectives. As will be seen in the analysis of the case studies, the transformative potential of contemporary urban practices lies not in verifying biodiversity, resilience, or well-being as isolated factors, but in examining how their systemic integration generates innovative results. This chapter analyzes three case studies - described in section 3 - Emscher, Lyon La Confluence, and the North-South Green Belt in Berlin. Widely known and considered exemplary approaches to ecosystem regeneration, they are characterized by very different scopes of intervention and approaches. However, they are united by the attempt to integrate the feedback between biodiversity, resilience, and well-being in strongly anthropized environments; the relationship between ecosystem services and ecosystem functions; and the creation of habitats for other species beyond human-centric urban landscapes. The large-scale restoration of the Emscher basin in the Ruhr region constitutes a territorial laboratory where the reconstruction of river processes and the valorization of industrial heritage have generated new ecological and social balances. The Lyon La Confluence project, in contrast, interprets regeneration as an adaptive and incremental process, where green and blue infrastructures, energy innovation, and public participation contribute to redefining the relationship between the city and nature. Finally, the Berlin system connecting Park am Gleisdreieck and Natur-Park Südgelände embodies an approach based on the recognition and protection of spontaneous nature, transforming urban voids and former railway areas into

spaces of multispecies coexistence. To critically analyze these emblematic examples, we did not limit ourselves to a description of the results, but used three specific "trace concepts" or interpretive keys - indicated in detail in section 2 - to examine them and investigate their conceptual and practical implications. Through these three analytical lenses, the chapter aims to offer a critical reflection - discussed in section 4 - on the role and potential of nature-based strategies and solutions. Beyond the selected case studies, which were chosen for their international relevance and their alignment with the main analytical parameters of the study, recent literature documents numerous additional examples demonstrating the potential of Nature-based Solutions (NbS) to address the interconnected challenges of climate change, biodiversity loss and human health (World Bank 2021). However, the present research focuses on three particularly significant cases, widely recognised at the global level, in order to undertake a critical investigation through different analytical lenses.

2. Keys to analysis for case studies

The selected case studies illustrated in the following section are emblematic projects of urban regeneration including ecosystem conservation and restoration; these successful examples have been described and analysed at length in literature, we therefore aim at focusing on specific analytical tools for a new and different key of examination of projects' results. The proposed keys to analysis are reported one by one in the following subsections, where the analytical criteria are defined in a general way, namely not declined into specific urban regeneration projects.

2.1. Feedbacks between biodiversity, resilience and well-being in urban environments

A first criterion for investigation of the case studies concerns the interdependence between biodiversity, climate resilience and human well-being in urban environments. Biodiversity loss undermines the capacity of ecosystems to provide essential services, including climate regulation, water and air quality, and food provision (IPBES 2019). Ecosystems characterised by high levels of diversity exhibit greater resilience to climate-related impacts, thereby enabling more effective processes of adaptation and mitigation (Knapp et al. 2019; IPCC 2023). Urban nature plays a pivotal role not only in maintaining climatic and environmental equilibrium but also in influencing human health and well-being directly, by supporting both physical and mental health (EC 2021a; UN-Habitat 2022). Human health is fundamentally dependent on healthy and diverse ecosystems, which sustain the essential conditions for life while simultaneously offering protection against extreme climatic events and disease risk (WHO 2021).

Building on these premises, the critical assessment of the case studies is structured around three interrelated dimensions:

Biodiversity: the analysis addresses strategies to reduce habitat fragmentation and enhance ecological connectivity, the promotion of native species – including pollinators – and the strengthening of both floristic and faunal diversity.

Climate resilience: attention is given to adaptive responses to climatic hazards, such as extreme precipitation events and the urban heat island effect, as well as to mitigation strategies that emphasise carbon sequestration through vegetation and soil storage.

Human well-being: the availability of inclusive and accessible public spaces is considered in relation to their capacity to foster physical activity and recreation, with demonstrable benefits for physical and mental health, stress reduction, and overall quality of life, alongside improvements in air and water quality.

From this perspective, the critical assessment of projects lies not in verifying biodiversity, resilience, or well-being as isolated factors, but in examining how their systemic integration generates innovative outcomes, or conversely, how their disjunction risks reducing interventions to partial solutions. The transformative potential of contemporary urban practices is thus revealed in the interplay of these three parameters, which determines their capacity to serve as models of sustainability.

2.2. Ecosystem services and ecosystem functions, when urban regeneration projects provide both

Sustainable urban regeneration is a broad process of transforming city areas to improve their liveability, resilience, and inclusivity by integrating environmental, social and economic interventions aiming to reduce environmental impact, enhance quality of life, and create long-term value for all stakeholders. Indeed, this holistic process integrates benefits from both human-derived and natural capital, and most importantly should provide not only enhanced ecosystem services, but also improved environmental and ecological conditions of urban spaces. Therefore, a key analytical tool for the assessment of urban regeneration projects consists in evaluate whether project outcomes include ecosystem conservation and restoration with resulting improved ecological functions and Nature-based Solutions' implementation with resulting improved ecosystem services, as these two concepts are not identical (Waylen et al. 2024, Carbonari and Solari 2025).

Ecosystem restoration is defined as "the process of halting and reversing degradation of ecosystems worldwide, resulting in improved ecosystem services and recovered biodiversity" (UNEP-WCMC 2021, IUCN 2021). Ecosystem restoration aims at the regeneration of natural processes through carefully planned interventions, primarily aimed at eliminating human-induced pressures. This approach involves a form of "assisted regeneration" that is largely guided by ecological objectives (Shackelford and McDougall 2023). This means that the main goal is ecosystem functions restoration together with enhancing habitat complexity and biodiversity, which are possible if anthropogenic stressors on the environment are reduced. This is actually an ecocentric perspective according to which ecological recovery and biodiversity gain are valorized for their intrinsic value besides ecosystem services (Carbonari and Solari 2025).

In addition to ecological restoration, there is the concept and implementation of NbS, which, while distinct from ecosystem restoration, share certain similarities (Carbonari and Solari 2025). The International Union for Conservation of Nature, IUCN, defines NbS as "actions to protect, sustainably manage, and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously benefiting people and nature" (IUCN 2016). Therefore, in NbS, with respect to restoration, ecosystem services are more central with closer attention paid to people's needs: NbS address major societal challenges (IUCN 2020, Sowińska-Świerkosz and García 2022), thereby anthropocentric goals prevail and eco-health fades in the background. Dealing with NbS, even when particular care is devoted to interventions to tackle environmental degradation and biodiversity loss, such actions are often conceived to boost ecosystem services (Carbonari and Solari 2025), which serve society following an anthropocentric perspective (for instance, healthier freshwater ecosystems represent improved resources for primary production and provisioning services; many other examples in this sense can be found in literature (Basak et al. 2021, Buckley et al. 2024, among others)).

In light of the definition of NbS and ecological restoration, we can affirm that the main common element between the two is the goal and ensuing actions to restore natural processes; in case of NbS this is a co-benefit, while when dealing with ecosystem restoration this is the core benefit. In many cases, however, ecological restoration is properly designed and implemented alongside targeted efforts to provide additional ecosystem services, making it unclear whether the recovery of natural processes is the primary objective or merely an added benefit. Moreover, if the interventions are highly multipurpose and bring together multiple stakeholders including social and economic interests, such actions can be identified both as Nature-based Solutions and ecosystem restoration measures (Carbonari and Solari 2025). In these conditions, therefore, regeneration projects improve both ecosystem services and ecosystem functioning.

2.3. Setting-up habitats for other species rather than just human-centric urban landscapes

The third criterion on which the analysis of the case studies presented in this chapter is further developed aims to contribute to highlight how, and to what extent, there is an awareness of the role of human actions in creating habitats for other species within urban spaces. Consequently, we question if and how much this awareness is translated into oriented and intentional planning and design approaches. Indeed, in the evolution of the technical and scientific disciplines that study densely anthropized environments, the shift from an anthropocentric to an ecocentric perspective has allowed for a more in-depth investigation of the interaction processes between us and other living beings: a community with which we cohabit environments where our action is dominant but is neither the only one nor certainly the sole one. Over the last fifty years, we have witnessed an evolution that has taken territorial planning from an approach exclusively focused on designing spaces for functions specifically reserved for humans, to a growing sensitivity in recognizing, protecting, and restoring spaces for all species. In this regard, one must recall Ian L. McHarg, a pioneer of ecological urbanism and a prominent member of a generation of scholars strongly oriented towards recovering a harmonious relationship between humanity and the environment. In numerous publications, including his most famous work, Design with Nature (1969), he expressed an approach to planning founded on the knowledge of ecological processes and inspired by them for a harmonious coexistence with the entire biosphere. Sylvia Crowe, as a militant and passionate landscape architect, for all her long professional and academic career, urged public decision-makers, planners, designers, and society as a whole to recognize the plurality of life in the complex biocenoses of which we are a part, and to integrate our actions with observance and respect. In this vein, starting from the late 1970s, the perspective of the city as a complex mosaic of habitats began to consolidate, eventually being articulated into a distinct discipline: urban ecology. In recent times, the awareness of cohabitation in urban space between humans and other living beings has led to the development of possible conceptions and interpretive models, including "ecological urbanism" (Mostafavi, Doherty 2016), "multispecies urbanism" (Solomon, Nevejan 2019), "botanical city" (Gandy, Jasper 2020), and "biophilic city" (Beatley 2011). It is precisely from this last model that the concept of functional coexistence in the urban environment emerges with explicit clarity. According to this concept, the actions of humans are interrelated with and inseparable from the actions of other cohabiting species, and urban natures (Corrado, Lambertini 2011) are not merely a "remnant" of wild nature, but a complex and dynamic eco-

system that requires careful understanding and a more eco-conscious intention in satisfying our desires. The definition of coexistence modalities proposed by this conception is based on the pursuit of a common, pluralistic, and non-speciesist perception of the presence of other species. It also relies on the dissemination of an aesthetic that recognizes in everyday urban landscapes not only the habitats we can intentionally create for ourselves and other species, but also the unintentional ones, which are shaped by spontaneous naturalization processes and guided by unplanned ecological dynamics, a phenomenon that the ecologist Ingo Kovarik defines as "fourth nature" (Kovarik 2005; Kovarik 2013).

3. Selected case studies

3.1. Emscher Park: Systemic Ecological Restoration and Coexistence in a Post-Industrial Riverscape

3.1.1. Introduction to case study

The Emscher catchment restoration is a large-scale intervention on the entire basin of the Emscher River (Figure 1) in the "Ruhr Metropolitan Area" in North Rhine-Westphalia (Germany); the Emscher restoration intervention can be labelled as an integrated set of either riverscape NbS or river restoration measures (Carbonari and Solari 2025) also including urban and industrial regeneration. The Emscher River is a tributary of the Rhine River, its catchment covers 865 km^2 of urban and peri-urban areas densely populated (average 2775 inhabitants per square kilometer). The entire area presents a post-mining and post-industrial landscape. In 1990, the catchment was characterized

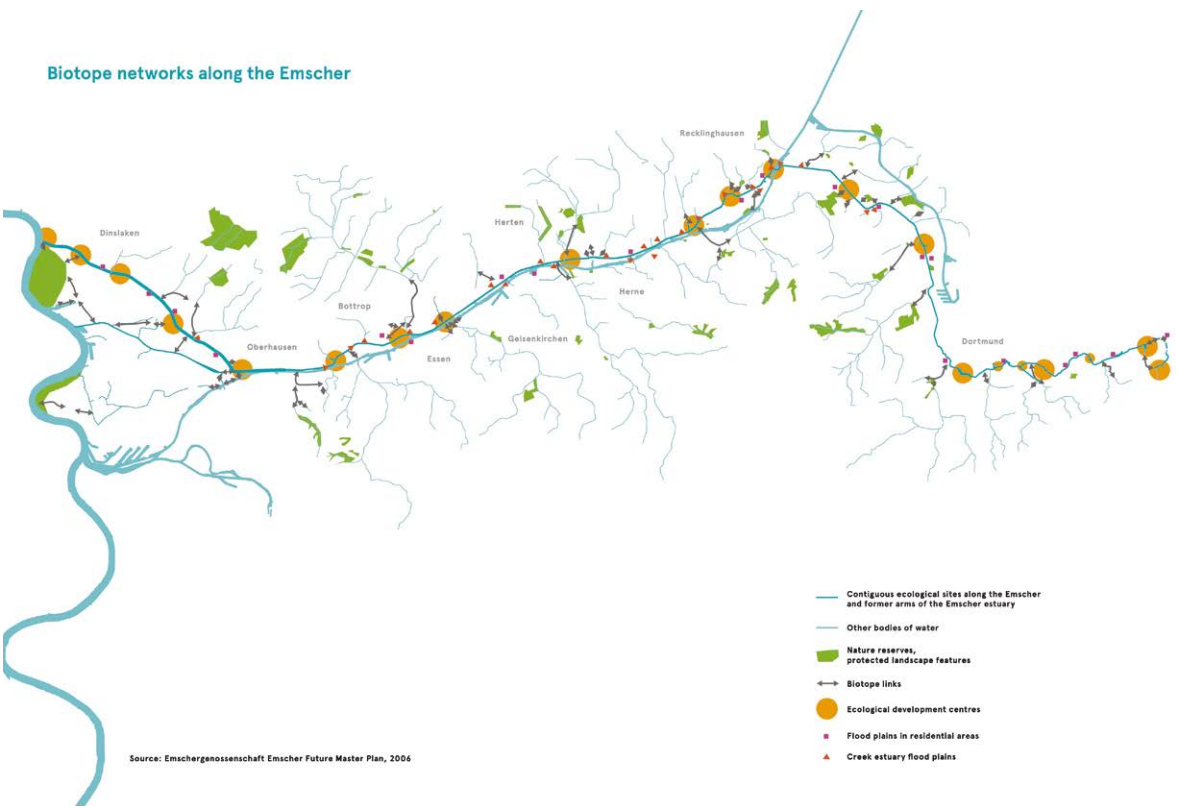

Fig. 1 – Biotope network along the Emscher river (Source: Emschergenossenschaft Emscher Future Master Plan, 2006).

Fig. 2 – Testo Emscher river at Herne and Recklinghausen (Germany). In the background the electricity-museum (Source: Arnoldius 2006, Wiki Common CC By 4.0).

by abandoned mines and factories, along with extensive impermeable and artificial land surfaces. The Emscher River and its tributaries were not only channelized and paved but also served as direct conduits for wastewater. That same year, a 30-year, catchment-wide restoration project was launched with the goal of transforming the Emscher and its tributaries back into natural streams, establishing a separate sewage system, restoring and reconnecting the floodplain, and enhancing the resulting ecosystem services (Gerner

Fig. 3 – A view of Duisburg-Nord park. Design by Peter Latz 2016 (Source: Wiki Common, Autor: Zairon, 2016 CC By 4.0).

et al. 2018 2023). The restoration project started with the construction of a 423-kilometer underground sewer system to separate wastewater from river water, accompanied by the installation of phytoremediation basins. Subsequently, the concrete linings of the streams were dismantled, and the channel cross-sections were widened, including the reclamation of terraces and floodplain. Alongside the restoration of both vertical and lateral connectivity, the renaturation process also involved the establishment of riparian vegetation. The project also included the transformation of a post-industrial area into a permanent lake with flood mitigation objectives: this artificial basin is the Lake Phoenix (Dortmund), which stores 700,000 m^3 in normal weather and can accumulate an extra volume of 240,000 m^3 during flood events (Gerner et al. 2018).

In parallel with the hydrological and ecological interventions, the project also entailed extensive urban and landscape transformations. The restoration was closely integrated with urban planning strategies aimed at improving the quality and accessibility of public spaces along the river corridors. Former industrial areas were reconfigured into green-blue infrastructures, linear parks, and recreational paths connecting urban centers, while new landscape designs emphasized visual continuity between the watercourses and the surrounding built environment (Figures 2 and 3). These interventions redefined the spatial relationship between the river and the city, turning the restored river corridors into structuring elements of the metropolitan landscape (Wuppertal Institute 2017; Laser and Sørensen 2021).

3.1.2. Regenerating Post-Industrial Landscapes: The Emscher as a Laboratory of Biodiversity, Resilience and Well-being

The Emscher renaturation project constitutes an emblematic case for understanding how the full integration of biodiversity, climate resilience, and human well-being can generate innovative outcomes in territorial regeneration (Climate-ADAPT 2024). The restoration of approximately 170 km of watercourses and the reintroduction of complex fluvial morphologies – meanders, wetlands, and vegetated banks – not only re-established functional habitats and enriched biological diversity (with aquatic species rising from 170 to 300 and avifauna from 38 to 147 species), but also strengthened the system's capacity to absorb climate shocks, transforming ecological infrastructure into an active safeguard against floods and extreme events (Climate-ADAPT 2024; Gerner et al. 2018). At the same time, these processes created high-quality spaces for everyday life, demonstrating how biodiversity can be translated into social and health capital (Zimmermann and Lee 2021). The creation of over 300 hectares of water retention areas and natural floodplains, together with the desealing of urban soils, illustrates the inherently multi-functional nature of the interventions: measures designed to mitigate climate risks simultaneously fostered ecological habitats and enhanced urban liveability by reducing heat islands and expanding opportunities for collective use (Climate-ADAPT 2024; Zimmermann and Lee 2021). Similarly, the Emscher Landscape Park – a 70 km ecological corridor connecting 17 cities – demonstrates that green infrastructure can simultaneously serve as an ecological device, a resilience tool, and a social infrastructure, with direct impacts on health and territorial cohesion (EC 2022). The transformation of industrial heritage into parks, museums, and cultural centres further confirms that environmental regeneration gains strength when it is also translated into symbolic and community regeneration, restoring shared identities to post-industrial territories (Kaçar 2016; Labelle 2001). A critical reading of the case, however, highlights that disarticulation among the three parameters risks reducing the transformative scope of the intervention. The impossibility of fully restoring original ecosystems due to deep soil alterations, the structural dependence on engineered infrastructure such as sewers and pumping sys-

tems (Laser and Sørensen 2021), and the persistence of local inequalities in access to green spaces (Zimmermann and Lee 2021) reveal that biodiversity, resilience, and well-being are not always pursued in a balanced way. The innovative value of the project therefore lies not only in the outcomes achieved, but in its ability to weave together ecological, climatic, and social dimensions within an integrated framework. It is precisely in their interconnection – rather than in the sum of sectoral objectives – that the transformative capacity of contemporary regeneration practices can be measured (Gerner et al. 2024).

3.1.3. The Emscher intervention outcomes in both enhanced ecosystem services and ecological functioning

The Emscher interventions definitely met the goal of ecological restoration since the set of integrated measures goes beyond the setting-up of new green and blue areas. Indeed, river processes and ecological functioning were restored thanks to the achievement of the necessary prerequisite consisting in the mitigation and even removal of the anthropogenic stressors, for instance pollutants, which were the main cause of ecological degradation of both aquatic and terrestrial ecosystems. The extensive reafforestation of stream banks and floodplain reconnection allowed relevant nitrogen, phosphorus and carbon retention quantified in tonnes per year, comparing pre- and ex-post intervention conditions (Gerner et al. 2018). A similar quantitative analysis was conducted for habitat quality and species diversity, focusing on the increased number of watercourses' kilometers achieving good ecological status (as defined by the Water Framework Directive (European Parliament and Council of the European Union 2000, European Commission 2016)) and the rise in taxa richness (Gerner et al. 2018 2023). The Emscher catchment restoration also provided enhanced ecosystem services, which were designed and measured, together with ecological outcomes, all throughout implementation phases according to both biophysical and economic evaluation. For instance, the economic benefits of reducing flood risk due to the artificial Lake Phoenix are assessed in terms of avoided costs of flood damage, the rise in real estate value due to the natural amenities offered by the lakeshore, and the added opportunities for recreational and cultural ecosystem services. In general, ecosystem services were planned and assessed according to the DESSIN ESS Evaluation Framework (Anzaldua et al. 2018), a procedure developed within the European research project DESSIN (Demonstrate Ecosystem Services Enabling Innovation in the Water Sector 2014-2017) giving guidance to analyse the difference in value of Ecosystem ServiceS (ESS) in a system before and after restoration and management measures. Moreover, the Emscher case study can be labelled as a successful implementation of multiple and integrated NbS with a resulting improvement in ecosystem services delivery because the solutions adopted are highly multipurpose, also addressing social and economic needs, and present an extensive engagement of multiple stakeholders. Indeed, with respect to this last issue, the DESSIN ESS Evaluation Framework relates each case-relevant ecosystem service to local stakeholders (Anzaldua et al. 2018), in particular water board and residents; stakeholders are then informed and often actively involved in co-design since the beginning of the planning phase.

3.1.4. Emscher renaturation project and Duisburg-Nord park as a model for Ecological Coexistence

The widespread industrial decline of the twentieth century left a legacy of derelict, post-industrial landscapes often viewed as ecologically degraded and functionally obsolete (Loures and Panagopoulos 2007; Rahdar and Milani 2025). Traditional landscape design,

frequently prioritizing aesthetics or singular functionality, has historically failed to address these complex sites, often overlooking their potential for ecological integrity (Rahdar and Milani 2025). In response to this failure, a paradigm of ecological landscape design has emerged, advocating for holistic approaches that integrate natural processes, biodiversity, and human social needs (Rahdar and Milani 2025). The Emscher renaturation project and the Landschaftspark Duisburg-Nord, designed by Latz and Partner, stands as a seminal exemplar of this philosophy. Rather than eradicating the site's industrial past, the project demonstrates how planning and design can leverage industrial remnants to create complex new habitats, fostering remarkable biodiversity and facilitating a functional coexistence between human activity and non-human species. The design strategy for Duisburg-Nord represents a radical departure from conventional reclamation, which typically involves remediation and erasure. The Latz approach was instead based on interpreting the existing fragmented layers of the site (Loures and Panagopoulos 2007). The architects fundamentally "accepted the dynamic nature of nature as the basis of their design" (Treib, in Latz 2016). This acceptance of industrial nature—the spontaneous vegetation and ecological processes already occurring on the derelict site (Keil 2019)—was the project's foundational principle. Instead of imposing a new, idealized "natural" landscape, the design aimed for a harmonious reclamation of both the natural and the built environments (Loures and Panagopoulos 2007). This methodology treats the industrial structures not as liabilities to be cleared, but as essential components of the new landscape, transforming the former steelworks into a multifunctional, socially engaging, and ecologically sustainable space (Rahdar and Milani 2025). A primary success of this approach is the park's function as a significant refuge for biodiversity. Industrial brownfield sites, contrary to perception, often form the "backbone of urban biodiversity" in post-industrial regions (Keil 2019). The structural variety of the Emscher renaturation project, with its disparate soils, railway embankments, concrete bunkers, and retaining walls, creates a mosaic of unusual microhabitats (Latz 2016; Keil 2019). This physical complexity supports an almost complete spectrum of successional stages, from pioneer communities on raw slag to established pioneer forests (Keil 2019). The park is now considered a "local hotspot for biodiversity," vital for the preservation of many rare and endangered species (Keil 2019). Areas where mining subsidence created inaccessible swamps, for example, were not restored but protected as valuable habitats, contributing to biodiversity by allowing natural processes to unfold without human interference (Latz 2016). Furthermore, the project pioneers favorable conditions for coexistence by integrating human-nature interaction directly into its ecological framework (Rahdar and Milani 2025). Emscher renaturation project and Duisburg-Nord are not a fenced-off nature preserve; they constitute a natural park that utilizes the industrial remains of past industry to create culturally stimulating landscapes (Loures and Panagopoulos 2007). Visitors are invited to experience this emergent industrial nature, climbing blast furnaces that overlook pioneer forests or walking on elevated structures above the wilderness (Latz 2016). The design facilitates coexistence through spatial separation that allows for observation without disturbance; the most wild areas are often inaccessible but remain visible from railway embankments (Latz 2016). The importance of the Emscher renaturation project and the Landschaftspark Duisburg-Nord lies in its successful synthesis of industrial heritage, ecological processes, and human social needs (Loures et al. 2006). It provides a powerful, practical precedent, demonstrating that ecological design can transform seemingly damaged landscapes into vital habitats for diverse species (Keil 2019; Latz 2016). By rejecting erasure and instead embracing the dynamic processes of industrial nature, the park creates the necessary conditions for a new form of coexistence, proving that post-industrial sites can be reclaimed not only for society and culture, but for the environment itself (Loures and Panagopoulos 2007).

3.2. Lyon Confluence: An Adaptive Landscape for Societal and Fluvial Resilience

3.2.1. Introduction to case study

The La Confluence district in Lyon is situated at the edge of the historic city, on the artificial peninsula located between the Rhône and Saône rivers. This area was urbanized in the 19th century, during the industrial revolution, to accommodate the river port, industrial zones, and rail and road infrastructure. Following the manufacturing sector crisis beginning in the late 1970s, the entire area, encompassing approximately 76 hectares, experienced extensive phenomena of dereliction resulting from progressive de-industrialization. In the late 1990s, the municipal administration defined an urban renewal program aimed at the urban reconversion of the district. An international competition was launched to acquire a strategic masterplan, and a public-private urban transformation company was subsequently established. The winning masterplan project, designed by Michel Desvigne and François Gréther, envisions a dynamic urban structure where the enhancement and reconversion of industrial infrastructure are integrated with an evolving system of gardens, the *jardins provisoire* (provisional gardens). This system is founded upon the action of *preverdissement* (pre-greening): a preventive planting strategy that supports the concept of establishing various temporal identities and configurations, oscillating between temporary and permanent states, for the new green spaces—totaling approximately 30 hectares. This strategy allows for the implementation of public spaces prior to the completion of construction interventions (residential buildings and offices), accompanying them according to an incremental logic. In the development of the masterplan (Figure 4), a 'two-speed' landscape is devised. Here, certain temporary elements—such as meadows, specific vegetated strips, and pioneer woods—are established preemptively within an open space system that

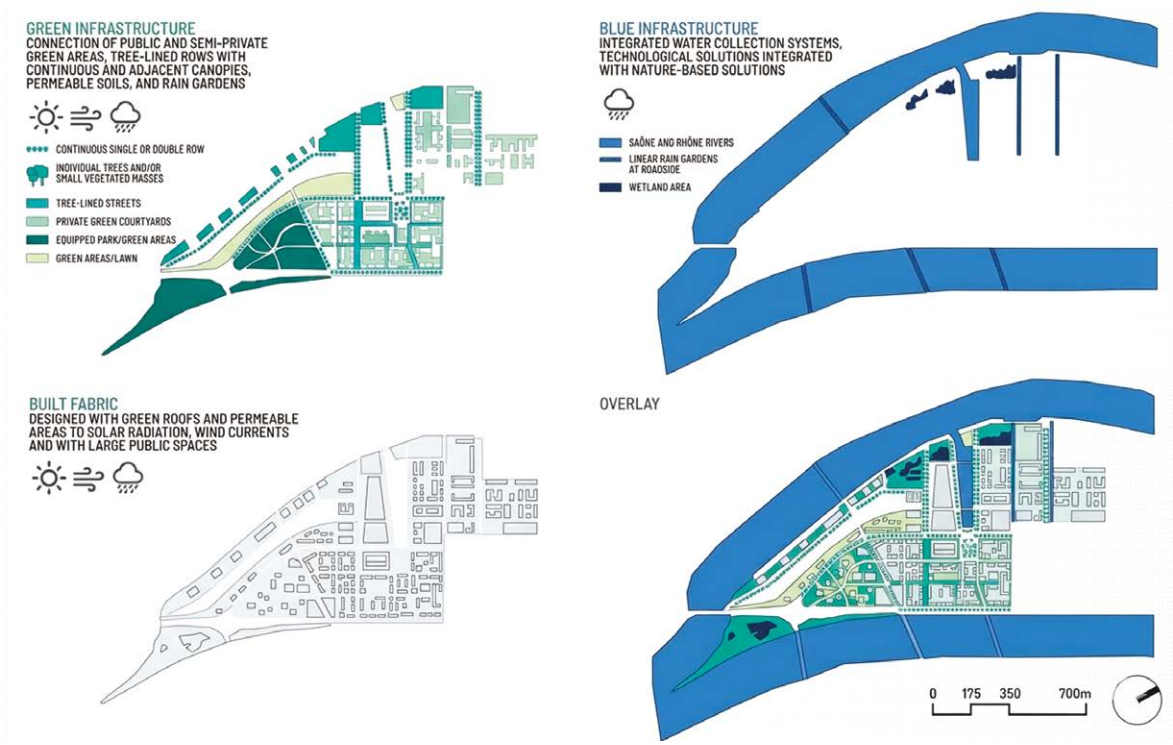

Fig. 4 – The Confluence masterplan conceived by Michel Desvigne and François Gréther (Graphic processing and image source: Lorenzo Nofroni, 2025)

Fig. 5 – Jardin du Musée des Confluences at the confluence of the Rhône and Saône rivers designed by Coop Himmelb(l) au and EGIS aménagement. (Source: Wiki Common, Autor: Guilhem Vellut, 2017 CC By 2.0).

Fig. 6 – Jardin Aquatique Ouagadougou at La Confluence – Lyon (Source: Wiki Commons, Author: Guilhem Vellut 2017 CC BY 2.0).

encircles areas awaiting construction. Conversely, the perennial elements, consisting of tree alignments, embankments, and infrastructure, are progressively constituted as the building interventions take shape, ultimately providing a structural and definitive vegetative configuration to the entire district. Particular attention is dedicated to the fluvial system and water management. Specifically, the project has resulted in a substantial transformation of the Saône's left bank, restoring this important ecotonal strip between the emerged land and the river to a pre-industrial conformation (Figure 5). Meanwhile, the new eco-district is situated within a dynamic context, influenced by the geomorphological processes of the two rivers. Wetlands, meadows, and forested ar-

eas ensure continuity of the green infrastructure (Figure 6), introducing high environmental value and increasing vegetal and animal biodiversity within the urban system. This is achieved through the reconstruction or spontaneous definition of numerous and diversified habitats suitable for marsh species, birds, insects, and aquatic animals. The Confluence project leverages the inherent instability of the area as a strength, implementing a strategy of progressive and evolutionary infiltration of vegetation that occupies the spaces and develops concurrently with the city's growth. This represents an exemplary intervention based on the rehabilitation of the fluvial ecosystem and a system of provisional parks, capable of accommodating all transformations without necessitating the completion of the ultimate grand design (Corner and Tiberghien 2009).

3.2.2. City, nature and community: the transformative capacity of La Confluence

The *La Confluence* project in Lyon stands as one of the most ambitious examples of urban regeneration in Europe, grounded in an integrated approach where biodiversity, climate resilience, and human well-being are treated as foundational principles rather than supplementary objectives (SPLLC 2019; Ferretti 2020). The reintroduction of nature – through the creation of a continuous green framework, large-scale soil remediation, and the development of diverse habitats – reconnected the new district to territorial ecological networks and initiated processes of ecosystem reconstruction (SPLLC 2019; Lyon Confluence 2025). These actions, however, extend beyond the ecological dimension: they also enhanced urban resilience by increasing rainwater retention, reducing urban heat islands, and improving microclimatic quality, thus demonstrating how biodiversity and resilience measures can generate cross-cutting co-benefits (GRAIE-OTHU 2025; Zimmermann and Lee 2021). At the same time, sustainability and energy strategies – such as the *Hikari* block, the first positive-energy mixed-use complex in Europe, equipped with a district-level smart grid – illustrate the interplay between resilience and well-being at both building and urban scale. Energy efficiency and microclimatic adaptation provide immediate benefits for residential comfort while contributing to broader goals of carbon neutrality (Darchen 2020; Morishita-Steffen et al. 2021). Similarly, SuDS installations function not only as technical devices for stormwater management but also as urban habitats that foster biodiversity while improving the usability and comfort of public space (Lyon Confluence 2025). Resident well-being emerges as the synthesis and the true measure of the project's transformative capacity. The provision of local green spaces, the emphasis on *mixité* and social housing (23%), design principles such as guaranteed solar access for each dwelling, and the development of health-oriented facilities such as the therapeutic garden within the *Eurêka* block show how biodiversity and resilience were also translated into instruments of inclusion, health promotion, and social cohesion (SPLLC 2019; Ferretti 2020). Public participation further reinforced this collective dimension: the initial exhibition attracted more than 24,000 visitors and over 1,000 comments, leading to revisions of the masterplan, while post-occupancy surveys continue to integrate user feedback into subsequent *Cahiers des Charges*, ensuring an iterative and adaptive design process (Lyon Confluence 2025). Nonetheless, a critical reading reveals limitations that arise when the three parameters are only partially integrated. While around 35 hectares of green space and 4,500 new trees were created, systematic ecological monitoring has not been implemented, limiting the ability to assess measurable biodiversity improvements (Carbonari and Solari 2025). Moreover, with only one-third of the district served by a separate sewer system, the intervention falls short of being considered true ecological restoration, as anthropogenic stressors have not been sufficiently reduced to achieve large-scale ecological recovery (Carbonari

and Solari 2025). In conclusion, the transformative strength of *La Confluence* lies in the systemic interplay between biodiversity, resilience, and well-being: when these parameters are mutually reinforcing, they generate innovative outcomes capable of redefining the relationship between city and nature; when pursued unevenly, they risk producing a sum of sectoral actions that, while improving urban quality, fall short of full ecosystemic regeneration. The project demonstrates that the measure of urban sustainability rests on maintaining this systemic integration, avoiding the drift towards parallel but disconnected trajectories.

3.2.3. The Lyon Confluence regeneration, a case study successfully addressing societal challenges and overlooking environmental and ecological actions

The Lyon Confluence regeneration includes integrated and progressive interventions highly multipurpose and addressing several societal needs; the whole intervention is carried out through an effective and extensive cooperation between public and private sectors, complemented by a systematic and continuous involvement of the local community. The project brought off a diverse, inclusive, and sustainable district by developing a built environment with high functional diversity. By 2030, it will deliver 5000 new housing units, including social housing, and ensure buildings meet high energy performance standards. It also supports a vibrant and diverse economy, home to 1650 businesses, and features a wide range of educational, cultural, and recreational facilities. A key achievement is the successful transformation of the waterfront (Figure 5), which has restored natural features and improved access for residents. Notably, the Saône riverbanks have been redeveloped into Quai Rambaud, a five-kilometer continuous promenade now reconnected to the wider city and equipped with integrated infrastructure for soft mobility (SPL Lyon Confluence). With regard to ecological restoration, however, the measures undertaken are not as effective as the social, economic and urbanistic ones (Carbonari and Solari 2025). Actually, extensive green areas totaling 35 hectares have been developed, along with the planting of 4500 new trees; the blue-green spaces are spread across key areas, including the main Champ Park (Figure 6), three aquatic gardens, and several neighborhood gardens; tree species were carefully chosen to enhance biodiversity, and in 2011, a survey of the animal species inhabiting these blue-green spaces identified 32 different bird species (SPL Lyon Confluence). However, two main issues persist: i) the measures taken to reduce human-induced pressures contributing to ecological degradation have not been thoroughly or scientifically addressed, for example, less than one-third of the district is equipped with a separate sewage system for waste and grey water, and there is no documented evidence of improved water quality in the receiving bodies; ii) with respect to the new green-blue spaces there is no analytical assessment of ecological enhancement, for instance a consistent quantitative monitoring is not provided (i.e. absence of quantitative comparison pre-post intervention or restored-unrestored areas). Regarding this last point, it is emblematic that literature tends to assess the value of green-blue spaces of the district just in terms of boosted value of real estates (Roebeling et al. 2017).

3.2.4. Design a complex habitat system for a new model of coexistence among all species of the Lyon urban ecosystem

The primary objective of the masterplan (Figure 4), designed by Michel Desvigne and François Gréther, was to reconstruct the relationship between the city and its rivers. This vision translated into a complex environmental strategy that extends beyond

a simple urban park system, aiming to reintroduce habitats for plant and animal species to create favourable conditions for coexistence between humans and all other species. The masterplan's greatest innovation is realizing a system of diffused parks and gardens as an ecological strategy to create a network of habitats and urban ecological corridors. The urban regeneration plan is thus conceived starting from the creation of a green infrastructure based on the connection between open spaces, including tree-lined rows with continuous and contiguous canopies that act as corridors for avifauna, and the widespread use of permeable soils and rain gardens. These fragmented yet connected elements create a mosaic of micro-habitats that allows fauna and flora to move and thrive within the urban fabric. To ensure the area's immediate vitality, the concept of a "two-speed" landscape was introduced: alongside perennial and long-term plantings, jardins provisoires (provisional gardens) were implemented. These allowed for the creation of favorable conditions for plant colonization in areas awaiting urban and building development, activating ecological cycles from the project's very first phases. In parallel, the project developed a sophisticated blue infrastructure, based on the renaturalization of the Rhône and Saône banks and the creation of numerous floodable open spaces. These rain gardens and infiltration basins not only prevent flooding and reduce the load on the sewer system but also create essential wetland habitats and become vital places for amphibians, aquatic insects, and specific hygrophilous flora, significantly diversifying the district's biodiversity. An emblematic example that translates the philosophy contained in the Desvigne and Gréther masterplan to a neighborhood project scale is the Champ de la Confluence (Figure 6), designed by the landscape architecture firm BASE. Described as the "missing piece" in the district's overall park strategy, it was envisioned as an urban woodland that functions as a cohabitation space among species. In this sense, the most relevant aspect of the BASE project is the fruitful designed configuration of spaces that replicates the logic of the river's geographical movements. In fact, instead of imposing a rigid design, the project mimics the site's natural processes; the streets themselves are designed to wander around buildings in an "alluvial nature." This process-based approach works with the nature of the place, creating varied topographies (mounds, swales) and utilizing post-industrial soil to encourage the spontaneous colonization of pioneer vegetation. This "alluvial nature" creates a dynamic, evolutionary landscape due to generates a mosaic of micro-climates and soil conditions (dry on the high points, wet in the basins) that maximizes the diversity of ecological niches—a system designed to trigger ecological processes that, over time, attract and support all species adapted to a river confluence environment.

3.3. From Park am Gleisdreieck to Natur Park Südgelände, the North-South green belt of Berlin: a rich and diversified system of open spaces for the urban ecosystem (Lorenzo)

3.3.1. Introduction to case study

The system of open spaces (map in Figure 7) situated between Park am Gleisdreieck (Figure 8), in central Berlin, and Natur Park Südgelände (Figure 9) in Schöneberg, represents a prime example of how a complex urban trajectory, structured by intricate social and environmental events, can transform into an open-air laboratory for experimenting with novel paradigms for interspecies coexistence within the urban environment. This instance, unique in certain respects due to its origins in the peculiar historical, geopolitical, and urban context of Berlin, has generated new contemporary urban landscapes for the Western city. These landscapes consist of hybrid and not entirely programmed spaces, where coexistence, diversity, resilience, and health

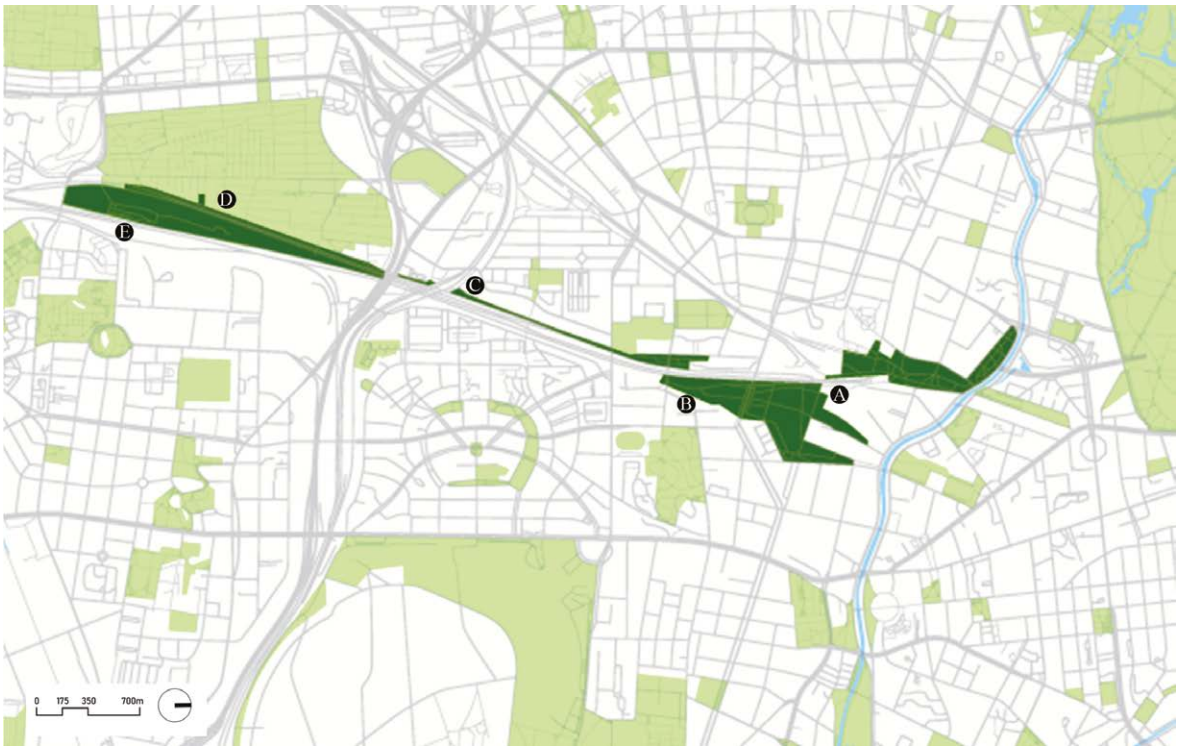

Fig. 7 – The park system, indicated by letters on the map: Park am Gleisdreieck (A), Dora-Dunker park (B), Nord-Süd-Grünzug (C), Parkbereich Insulaner (D), and Natur Park Südgelände (E). (Graphic processing and image source: Lorenzo Nofroni, 2025).

manifest as quotidian and infra-ordinary phenomena (Perec 1989). These phenomena transcend the wholly artificial critical threshold that separates our species from the remaining living organisms and occur across the entirety of the biocoenoses coexisting within this urban space. If a satellite image of central Berlin is observed, focusing on Potsdamer Platz and tracking the infrastructural alignment constituted by the railway bundle running from the center toward the southwest, a rarefied urban fabric is readily apparent. This fabric is characterized by extensive open spaces rich in vegetation which, despite minor discontinuities, collectively form an articulated and complex ensemble of urban parks spanning approximately 100 hectares. Encountered sequentially from north to south are the following components: Park am Gleisdreieck (26 ha), Dora-Dunker park (6 ha), the Nord-Süd-Grünzug—a linear park approximately 2 Km long, Hans-Baluschek Park (6 ha), Parkbereich Insulaner (16 ha), and Natur Park Südgelände (18 ha). This parks and open spaces system stands as an exceptional laboratory, in the unique context of Berlin, marked by wartime destruction and political division, resulted in the emergence of vast urban voids, most notably the extensive, abandoned railway yards (Figure 8 and 9) (Kowarik and Langer 2005). Left to undisturbed natural colonization processes for decades, especially in the isolated territory of West Berlin, these "iron landscapes" (Gandy 2020) became incubators for novel ecosystems. This phenomenon gave rise to a spontaneous and resilient ruderal vegetation, termed "urban wilderness" or "nature of the fourth kind" (Kowarik 2005, cited in Kowarik 2015). The park system connecting Park am Gleisdreieck and Natur-Park Schöneberger Südgelände is a direct product of Berlin's conscious decision to integrate rather than erase these unique ecological assets. This approach, formalized in planning instruments like the 1994 Landscape Program, treats spontaneous nature as a valuable component of the urban green infrastructure. The north-south

Fig. 8 – One of the clearings with grass and pioneer vegetation in the Park am Gleisdreieck (Source: Wiki Common, Autor: Lienhard Schulz, 2011 CC By 3.0).

Fig. 9 – Groups of shrubs and a pristine forest grew out of the former railway wasteland, all without human influence in the Natur Park Südgelände (Source: Wiki Common, Autor: Dirk Ingo Franke, 2009 CC By 2.0).

parks system represent distinct yet complementary strategies for managing this new wilderness. Natur-Park Schöneberger Südgelände, developed on a former freight yard, exemplifies a conservation-led approach. Here, the design preserves the spontaneous pioneer forest by "staging" it through minimal interventions, such as elevated walkways, effectively linking conservation with recreation (Kowarik and Langer 2005; Kapitza and Hofmeister 2020). Conversely, Park am Gleisdreieck, located near the central Potsdamer Platz, masterfully integrates high-value wilderness areas with intensive public use through sophisticated, deliberate zoning (Kowarik 2015). This park demonstrates how "urban wilderness" can be a core, branded component of a modern, highly-frequented park, not just a residual element (Kowarik 2015).

3.3.2. The urban ecological regeneration of Natur Park Schöneberg Südgelände between biodiversity, climate resilience and wellbeing

The Natur Park Schöneberg Südgelände (NPS) in Berlin represents an emblematic case of urban transformation capable of systematically integrating biodiversity, climate resilience, and human wellbeing, overcoming the fragmentation of sectoral approaches (Lambertini 2006; Kowarik 2022).

The project originated from the reclamation of a large disused railway area – the former Tempelhof freight yard – which had been abandoned for around fifty years, where residual infrastructural elements intertwine with established spontaneous vegetation (Kowarik and Langer 2005; Dellatorre 2022).

A critical analysis of the Südgelände highlights the virtuous interaction between these three dimensions and illustrates how an approach based on the coexistence between habitats and human use can generate innovative outcomes (Boschiero et al. 2022; CEREMA 2012).

Biodiversity constitutes the founding element of the project, which led to the site being recognised as an urban ecological reserve. The area hosts an extraordinarily rich ecosystem, which developed thanks to the long period of abandonment: more than 350 plant species, at least 30 breeding bird species, and 95 species of wild bees – including 34 protected ones – have been recorded (Kowarik and Langer 2005; Natur Park Südgelände 2025). The spontaneous vegetation originally present has been progressively enriched with alien species, recognised by the Berlin school of urban ecology as structural components of the urban ecological mosaic (Kowarik and Langer 2005; Dellatorre 2022).

The conservation of this area within a densely built context plays a crucial role in reducing ecological fragmentation and strengthening connectivity among different urban habitats, making the park a strategic node within Berlin's green network (CEREMA 2012; Wolff et al. 2023).

Spontaneous ecological processes are recognised as resources that contribute to climate change mitigation and adaptation. The species colonising these environments show a high degree of resilience, adapting to conditions of aridity, thermal stress, and poor soil (Kowarik 2022).

In this way, the site functions as a natural device for mitigating urban climatic hazards, such as the heat island effect. Although no quantitative data are available on carbon sequestration, the existing vegetation contributes to a diffuse green network, improving the carbon balance and mitigating the impacts of climate change (Annese, Mininni, and Scalera 2021).

The Südgelände was conceived as both an ecological and cultural infrastructure, returning to the community a place subtracted from the city for decades. The park provides spaces for leisure and physical activity, promoting psychophysical wellbeing and stress reduction, becoming a space for social interaction and direct contact with nature (Rinaldi 2024). The protection of spontaneous vegetation, valued for its ecological role, also contributes to the improvement of air quality and the urban microclimate. A distinctive architectural feature is the metal grating walkway, raised about 80 cm above the ground, allowing visitors to cross four hectares of protected natural reserve safely, ensuring public accessibility without compromising the habitat (Kowarik and Langer 2005).

Local artists have also reinterpreted the former railway tracks, blending art, ecology, and memory of place (Dellatorre 2022).

The innovation of the NPS does not stem from a single element but from the interdependence between conservation, adaptation, and public use. The project demonstrates

how biodiversity can be enhanced through the protection of spontaneous habitats, even those partly inaccessible to humans, and how resilience emerges from ecological systems capable of adapting and evolving over time (Kowarik 2022). Similarly, the park's public experience is founded on a direct and respectful relationship with nature, in which human wellbeing and ecological integrity mutually reinforce one another (Annese, Mininni, and Scalera 2021; Rinaldi 2024). From this perspective, the Südgelände stands as a paradigm of ecological urban regeneration, successfully integrating nature, culture, and design (CEREMA 2012; Boschiero et al. 2022).

3.3.3. Berlin's parks network both improves ecosystem services and ecosystem functions, but cause-effect assessment of restoration outcomes and assessment of reduction of anthropic stressors are partial and scattered

Berlin's parks network is an emblematic example of urban rewilding, which restored, over decades and across large scales, natural habitats within city environments starting from degraded areas transformed into self-sustaining ecosystems with minimal long-term human intervention. German ecologists are indeed the initiators of urban ecology and since the 1970's they restored Berlin "wastelands" – former industrial sites colonized by novel mixtures of native and non-native species – according to the principles of rewilding (Kowarik 2018, Kowarik and Langer 2005, Kowarik 2019, Kowarik 2023).

The ecological outcomes of these rewilding processes and conservation of habitats has been widely mapped and monitored with interesting and even surprising results, like the one that non-native species are not necessarily ecologically harmful: in areas with prevalence of non-native species such as black locust trees from North America, many organisms, such as ground beetles and spiders, were as abundant as in areas dominated by indigenous plants; and also, less than 6% of Berlin's endangered plants are threatened by non-natives species (Kowarik 2019, Kowarik 2023). Ecology studies documenting ecological improvement in specific areas of Berlin's parks network are several. For instance, Kowarik and Langer (2005) documented in Natur-Park Südgelände (approximately 18 ha) the spontaneous doubling of woodland between 1981 and 1991 passing from 37 to 70% of the park area. This colonization was mainly carried out by pioneer species, such as birch and locust trees, then followed by maples. Another example of documented ecological results in specific areas of the park network is the one of a bird community in the Tiergarten (over 200 ha) illustrated in Felgentreff et al. (2024). The authors document number of species and functional richness of birds community from 1850 to 2022: in the years 1850, 1950 and 2022 the number of species passed from 53, to 16, to 59, respectively, and values of functional richness were 0.72, 0.28 and 0.82; the authors also state that a highly frequented park situated in a city center can shelter a high species richness. However, the research does not explicitly relate the time changes of bird population to vegetation changes, it just states that the park extension and the vegetation heterogeneity favour the good status of the bird community. In other words, a cause-effect assessment of ecological results is lacking. This is also missing in the previous example of plant colonization in Natur-Park Südgelände (Kowarik and Langer 2005): for instance, what are physical, chemical and biological changes in the soil matrix, which are clearly among the drivers of plant community changes? For example, it is acknowledged that nitrogen fixation is needed for the passage from pioneering trees to more demanding species (Kowarik and Langer 2005), but no quantitative measures of it are provided. Overall, ecology researches on Berlin's parks broadly lack a quantitative assessment of contaminants

and other stressors trends, which are related to management changes of green areas, thus overlooking the changes of anthropic pressures that are among the primary regulators of ecological status.

Some ecosystem services (ES), in particular provisioning and regulatory ES such as air, soil and water purification and climate regulation, due to Berlin's parks are also poorly assessed in a quantitative way. For instance, scientific literature scarcely focuses on the microclimatic effects (e.g. heat waves, physiologically equivalent temperatures) of the parks (Langer et al. 2021) and rather places the parks in more global climatic trends to which the parks as well as the rest of the Berlin area are subject (Fenner et al. 2019, Mukherjee et al. 2025). Conversely, recreational and cultural ecosystem services are better assessed in the available literature (Rinaldi 2024, Mukherjee et al. 2025, among others).

Overall, the partial and scattered quantitative assessment of cause-effect relations in ecological results and of provisioning and regulatory ecosystem services is also due to the prevalence in literature on Berlin's parks and rewilding of disciplines such as urban planning and design, social sciences and urban studies, urban ecology; while environmental chemistry, water resources, atmospheric sciences are not quite so present. This results in an insufficient attention paid to the status of environmental matrices underpinning the outcomes of ecosystem restoration and ecosystem services. Finally, it is possible to affirm that Berlin's parks network both improves ecosystem services and ecosystem functions even if a complete transdisciplinary analysis is not available. Eventually, we recall that a deeper insight into cause-effect relationships and wider quantitative assessment are not the pretension of a one hundred percent deterministic understanding of complex realities, but rather an effort toward a systematic interpretation of changes drivers.

3.3.4. Between Gleisdreieck and Südgelände: A Laboratory for Staging New Wilderness for Urban Coexistence

The contemporary urban ecosystem is a paradox: while we are witnessing a dramatic impoverishment of global biodiversity, cities are unexpectedly revealing themselves as places of concentration for high biological diversity (Rinaldi 2024). This observation demands a radical reconsideration of the role of urban planning and design. No longer just actors in growth and the management of human flows, but fundamental mediators in the construction of new habitats and coexistence strategies among the species that inhabit urban ecosystems. Berlin represents, in this sense, an exceptional laboratory. Its unique 20th-century history—wartime destruction, the division of the Wall, and the consequent emergence of vast urban voids—created the conditions for the development of unique ecosystems. Decommissioned industrial areas, and particularly the vast railway yards, were left abandoned for decades. In these "no-man's lands," especially in isolated West Berlin, natural colonization processes took place undisturbed (Kowarik and Langer 2005). This phenomenon led to the birth of what has been defined as "nature of the fourth kind" (Kowarik 2005, cited in Kowarik 2015): a spontaneous, resilient nature that thrives on the debris and infrastructures of the Anthropocene, creating hybrid habitats of extraordinary ecological value. The fall of the Wall posed a crucial question: what to do with these "iron landscapes" (Gandy 2020)? The city's answer was not tabula rasa, but a conscious approach of integration and valorization. This awareness translated into cutting-edge planning tools. As early as 1994, reunified Berlin equipped itself with the Landscape Program (Landschaftsprogramm) and the Land Use Plan (Flächen-

nutzungsplan), which assigned a central role to the open space system and the protection of diffuse naturalness. It is in this political and cultural context that the park system connecting Park am Gleisdreieck to Natur-Park Schöneberger Südgelände was born, transforming an infrastructural fracture line into an ecological backbone. The Natur-Park Schöneberger Südgelände is perhaps the most radical example of this vision. Developed on the former Tempelhof freight yard, the park is the result of planning aimed at "linking conservation and recreation" (Kowarik and Langer 2005). Instead of imposing a traditional design, the project opted to preserve the ecological succession already underway—a pioneer forest of birch and black locust trees that had grown spontaneously between the tracks. The design intervention was minimal and targeted: the insertion of a system of paths and a system of rules capable of gradually dosing and conditioning human accessibility, based on the degree of protection and respect for the ecological functions of the park's different areas. This choice is a masterful coexistence strategy: humans are invited to enter in the wilderness as observers, to feel and interact with respect and a sense of community. The park is not tamed nature, but a hybrid nature carefully staged (Kapitza and Hofmeister 2020). The park's management continues to follow this principle, balancing rigorous conservation of some areas with public access, fostering a co-evolution among the industrial vestiges, the flora and fauna, and the human visitors (Suhrhoff 2022). If Südgelände represents the pole of conservation, Park am Gleisdreieck, closer to the city's beating heart (Potsdamer Platz), embodies the pole of intensive recreation (Kowarik 2015). The challenge here was complex: how to integrate the precious areas of ruderal vegetation—the urban wilderness—with the pressing public demand for space for sports, play, and leisure (Gandy 2020). The solution by Atelier Loidl, winner of the international competition and developer of the project drafted and implemented between 2006 and 2013, was a conscious and intelligent zoning. The park is divided into high-maintenance areas, intended for intensive human use (lawns, plazas, sports areas), and low-maintenance areas, where spontaneous vegetation has been not only preserved but actively integrated into the design (Kowarik 2015). These habitats are protected, but made visible and appreciable, an integral part of the park's aesthetic experience. Gleisdreieck demonstrates how urban wilderness became possible within a highly-frequented park, not as a remnant, but as an essential and characteristic component of the park's identity itself (Kowarik 2015). Ultimately, the park system developing along the railway axis between Potsdam and Schöneberg is the implementation of a possible response to the fundamental challenges facing the urban choices of many European cities. Among these is overcoming the public perception that sees uncultivated spaces as disorderly, dirty, or unsafe (Rinaldi 2024) and striving to leave a habitable environment for our descendants of different species (Lambertini 2022). They do so through the power of design. Landscape architecture acts as a cultural mediator, building "a balance between ecology and sentiment" (Rinaldi 2024). The walkways of Südgelände and the clear zoning of Gleisdreieck frame the wild, making it legible, accessible, and characteristic, rooted in the experience of an urban phenomenology that is found all around us. These projects define a "new ecological imaginary" (Gandy 2020) for the 21st-century city. They demonstrate that coexistence between humans and non-humans is not a utopia, but the result of intelligent design, far-sighted planning, and the political will to recognize the city, in its entirety, as a shared habitat. It is therefore a matter of asking how urban settlements can collaborate with other "terrestrials", undertaking courageous exercises of imagination and embracing the wild as one of the constitutive components of diffuse naturalness and open spaces in current urban landscapes (Lambertini 2022).

4. Lessons learned from comparative case studies on application of Nature-based Solutions

The comparative analysis of the three case studies—Emscher, Lyon Confluence, and the Berlin North-South Green Corridor—through the thematic lenses of the interdependence between biodiversity, resilience, and well-being (topic 2.1); the relationship between ecosystem services and ecosystem functions (topic 2.2); and the creation of habitat and multi-species coexistence (topic 2.3), reveals how urban regeneration projects are evolving towards integrated approaches, albeit with distinct strategies and priorities. On the first topic, the cases demonstrate different models of integration. Emscher Park emerges as an emblematic example of near-total systemic integration. Here, biodiversity restoration has directly generated climate resilience and human well-being, demonstrating how the three elements can be synergistic and mutually reinforcing. In Lyon Confluence, while well-being and resilience are effectively integrated, we observed a less robust connection to biodiversity, highlighting a deficiency in systematic ecological monitoring to measure actual increases. The Berlin system achieves integration by balancing areas of high human use with the strict protection of spontaneous habitats, managing resilience through the inherent naturalness of the sites themselves. Regarding the second topic, a greater diversification of approaches emerges among the cases. In Emscher Park, a strong integration in the pursuit of both ecosystem services and ecosystem functions objectives is observed. Indeed, it can be described as a major ecological restoration strategy—removing anthropogenic stressors (pollutants) and reactivating fluvial processes—which is progressively implemented through a convincing quantification and valorization of ecosystem services, such as hydraulic risk reduction and increased recreational value. Lyon presents an excellent application of NbS focused on services to respond to social and economic challenges; however, the objective of functional restoration of the fluvial environments appears not yet fully achieved, as stressors (e.g., due to inappropriate sewage system) have not been completely removed, and an ecological assessment of actual recovery is lacking. Berlin, while promoting both aspects through rewilding, presents a quantitative assessment of functional restoration (e.g., pollutant reduction) that is partial and sparse. Finally, on the third topic, all cases move beyond an anthropocentric approach, but with different design philosophies. In Emscher, particularly at Duisburg-Nord, the post-industrial landscape is reinterpreted, utilizing its own rubble as a substrate for new, complex micro-habitats. Lyon adopts an adaptive and incremental strategy, activating early ecological cycles via "jardins provisoires" and weaving a network of blue-green corridors that develops with the city. Berlin offers the most radical model: the cultural legitimization of "fourth nature" (spontaneous wilderness). Here, the design of open spaces does not create the nature of the sites, but rather highlights it, making it legible and perceptible.

In conclusion, the three cases outline important reflections on the approaches and modalities for applying NbS for biodiversity in urban contexts. Specifically, it can be affirmed that no single model can be determined; diverse modalities exist because each ecosystem presents a unique geography and a unique history of the human-environment relationship that must be read, interpreted, and re-imagined. Safeguarding and enhancing biodiversity means, first and foremost, shifting from a sectoral to a multidisciplinary approach that involves different fields of knowledge, including through the active participation of inhabitants, as such action is primarily generated by a cultural process. Balancing services and functions—that is, making conscious decisions that posit a principle of ecological equity between what we demand and what we contribute to creating in the urban ecosystem—is therefore fundamental. In this sense, NbS acquires greater efficacy when employed downstream of nature-based approaches aimed at identifying criticalities and potentialities through the

systemic observation of environments. This orientation must be directed not only toward well-being, resilience, or the services the environment can provide, but also and above all toward what we ourselves can contribute and achieve as an integral and integrated part of the bio-community, in a sentiment of renewed alliance and coexistence with all species.

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