Regenerative Housing

REGENERATIVE DESIGN PRINCIPLES FOR POST-WAR BUILDING RENOVATION

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jan ‘25

Research

ADVANCED HOUSING DESIGN

Tutors

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ABSTRACT

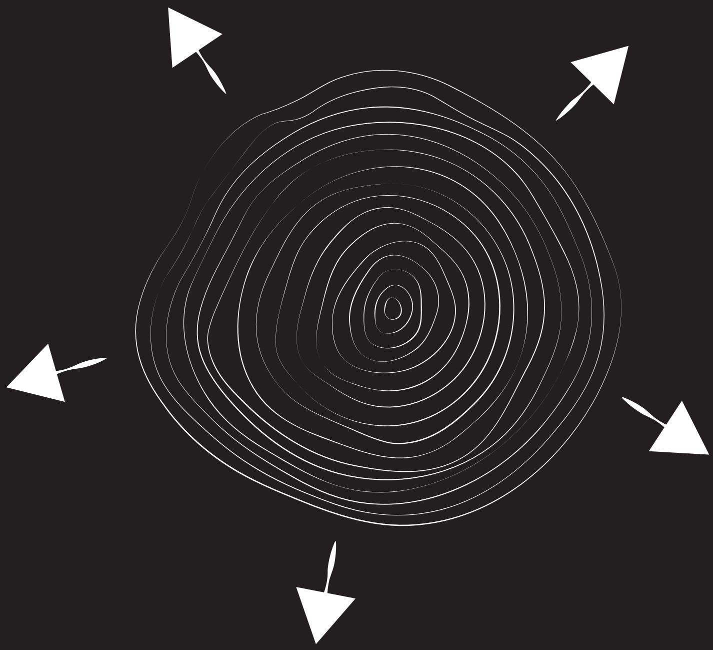
This research focuses on the renovation and densification of post-war neighborhoods, often characterized by a monoculture in both housing and green spaces. These areas lack variation and connectivity, which not only limits biodiversity but also reduces the quality of life for residents. The main research question is: *Wich regenerative design principles for the renovation and densification of a post-war building contribute to the densification of biodiversity within the ecologies of the urban fabric?* he aim is to demonstrate that urban densification does not have to come at the expense of biodiversity but instead offers opportunities for synergy.

To answer this question, methods such as literature review, case studies, and ecological analyses were employed. By studying urban biotopes and the dynamics between humans and nature, design principles were developed to integrate biodiversity into existing urban structures. Key guidelines include location-specific design, introducing more variation and strengthening connections, or disconections.

The research shows that cities are not inherently detrimental to biodiversity but possess their own ecology where flora and fauna adapt. By applying regenerative principles, cities can be transformed into living environments that support both human well-being and biodiversity. A focus on natural habitats, such as nesting opportunities for birds and bats, makes buildings an integral part of the ecosystem.

The conclusion is that urban densification offers an opportunity to combine biodiversity with human needs, provided that flora and fauna are included as key actors from the start of the design process. This research highlights the importance of regenerative designs that redefine cities as dynamic ecosystems.

Recommendations include developing methods to measure biodiversity in urban projects and involving ecologists and residents in the design process. This research provides valuable insights for architects, urban planners, and policymakers striving for sustainable and biodiverse urban development.



'The periphery is like the cambium of a tree, it is the only living layer that thereby determines the shape of its growth.'

FLORIS ALKEMADE

GREEN STREET

PREFACE

The inspiration for this research stems from a personal sense of displacement in urban environments. I have always felt more at home in a village, surrounded by open spaces and a tangible connection to nature. This preference sparked a question that has guided much of my academic journey: What makes one feel at home in the city, and how can those qualities be brought into an urban context? This curiosity has shaped my interest in housing and urban design, especially in reimagining how cities can become places where people and nature coexist harmoniously.

Throughout my academic career, I have explored green architecture in various capacities, both in my Bachelor's and Master's studies. These explorations have included designing a website and handbook for nature-inclusive building materials, developing a mycelium building block, and integrating green façades into architectural projects. Each of these endeavors deepened my understanding of sustainable design and ecological integration, but I often felt that something was missing—a cohesive framework, a guiding principle that tied these elements together. I wanted to go beyond isolated interventions and uncover the core ideas that could unite and elevate these aspects into a comprehensive approach.

This research is an attempt to address that gap. It delves into the intersection of urban housing and biodiversity, focusing on how architecture can serve as a mediator between human needs and ecological systems. What makes this project particularly exciting and challenging is the context: a neighborhood where biodiversity is scarce, but where socio-economic challenges also demand a careful balance between ecological and social goals. This duality has driven me to think critically about how to design spaces that are not only ecologically vibrant but also socially equitable and accessible.

The district of Groot-IJsselmonde provides a fertile ground for this exploration. Its post-war urban fabric, characterized by repetitive housing blocks and a lack of ecological variety, offers a compelling opportunity to reimagine the relationship between humans, buildings, and nature. This neighborhood, with its layered challenges, exemplifies the complexities of creating an "ideal" urban environment. It pushes the boundaries of what housing can achieve, asking how architecture can foster not just habitation but also connection, resilience, and cohabitation with other species.

This project also gains urgency and relevance in the context of today's housing shortage and the escalating climate crisis. Both issues demand innovative and regenerative design solutions that not only provide shelter but also address broader environmental and social challenges. The dual pressures of creating affordable, accessible housing and mitigating climate impacts make this project especially timely. It highlights the need for architecture that is not only functional but also adaptive, inclusive, and ecologically conscious.

SUSTAINABILITY

A design process that considers long-term impacts on the environment, social structures, and economic stability. In the context of architecture, sustainability involves the use of energy-efficient materials, integration of biodiversity, and minimizing CO_2 emissions during construction and use. The goal is to create buildings and environments that meet the needs of the current generation without compromising the ability of future generations to meet their own needs.

REGENERATIVE

An approach in design and architecture that goes beyond sustainability by not only minimizing environmental impact but also actively restoring and enhancing natural and social systems. Regenerative designs focus on creating systems that are self-sustaining, promote biodiversity, and support resilient communities. The goal is to design buildings and environments that contribute to a positive balance in ecosystems and the social fabric, rather than placing a burden on them. van belang zijn.

ECOSYSTEM

An ecosystem refers to a dynamic community of living organisms—such as plants, animals, and microorganisms—interacting with each other and their non-living environment, including air, water, and soil. These interactions create a network of energy flows and nutrient cycles that sustain life within the system. Ecosystems can vary in scale, from a small pond to a vast forest, and their health and balance are essential for maintaining biodiversity, resilience, and the overall stability of natural and human systems.

BIOTOOP

A biotope is a specific area or habitat that provides the essential environmental conditions for particular plant and animal species to thrive. It encompasses both the physical characteristics, such as soil, water, and climate, and the biological elements, including flora and fauna, that define the habitat. Biotopes are integral to maintaining biodiversity and ecosystem health, as they support species diversity and ecological processes within a localized space, whether natural, urban, or semi-natural.

BIODIVERSITY

Biodiversity is a concept that has become increasingly important in discussions about nature and ecology. It refers to the number and degree of variety of life forms within a specific ecosystem or across the entire planet. Biodiversity is a key indicator of the health and resilience of an ecosystem. It is a broad concept encompassing three critical components: genetic diversity, species diversity, and ecosystem diversity.

ECOLOGY

Ecology is the science that studies the complex relationships between living organisms and their interactions with the environment. This discipline encompasses various approaches, such as examining species, groups, geographic locations, and cycles of matter and energy. It explores dynamic processes, including distribution, interactions, coherence, and succession of species within communities, while addressing both biological and broader sustainability aspects. Ecology recognizes that all elements within a system are interconnected and evolve over time.

HABITAT

A habitat is the specific environment where an individual species or population lives and fulfills its life requirements, such as food, shelter, and reproduction. It is species-centered, focusing on the relationship between an organism and its immediate surroundings. Unlike a biotope, which describes a broader area with uniform environmental conditions supporting multiple species, a habitat is unique to a single species, emphasizing its specific ecological needs within a larger biotope or ecosystem.

BIOTIC & ABIOTIC

Biotic and abiotic factors are the two fundamental components of ecosystems. Biotic factors refer to all living organisms within an ecosystem, such as plants, animals, fungi, and microorganisms, and their interactions. Abiotic factors, on the other hand, are the non-living elements that influence the environment, including sunlight, temperature, water, soil, and air. Together, biotic and abiotic factors shape ecosystems by interacting to create the conditions necessary for life, determining the structure and dynamics of ecological communities.

VERTICAL FORREST - WOHA Architects

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“Sustainability is no longer about doing less harm. It’s about doing more good.”

JOCHEN ZEITZ

PALE BLUE DOT - NASA

Research Plan

The research plan provides a thorough context and addresses various questions at different scales. From a global perspective, the focus is on the climate crisis and biodiversity loss. At the national level, the need for construction in the Netherlands is examined, after which the focus narrows to the specific locations for construction. At the neighborhood level, the research problem is introduced. This introduction, which runs through several scales, ultimately leads to the formulation of a research question and associated sub-questions.

1.1 INTRODUCTION

In 1990, NASA's Voyager 1 produced an impressive image from a distance of 6 billion kilometers: a stunning image of our home planet, Earth (Image X). Only one pixel graced the center - the "pale blue dot. This visual representation emphasized the crucial need for careful handling of our planet. This tiny dot, surrounded by darkness, serves as a symbol of our unique habitat, which exists undisturbed, with or without our presence. Maintaining the viability of our planet rests on our shoulders, as there is no alternative destination for our collective existence.

However, this viability is under increasing pressure. We are systematically exceeding the limits of the earth, resulting in increasing pressure on various ecosystems and biodiversity. Simultaneously, the world's population continues to grow, resulting in a growing demand for space and other goods. These global challenges converge and intensify in urban areas, where increasing urbanization leads to an intense struggle for space. This struggle, due to our anthropocene view of nature, has often come at the expense of various ecosystems and their associated services.

A historical example of this is the rise of suburbs in the 20th century, which resulted in large-scale urbanization sacrificing agricultural and natural areas, leading to shifts in urban boundaries. This caused a growing need for space to densify cities, with demonstrable impacts on the terrestrial ecosystem, such as loss of biodiversity and climate change. In this light, Gibson urgently calls for a paradigm shift to a more caring approach to survival on Earth (Gibson, 2020, p. 111). In the Anthropocene, where human activities are irrevocably transforming the earth, the planet faces a crucial challenge: maintaining biodiversity amid ongoing urbanization (Steff et al., 2007).

Dutch housing crisis

The Netherlands is currently experiencing a significant housing crisis, which is expected to worsen in the coming years. This crisis is caused by various factors, including changing family structures, urbanization, and continued immigration on the demand side, as well as rising construction costs, fewer permits being issued, and limited space on the supply side. Consequently, there is an increasing need for affordable and sustainable housing. The Dutch government has set a goal of constructing 917,193 new housing units between 2022 and 2030 (central government, 2022) in response to the housing crisis.

However, this crisis differs from previous ones in several ways. Firstly, due to the ongoing urbanization of society, many of the new homes will have to be built within the existing urban fabric. This presents unique challenges, such as space constraints and the need to balance the demands of different stakeholders. Furthermore, there is an increasing recognition of the significance of environmental concerns and social objectives. As a result, new residential developments must be planned with sustainability and diversity in mind. A wide range of individuals, including students, young and older couples, families, seniors, migrants, and locals, currently reside in substandard housing or unfavourable living conditions. Additionally, established neighbourhoods in close proximity to the city centre are experiencing a decline in their homogeneous structures.

Rotterdam's periphery

The Dutch government aims to construct almost one million homes by 2030. As urbanization increases, a significant portion of these homes will need to be built in cities. Historically, our city centres have been the focal point for a growing number of surrounding expansion areas. This development places increasing pressure on urban centers and often results in painful segregation between promising and disadvantaged residents. As a result, the disadvantaged population experiences significantly lower livability in these cities (Alkemade, 2016). This trend is also evident in Rotterdam, where the perceived livability gap between the city's wealthiest and poorest neighborhoods has actually widened. Livability refers to the extent to which the environment meets people's demands and desires.

PROTEST WONINGTEKORT - KOEN VAN WEEL/ANP

In 2008, the difference between the neighborhoods on the north side of the Meuse River and the southern garden cities was 0.6 points, while in 2021 it had increased to 0.9 points (Rijksoverheid, s.d.). The difference between the two areas is clearly visible in Figure X. Additionally, the streetscape index map (green/paving ratio) shows the opposite. Therefore, the solution to improving livability in the city goes beyond just greening the city.

These urban residents often live in neglected post-war suburbs, which, due to their spaciousness, should now be the focus of renewal. Rotterdam's periphery can provide a solution to various issues. If we consider the current state of Rotterdam's post-war housing estates as the first layer on
which we can build, many opportunities arise. The neighborhoods have a high absorptive capacity. Many of the problems we face today, such as the housing shortage, societal segregation, and climate and sustainability issues, can be addressed by improving existing post-war neighborhoods. This will significantly increase their importance and improve the quality of life for residents.

Monoculture

Urbanization in the Netherlands not only affects the housing market but also endangers biodiversity and alters ecosystems in urban areas, such as the Groot-IJsselmonde area. The housing typologies in this area are homogeneous, and the green structures are based on the social principles of the garden city (refer to Figure X). The green space, designed by humans with an egocentric approach, has a limited contribution to biodiversity and essential ecosystem ser-

GREENERY VS LEEFBAARHEID - CBS/Leefbarometer vices such as water retention, air purification, and pollination. Monoculture, which refers to an abundance of a single dominant species, whether native or invasive exotic, is rarely beneficial.In the long run, this system becomes unstable, fragile, and lacks resilience, leading to a decline in biodiversity (Vink et al., 2023).

To address the issue of scarce space in the Netherlands, it is necessary to promote ecosystem services for multiple and efficient use of space. This can be achieved through a nature-inclusive design approach for the future city, which provides targeted space for humans, flora, and fauna. The aim is to maximize and popularize ecosystem services and synergy (Stiphout, 2019).

Nature-inclusive design contributes to efficient use of space and an integrated approach to challenges, enriching the monoculture of housing and green space. This results in neighbourhoods that serve multiple functions and create a resilient system between the city and nature. The research aims to increase understanding of urban ecology and provide practical solutions by creating a resilient system between the city and nature.

1.2 RESEARCH QUESTION

To address the ecosystem issues just mentioned, without losing sight of the social aspects of a neighborhood, regenerative design is a good angle. Therefore, the following was formulated:

Wich regenerative design principles for the renovation and densification of a post-war building contribute to the densification of biodiversity within the ecologies of the urban fabric?

This research question will be answered through the following sub-questions:

The challenges

What are the ecological and social challenges in post-war neighborhoods, particularly regarding biodiversity loss, housing typologies, and community well-being? This question is addressed through an extensive literature review focusing on the monoculture in housing and green spaces in post-war neighborhoods. The research examines how this monoculture contributes to biodiversity loss, fragmentation of ecological networks, and a lack of social interaction and resilience. Broader societal challenges, such as the climate crisis and the shortage of affordable housing, are also considered to highlight the urgency of regenerative solutions.

The solution:

How can the integration of flora and fauna address these challenges while enhancing biodiversity and human well-being? This question is explored through literature reviews and case study analyses that demonstrate how nature-inclusive design enhances biodiversity and social cohesion. The study specifically investigates how flora and fauna support ecosystems, such as the role of linear green structures as ecological connectors. Additionally, it examines how social interactions can be fostered by creating multifunctional green spaces that support both humans and nature. These solutions contribute to improved quality of life and resilience.

The application

How can regenerative design principles incorporate biodiversity and social needs into post-war neighborhoods? This question is answered by developing regenerative design principles based on the findings from the previous questions. These principles are translated into concrete design strategies that integrate biodiversity and human needs within the existing urban fabric. Practical applications are tested through case studies and conceptual designs, focusing on elements such as ecological corridors, variation in housing typologies, and shared spaces. The goal is to create a framework that can be broadly applied in similar urban contexts.

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Personal Interest & Motivation

Design Brief

Problem Statement

Wich regenerative design principles for the renovation and densification of a post-war building contribute to the densification of biodiversity within the ecologies of the urban fabric?

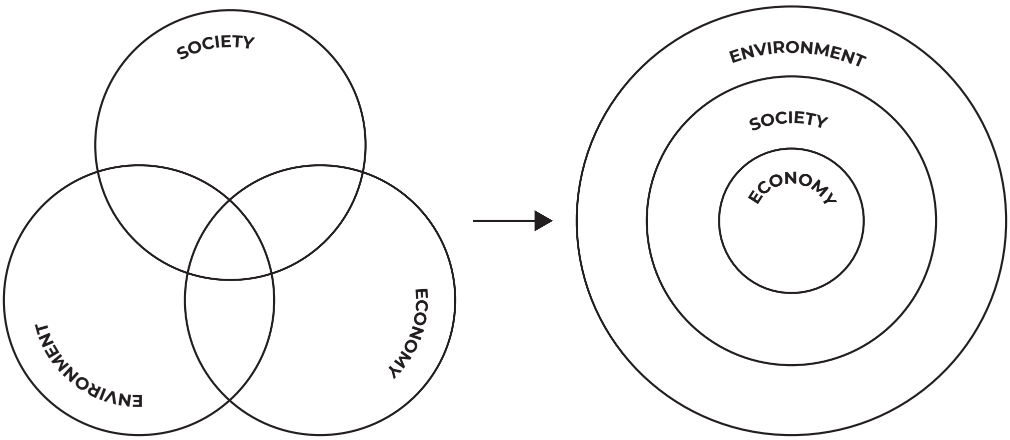
1.3 THEORETICAL FRAMEWORK

In 1896, Swedish Nobel laureate Svante Arrhenius opened the way to a paradigm shift by being the first to acknowledge that human activity, with its greenhouse gas emissions, can cause global temperature rise. This landmark work marked the beginning of a long and complex trajectory on which the development of consensus on climate change has progressed. For decades, scientists tirelessly collected data and conducted analysis, constantly highlighting the human impact on climate. A significant milestone was the Club of Rome's 1972 "Limits to Growth" report, which warned of the depletion of the planet's resource supply with an increasing world population. Rachel Carson warned about the overuse of pesticides as early as 1962 in her book "Silent Spring" and predicted a future spring without the singing of birds. (Finch et al., 2017)

In the 1970s, these warnings led to an increased focus on nature and conservation, including in architecture and urban planning. Although ecological gardening and architecture became a trend, attention quickly shifted to limiting the use of fossil fuels and seeking sustainable alternatives. Nature seemed to take a back seat for several decades after that. (Vink et al., 2017)

However, later research showed that the continued consumption of fossil fuels would not only deplete supplies, but also lead to a more serious problem: rapid climate change due to elevated CO2 concentrations in the atmosphere. In the 1990s and 2000s, conviction and support grew, consolidated by international reports and collaborations. The first IPCC First Assessment Report in 1990 marked a crucial turning point and laid the groundwork for the historic 1992 Climate Convention (UNFCCC).

The impact of this knowledge goes beyond reports and collaborations. It has influenced the perspective of countless researchers, causing them to rethink their approach to sustainability, economics and our relationship with nature. With climate change a daily reality, the world has slowly shifted to reducing carbon emissions and utilizing alternative energy sources. This paradigm shift has led to a greater awareness of the need for a holistic approach to ensure a resilient and sustainable future for our planet.



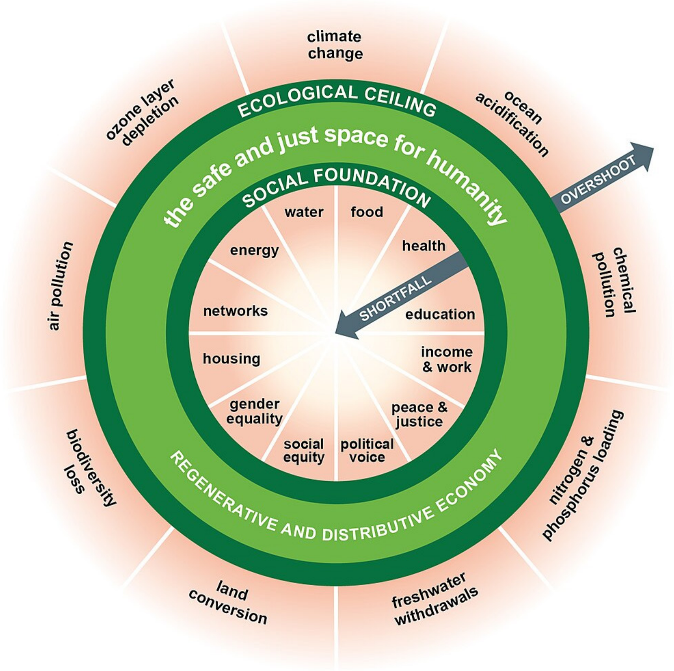
Sustainable development

In 1896, Svante Arrhenius, a Swedish Nobel laureate, was the first to acknowledge that human activity, with its greenhouse gas emissions, can cause global temperature rise. This discovery marked the beginning of a long and complex trajectory towards the development of a consensus on climate change. For decades, scientists have tirelessly collected data and conducted analysis, constantly highlighting the human impact on climate. The Club of Rome's 1972 report 'Limits to Growth' was a significant milestone. It warned of the depletion of the planet's resources due to the increasing world population. Similarly, Rachel Carson's 1962 book 'Silent Spring' warned about the overuse of pesticides and predicted a future without the singing of birds.

These warnings led to an increased focus on nature and conservation in the 1970s, including in architecture and urban planning. Although ecological gardening and architecture were once popular trends, attention quickly shifted towards limiting the use of fossil fuels and seeking sustainable alternatives. For several decades, nature seemed to take a back seat. However, later research showed that the

continued consumption of fossil fuels would not only deplete supplies, but also lead to a more serious problem: rapid climate change due to elevated CO_2 concentrations in the atmosphere (Vink et al., 2017). During the 1990s and 2000s, conviction and support for climate change grew, consolidated by international reports and collaborations. The first IPCC First Assessment Report in 1990 marked a crucial turning point and laid the groundwork for the historic 1992 Climate Convention (UNFCCC).

The impact of this knowledge extends beyond reports and collaborations, influencing the perspective of countless researchers and causing them to rethink their approach to sustainability, economics, and our relationship with nature. Given the daily reality of climate



DONUT ECONOMY - Kate Raworth

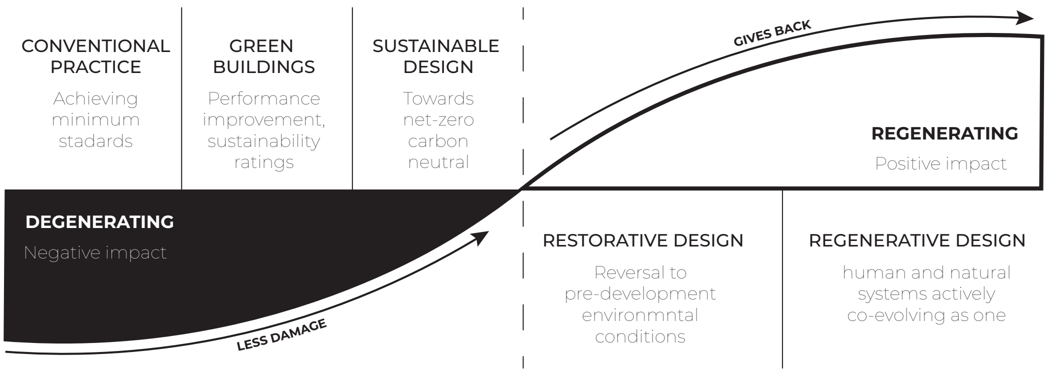
change, the world has gradually shifted towards reducing carbon emissions and using alternative energy sources. This change in paradigm has increased awareness of the need for a comprehensive approach to ensure a resilient and sustainable future for our planet.

Sustainable vs regenerative

Regenerative design is an approach that emphasizes the creation of new relationships to improve the health of human and natural ecosystems. This includes the use of appropriate construction and technological solutions, requires in-depth knowledge of multiple disciplines and the involvement of different specialists and appropriate tools to develop and frame approaches and solutions. Current action on climate change and biodiversity is inadequate given the urgency and magnitude of predicted impacts. Current targets mostly focus on reducing negative impacts or at best achieving "neutral" operational energy use. However, new building construction and renovation must go beyond reducing environmental impacts and deliver positive environmental benefits. A holistic approach is needed that considers carbon, resource use, waste and water. Regenerative design methods aim not only to reduce the causes of climate change and ecosystem degradation, but also to reverse them (Figure 1).

The concept of regenerative design was first introduced by American landscape architect John T. Lyle (1996) in his book "Regenerative Design for Sustainable Development," although the term had previously been formulated by Robert Rodale (1972) in relation to agriculture. Regenerative design has become a major approach to sustainability, with scholars such as Bill Reed (2007) and Raymond J. Cole (2012a) exploring definitions and applications. Today, a group called Regenesis has developed its own theory and methodology of regenerative development that goes beyond the biophysical and contracts with the entire social-ecological system to grow its potential (Cole, 2012b). Regenesis' work is guided by three approaches: Living Systems Thinking, permaculture and developmental change processes. According to Regenesis, the goal of regenerative design and regenerative development is to "reconnect human aspirations and activities with the evolution of natural systems - essentially co-evolution" (Mang & Reed, 2012).

It is crucial to understand that regenerative work is not separate from sustainability. According to Bill Reed, the concept of sustai-



nability is impossible without regeneration. The question is how we can change our thinking and being to be participatory and co-creative, that is, co-evolutionary (Mang & Reed, 2012). If what we create does not have the capacity to evolve itself, entropy means it will eventually deteriorate. Not only must the project or living system we work with have the capacity to evolve, but it is also necessary to continually regenerate ourselves in relation to evolutionary processes. For planners, designers and developers, working from the Regenesis perspective has challenging implications, the most difficult of which is to accept that "it's not about the building," as was the case with the Brattleboro Food Co-op. The initial design intervention can become a catalyst for community and ecosystem restoration even if no building is ultimately constructed (Mang & Reed, 2012).

According to the same research, "green buildings" are no longer the exception, and regulations and certifications are becoming increasingly ambitious. Although these buildings are often labeled as "green" and "sustainable," they aim for higher environmental performance compared to regular buildings and are primarily aimed at reducing "negative" impacts. However, the stated goals in the Paris Climate Agreement, the United Nations Sustainable Development Goals (source) and the recent IPCC report (source) will not be achieved by simply slowing the rate of depletion and degradation of the environment and human health. There is growing recognition that a net positive approach is needed to achieve these goals and undo the damage already done. Moreover, the complex challenges surrounding sustainable development have traditionally been highlighted from a reductionist, mono-disciplinary perspective.

Humans & nature

Not only has the perspective on sustainability changed due to increasing knowledge and recognition of climate change, but our view of and relationship with nature has also shifted. It is not the first time that humanity reevaluates its connection to nature. In prehistoric times, hunter-gatherers and possibly later nomadic peoples lived in a natural manner, without considering themselves exceptional or superior. Nature was treated with respect and seldom feared or exploited. This connection with nature changed with the rise of settlements and the advent of agriculture and animal husbandry. A separation between nature and culture emerged, requiring the protection of both livestock, crops, and humans against the perceived hostility of the wilderness (Vink et al., 2017).

This separation found philosophical and cultural justification in thinkers like Aristotle, who elevated humans above irrational plants and animals. Later, monotheistic religions, particularly Christianity, adopted this notion of human dominion over creation. However, an alternative attitude developed in China. Daoism embraced nature in a broader sense, with Daoist monks formulating conservation measures as early as the sixth century. LaoTzi emphasized in the sixth century that 'The way is Nature,' and Confucius declared around 500 BCE that 'nature and humans are inseparable.' This sharply contrasts with Western views, where the earth was considered 'God-given' and susceptible to exploitation, leading to further colonization and exploitation (Vink et al., 2017).

In the nineteenth century, when the exploitation of nature reached its peak, a counter-movement emerged that reshaped our attitude towards nature. The rise of biology, especially the specialization in ecology, brought a deeper understanding of the natural world. Pioneering this understanding, Alexander von Humboldt described the interdependence of species and climate in South America. During the Romantic era, poets and painters began to depict wild nature in positive, admiring terms. Despite this changing attitude, the relationship often remained one of humans versus nature, with the Romantic concept of the 'sublime' emphasizing awe for the grand and dangerous aspects of nature (Vink et al., 2017).

This evolving attitude eventually led to the establishment of the first protected national parks, where nature was considered sublime. In the twentieth century, conservation gradually evolved towards a greater focus on the value and ecological significance of nature, detached from the potentially sublime experience. Despite this evolution, the protective attitude often continues to position humans as guardians and stewards of nature (Vink et al., 2017).

Scientists, including James Lovelock, who formulated the Gaia hypothesis in 1974, and Bruno Latour, emphasize the need for a new approach. Lovelock situates humans as part of a complex self-regulating system, while Latour argues that we must reposition ourselves as humanity within the earth, acknowledging that we do not occupy a position free from influence outside of nature.

This fundamental shift challenges humanity to find a common ground in the new Anthropocene era, where the distinction between nature and culture is no longer sustainable. In this new environment, architecture must land and strive for a synthesis in which the human-made and the natural are inseparably intertwined.

In the book 'Building Urban Nature,' the authors delve deeper into the recent perspectives of climate and nature thinkers on the attitude towards nature. According to them, we must realize that we are inherently connected to nature, and our presence and actions are entirely entwined with the life systems around us. If these systems weaken, we weaken ourselves; if we exploit them, we exploit ourselves. The idea that humans stand opposed to or alongside nature is outdated (Vink et al., 2023).

According to Vink et al. (2023), our own surv val is directly endangered. The preposition that assumes humans live off nature might be better replaced by inclusive notions such as with nature, as nature, or in nature. The anthropocentric attitude must be adjusted to an ecocentric one. We live with all plants and animals together on a planet that clearly has its limits. Only together can we navigate through our challenges.

Vink et al. (2023) mention recent discussions speaking of a necessity for a symbiocene, a system beyond the Anthropocene, where humans and their technology are balanced with nature.

According to Vink et al. (2023), the solution does not lie solely in technological fixes, where we solve problems in our way, such as synthetic food production and genetic improvement of species, which may provide temporary relief but can never be the ultimate solution.

Urban ecology

The history of ecology in urban areas reflects a gradual evolution in human perceptions of natural ecosystems and the dynamics of interaction between humans and their environment. In the quest to enhance the ecological system in urban development, the systems approach has proven its essential value (Marzluff et al., 2008). The Ecological Society of America defines ecology as the study of the relationship between living organisms, including humans, and their physical environment. In the urban landscape, ecology is often approached through urban ecology, an interdisciplinary concept focused on the complex interactions between ecological and human processes in human-dominated urban systems.

Urban ecology regards the city as a socio-ecological system, where human activities are intertwined with the natural environment. This system integrates technology, economy, politics, and culture within the biosphere, the part of the Earth where life is possible (Berkes et al., 2000; Maes et al., 2016). Consequently, the ecological subsystem of cities must be considered on an equal footing with economic and social systems.

A retrospective look at the historical context reveals a paradigm shift in perceptions of nature in urban areas. Before the 18th century, nature was considered wild and hostile, with efforts focused on its taming. In the 19th century, this view changed, with an increasing awareness that integrating nature had positive effects on the health of city dwellers. However, to avoid uncontrolled growth, nature underwent regulation and domestic transformation (Bourdeau-Lepage, 2014). After the war, ecology evolved into something aesthetic and luxurious, giving rise to the concept of urban ecology as an incidental economic value (Bess, 1995; McDonnell, 2011).

During the 20th century, awareness of the value of nature grew, resulting in a new approach to ecology. This approach seeped into scientific research and established itself as a distinct scientific discipline. McDonnell (2011) emphasizes that by the mid-20th century, it became clear that human influences had altered most ecological systems. Nevertheless, it wasn't until the end of the 1990s that urban ecology was fully recognized as an autonomous discipline, separate from broader ecology.

The current transition marks an era in which ecology is considered an inherent part of the system in which humans actively participate. The distinction between human-dominated and non-human-dominated ecosystems is now acknowledged. Urban ecology is regarded as an autonomous discipline, and professionals in urban planning and design increasingly recognize the value of an ecological approach (Heymans et al., 2019).

In the 2000s, concepts for a more comprehensive socio-ecological system approach to urban planning emerged, driven by the growing awareness of the negative effects of urbanization on the environment, human well-being, and sustainability (Newman and Beatley, 2011). This new approach indicates a shift from the modernist paradigm of urban development, where humans were detached from nature, towards a more ecological direction. Importantly, new strategies are not only focused on improving connections within the urban ecosystem but also on the integration of sustainability principles (Heymans et al., 2019).

A critical aspect in urban development is the phenomenon of ecological gentrification. Urban greening initiatives can lead to gentrification, where higher-income groups move to areas with lower incomes. Wolch et al. (2014) introduce the strategy of 'just green enough,' creating green space without significant price hikes that promote gentrification. Implementing this strategy requires systems thinking, involving local stakeholders and citizens to prevent ecological gentrification when designing areas that are 'just green enough.'

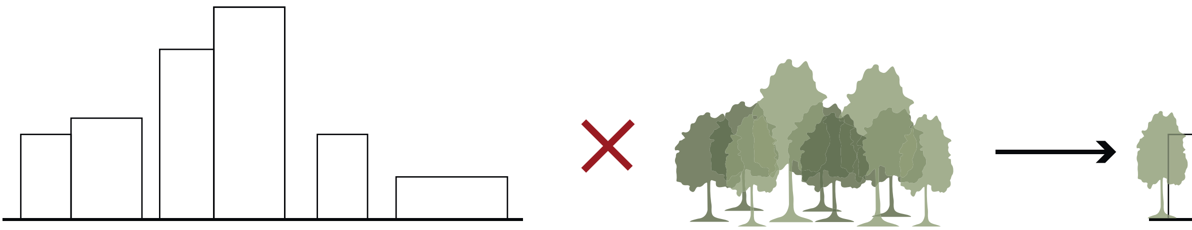
Biodiversity in the city

Urban biodiversity is becoming an increasingly important focus in cities worldwide. It is well-known that urbanization poses a major threat to biodiversity, with urban development often leading to habitat loss and fragmentation, as well as increased pollution, invasive species, and disrupted ecological processes. However, recent research has shown that urban areas can form important habitats for a wide range of species and promote biodiversity conservation.

In his book "Darwin in the City," Menno Schilthuizen explores the evolution of urban biodiversity and emphasizes the unique challenges and opportunities that cities offer for the adaptation and evolution of species. Schilthuizen suggests that urban areas can act as "evolutionary hotspots," where species are exposed to new environmental conditions and selective pressures, leading to rapid adaptation and evolution. This can result in the emergence of new species and the evolution of unique, city-adapted traits (Schilthuizen, 2018).

Building on this, the book "Making Urban Nature" examines ways in which cities can be designed and managed to promote biodiversity conservation. The book emphasizes the importance of green spaces in cities, such as parks, gardens, and green roofs, as crucial habitats for a wide range of species, from insects and birds to mammals and reptiles. It also explores the role of citizen science and community engagement in promoting urban biodiversity, highlighting the importance of considering social equity in urban biodiversity conservation (Vink et al., 2017).

Overall, these books demonstrate that cities can play a crucial role in biodiversity conservation and suggest that urban areas can serve



as important refuges and habitats for a diverse range of species. However, careful planning and management are required, along with recognition of the social and ecological complexity of urban environments. By incorporating biodiversity conservation into urban planning and design, cities can help ensure that they remain vibrant, resilient, and diverse ecosystems for both humans and other species.

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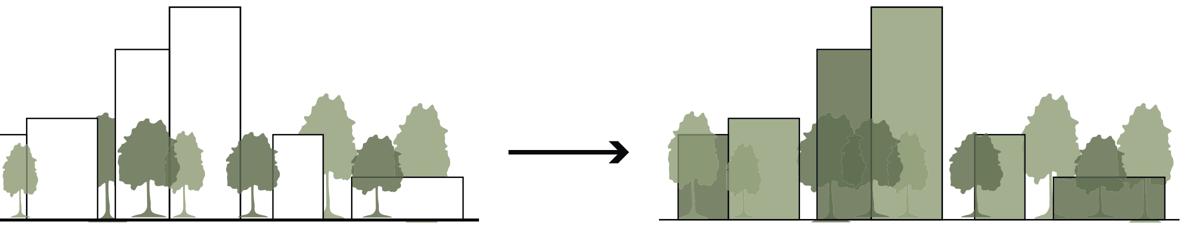

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“We are living on this planet as if we had another one to go to.”

TERRI SWEARINGEN

DROUGHT DUE TO LACK OF RAINFALL

The Big Picture

The contemporary issues and challenges addressed in the problem statement are too extensive and intricate to be merely encapsulated within a sub-paragraph. This chapter elucidates three pivotal themes crucial for shaping our prospective living environment.

2.1 OUR PLANET

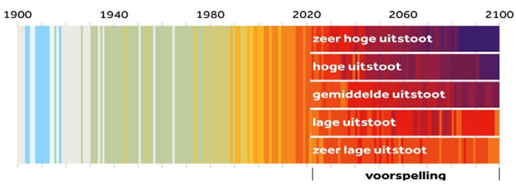
Climate change

The world has recently witnessed alarming climate records, including the global annual temperature record and notable extremes in the Netherlands, such as the highest temperatures since the twentieth century and unprecedented precipitation levels (KNMI, 2024). This unequivocally underscores that climate patterns are undergoing profound changes, primarily attributed to human activities, land-use changes, and urban densification (European Parliament, 2020).

Since the groundbreaking report of the Intergovernmental Panel on Climate Change (IPCC) in 1990, which first presented alarming insights into the growing impact of human activities on the climate, the scientific community has been actively engaged in analyzing global-scale climate change (IPCC, 1992). The recent IPCC report of 2023 provides a disturbing glimpse into the current state of the climate. It unequivocally emphasizes that since 1900, the Earth has been warming due to human activities and predicts that this warming will persist until 2040, mainly due to ongoing CO2 emissions despite efforts to reduce them (IPCC, 2023).

These alarming trends are not disconnected from the Anthropocene, a term introduced in 2002 by Crutzen to describe the current era in which human activities exert the dominant influence on the Earth (Crutzen, 2002). The Anthropocene symbolizes a period in which humanity is not merely witnessing climate change but has become an active force shaping the planet.

TEMPERATURE IN THE NETHERLANDS - KNMI



In this new climatological era, we face a crucial challenge. The United Nations emphasize the fundamental importance of restoring biodiversity for our well-being and the protection of a healthy planet (Convention on Biological Diversity, 2021). The European Commission also warns of the loss of biodiversity and the collapse of ecosystems as one of the greatest threats to humanity in the coming decade (European Commission, 2020).

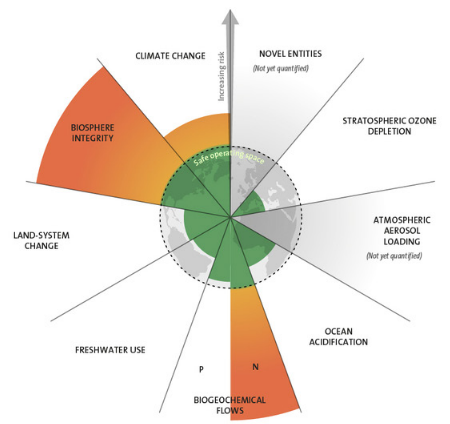
In the context of climate change, human influence, and the Anthropocene, it is essential to delve deeper into the crucial indicators of climate change. The construction sector and the use of traditional building materials have also significantly contributed to CO2 emissions and, consequently, climate change. The recent IPCC report of 2023 highlights that global warming is leading to more extreme weather conditions, including rising temperatures resulting in heat stress, an increased likelihood of floods, and waterlogging due to changing precipitation patterns. These far-reaching consequences not only affect ecosystems and biodiversity but also directly impact human societies, heightening the urgency to develop sustainable solutions.

Planetary boundaries

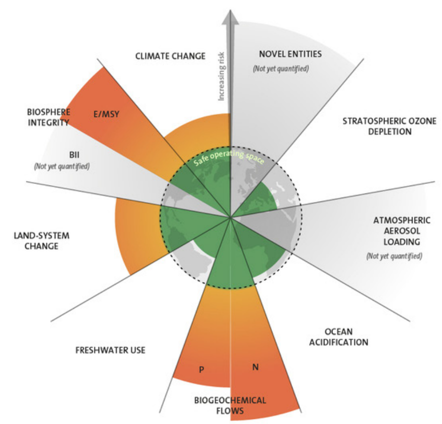
Since 2007, the Stockholm Resilience Centre has been investigating the ecological boundaries of our planet, critically examining nine "planetary life support systems." In 2009, the results were first presented in a diagram, highlighting exceedances of the "safe operating space for humanity" in red. Both the 2015 version and the recent update of 2022-2023 confirm alarming trends (Stockholm Resilience Centre, 2023).

The 2009 version lacked quantitative data for some sectors, but the latest update in September 2023 reveals figures and their impact on all nine examined systems for the first time. Unfortunately, these data offer little reassurance. Beyond well-known issues like nitrogen and phosphorus challenges and escalating climate change, it appears that biodiversity loss has long surpassed the safe threshold.

Since 2015, the Stockholm Resilience Centre has designated biodiversity as biosphere integrity, divided into genetic and functional



7 boundaries assessed,
3 crossed



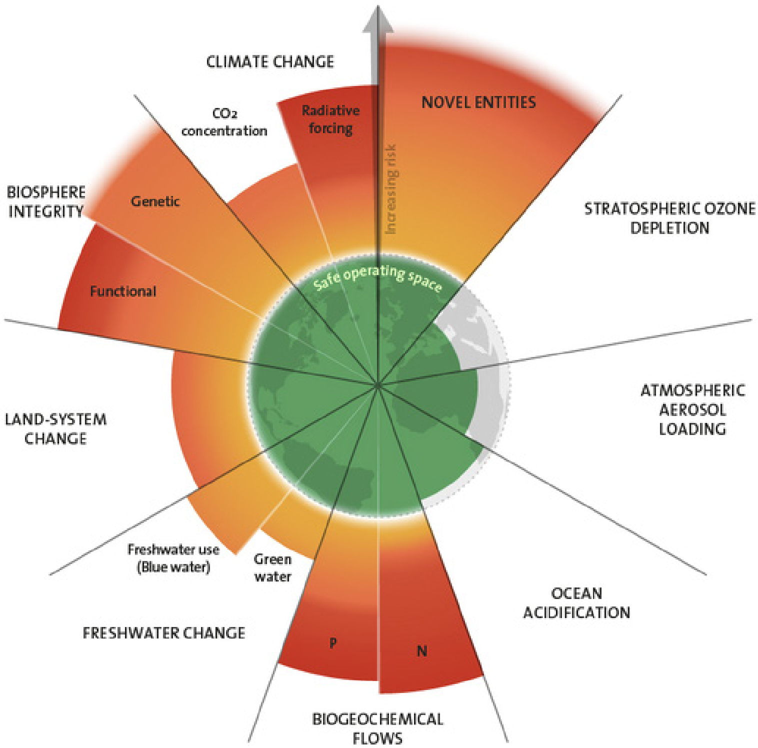
7 boundaries assessed,
4 crossed

PLANETARY BOUNDRIES 2009 & 2015 - Stockholm Resilience diversity. The former illustrates the disturbingly high rate of species loss, while the latter describes the impact of this loss on various ecosystems, measuring the health of these ecosystems and the ecosystem services they provide. Exceeding these boundaries, especially in biodiversity, has direct consequences for the ecosystem services that make cities livable. The impact on planetary life support systems is still unknown, but the quantity is already considered beyond the safe operating space (Vink e t al., 2023).

It is not surprising that we are surpassing all boundaries; another study in 2020 (Elhacham et al., 2020) revealed that the total human-made construction mass around that year exceeded the total biomass. This human-made mass primarily concentrates in buildings, consisting of metals, asphalt, stone, and notably concrete, which also significantly contributes to climate change through CO2 emissions during production. Humans, along with domesticated animals, constitute over 95 percent of mammalian biomass, underscoring how profoundly human influence disrupts the balance in nature.

Loss of biodiversity

Biodiversity encompasses genetic diversity, species richness, and ecosystem diversity. Globally, biodiversity is decreasing across all three of these dimensions, despite the discovery of new species and international agreements to protect rare species and habitats. The worldwide loss of biodiversity is an alarming phenomenon primarily fueled by human activities and changes in land use, as emphasized by the European Parliament (2020). It affects not only remote



PLANETARY BOUNDRIES 2023 - Stockholm Resilience Centre ecosystems such as tropical rainforests and coral reefs but also everyday species like the house sparrow in the Netherlands, with currently 16 percent facing global extinction (United Nations, 2019a). This worrisome trend has prompted significant international concern, with the United Nations considering biodiversity restoration crucial for prosperity and the preservation of a healthy planet (Convention on Biological Diversity, 2021).

The European Commission warns that the loss of biodiversity and the collapse of ecosystems pose not only an ecological threat but also one of the greatest threats to humanity, even from an economic perspective (European Commission, 2020). The Council for the Environment and Infrastructure (Rli) in the Netherlands shares this concern, asserting that the biodiversity crisis is as serious as the climate crisis (Rli, 2022).

Netherlands itself is not exempt from this global crisis. Historical time series of nature indicators, calculated by Statistics Netherlands (CBS), reveal alarming shifts in the flora and fauna of agricultural areas. Since 1900, arable plants have declined by 35 percent, grassland butterflies by 80 percent, and characteristic birds of open farmland by as much as 85 percent (CBS, 2020).

In addition to urbanization, various human activities contribute to biodiversity loss. Resource depletion and land use changes through deforestation, mining, and intensive agriculture render large parts of the planet unsuitable for sustainable ecosystems, leading to the disappearance of essential species. Even adapted uses, such as the construction of ports and cities, result in habitat loss and ultimately species extinction. Construction activity in urban areas contributes to the fragmentation of larger areas, with additional negative effects (Vink et al., 2017).

Climate change exerts further pressure on ecosystems. Despite the inherent resilience of nature, species and ecosystems' evolution does not occur rapidly enough compared to the current rate of climate change. Human consumption behavior, along with industrial and agricultural activities, contributes to significant pollution and poisoning of the earth, promoting species extinction (Vink et al., 2017).

In the face of global warming and increasing pressure on ecosystems, humanity is confronted with a cascade of problems that collectively could lead to the collapse of entire ecosystems. The current biodiversity crisis is not only an ecological challenge but also a profound issue for our system, where natural conditions and specific ecological interdependencies are inseparably linked to our human society (Vink et al., 2017).

An example is the nitrogen issue in the Netherlands. This problem illustrates the paradox of nitrogen as an essential building block for plant growth and simultaneously as a threat to biodiversity. An excess of nitrogen, caused by human activities such as agriculture and industry, promotes the growth of nitrogen-loving plants such as nettles and grass, resulting in the displacement of plants like heather and rare species in nature reserves. This leads to the disappearance of specific plants and the dependent butterflies and insects, impoverishing biodiversity. In water bodies, excess nitrogen causes algae growth, reduced oxygen, and an unsuitable habitat for aquatic plants and fish. The disruption of the ecological balance in the ecosystem has broad consequences for the system. However, what applies to the system as a whole does not necessarily apply to individual species (Vink et al., 2017).

Even at the building level, animals utilize our living environment as nesting and shelter opportunities, and plants thrive when given space. Buildings constructed before 1980 contain numerous nesting and shelter places for birds in cracks and gaps in the facade, thanks to the space under the roof tiles. These animals have found opportunities in the ledges, crevices, and gaps of our older buildings and have adapted to urban life. However, new construction methods have progressively diminished these dwellings. Animals and plants were not considered as full-fledged users, weakening the ecological system of the city (Vink et al., 2023).

Consequences in the city

Biodiversity loss and climate change have direct repercussions on ecosystem services, wherein these services provide essential benefits to humans through ecology and biodiversity. A decline in biodiversity consequently signifies the loss or weakening of ecosystem services that directly impact the well-being and health of individuals (Sandifer et al., 2015). Especially in cities, increasingly facing the urban heat island effect and floods due to escalating urbanization, these ecosystem services are crucial for maintaining livability.

The prevalence of extensive pavement and concrete in the city retains a significant amount of heat, further intensified by heat emissions from traffic, businesses, and residences. In the city, the average temperature is consequently higher than in rural areas, up to 6 degrees Celsius in summer. This phenomenon is termed heat stress or the urban heat island effect. This heat effect has implications for public health. Human health is inevitably linked to the environmental temperatures to which populations are acclimatized. Deviations from non-optimal temperatures will lead to consequences for morbidity and mortality (Gasparrini et al., 2015). Temperature extremes contribute to this health burden, with heatwaves already having the highest cumulative mortality rates among all extreme weather-related events in Europe (European Environment Agency, 2017), disproportionately affecting the elderly, individuals with existing health issues, and those residing in urban areas. Air and noise pollution, more prevalent in urban environments, are also recognized as causes of adverse health effects in individuals (Basner et al., 2014; Lelieveld et al., 2019).

The concept of urban ecology, studying the relationships between nature and humans in urban environments, is becoming increasingly critical. Cities not only impact local ecosystems but also influence areas beyond urban boundaries, such as fertile agricultural lands and wildlife habitats (Vink et al., 2017).

Scientists acknowledge the pivotal role of urban ecosystems for the future of our planet. The living and non-living elements of urban ecosystems, along with their interconnections, are deemed essential to avoid surpassing planetary boundaries. Efforts to develop cities more sustainably should focus on a systematic approach rather than fragmented development. This entails integrating buildings, infrastructure, and green structures instead of developing them separately (Vink et al., 2017).

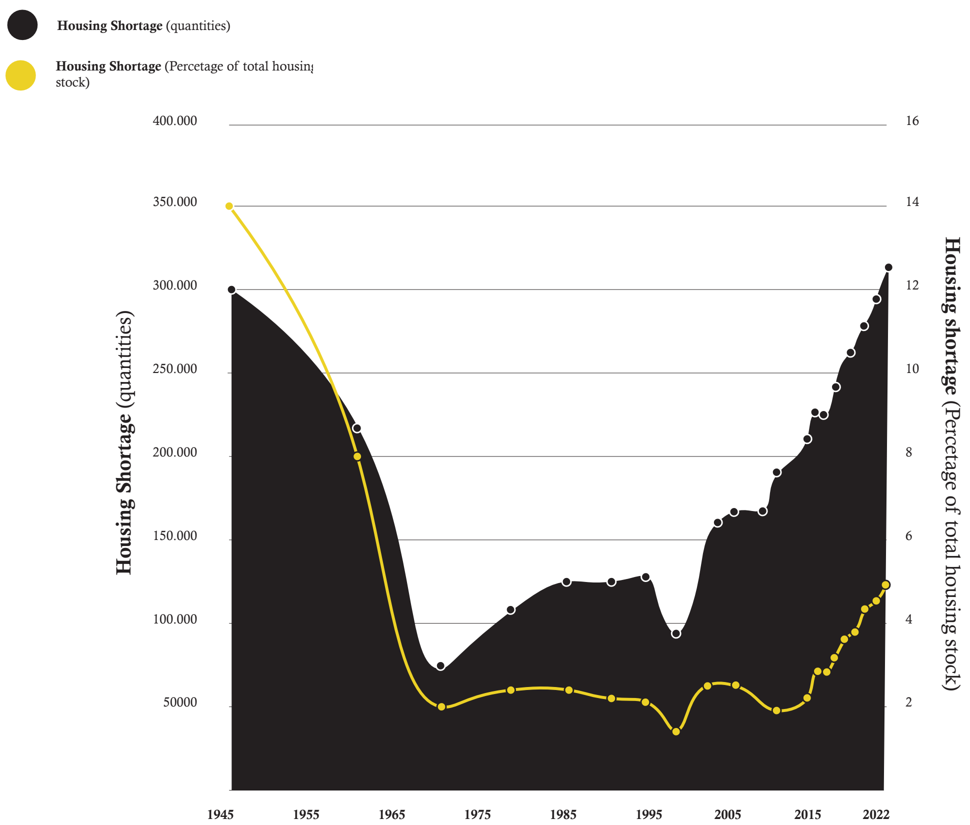
2.2 HOUSING CRISIS

Persistent housing shortage

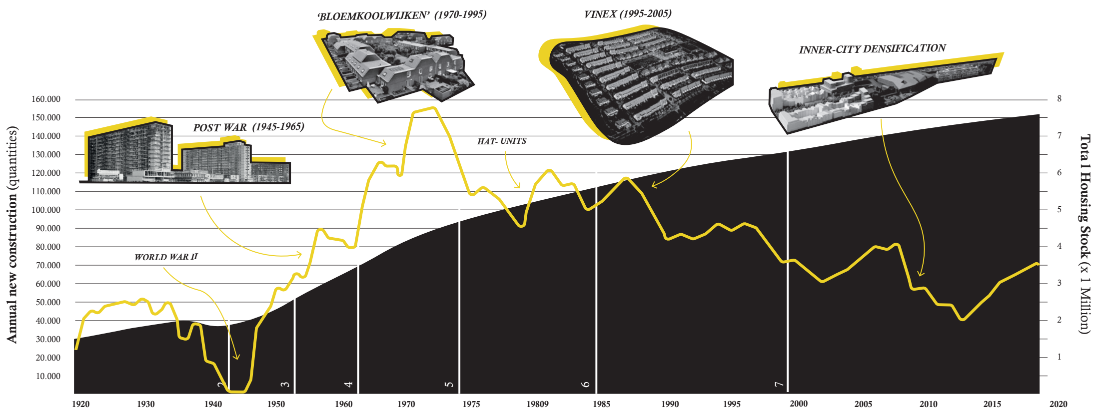
The housing shortage has been a longstanding issue in the Netherlands, as depicted in the graph. However, the graph does not precisely illustrate the origins of this housing shortage, as each period has its own causes and complexities. The most significant relative scarcity, for example, occurred after World War II due to the destruction of homes and population growth resulting from the baby boom. Housing shortage is always a interplay between the demand for housing and the supply of suitable homes.

The graph is highly dependent on the definition of "housing shortage," which has evolved over the years. The extent of the housing shortage strongly relies on assumptions, definitions, and perspectives. The current measurement method, derived from the calculations of the ABF (2023), distinguishes between different regions: someone looking for housing in Maastricht will not consider moving to Groningen. On the demand side, consideration is given to all home sharers aged 25 and older, as well as the number of first-time homebuyers. With this definition, the estimated housing shortage in 2022 is projected to be 331,000 homes. Another calculation method, from the "Atlas of Municipalities 2022," also takes into account the housing needs of those under 25 and arrives at a housing shortage of 390,000 homes.

A housing shortage consists of two components: Demand and supply. The supply comprises the housing stock, which has increased every year since 1920. Even during World War II, when many homes were damaged, there



HOUSING SHORTAGE - Based on Info CBS



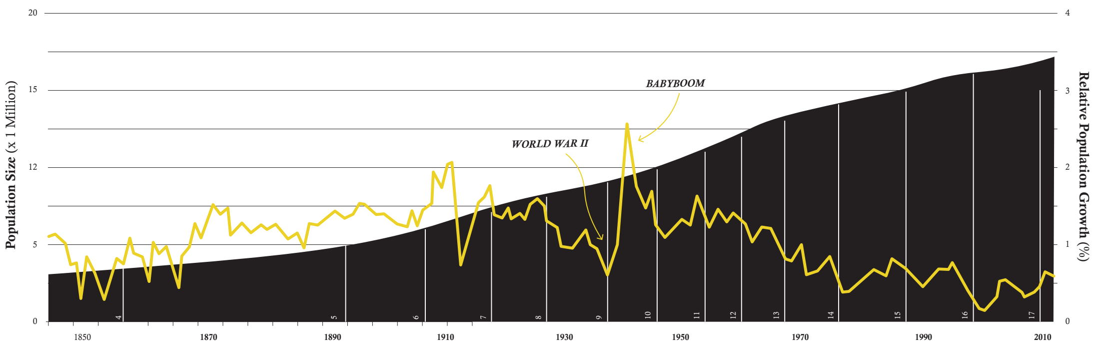
X. TITEL - BRON

was a positive balance of 120 homes. Over the years, the Netherlands has tried to adapt to the changing housing demand. For instance, after World War II, there was a rapid need for housing, resulting in a lot of prefabricated construction. When the demand for larger family homes increased, cities built Vinex districts outside the city limits. In the last 20 years, the space for construction has become scarcer, partly due to the call for green space and nature conservation around urban areas. This has led to densification, primarily within the city, exemplified by the 'rail zone' in Delft.

The other factor contributing to the housing shortage is the demand for housing, which, as mentioned earlier, can be interpreted in various ways. Population growth has at least a positive impact on the growth of demand. The most striking aspect in the population growth graph is the sharp decline during World War II, followed by a very high peak known as the baby boom, which significantly contributes to the aging of the Dutch population today. The second notable observation is that since this peak, the growth has shifted into a downward trend..

Changing households

As shown in the previous pages, the housing supply has increased much more in 100 years than the population, yet the housing shortage has not disappeared in these 100 years; in fact, it has increased again in the last 20 years. The reason for this lies in another factor in the demand for housing; the size of the population does not tell the whole story. To get a good picture of the demand, we need to look at the



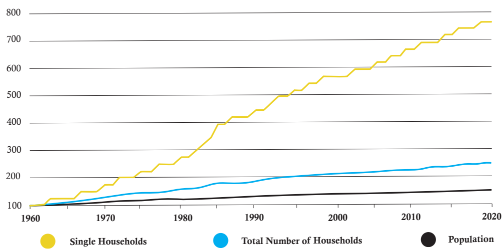
POPULATION - Based on Info CBS

number of households and the required living space, as these have increased significantly in the past 100 years. While a household in 1900 averaged 4.7 residents, this number will be only 2.2 in 2020. This difference is due to a relative decrease in 4-person households and an increase in single-person households. These smaller households and the increasing size of homes together contribute to a significant rise in average living space per person.

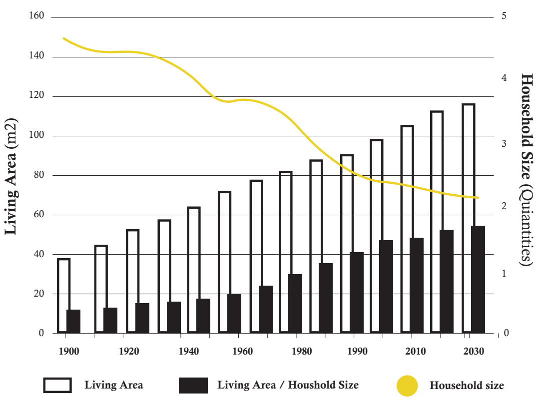
Current crisis

Zooming in to gain a better understanding of the current housing shortage, we observe in the supply that the financial crisis of 2008 caused a

NUMBER OF HOUSEHOLDS - CBS, 2024



LIVING AREA & HOUSEHOLD SIZE - CBS, 2024



significant dip in new home construction. An even more recent issue is the shortage of issued building permits; here, multiple problems play a role, with PFAS and nitrogen being important factors. The construction of social rental housing in the Netherlands is carried out by housing cooperatives. In 2013, a landlord levy was imposed on these housing cooperatives to replenish the state treasury after the 2008 financial crisis. This led to a roughly 50% decline in the construction of social rental housing, resulting in long waiting lists for obtaining social rental housing today.

The housing shortage is a highly complex problem; there is also not one single cause. On the supply side of the problem, the issues can be summarized as follows, and the justification for these problems can be found in Appendix X:

High Construction Costs

Various factors contribute to a significant increase in construction costs. Due to a tight labor market in the Netherlands, labor is very expensive. Additionally, the coronavirus crisis and the war in Ukraine have doubled the cost of some building materials compared to 2020.

Lack of Permits

In recent years, fewer building permits have been issued by municipalities, largely due to the PFAS and nitrogen issues in the Netherlands. This is a significant problem, especially in areas around nature reserves.

Lack of Space

In recent years, there has been a lot of densification within cities, but the locations for this densification are running out. The 'not in my backyard' mentality and the taboo on building in green areas also contribute to the scarcity of space for new construction.

Housing as an Investment

Homes are more than ever seen as an investment, leading to homes being bought up by wealthy investors. Not only homes but also land has become more expensive, resulting in extreme cases where developers simply leave the land undeveloped.

The contemporary housing shortage is a national problem; however, this does not mean the problem is the same everywhere. The "heat map" provides a clear picture of where the problems are most significant: the Randstad and major cities. This heat map examines the housing shortage and the price level of homes. It also shows that people in the Randstad have the smallest share of high average living space per inhabitant, as it is the lowest on average in the Randstad. In Rotterdam, for example, the average living space is 43.7 square meters, nearly 10 square meters less than the national average. If we further zoom in on the shortage of social rental homes, we also see differences, even within the Randstad. For example, the average waiting time for a social rental home in Amsterdam is more than 8 years, and in Rotterdam, it is just over 2 years.

As seen on the previous pages, the housing supply has increased much more in a hundred years than the population, but the housing shortage has not disappeared in these hundred years. In fact, it has increased again in the last twenty years. On the demand side of the problem, the issues can be summarized as follows, and this justification with numbers and graphs can be found in Appendix X:

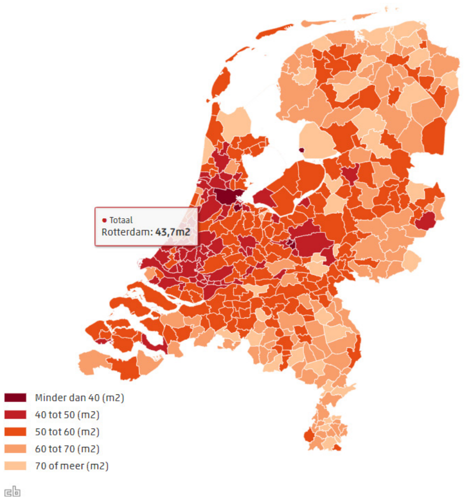
Growing Population and Households

The population in the Netherlands continues to grow every year; natural growth is decreasing and was even close to a decline in 2022. Especially, the migration balance contributes to population growth, which is very unpredictable.

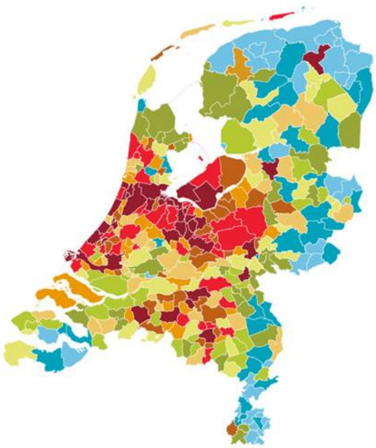
The Gap

High house prices combined with a high mortgage interest rate make homes unaffordable for starters, except for starters with wealthy parents who can tax-free gift €100,000 to their children, creating a skewed housing market.

AVERAGE LIVING AREA - CBS, 2018



HEAT MAP - BPD, 2023



Average Living Space

The average living space per capita continues to rise due to changes in households (e.g., more single-person homes) and increasing aging. The housing market does not seem flexible enough to respond to this.

Downsizing

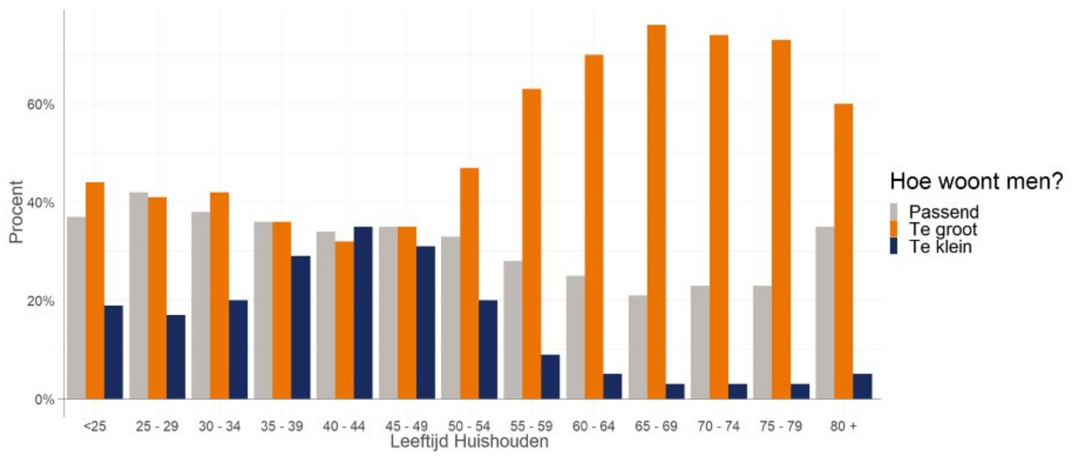
A frequently mentioned problem in municipalities is the influx of older people into smaller homes, as seen in the graphs below. Although older people often have smaller households, the average living space is growing. The supply of the right homes is not always the problem, and older people often do not want to move.

Urbanization

The global trend of urbanization shows an expected increase, with an estimated nearly 70% of the world's population living in urban areas by 2050 (United Nations, 2019b). In the Netherlands, the CBS (2023) confirms this development. The Dutch population has explosively grown over the past century, from 5 million in 1900 to over 18 million in 2023. This population growth has led to the expansion of existing cities and the urbanization of rural areas. However, this demographic dynamic has also resulted in population decline, especially on the outskirts of the country, in regions such as parts of the northern provinces, the Achterhoek, South Limburg, and Zeeland. Furthermore, these regions are aging, as young people move to cities for study or work.

Since the turn of the century, population growth has been concentrated primarily in and around large cities in the Randstad, as well as in other cities such as Groningen, Zwolle, Arnhem, Nijmegen, Amersfoort, Haarlem, and Eindhoven. While some regions experience less decline due to the influx of immigrants, many of these municipalities at the outskirts are expected to shrink until 2050 (image X), in contrast to the areas mentioned earlier. In compact Netherlands, where undeveloped land in cities is scarce, this poses significant challenges. Cities cannot expand indefinitely, requiring municipalities to find solutions within their urban boundaries. This results in further densification of existing cities.

This urbanization not only impacts demographic patterns but also has far-reaching consequences for the environment. Rapid and profound environmental changes caused by urbanization have negative effects on ecosystems



WHO LIVES TOO BIG? - CBS, 2024

and biodiversity (Dearborn & Kark, 2009). The expansion of urban areas often involves the loss of valuable natural habitats, leading to biodiversity loss and threats to ecological stability. Additionally, urbanization frequently brings about heat stress, where urban areas become warmer than their surroundings, harming both human health and local ecosystems. Cities also increasingly experience waterlogging due to extreme weather conditions and the abundance of concrete and asphalt, a trend expected to intensify due to climate change (KNMI, 2021). These challenges underscore the urgent need for an integrated approach to promote sustainable and resilient urban development, carefully considering both demographic and ecological aspects.

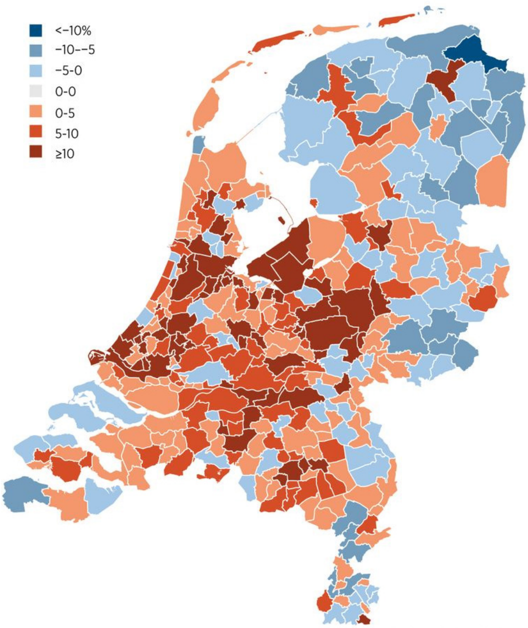
Policy

As of now, there is a plan to build approximately 1 million additional homes by 2030 in the Netherlands. The approach to realizing this goal varies within the Dutch government. Hugo de Jonge, the current Minister of Housing, focuses on large-scale projects, both within and outside cities, with 30% dedicated to social housing. Various provinces have also signed a document outlining their contributions to these 1 million homes, and once again, a significant portion is expected to be realized in North and South Holland.

This is an ambitious plan, but just two years after its formulation, it appears to be unattainable. The target of constructing 100,000 new homes annually was not met in 2022, with only 66,000 being built. Furthermore, it is anticipated that even fewer homes will be constructed in 2023, despite the increased number of permits being issued.

The challenges in meeting these housing targets are multifaceted, encompassing issues such as the choice of housing locations, the allocation of social housing, and the coordination among various government levels and provinces. The discrepancy between ambitious goals and actual achievements emphasizes the need for a comprehensive and adaptable strategy to address the complex factors influencing housing construction in the Netherlands.

POPULATION DEVELOPMENT - CBS, 2023



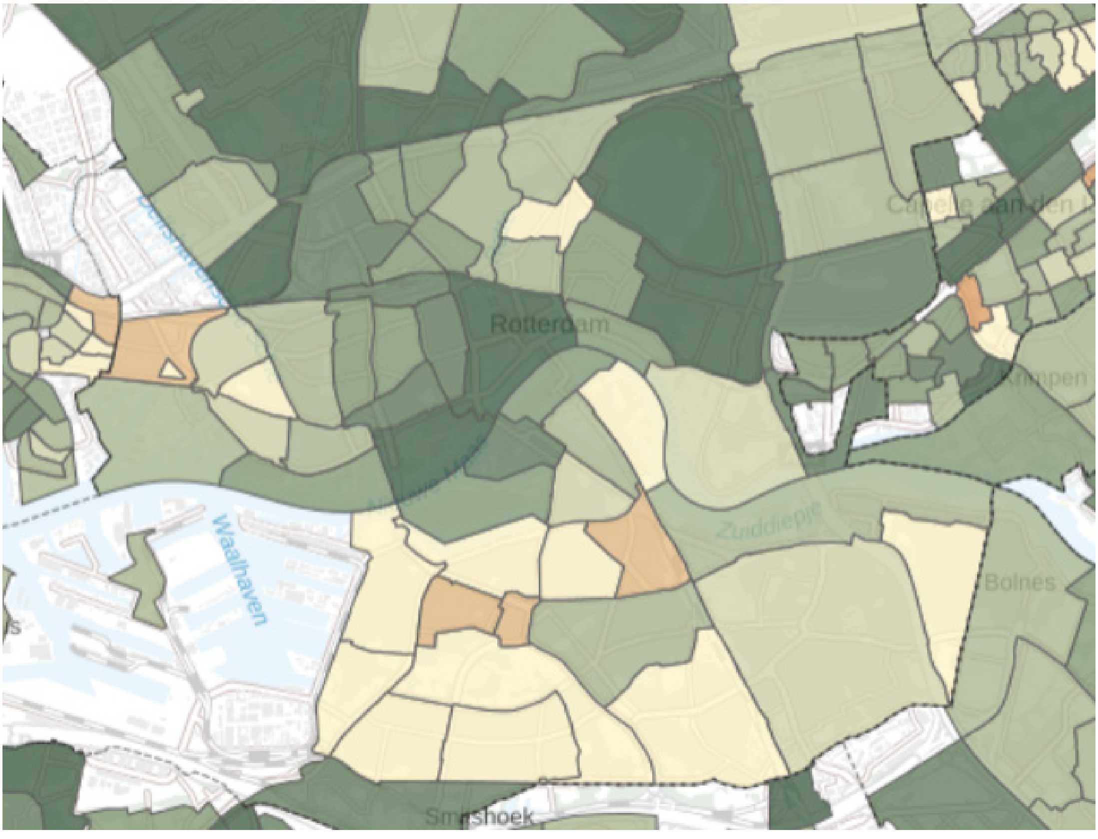
2.3 THE PERIPHERY

Residents of post-war neighborhoods

The more than 710 thousand inhabitants of post-World War II urban districts face socio-economic challenges more frequently than residents in most other neighborhoods. According to CBS research (2016) on 68 post-war districts in 30 major municipalities, these districts, with 711 thousand residents in 2016, are often characterized by social housing and a lower average property value than the national average. The majority of residents are under 45 years old, and 30 percent of them are between 25 and 45 years old. The proportion of seniors is above the average in major municipalities.

Remarkably, over 7 percent of the residents of post-war districts received social assistance benefits at the end of 2016, which is higher than the national average of 3 percent. Furthermore, 8.2 percent of residents between 15 years and the retirement age received a disability benefit, also above the average. The percentage of households with an income below or at the social minimum is over 14 percent, higher than in major municipalities and the Netherlands as a whole. (CBS, 2016)

These neighborhoods are characterized by a high percentage of single individuals (48 percent), fewer married individuals, and an above-average representation of people with a non-Western migration background (32 percent). The findings illustrate the socio-economic challenges faced by residents of post-war districts and emphasize the need for targeted



LEFBAARHEID ROTTERDAM - BZK, 2022

policy measures to support these communities. (CBS, 2016)

Rotterdam's periphery

Rotterdam, divided by the Maas River, reveals a notable dichotomy in livability and urban development between Above the Maas (northern part) and Below the Maas (southern part). Especially the southern part has historically grappled with socio-economic challenges. (BZK, 2022)

The history of Rotterdam after the wartime destruction not only involved the development of suburbs but also the complete reconstruction of the city center after bombings. Despite these efforts, the municipality of Rotterdam continues to address housing shortages by (re)developing areas into densely populated spaces.

E. Bakker (2021) conducted research on reasons in the physical environment contributing to the lagging livability in two of the southern garden cities; Pendrecht and Tarwewijk. She mentions the Broken Window Theory (Wilson & Kelling, 1982), which provides an insightful framework for understanding the social dynamics in these neighborhoods. Small apartments led to selective migration, reduced social cohesion, and increased anonymity. Monotonous streets and a lack of green space reinforced this effect, while long building blocks and a low level of amenities reduced walkability and "eyes on the street," impacting safety.

Walking through the post-war city districts in Rotterdam, the abundant greenery immediately stands out compared to the city center. Nevertheless, the city center remains an attractive residential location. The simplistic idea that greening neighborhoods can solve all problems is refuted by the situation in Groot IJsselmonde. Here, not only homogeneity in housing typologies manifests but also a monoculture in green structures, rooted in the social principles of the garden city. These human-designed green spaces contribute minimally to biodiversity and essential ecosystem services such as water retention, air purification, and pollination. Moreover, these green structures and inner courtyards often suffer from a lack of human scale, which can lead to anonymity and unreadable neighborhoods, as described by Newman (1972), potentially resulting in undesirable behavior. While the lack of public green reduces meeting places, and the housing stock, with small outdated apartments, contributes to selective migration and decay according to the Broken Window Theory.

'Nieuwe wijk'

Addressing issues in outdated neighborhoods requires not only the addition of green spaces and higher-end housing. Van Bockxmeer (2021), in an article in De Correspondent, emphasized the effectiveness of such measures. Renovations in old neighborhoods are often presented as a solution to various problems, such as improving living conditions, increasing housing supply, and reducing social issues. Upon closer examination, however, the motivations behind these renovations are not always favorable for the original residents.

The concept of 'mixed neighborhoods' is used as justification, where the presence of wealthier residents is seen as potential assistance for the existing population. Nevertheless, scientific studies show that this is rarely the case (Platform31, 2018). The arrival of new affluent residents does not significantly contribute to improving the situation of the original, often less affluent, residents. Although refurbished neighborhoods, on paper, show an increase in average income and a decrease in social problems, these improvements are mainly attributed to the influx of new residents (Van Bockxmeer, 2021).

However, these renovations have profound consequences for the original community. Often, the old residents not only lose their familiar place but also social connections and trust in the government. The pursuit of 'neighborhood improvements' contributes to deepening inequality in society. Although some cities attempt to maintain the number of social housing units, not all displaced residents return. The new mix of residents contributes little to the living situation of the less affluent residents. The social problems in renovated neighborhoods are often the result of policies, where cheaper social housing has been allowed only for those with low incomes since 2016. Existing residents are often overlooked, leading to deeper social inequality. There appears to be an urgent need for an alternative approach, where renovation plans are developed collaboratively with existing residents, respecting their community and interests (Van Bockxmeer, 2021).

2

“The ground being too hard for our bare feet we make ourselves sandals of softer material than the ground, but tougher than our feet.
[...]

For the foot the surface of the sandal represents a little piece of soft ground, whereas the underside acts as a toughened foot in relation to the ground. In the same way the inside of the house is for man a piece of habitable environment, while on the outside, where it confronts nature, it stands for a fortified human existence.”

DOM HANS VAN DER LAAN

WONINGPROTEST - Stefano Boeri Architteti

Regenerative City

Previous chapters highlighted problems, partly arising or exacerbated by urban developments. This chapter explores the potential of a regenerative city as a solution to these challenges. Since cities contribute to problems, solutions must also be sought within the city. The anthropogenic mass, all human-created elements such as cities, demands a reevaluation to minimize environmental damage and restore nature. This requires a paradigm shift, considering buildings and cities not as standalone entities but as integrated with nature.

2.1 New design practice

Historically, cities served as protection against natural and animal influences; however, contemporary urbanization requires a reconsideration given the growing environmental impact. A critical review of mindsets and practices is crucial for sustainable, regenerative cities. The competition for space in the city is substantial, and architects nowadays face more restrictive regulations than before. It is not an easy task. But problematizing the situation does not help. It is more fruitful to see opportunities and challenges in it. After all, the not-so-easy demands of hygiene and sustainability have also led to a new architecture. Why wouldn't the new requirement to incorporate nature on and around our buildings be equally transformative? Throughout history, we have learned that nature in the city is beautiful and even essential for our health and well-being. It is just a small step to start looking at our city and buildings in the same way.

Nature inclusive city

Regenerative architecture seeks solutions where the aspect of growth translates into ecosystem services that also benefit people, such as cooling, water management, and cleaner air. The term 'regeneration' encompasses not only creation but also continuous adaptation to a changing condition, an inherent characteristic of life and nature, yet not so obvious for buildings. Stewart Brand emphasized in his influential work "How Buildings Learn" that buildings should be seen as subject to permanent change over time.

In the pursuit of circular construction, inspired by biological and ecological principles, nature-inclusive architecture is a promising approach. Environmental philosopher Glen Albrecht introduced the idea of the 'symbiocene' in 2011, in which humans, nature, and technology strive for a new balance. Nature-inclusive architecture aims for the ultimate symbiosis between humans and nature, where technology and nature are inseparably linked.

Nature-inclusive building requires a different perspective on the execution, use, and maintenance, primarily of facades and roofs. It invites non-human users and adds new functional requirements to the program of demands. Inviting nature onto and around buildings requires a fundamentally different design attitude, from nature-resistant to nature-inclusive. Buildings and cities can no longer be the cause of problems but must evolve into solutions. This approach also requires a different design attitude from architects, moving away from the traditional human perspective. An example is the Groot-IJsselmonde district in Rotterdam, where green structures were designed from a human perspective, leading to a green monoculture with limited contribution to biodiversity. This is unfortunate because nature can provide essential services in urban areas, such as capturing fine particles, mitigating heat stress, and regulating water management. A city without nature is uninhabitable for humans.

Nature-inclusive conditions

According to (Van Doorn et al., 2016), nature-inclusive development is characterized by three conditions:

Natural Systems

The first condition of nature-inclusive development is optimal utilization of the power of natural systems and processes to address societal challenges. This involves employing "natural solutions" to tackle issues like climate change and sustainable agriculture. Natural solutions entail collaborating with and enhancing natural systems to address these problems, rather than relying solely on technological or artificial solutions. For instance, utilizing green roofs and walls to reduce the urban heat island effect or applying natural techniques for flood management, such as restoring wetlands to decrease flooding.

Restoration and Conservation

The second condition of nature-inclusive development involves the preservation and restoration of nature and biodiversity, encompassing plants, animals, their habitats, and natural processes. This extends beyond protecting nature within designated reserves or protected areas to include urban and rural landscapes. It entails ensuring adequate space and habitat for diverse species to thrive and maintaining natural processes like nutrient cycles, pollination, and seed dispersal.

Within Limits

The third condition of nature-inclusive development is that human activities occur within the bounds of natural systems. This implies that activities should not cause irreparable harm to natural systems or deplete natural resources beyond their capacity for renewal. Examples include using renewable energy sources instead of fossil fuels, reducing waste and consumption, and designing buildings and infrastructure that collaborate with, rather than oppose, nature. It also involves implementing practices like sustainable agriculture and forestry to preserve the long-term health and productivity of natural systems.

These conditions open up a new realm for the 'ecological designer' or ecotect, who navigates between landscape design, architecture, and ecology. This field requires ecological knowledge, design skills, and monitoring, emphasizing the courage to take initiatives. Nature-inclusive architecture is an ongoing process without a sharply defined endpoint, based on the realization that we are inherently part of nature and must design in collaboration with it. It calls for the pursuit of symbiosis, where architecture plays a reinforcing role for urban nature, and where the program of requirements allows nature to have a say in decision-making, moving towards a city where we shift from egocentric to ecocentric thinking.

Changing aesthetics

The aesthetics of architecture are also undergoing changes. Contemporary architecture is characterized by compactness, smoothness, precision, and neatness, but it offers limited space for nature. An ultra-flat, smooth glass curtain wall does not provide a habitat, whereas a porous, rugged façade does. Compact buildings, understandable from an energy-saving perspective, lack attachment points for nature, with no crevices, ledges, edges, recesses, or horizontal surfaces where birds can seek shelter, build nests, or bats can find refuge. The maintenance of nature-inclusive buildings differs from what we are accustomed to; some degree of 'messiness,' at least as we perceive it, must be allowed. Modern architecture is predictable and built with maximum control for specific users with specific needs. Deviations are corrected, but anticipating changing use is wiser and necessary for both humans and nature development. Ecology is characterized by dynamics in resource and energy flows, population developments, and species succession, limiting predictability.

This does not mean that buildings must be unfinished, unhygienic, or leaking. The desire to build more naturally is additional to the necessity of healthy and sustainable construction. Both requirements do not exclude each other and can even reinforce each other. A green city is healthy, and green roofs or facades reduce warming and wind nuisance, reducing the demand for cooling and heating.

Future building materials will evolve compared to current standards. Natural materials gradually replace harmful building materials for the climate and the environment. Brick and natural stone may retain a limited role, while concrete, despite bio-receptive concrete, seems outdated due to significant CO2 emissions in production. The direct use of bio-receptive, wooden prefab panels provides an alternative. Prefabrication allows for efficient production at a central location with possibilities for later reuse. Sustainable wood from managed forests can replace brick and concrete, with concrete perhaps only remaining relevant for foundations. Alternatives such as mycelium and straw illustrate the potential of natural materials. Synthetic materials persist, but manufacturing shifts to plant-based sources. Circularity plays a greater role in regenerative construction processes, with the construction sector emphasizing short cycles and minimizing distances, both literally and figuratively.

Synergie

The ongoing challenge for Rotterdam and the Netherlands is the efficient use of space. Under current political policies, the population continues to grow, while the physical size of the Netherlands does not expand. Allocating functions to the available space can only occur once. Hence, synergy in the urban context becomes increasingly essential. In cities where the demand for space increases due to population growth and limited available areas, embracing synergistic solutions becomes crucial. The collaboration between nature and culture not only provides opportunities for sustainability and environmental conservation but also for creating livable and resilient urban environments.

The lack of space forces urban planners, architects, and policymakers to seek innovative approaches that harmoniously integrate both elements. Nature-inclusive urban development, where greenery and biodiversity are cleverly integrated into urban infrastructure, illustrates this pursuit of synergy. Green roofs, vertical gardens, and communal parks are not only aesthetically pleasing but also contribute to solving space issues in cities.

Synergy between nature and culture in urban areas goes beyond mere space efficiency. It promotes a healthier lifestyle, reduces the impact of urbanization on the environment, and creates a more pleasant living environment. For example, integrating green zones in the city allows people to enjoy the natural surroundings without traveling far. This not only contributes to the well-being of residents but also to the biodiversity and preservation of ecosystems in urban areas..

Zoonomic Achitecture

The zoonomic organizational model contributes to ecological restoration by integrating the interests of non-human life into the decision-making processes within the organization. This exposition originates from the policy statement of The Zoonomic Institute, an initiative of Het Nieuwe Instituut (2002), a Dutch museum for architecture and design. It raises questions about how we can involve non-human entities, such as plants and animals, in participatory roles in political decision-making processes, as well as considerations regarding animal rights.

Based on these considerations, we can propose a zoonomic architecture, a design and realization process in which animals and plants have an equal voice in decision-making. If consistently applied, this has the potential to profoundly transform architecture, although the exact nature of these changes cannot be accurately predicted. Such an approach would imply a radical equalization of humans with all other forms of life, in a pure form of ecocentrism. However, it proves challenging for many architects, and possibly also clients, to grant actual access to buildings for animals. This is noteworthy given the existence of building-dependent animals that, unlike plants, cannot survive without our structures. In an ecologically just construction and decision-making process, this objection would no longer be relevant.

2.2 ECOSYSTEM SERVICES

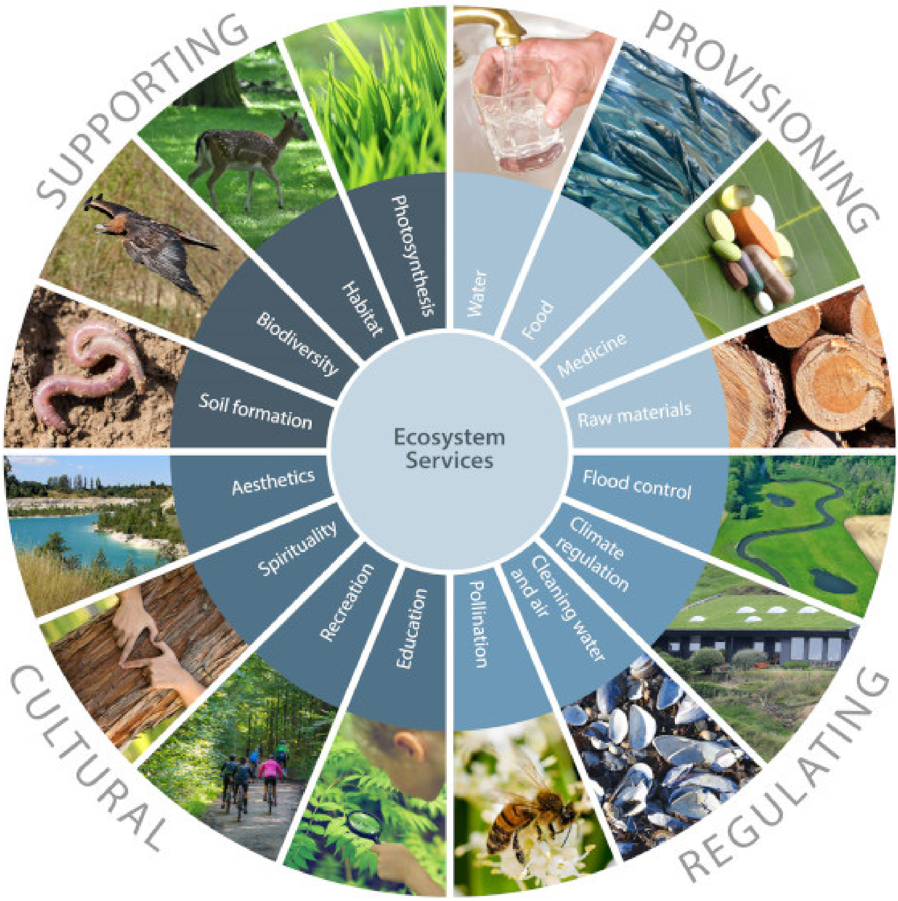
In preceding chapters and paragraphs, the importance of nature and a resilient ecosystem has been repeatedly linked to the provision of ecosystem services. Various types of plants and animals benefit from their presence in the city, and in turn, the city also derives advantages from their presence. Beyond ethical and aesthetic considerations, nature also offers functional benefits. Without nature, the city does not function optimally. These so-called ecosystem services are diverse and include provisioning services, such as providing food and fuel, to cultural services, such as recreational opportunities. However, unlimited use of these productive and cultural services can lead to depletion. This is not the case for the most crucial category, namely regulatory services. These include aspects that a well-functioning ecosystem naturally provides without the risk of depletion. This encompasses supporting services that contribute to the functioning of the system itself, such as promoting a healthy soil life, preserving biodiversity, and natural pollination, which is essential for our food supply.

The conservation of nature and biodiversity in cities is thus not only about ethics but also about survival. Humans are intrinsically dependent on the natural systems that provide clean air, water, and food. These ecosystem services not only ensure the physical resilience of a neighborhood or city but also provide social resilience and associated health benefits. Therefore, it is crucial to make cities and buildings nature-inclusive, necessitating adjustments to human-made materials and processes to support the natural system.

Physical Resilience

As mentioned earlier, cities face significant challenges, and without intervention, these problems will only escalate. One way to counteract this is by strengthening ecosystems in the city, resulting in more and more resilient ecosystem services.

A biodiverse environment can provide regulatory ecosystem services that regulate severe floods and waterlogging (Carter et al., 2018) and buffer water scarcity (Ellison et al., 2017). In locations where health standards are exceeded, the potential of trees and other plant



ECOSYSTEM SERVICES - PBL & WUR, 2014 species to regulate concentrations of air pollutants and reduce noise can be particularly important (Cohen et al., 2014; Haase et al., 2014; Salmond et al., 2016). There is also evidence that tree diversity has a significant impact on reducing air pollution in cities (Churkina et al., 2015; Grote et al., 2016).

The construction of greenery can also cool the city. Especially, trees have an enormous cooling effect in the city due to the shade they provide and the evaporation of water. The design of cities can influence people's exposure to extreme heat. Increased ground and air temperatures in urban areas are mainly due to the replacement of natural ground cover with impermeable coverings with various thermal and structural properties (Gunawardena et al., 2017, Oke, 1982). The cooling properties of vegetation and water (through evaporation and/or shade) mean that even modest amounts play a crucial role in temperature moderation, influencing people's thermal comfort and reducing heat stress (Bowler et al., 2010a). The abundance of vegetation, structural features, taxonomic diversity, species composition, functional diversity, and functional identity all influence the degree of cooling provided (Lindley et al., 2019, Schwarz et al., 2017, Ziter, 2016).

Lastly, nature in the city contributes to food and biofuel provision. While the emphasis on this primarily lies in the agricultural outskirts, food can also be produced within urban

.EXAMPLE OF ECOSYSTEM SERVICES - PBL & WUR, 2014 areas. Recent examples of urban farming and the emergence of community and neighborhood gardens initiated by residents bring urban dwellers closer to nature and significantly contribute to knowledge of and support for urban nature in general (Vink et al., 2017).

A balanced and diverse ecosystem in the city also reduces the likelihood of nuisance from certain pests. Bats and birds play an active role in consuming insects, contributing to the control of mosquitoes, positively influencing people's quality of life (Vink et al., 2017).

Health & welfare

In addition to the regulatory services of urban ecosystems directly influencing the health of city residents, such as utilizing green spaces for cooling to reduce heat stress, air purification, and noise reduction, nature and greenery in the city, through activities like green recreation, also exert indirect influence on the health of its inhabitants. In recent years, numerous studies have pointed to positive and measurable effects of greenery on health, both preventively and curatively. Engaging with green spaces, even just through visual exposure, has been shown to have various beneficial impacts, including stress reduction, hastening the healing process in hospitals, and contributing to the stimulation of motor, cognitive, and emotional development. Marselle (2021) provides a scientific underpinning for these benefits.

Evidence of stress recovery is observed in reduced physiological arousal and negative emotions, along with increased positive emotions (Ulrich et al., 1991). Characteristics of the natural environment that promote stress recovery include moderate to high complexity, a focal point, a moderate to high level of depth, a ground surface conducive to movement, a lack of threat, a curved view, and the presence of water (Ulrich, 1983). Reduced physiological stress has been associated with greater plant species richness (Lindemann-Matthies and Matthies, 2018). Greater abundance of birds in the afternoon (Cox et al., 2017b) and perceived plant species richness (Schebella et al., 2019) are linked to reduced psychological stress.

Greenery also promotes physical activity, which is crucial for both physical and mental well-being (Biddle and Mutrie, 2008). Research suggests that physical activity in nature may yield greater physiological and psychological benefits than indoor or urban physical activity (Bowler et al., 2010b). Enriching street views by increasing biodiversity has been shown to promote physical activity (Säumel et al., 2016).

Two other social aspects in the city, social interaction, and social cohesion in neighborhoods are linked to health and well-being (Fone et al., 2014, Holt-Lunstad, 2017). Social cohesion refers to "shared norms and values, the existence of positive and friendly relationships, and the feeling of acceptance and connectedness" (Hartig et al., 2014, p.215); since social cohesion is more a characteristic of neighborhoods than individuals, it is susceptible to changes in the physical characteristics of the neighborhood (Baum et al., 2009). Biodiverse neighborhoods with more trees can provide a setting for social interaction with others, likely enhancing social cohesion (Sugiyama et al., 2008, Sullivan et al., 2004). In this way, nature and greenery can serve as meeting places. An example of this is the creation of city gardens where lonely elderly individuals can come together and meet other residents.

Furthermore, city dwellers can form emotional ties or place attachment to biodiverse environments (Ives et al., 2017, Manzo and Devine-Wright, 2019, Raymond et al., 2010). These emotional connections mean that these biodiverse environments can also be part of one's sense of place identity (Manzo and Devine-Wright, 2019). Both place attachment and place identity are associated with psychological well-being (Manzo and Devine-Wright, 2019). Previous research has found that both place attachment and place identity were positively associated with the abundance of tree cover (Dallimer et al., 2012), the actual and perceived richness of bird species (Dallimer et al., 2012, Fuller et al., 2007), as well as the perceived richness of butterflies and plants (Dallimer et al., 2012). Place identity was also positively related to the number of habitat types and the actual species richness of plants (Fuller et al., 2007).

Nature's rol in childhood

Green spaces are vital for children's physical, mental, and social development, shaping both their immediate well-being and long-term values. Child-friendly environments such as biodiverse parks, school gardens, and natural play areas encourage exploration, creativity, and physical activity, fostering healthier lifestyles. These spaces also reduce stress, enhance cognitive skills, and promote emotional resilience. Features like diverse vegetation, interactive play elements, open fields for group activities, and shaded rest areas prove particularly effective in supporting children's development (UNICEF, 2019; Marselle, 2021).

The benefits of green spaces extend beyond childhood. Adults who experienced frequent exposure to nature as children often develop a profound emotional connection to the environment, which motivates them to engage in conservation efforts and sustainable practices (Kals et al., 1999). Research by Asah et al. (2018) demonstrates that self-initiated play in nature during childhood is a strong predictor of lifelong environmental citizenship and active participation in nature-based activities. By providing opportunities for children to form these connections early, green spaces contribute to building environmentally conscious generations.

Green spaces also serve as critical social environments for children, promoting interaction, inclusivity, and community cohesion. Biodiverse and accessible areas such as city gardens and neighborhood parks become meeting points where children from diverse backgrounds can connect through shared play and activities, strengthening social bonds (Cities4Children, 2022). These interactions not only foster social skills but also create inclusive and supportive communities.

Investing in green spaces for children ensures their healthy development and nurtures future generations who value and protect the natural world. Such spaces serve as essential components of urban planning, bridging ecological and social needs while fostering a sustainable and resilient society.

3

“Our countryside increasingly resembles a green yet industrial desert. For the greatest variety of life, you need to be near cities. In fact, to teach people about biodiversity and natural cycles, you don’t need to go to Brazil or Australia. I can tell a wonderful story in a roadside ver-ge in Rotterdam about plants that feed insects, which in turn sustain songbirds, and ultimately keep sparrowhawks and peregrine falcons alive.”

JELLE REUMER

ROCK INHABITANT IN THE CTIY

The ecology of the city

The preceding chapters have focused on understanding the challenges faced by urban environments and have identified potential solutions. Insights have been provided, and strategies discussed to enhance the quality of life, increase ecological sustainability, and strengthen the resilience of cities. This new chapter marks a crucial transitional phase, wherein we project the acquired theoretical knowledge onto the ecology of the city. We delve deeper into the inhabitants of this city, encompassing both humans and animals, exploring how this diverse community of residents can coexist harmoniously in the emerging nature-inclusive city.

4.1 THE CITY AS LANDSCAPE

In urban areas, the city is perceived as a complex landscape where animals adapt to human-made structures. Street and urban furniture play significant roles for urban wildlife, especially birds that nest in high buildings. These structures serve as homes for birds such as pigeons and falcons, and the city is regarded as a kind of natural rock formation. Roaming birds, like swallows, view these tall structures as substitutes for natural cliffs, demonstrating their adaptation to city life.

At street level, small mammals, particularly mice and rats, create shelters and passageways in the underground labyrinth of urban pathways and sidewalks. These locations are not just infrastructure but also various small habitats with ecological consequences for these animal populations.

Architectural elements such as green roofs and vertical gardens provide spaces where urban animals, including insects and birds, can reside. These structures are more than just aesthetically pleasing; they are viable habitats that enhance the diversity of life in urban areas. Street lighting also influences nature, especially nocturnal animals like bats attracted to the light, capturing moths and other insects, indirectly providing food.

Water features in the city, such as ponds and fountains, serve more than decorative purposes. They function as small habitats for amphibians and waterfowl, where ecological interactions and diversity thrive. It is crucial to examine the city from the ecological perspective of the animals residing in it to better understand the relationship between humans and animals in urban areas. The city is viewed as a unique, interconnected ecosystem, with its primary characteristic being heavily influenced by human activity, offering a variety of small habitats for different animal species.

City as ecosystem

The notion that nature belongs outside the city is a perspective still voiced among policymakers and urban planners. However, this attitude is no longer tenable, especially in densely populated areas like those in Northwest Europe. These regions have evolved into contiguous urban entities with concentrated development around the old city centers and extensive suburban construction. More than half of the land area in these regions is urban or semi-urban. The green patches on contemporary maps largely represent agricultural areas, with only a small portion indicating nature reserves, which also require intensive management to survive. One might argue that there is no nature left in such agglomerations. However, this is not the case: in addition to forests, mountains, marshes, and many other natural ecosystems, the city is also its own ecosystem, where natural elements and human structures have converged. While primarily the habitat of humans, the city is equally an independent ecosystem with high biodiversity. Schilthuizen (2018) in his book 'Darwin in the City' highlights various examples of similarities between the flora and fauna in cities worldwide, emphasizing the city as a self-contained ecosystem. Urban habitats are often fragmented, yet some species have adapted so well to the city that they are now dependent on it (Vink et al., 2017).

Furthermore, urban areas may exhibit greater biodiversity than intensively managed agricultural regions (Baldock et al., 2015), where habitat uniformity and the use of pesticides and fertilizers could be significant contributors to the global decline of insects and birds (Donald et al., 2006). While biodiversity in rural areas continues to decrease, that of the city is on the rise. In 2015, it was already observed that butterflies in Dutch cities perform as well as those in natural areas, with agricultural areas seeing a decline in species diversity.

Different biotopes

In urban areas, the city is primarily characterized as a complex landscape with buildings and streets forming a stony environment. Amidst these structures lie various green and wet spaces, both large and small, diverse in nature and generally situated at reasonable distances from each other. It is the variety and dynamism that render the city so diverse. For instance, the juxtaposition of stone and greenery or differences in elevation makes the city an appealing habitat for many species, distinguishing it as a biotope from rural areas. Numerous species expelled from rural settings have found a permanent home in the city, evolving into true urban species unable to thrive beyond city limits (Vink et al., 2017).

In addition to this diversity of habitats, the city offers several advantages: it tends to be warmer, provides ample food resources, and, aside from active pest control, hunting is generally prohibited. The city is also dynamic, with ongoing construction, demolition, excavation, mowing, pruning, dredging, cleaning, planting, material transportation, changes in land use, importation of foreign soil, material removal, pervasive traffic, and the introduction, flight, and growth of organisms brought in by humans. This dynamic environment benefits species reliant on such disturbances, particularly those dependent on early successional stages. In the city, these dynamic areas are often available in the form of demolition sites, roadside verges, or vacant lots, making them crucial biotopes. It's essential to note that ecosystems with relatively few different species, like these fallow lands, can still hold significant value.

However, the urban dynamic of construction and reconstruction poses challenges to the establishment of stable biotopes, especially when alternative habitats are scarce nearby. The downside of this dynamism is that disturbance-sensitive species, which require more stability, may struggle to survive—though many species have adapted, or they are mobile enough to quickly colonize a nearby alternative if the current area undergoes transformation. The blackbird, once a shy woodland bird, has become a frequent visitor to our gardens and parks, exemplifying adaptation to urban environments. Quiet zones within the city also exist, typically characterized by mature trees in their final stages, benefiting species that avoid dynamism. Examples include old city parks or forests with ancient trees and minimal recreational activity, cemeteries, allotment gardens, and naturally managed areas with flower-rich meadows. The biodiversity of the city is determined by the combined presence of dynamic and more stable areas, as well as the unique urban combination of stone and greenery (Vink et al., 2017).

Several common urban biotopes include hills, rocks, and gardens—each possessing distinctive characteristics that host diverse flora and fauna.

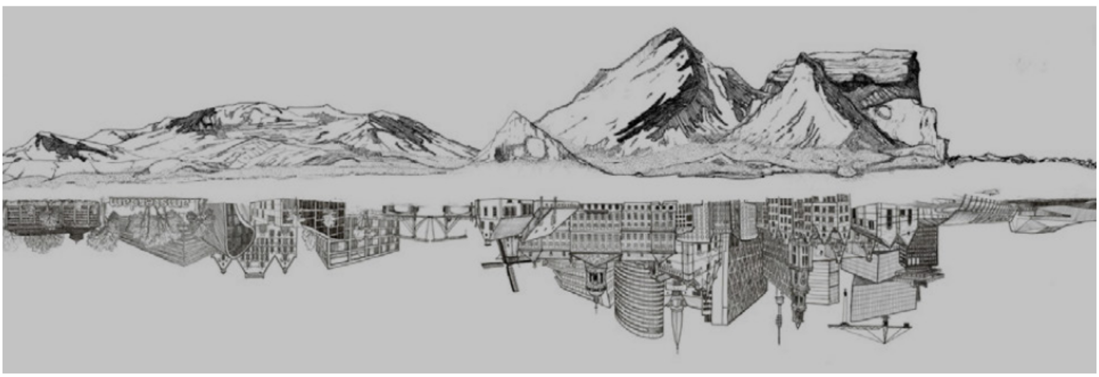
The Hill

Urban forestry encompasses not only trees in streets, parks, and industrial areas but also shrubs and "tiny forests" (Wheater, 2002). Parks introduce a new biotope: a forest edge representing a lush and diverse environment, saturated with nutrients. Trees play a crucial role in attracting insects to the location, resulting in a varied ecosystem of invertebrates. Whether the trees are alive or dead, they provide food for larger birds such as woodpeckers and finches.

A forested area can have a positive impact on the surroundings. Trees filter the air, positively influencing atmospheric pollution. Broad-leaved trees, for example, reduce dust deposition by 27%, while coniferous trees are even more effective, with a 38% reduction in dust deposition and the interception of 13% of particles (Wheater, 2002). Trees also serve as effective sound buffers, and for optimal results, a larger area with evergreen trees is ideal. Furthermore, these forested areas offer summer shade and, by retaining water, contribute to water buffering.

The Rock

When considering ecological layers, the value of rocky environments is often underestimated.



Walls, buildings, and paved surfaces with numerous cracks and crevices contribute to urban nature and can be seen as equivalents to cliffs and bare rocks, hosting their unique flora and fauna (Fassbinder, 2011). The additional effect of dense stony surfaces, known as the heat island effect, creates ideal conditions for some birds during flight (Schilthuizen, 2018).

Buildings also function as unique biotopes where various species converge. Urban buildings provide excellent nesting, resting, and perching sites for birds and bats, as well as habitats for lichens, mosses, ferns, flowering plants, and invertebrates (Wheater, 2002). Even unused patches of land with seemingly wild vegetation and sandy soil contribute to urban biodiversity. Some birds take sand baths, while others use this ground to build their nests. In this way, brown roofs, which may not be immediately recognized as biodiverse by people, can still contribute to strengthening a habitat similar to "the rock."

The Garden

The garden biotope, a characteristic environment in old city centers, comprises numerous ground-level gardens associated with residences. These gardens serve as habitats for wild plants and animals, forming an essential part of (sub)urban areas. These individual plots create a contiguous environment, where the awareness and involvement of private owners are crucial, as only 40% of the public space is owned by the municipality of Rotterdam. Connecting this system is essential, as animals and plants pay no heed to ownership boundaries and do not recognize them. An example is the hedgehog, a mammal that can travel kilometers at night, benefiting from these connections between different gardens.

Plants in gardens, often selected for their flowers and fruit, offer a diverse range of habitats. The presence of herbaceous plants and grasses makes this biotope ideal for insects. The greenery on facades and hedges in these habitats also serves as shelters for smaller songbirds. Despite many of these plants being non-native, the diverse proliferation of plant species contributes to ecological balance. Although the garden biotope is sometimes considered "messy," less aesthetically appealing elements, such as compost heaps and piles of firewood, contribute to maintaining this equilibrium. The interplay of diverse flora and fauna in these urban

4.2 ANIMALS IN THE CITY

As discussed in the preceding paragraph, urban landscapes comprise diverse habitats providing natural shelters for their respective inhabitants. Over the years, various animal species have chosen, whether willingly or not, to migrate to urban environments for diverse reasons. Some species have been displaced from surrounding areas, while others view the city as their new home due to the striking similarity between the urban ecosystem and their original natural habitat, as discussed in the previous section, exemplified by the 'rock' habitat. Additionally, certain species have sought out the city due to the abundance of food and warmth. Once in the city, they encounter an ecosystem where abiotic factors change rapidly, leading to significant selective pressures and swift adaptations within species.

Darwin comes to town?

Menno Schilthuizen (2018) explores the evolution of urban biodiversity in his book "Darwin in the City," emphasizing the unique challenges and opportunities cities offer for species adaptation and evolution. Schilthuizen (2018) suggests that urban areas serve as "evolutionary hotspots," exposing species to novel environmental conditions and selection pressures, leading to rapid adaptation and evolution. This process may result in the emergence of new species with characteristics specifically adapted to the urban environment (Schilthuizen, 2018).

The book cites numerous examples of rapid evolution and adaptations in urban settings. A notable case is the peppered moth, Biston betularia, which underwent a striking transformation in the industrial city of Manchester within a few decades, an evolutionary shift considered "remarkably swift" (Chapter 8: Moths and Myths). Another intriguing example is the London Underground mosquito (Culex molestus), adapted to subterranean life, showing noticeable genetic differences between individuals in different metro lines. This mosquito significantly differs from its counterparts outside the metro, even feeding on passengers' blood after laying its eggs. The global reach of this mosquito illustrates the human contribution to species dispersal.

The book is replete with similar examples of insects, birds, mammals, and plants adapting to the urban environment. Schilthuizen (2018) candidly acknowledges the difficulty in determining whether observed changes result from accelerated evolution or from learned behavior and adaptation to urban conditions. Nevertheless, he highlights that cities often exhibit greater biodiversity than the currently heavily modified countryside, where natural environments suffer disruptions due to human activities.

A shift attributed to learned behavior is termed Synurbization by Luniak (2004), referring to the effects of urbanization on the adaptation of wildlife and the differences in animals living in urban environments versus natural ones.

Synanthropic

Humans often categorize animals based on their relationship with humans, creating two major groups: domesticated and wild species. Domesticated species rely on humans for survival, varying in the degree of human involvement, including pets, livestock, and animals for entertainment. Wild species are perceived as independent of humans and capable of surviving without human assistance. Traditional conservation practices aim to protect wild areas from human influences by establishing nature reserves. However, these efforts to maintain a separation between humans and nature create perplexing situations (Gunawan, 2015).

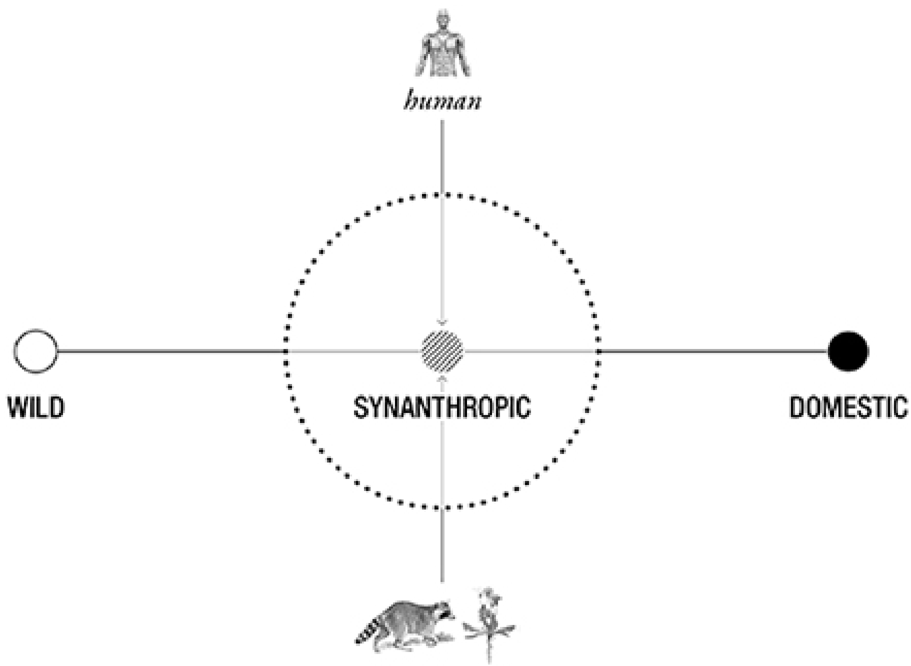
According to Lefebvre, people unintentionally transform wild areas into urban spaces by defining "forests" or "parks" as places for animals. The established relationship between humans and animals through conservation and restoration practices results in a state of "conservation reliance," where humans impact the wilderness, blurring the boundary between conservation and domestication (Gunawan, 2015).

The synanthropic condition exists between domestication and wilderness, describing species benefiting from human proximity but not controlled by them. Synanthropes thrive in urban areas, taking over infrastructure and varying in their role and value depending on the situation. While some consider synanthropes as pests, such as pigeons in city centers and spiders in living rooms, they can be welcomed in certain cases.

For most urban residents, synanthropic animals are not crucial to city life and, at most, evoke indifference, occasional irritation, or fear. These animals do not align with the notion of the city as a place devoid of nature, but despite efforts, they cannot be completely eradicated, only kept at a distance.

Urban development provides opportunities for synanthropes to adapt. Transforming urban areas creates "ecological vacuums" where adaptable species can thrive. This adaptation, known as synurbization, has enabled species to colonize cities more successfully than natural environments.

Animals living in urban populations generally have significantly longer lifespans than their rural counterparts due to various factors. The urban environment, for instance, poses less



risk from predators, provides protection against weather conditions, and offers abundant food. This also alters species' behavior, resulting in higher numbers, changed territories, extended breeding seasons, and increased tolerance toward humans (Luniak, 2004).

It is evident that synanthropic species, unlike humans, perceive the city as a place with ecological opportunities, not as a degradation. The cultural separation between city and nature, established by humans, does not apply to non-human species in the city. They seek opportunities to thrive and reproduce successfully, regardless of whether the environment is created by human or natural processes. Posthuman thinking attempts to understand animals' perspectives, dissolving the separation between nature and the city in favor of new forms. It resists human superiority and embraces inherent differences in others, broadening our understanding of the physical world. In this framework, the idea of "being" extends to all biological and technological hybrid conditions.

Invasive exotics

The introduction of exotic species into urban environments brings forth both opportunities and challenges, with the intricate relationship between humans and animals in urban settings central to the understanding of synurbization. The city provides favorable conditions for certain species, exemplified by the Japanese knotweed, an exotic thriving in the urban jungle. However, this adaptation to the city often leads to the displacement of native species, resulting in a decline in ecological diversity.

The disruption of balance is exacerbated by limited predation and competition, allowing long-lived generalist species to dominate, albeit often with reduced health qualities. The absence of natural predators promotes the survival of weaker species but also renders them more susceptible to diseases. While synurbization unveils an intriguing interaction between humans and animals in urban environments, it underscores the need for diverse native habitats to maintain ecological equilibrium (Gunawan, 2015).

On a broader timescale, cities undergo natural cycles where species interact with each other. However, when humans introduce invasive exotics, often unintentionally and over vast distances, an unnatural disruption of the ecosystem occurs. These species, relocated with or without awareness, can thrive without their natural predators and disrupt, weaken, or even endanger a system. Acknowledging that exotics may fare better in the city also implies accepting that the city has become a self-contained ecosystem. The city has inevitably altered our 'nature,' making it unrealistic to expect the flora and fauna of a century ago to thrive in our evolving environment. Nevertheless, this doesn't mean we should solely embrace exotics in our city; a balance must be struck among these different species. Finding this equilibrium ensures that the two types can complement each other, allowing native species to persist (Schilthuizen, 2018).

The critical factor lies in achieving a balance between the presence of native species and invasive exotics. Dominance by a single species, whether native or invasive, leads to instability and a lack of resilience, ultimately diminishing biodiversity. Therefore, striving for a harmonious interplay of various species, each playing a specific role, is essential for the equilibrium and vitality of the urban ecosystem.

Patterns

Jakob von Uexküll, a 19th-century German biologist, is pivotal in understanding how different species perceive the world around them. He formulated the Umwelt theory, referring to the perceived world of an organism. According to Uexküll, an organism's environment and actions depend on the complexity of the organism itself. The Umwelt theory is further elucidated by Uexküll's Funktionskreis, a cycle wherein perceptions lead to actions. Living beings, constantly needing to function and ultimately reproduce, undergo wear and tear in accordance with the second law of thermodynamics.

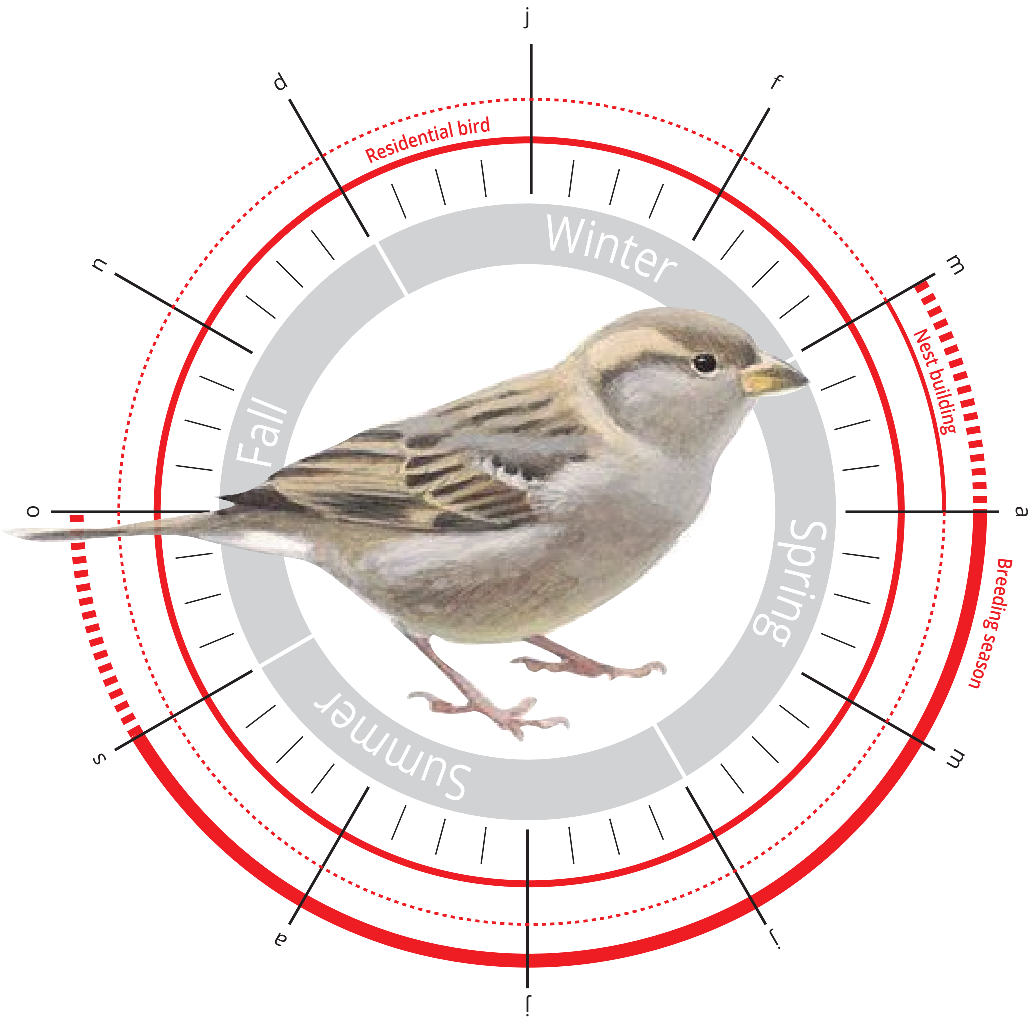
In the process of synurbization, where animals must adapt to urban environments, perception plays a crucial role. The ability of animals to identify specific conditions necessary for feeding, breeding, and thriving is essential for survival in the city. Uexküll divides the Funktionskreis process into two worlds: the Merkwelt (perceptual world) and the Wirkwelt (effector world), together forming the Umwelt of a species. This environment includes "carriers of meaning" or "signs," which are the only elements of importance to the organism.

This research aims to integrate the behavior of non-human beings into designs of connections, intending to provide more space for animals that prefer living in proximity to humans. It seeks mutual benefit in coexisting with synanthropic animals, where both animals and humans benefit from each other's presence. This approach to living with animals is introduced as "synanimalic," recognizing that what is good for animals can also be beneficial for humans. Considering synanthropic animals as valuable members of society can open up new possibilities for diversity in urban areas. People would actively contribute to facilitating ecological opportunities, supporting habitats, and providing food to encourage species' adaptation to urban changes. It would be the responsibility of citizens to promote variety in species and ensure the proper functioning of the urban ecosystem.

House sparrow

The house sparrow, being the most prevalent bird in Dutch gardens, heavily relies on the garden landscape for its well-being. House sparrows serve as exemplary synanthropic animals, demonstrating a strong connection with humans as genuine cultural followers. Their nesting places are typically associated with buildings, and their food source is significantly dependent on what humans consciously or unconsciously provide. Approximately 70% of house sparrows breed in urban areas, while the remaining 30% inhabit agricultural regions. However, the association with buildings is also the reason for the decline in the house sparrow population, leading it to be listed on the red list. This decline in the breeding population is attributed, among other factors, to changing architecture. House sparrows are most abundant around older houses in partially green, preferably slightly messy surroundings on the outskirts of cities or in rural areas. They are scarce or absent in newly built, neatly planned neighborhoods and the paved cores of large cities due to the lack of nesting opportunities and/or food (BIJ12, 2023b).

The habitat of the house sparrow must encompass a combination of crucial elements, all within a range of a few meters (cover near food sources) to several hundred meters of each other. The habitat should consist of a mix of spots for nesting, food (for both adult and juvenile house sparrows), cover (thorny bushes, evergreen shrubs and climber), places for dust baths, and access to drinking water. If any of these components are missing or are too far apart, the habitat becomes unsuitable (BIJ12, 2023b). The house sparrow's reliance on these specific elements highlights the intricate balance required for their survival and underscores the impact of human-altered environments on their population dynamics.



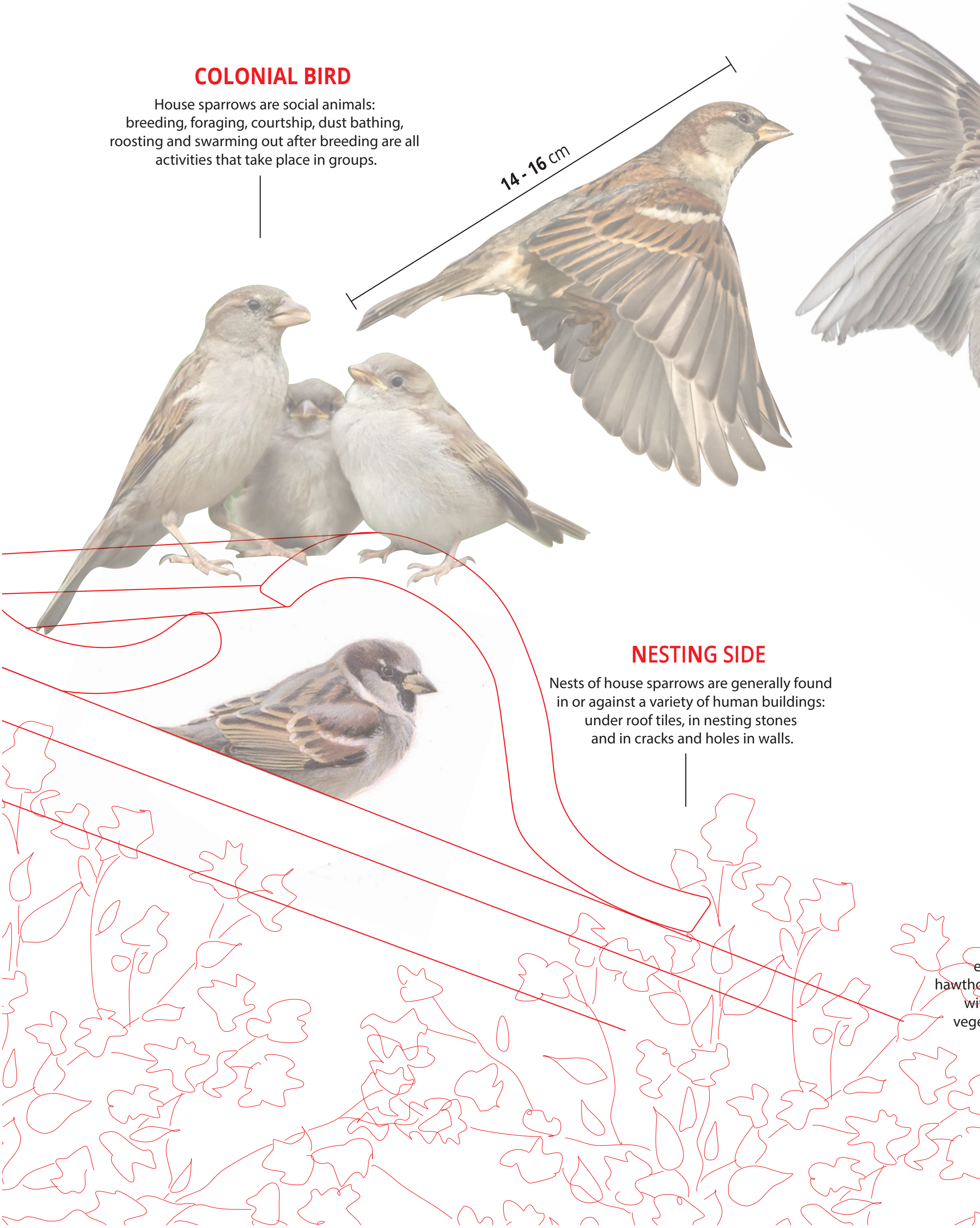
BREEDING

Usually two to three clutches are raised per pair per year.
One successful clutch per season is not sufficient to maintain the population at a satisfactory level; successful successive clutches are required each year.
The incubation period is 12 to 14 days, after which the young fledge after 14 to 16 days and are fed by their parents for another 10 to 14 days.

ANNUAUAL PATTERNS OF THE HOUSE SPARROW - Own image

COLONIAL BIRD

House sparrows are social animals: breeding, foraging, courtship, dust bathing, roosting and swarming out after breeding are all activities that take place in groups.

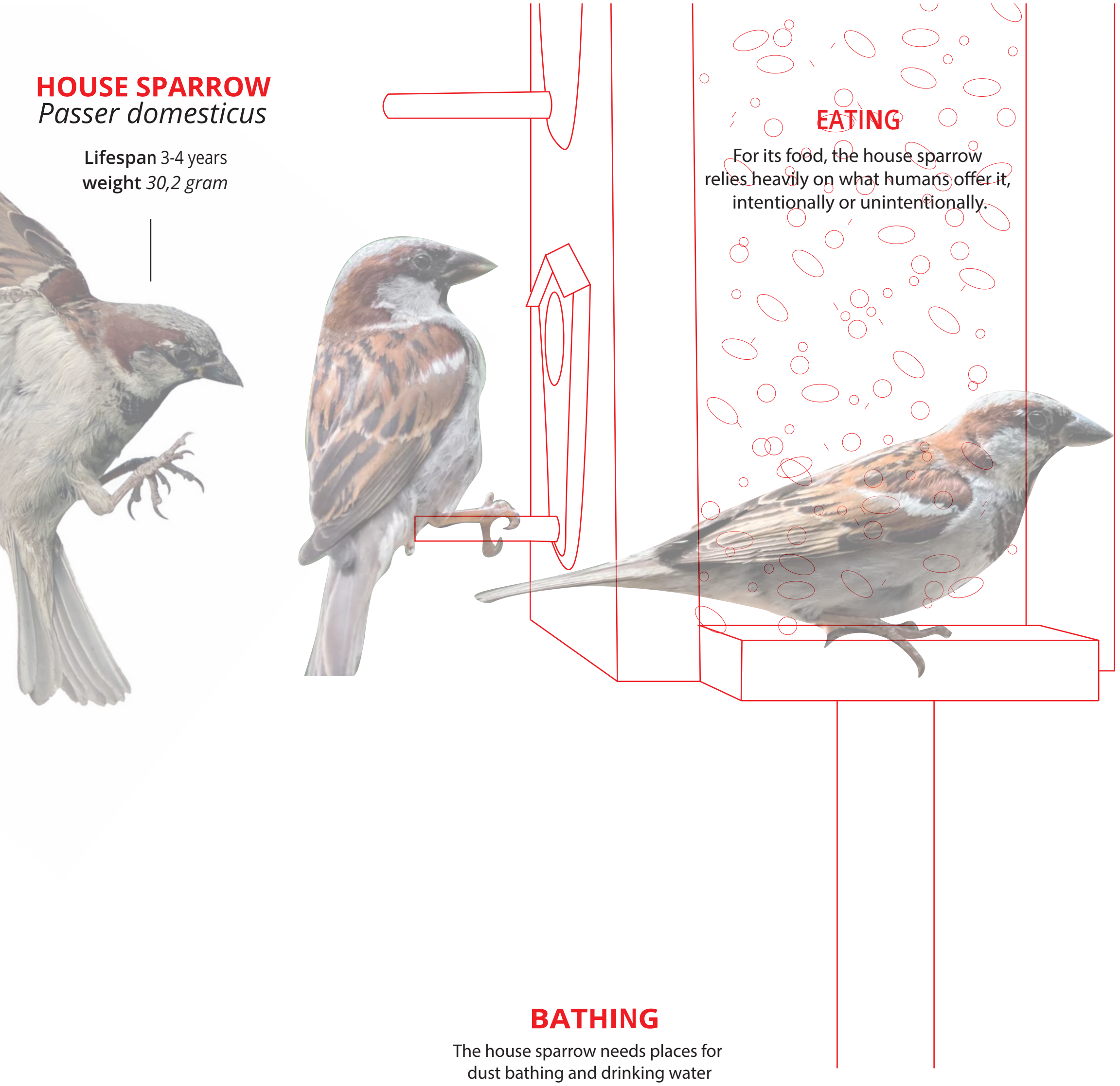


NESTING SIDE

Nests of house sparrows are generally found in or against a variety of human buildings: under roof tiles, in nesting stones and in cracks and holes in walls.

HOUSE SPARROW
Passer domesticus

Lifespan 3-4 years
weight *30,2 gram*

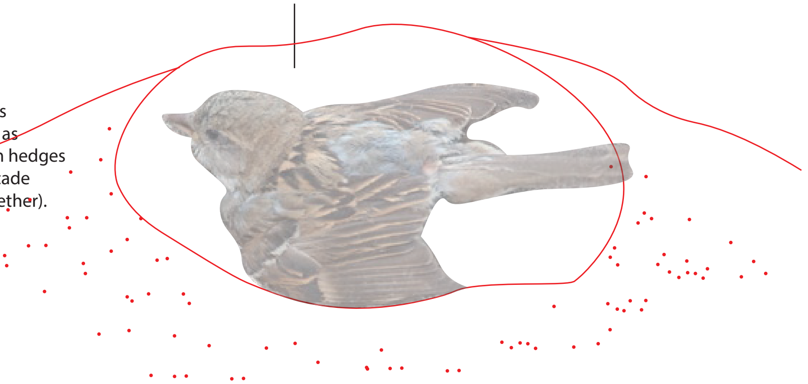


EATING

For its food, the house sparrow relies heavily on what humans offer it, intentionally or unintentionally.

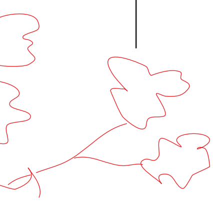
BATHING

The house sparrow needs places for dust bathing and drinking water



VERTICAL GREENERY

In winter, the house sparrow mainly uses vergreen shrubs, dense vegetation such as orn hedges, privet hedges and hornbeam hedges th a height of usually 3 to 4 meters or facade etation as places to spend the night (together).

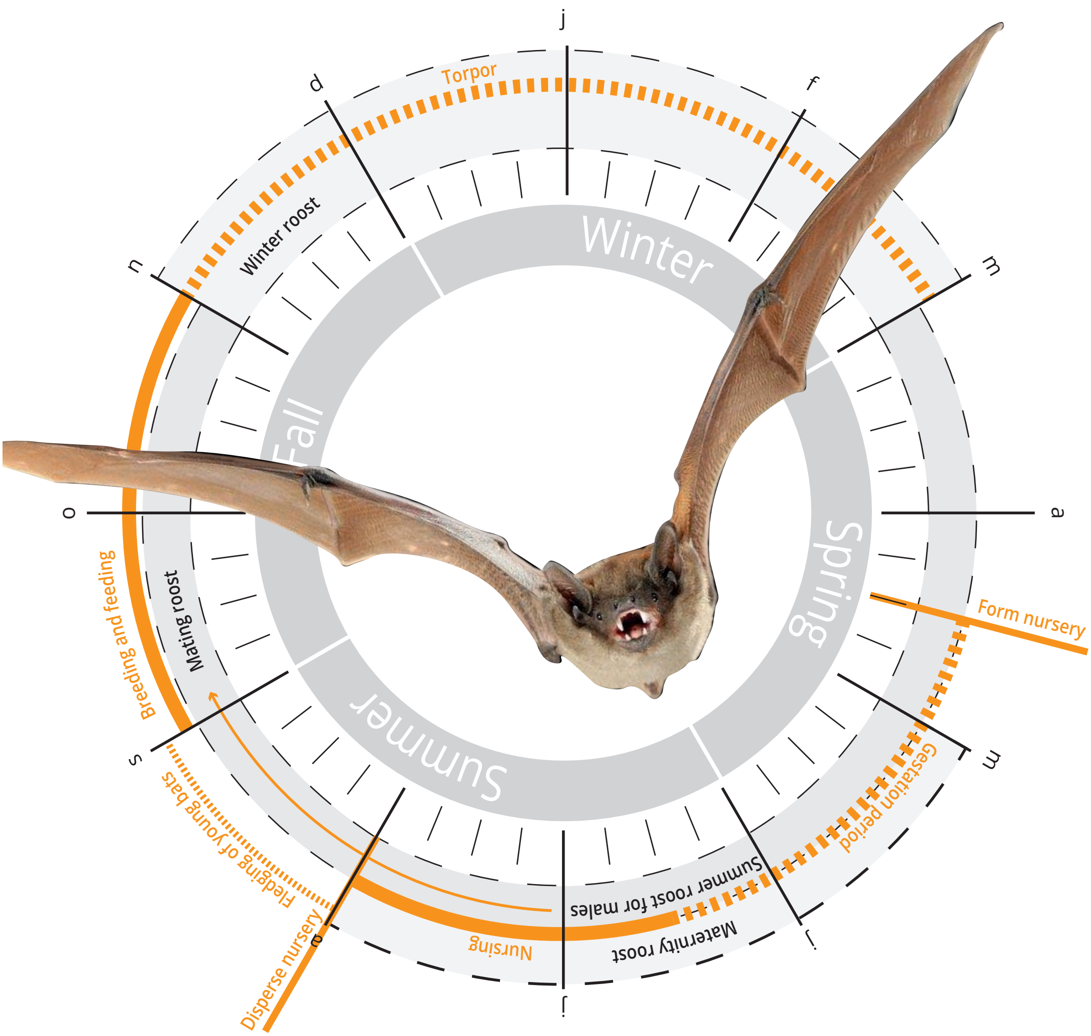


HOUSE SPARROW IN THE CITY - Own image

Common pipistrelle

The common pipistrelle bat stands as the most prevalent building-associated bat species. Its life cycle encompasses various phases, including hibernation, mating and courtship periods, and the lactation period for offspring. Roosts are typically situated in or around buildings, with different structures serving specific functions, such as birthing and nursing in one building and mating in another. During each phase, the bat has distinct requirements for its roost. Throughout the year and seasons, they utilize different roosts, flight routes, and foraging areas.

The common pipistrelle bat is a social species, living in colonies of genetically related females. During vulnerable periods, such as hibernation, they often gather in large groups. Male bats live alone or in small groups outside the mating season. Common pipistrelle bats use buildings as roosts throughout the year, including cavity walls, façade cladding, roof ledges, window shutters, roof tiles, wall crevices, etc. Occasionally, they are also found in gaps between exterior walls and insulation, in cold roof structures, sluices, viaducts, and expansion joints. Pair and individual roosts may also occur in trees, usually in slit-like spaces. Mobility is essential, as they move to find optimal thermal conditions. Large colonies are often found in centrally heated buildings such as nursing homes, care centers, and factories (BIJ12, 2017).



ROOSTING HABITATS

The common pipistrelle bat uses multiple roosting sites throughout the year.
It relies on specific habitats for different purposes, including summer roosts,
winter hibernation sites, mating roosts, and maternity roosts for raising young.
These seasonal roosts are essential for the bat's survival, supporting its life cycle and activities.

ANNUAL PATTERNS OF THE COMMON PIPISTRELLE - Own image

COMMON PIPISTRELLE BAT

Pipistrelle pipistrellus

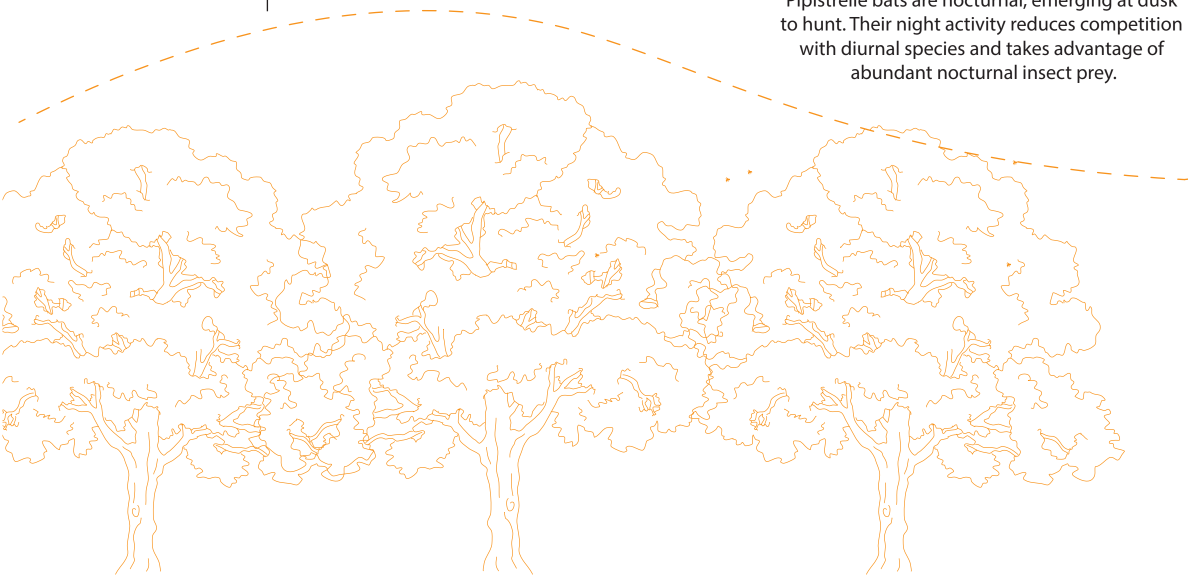
Lifespan 4 years
weight *3,5 - 8 gram*

LINEAR GREEN

Linear green structures, such as tree rows or hedgerows, are essential for pipistrelles. They use these corridors to navigate and forage, often flying just above these features.

NOCTURNAL ANIMALS

Pipistrelle bats are nocturnal, emerging at dusk to hunt. Their night activity reduces competition with diurnal species and takes advantage of abundant nocturnal insect prey.

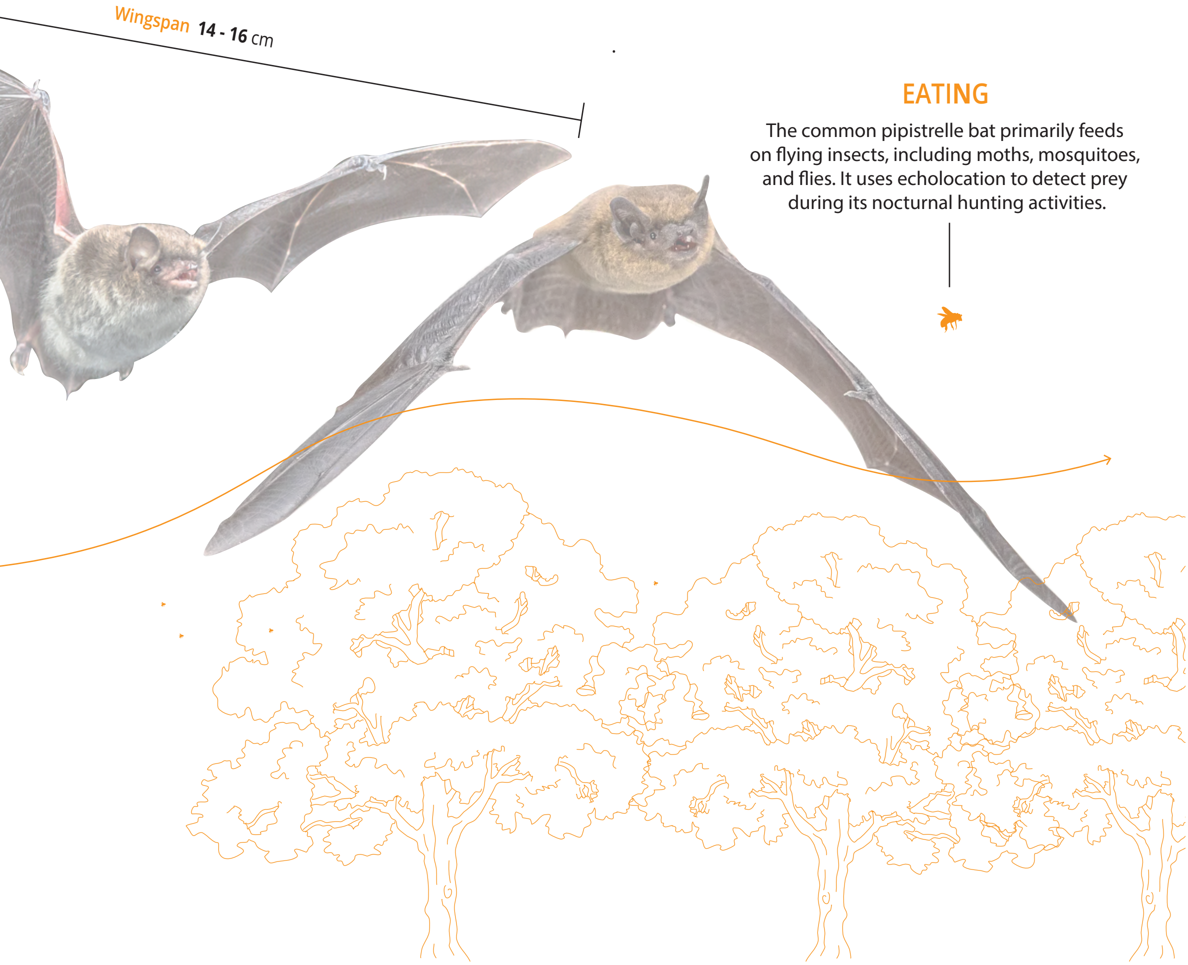


ROOSTING SITES

Pipistrelle bats use various roosts throughout the year, including summer, winter, and maternity roosts.
For roosts in cavity walls, spaces must be at least 2.5 cm wide.

EATING

The common pipistrelle bat primarily feeds on flying insects, including moths, mosquitoes, and flies. It uses echolocation to detect prey during its nocturnal hunting activities.

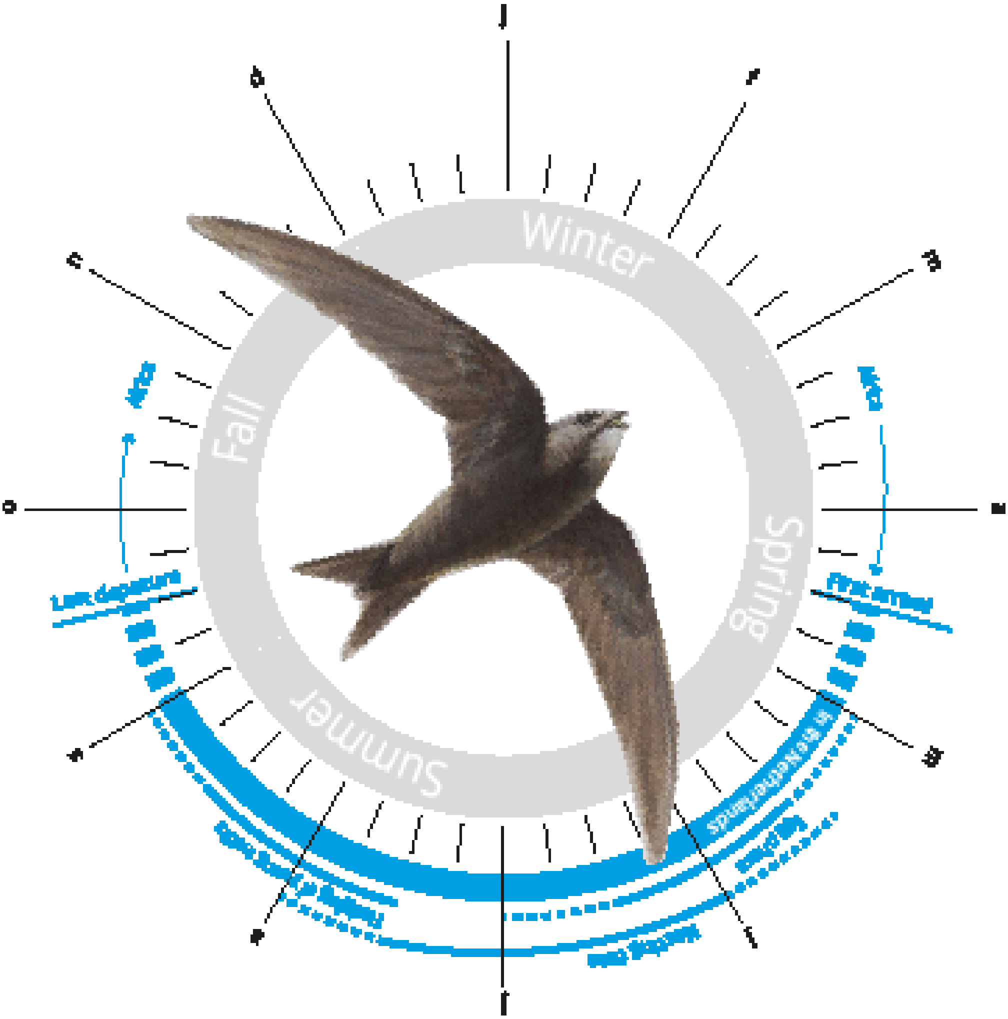


COMMON PIPISTRELLE IN THE CITY - Own image

Swifts

Swifts traditionally establish their breeding sites in rock crevices in mountainous regions and along the coast. In Western Europe, they have become strongly associated with human structures, primarily due to nesting in buildings, often behind crevices and gaps. These birds are typically (semi-)colonial breeders, with colonies varying in size, ranging from several dozen nests in one building to scattered nests throughout entire neighborhoods. Multiple pairs can nest in close proximity, each with its own entrance.

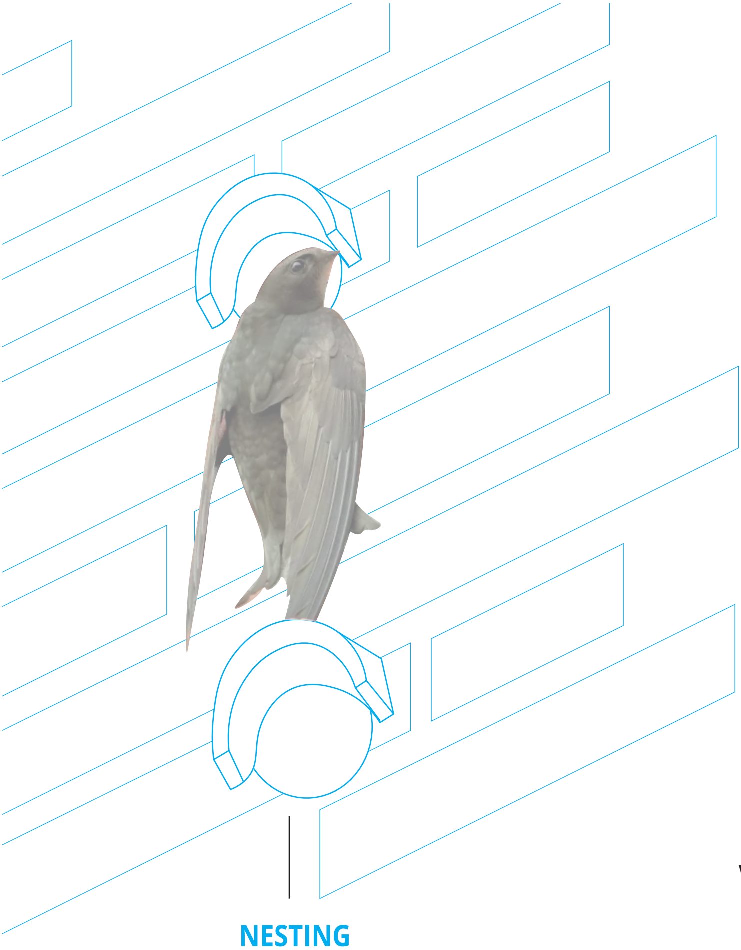
Swifts are predominantly present from April to August, with the highest concentration from May to July. During the other months, they reside in Africa. The arrival of the first breeding bird varies annually due to weather influences on the migration route. The return journey from Africa to the Netherlands occurs individually, resulting in the staggered arrival of breeding birds, usually from late April to early May. Young, non-breeding birds aged two to three years return between mid-May and mid-June, likely also in phases. Last year's offspring only return in early July. From mid-July, flocking flights emerge on beautiful summer evenings, with hundreds of birds flying and calling synchronously. In September and October, swifts from the far north may still pass through (BIJ12, 2023a).



ANNUAL PATTERNS OF THE SWIFT - Own image

BREEDING

The swift (Apus apus) is a migratory bird that arrives in the Netherlands to breed. They lay 2-4 eggs, which hatch after 17-27 days. Fledging occurs after 40-42 days, marking the young's readiness for flight. By late summer, both adults and juveniles migrate to Africa.

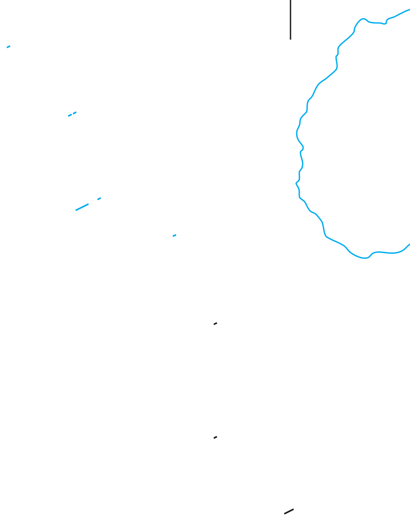


NESTING

Swifts nest in small crevices, often in urban environments like under roof tiles or within building gaps. They are highly loyal to their nesting sites, returning to the same spot each year.

SUMMER BIRD

The swift is a summer bird, arriving
the Netherlands to breed. They sta
from May to August before migratin
Africa for the winter.



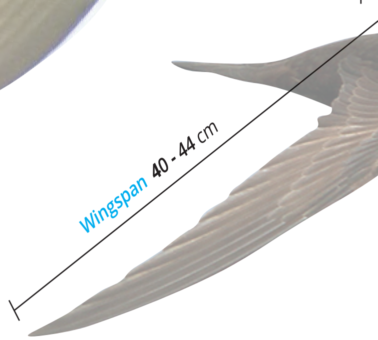
SWIFT

Apus apus

Lifespan 7 years
weight *38 - 42 gram*

SLEEP

Swifts are unique as the
flying. During migrat
weather, they rema
resting high in



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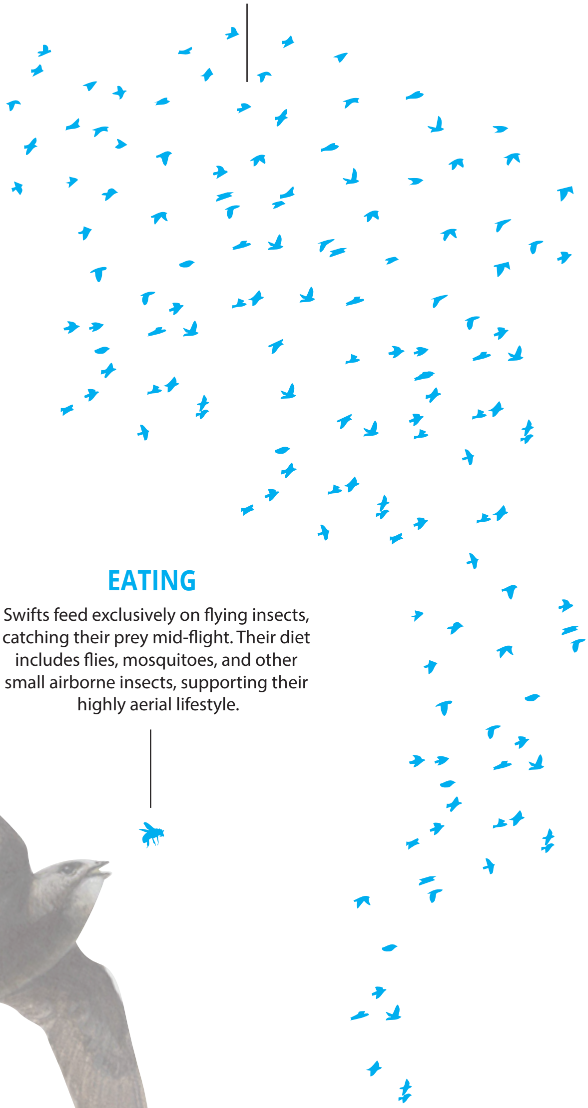
(SEMI)COLONIAL BIRD

Swifts are semi-colonial birds, often seen flying in large, synchronized flocks. These swirling groups, known as "screaming parties," are most common during summer evenings.



EATING

Swifts feed exclusively on flying insects, catching their prey mid-flight. Their diet includes flies, mosquitoes, and other small airborne insects, supporting their highly aerial lifestyle.

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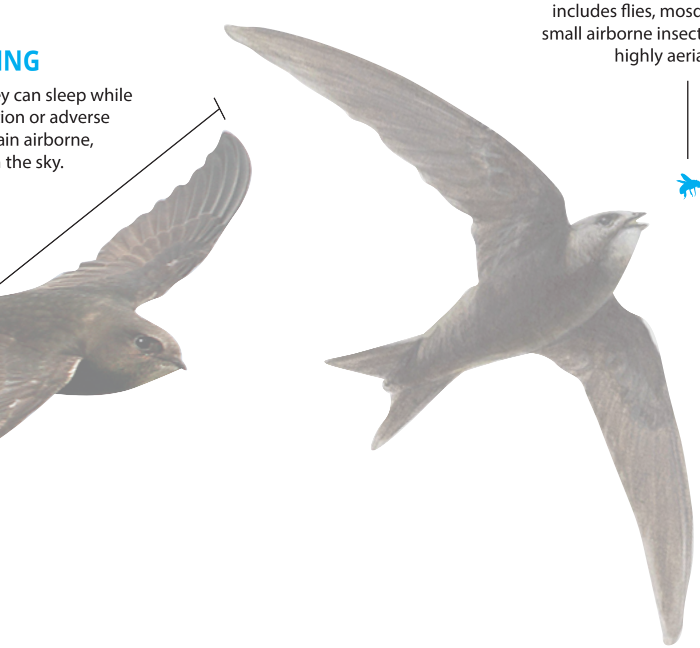


SWIFT IN THE CITY - Own image

4.3 PEOPLE IN URBAN NATURE

In the dynamic urban environment, animals are not the sole inhabitants; humans actively engage with urban nature in various ways. This human interaction with green spaces in the city extends beyond mere aesthetic value. The diversity of greenery in urban areas not only contributes to increased biodiversity but also provides a range of opportunities for diverse usage by city dwellers.

Urban nature serves various functions for residents. It contributes to stress reduction, alleviation of heat stress, and air purification, as discussed earlier. However, the diversity of greenery in the city caters to diverse needs of urban inhabitants. While some perceive nature as a refuge for tranquility and relaxation (Source), others view it as a meeting place (Source). Furthermore, urban nature serves as a source for food production (Source), establishing a direct and tangible connection with nature.

The variety of greenery in the city also acts as a means to attract different demographics, addressing the issue of monoculture in neighborhoods. Understanding the various ways in which people approach urban nature provides valuable insights for the design and management of urban green spaces. We explore the diverse roles and functions that city dwellers assign to the nature around them, and how this interaction contributes to fostering new connections with this nature.

Connection with urban nature

How can the connection between humans and nature be strengthened? It is essential to examine the specific needs of target groups. For instance, older individuals predominantly use urban nature for social interactions in communal gardens or extensive cycling routes for long rides (Veer & Van Middelkoop, 2002). Younger individuals often view nature as a meeting place or engage in sports activities such as running or football (Veer & Van Middelkoop, 2002). Additionally, some people benefit from the calming qualities of nature (Veer & Van Middelkoop, 2002).

A well-known and widely used categorization of target groups for natural areas is based on the various motives people have when visiting a nature reserve or landscape. The classification may slightly vary between studies due to the grouping of different categories. The following target groups/motives are often recognizable concerning urban nature (Veer & Van Middelkoop, 2002).

Active Users

Individuals actively utilizing urban nature value a direct connection with the surrounding environment, especially in ground-level residences. Active nature users may include older individuals appreciating a communal garden, providing a social aspect that mitigates loneliness among these seniors. Another example is families with children, for whom nature serves as an educational and recreational space. This group is more inclined to interact with urban animals, such as feeding birds in winter or leaving pruning waste to offer hedgehogs a better chance of survival during winter.

Seekers of Tranquility

Nature primarily serves as a sanctuary for those seeking tranquility, providing a space to unwind and enjoy the natural setting. Activities range from leisurely walks with a dog, inhaling refreshing air, to extended bike rides along well-connected cycling routes through diverse landscapes. To optimize this experience, tranquility seekers prefer winding paths through the landscape, partially shielded from urban hustle and bustle. They also seek stress-reducing features of greenery around their homes, with a preference for pleasant views and greenery that shields them from potential urban noises and unpleasant odors.

Entertainment Seekers

For entertainment seekers in urban nature, activity takes center stage. Nature and landscape primarily serve as a backdrop for sporting endeavors, with the social component often playing a significant role. Entertainment seekers, for example, enjoy a delightful picnic with family and friends or unwinding on a terrace. Unlike other groups, this demographic places less value on greenery in and around their own homes; for them, it is mainly about the social aspect of greenery, which may also be located a bit farther from their residence. This involves communal activities amid a green environment, contributing to social cohesion and enhancing the well-being of urban residents.

In Rotterdam, particularly in Groot IJsselmonde, various target groups reside, each utilizing green spaces differently. According to Leefstijlvinder (2023), tranquility seekers constitute the largest target group in the Groot IJsselmonde district. This implies that this type of nature should be considered in urban development in this area. However, to attract other target groups in the district and accommodate changes in households and demographics, a combination of these types of nature must be sought. It is not always black and white; people may seek tranquility one day and desire a family picnic the next. Therefore, it is crucial to combine different types of urban nature to offer a diverse range to the city's residents.

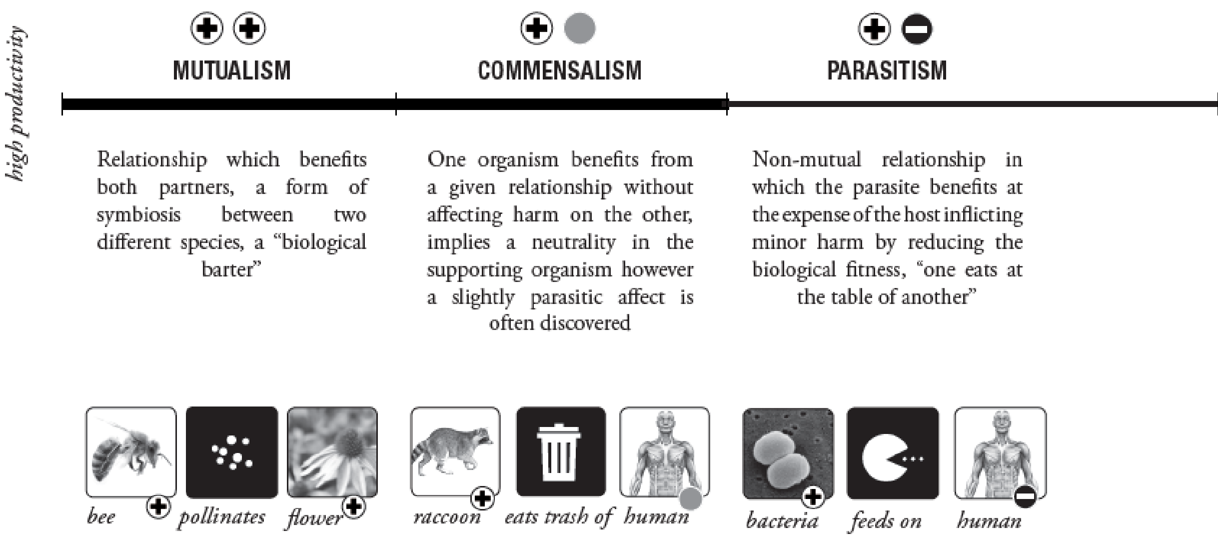
4.4 COHABITATION

In the preceding paragraphs, the various inhabitants of the urban ecosystem, both human and non-human, have been discussed. As observed, these inhabitants have diverse demands and needs concerning their living environment. It is now incumbent upon the designer, in this case, the urban planner and the architect, to create a harmonious cohabitation among these diverse inhabitants.

Symbiosis

To explore the possibilities of cohabitation, we examine various forms of living together among species, as described in biology. Encounters between humans and species can have different effects: positive (+), negative (-), or neutral (0) (Moon et al., 2010). Mutualism (+,+) occurs when both species benefit from each other's existence, representing an optimal situation. On the other hand, conflicts arise in competition (-,-), where species compete for the same resources. However, there are also situations in between (Figure X). Commensalism, for example, (+, 0), occurs when one species benefits from the existence of another, while the other species - in this case, humans - is not affected. Here, the relationship between species and humans becomes interesting and complex, giving rise to most conflicts.

To create the desired state of coexistence, species and humans within the city must live in a condition where they do not have negative consequences for each other. This positive condition is called symbiosis, whether it is mutualism, commensalism, or parasitism, originating from the original Greek word for 'living together.' Cohabitation occurs when this state of harmonious living takes place in the same space. The introduction of a context is implied here, and therefore, the concept of architecture can have an impact. Cohabitation must be encouraged by architecture. Or, in other words: "The architecture of cohabitation anticipates possible conflicts and enables their resolution. It provides contact spaces for encounters between non-human animals and humans." (Marc Frohn & Thomas E. Hauck, 2021) How do we



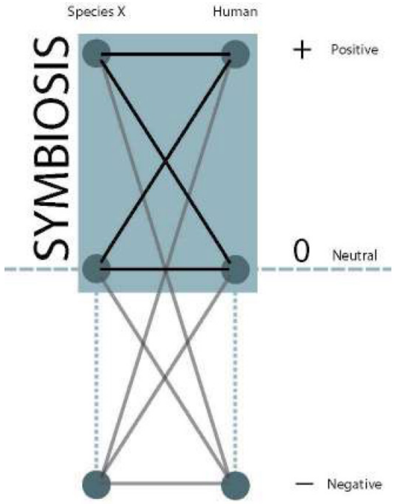
proceed then in resolving these conflicts? Two types of lenses are possible to examine this diagram: either we endanger the living situation of species through human actions or vice versa. Therefore, two types of conflicts arise in this diagram: on the one hand, the negative consequences affect humans, and on the other hand, the negative consequences affect the animal.

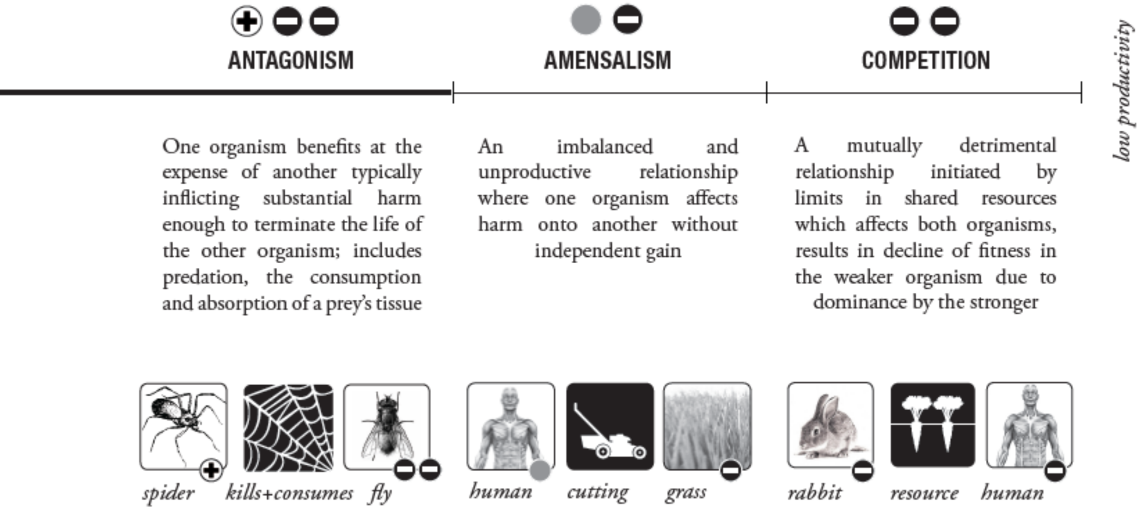
Confclits

Animals can negatively impact cohabitation with humans in urban areas in various ways. In some cases, encounters between humans and animals evoke negative feelings. While previous chapters have focused on the harmful effects humans have on other flora and fauna, animals and plants can also trigger negative responses from humans.

Certain species may be considered undesirable, although terms like "pests" and "weeds" should be avoided as they represent subjective assessments depending on the context. Managing city pigeons, for example, requires design elements such as avoiding nooks and ledges where they can breed, while rat infestations can be reduced by placing waste in sealable bins.

Additionally, specific animals can carry diseases, such as leptospirosis transmitted by rats. Controlling the food supply, such as waste, can influence concentrations of unwanted





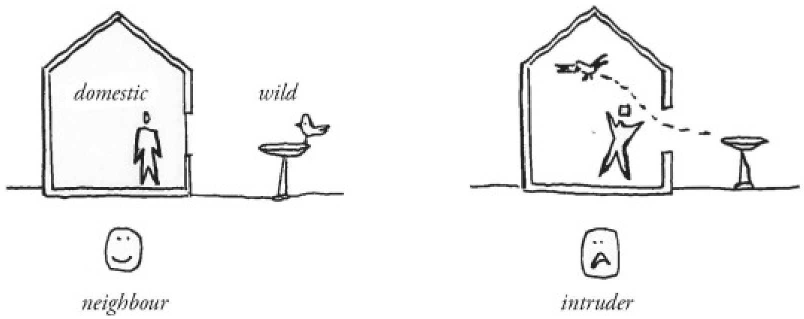
species. Avoiding stagnant water in places like gutters, rain barrels, and plant pots is crucial to prevent mosquito infestations and potential disease transmission.

Within homes, rodents, spiders, and silverfish can cause disturbances. Food, warmth, humidity, and hiding places determine their presence. For green roofs, green facades, and gardens, preventing the planting of invasive species and actively removing unwanted plants is essential to maintain inclusive flora. Eliminating basic conditions like moisture and light prevents the accumulation of unwanted flora in the design, thereby keeping the area nature-inclusive. (Vink et al., 2023)

Control & borders

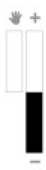
In the interaction between humans and animals in synanthropic environments, both physical and conceptual boundaries play a pivotal role. These boundaries, including fences, cages, and natural territories, constitute the framework within which humans and animals engage. Understanding these intricacies is imperative for a comprehensive grasp of the human-animal relationship. Biological interactions, encompassing waste management, food consumption, and disease transmission, occur within shared physical spaces. Concurrently, spatial conditions, such as territories and conceptual boundaries, play a role in shaping these interactions (Gunawan, 2015).

The interactions between physical and conceptual boundaries give rise to spaces of conflict, potentially serving as locations for design interventions. Various types of these boundaries exist: coplanar boundaries run along the same lines, such as the physical territory of a spider coinciding with its conceptually defended area. Overlapping boundaries arise when hu-



From within the house, the bird is a visually appealing presence. It is *perceived* as a friendly neighbour, even admired as a form of “wild” in the city.

The building envelope is an architectural boundary that divides interior from exterior and provides the human occupant with *control* of its domestic environment.



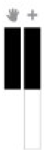
Opening the window blurs the physical limit between insde and out. *Control* is relinquished and the bird is now capable of entering the domestic realm.

Human *perception* deems the presence of the bird within the house as undesirable. It is disruptive, *uncontrolled* and a threat to the conditions of domesticity.

man-created boundaries align with conceptual limits of animals, like a fence intersecting the conceptual habitat of a migratory bird. Isolated boundaries manifest when a conceptual boundary exists without a physical barrier, such as a bird defending a conceptual territory without a clear physical delineation (Gunawan, 2015).

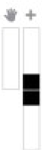
Human constraints of control and perception govern these interactions. Control, as the exercise of authority, structures relationships between humans and non-humans. Historically, human efforts to control ecology, such as the domestication of wolves, have shaped the relationship between both parties. Perception, influenced by history, context, culture, and politics, evolves over time. From a purely utilitarian view of nature in hunter-gatherer societies to contemporary variations, where ecology is seen as a resource or intrinsically valuable. The link between control and perception is mutually influential. The perception of a species by humans determines the extent of control exercised, while the level of control influences human tolerance and proximity to the animal. This dynamic is evident in everyday scenarios, such as the shift in perception of a bird from entertainment to an intruder once it enters a house (Gunawan, 2015).

The primary tension between humans and animals seems to center on the domestic territory of the house, especially in suburban areas where adaptive animals seek new habitat opportunities. The design of physical interfaces, such as walls, windows, and roofs, can influence the potential to support or limit relationships between humans and animals. Architectural elements are not merely viewed as structural components but as inhabitable membranes capable of supporting living organisms (Gunawan, 2015).



A cage is used to contain and *control* the actions of the bird. The relationship between human and animal is restructured within the house.

The *perception* of the bird is that it is a pet, treated with respect and kept within the house for entertainment and companionship.



Cohabitation between human and animal occurs in the thickness of the building envelope. The physical limit of the house provides habitat for the bird and blurs the degree of *control* the human has over the bird.

The conceptual limits of human and animal territory are poorly defined. For some humans this may be tolerable, for others it could be considered perverse.

The potential of synanthropic design lies in thickening and multiplying physical interfaces between humans and animals to create an intentionally inclusive urban environment. This transcends smoothing the boundary; it involves multiplying its forms and complexity. Architectural systems can be designed to create inhabitable spaces along physical boundaries, enabling synanthropic species to thrive and even provide ecosystem services. Redefining the limits between humans and animals as spaces of intensification opens possibilities for hybrid interactions. Buildings can serve not only the needs of humans but also those of synanthropic animals. By culturally appreciating synanthropic space, architects can contribute to a more inclusive and sustainable relationship between humans and animals, where boundaries no longer conflict but meld into a shared environment. This offers a new perspective on urban coexistence, where both humans and animals have the right to become citizens of the city. This information can be projected onto architecture by considering the complex relationship between humans and animals when designing buildings and urban spaces. Here are some ways in which this can be integrated:

Design of Physical Interfaces

Architects can incorporate physical interfaces between humans and animals into their designs. This may take the form of inhabitable membranes such as green walls, animal crossings, or wildlife corridors. The goal is to enable animals to enter human spaces in a way that is mutually beneficial for both humans and animals.

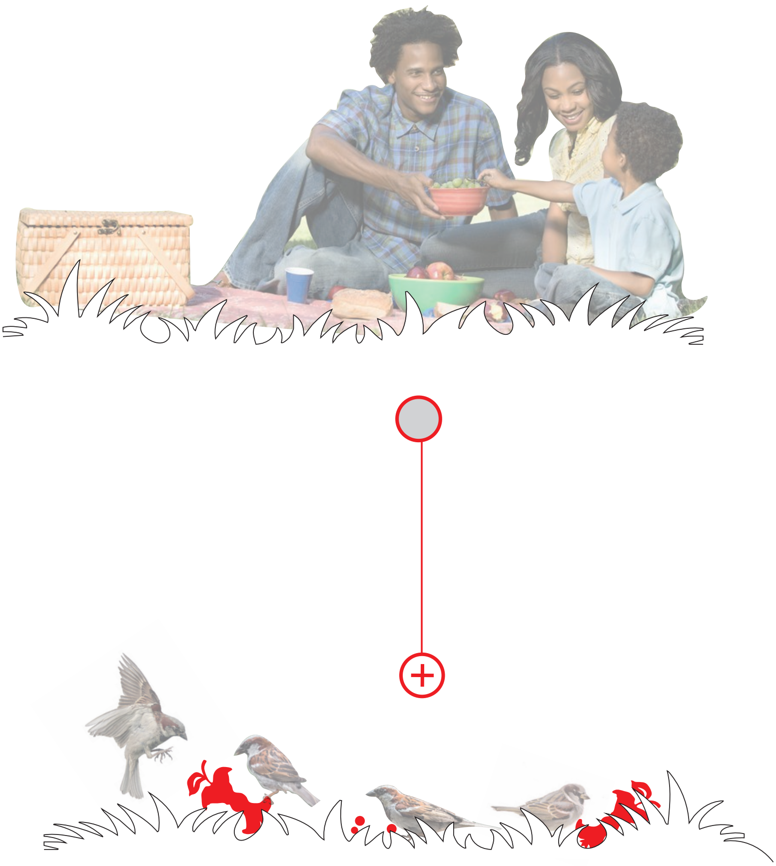
Flexible Architectural Boundaries

Architectural boundaries can be designed more flexibly, rethinking the traditional separation between indoor and outdoor spaces. For example, integrating inhabitable portions into buildings that invite animals to live within human spaces without being perceived as intruders.

Culture of Coexistence:

Design can contribute to a culture of coexistence, where synanthropic animals are not seen as threats but rather as cohabitants of the city. This can be achieved by disconnecting architecture from cultural biases and considering new priorities based on coexistence.

By applying these principles, architecture can play an active role in shaping urban environments that are both functional and inclusive for both humans and animals. The objective is to promote harmonious coexistence and break down the traditional boundaries between humans and nature.



COMMENSALISM - Own image

Commensalism

Human activity can create opportunities for wildlife. For instance, food scraps left behind from a picnic provide a valuable food source for house sparrows, supporting their survival in urban areas.

AMENSALISM - Own image

Amensalism

Light pollution from homes negatively impacts bats, disrupting their hunting and navigation patterns. This highlights how urban environments can harm wildlife, even when human actions are neutral in intention or effect.

4

Making Urban Nature

The central question addressed in this chapter is how to translate the acquired knowledge from previous chapters into tangible and practical design strategies. It commences with a concise general description of design strategies applicable at all scales. Subsequently, the chapter progresses from the largest scale (the city) to the smallest scale (details), providing examples through various case studies at each scale.

5.1 DESIGN PROCES

When designing urban nature, a thorough inventory of the existing situation and an understanding of the interrelationships among species, as well as biotic and abiotic factors at the local level, are crucial. Creating an entirely new ecosystem is practically impossible and, in fact, undesirable given the complexity of ecosystems with numerous subsystems. Sometimes, the focus is not on creating something but rather on leaving something undisturbed. In certain cases, the outcome may even be better or comparable with less effort by allowing nature to take its course.

However, in the urban environment, it is not always feasible to leave nature entirely undisturbed. Urban nature constantly faces pressure from urban dynamics, where habitats are threatened, and crucial connectivity routes are unintentionally disrupted. Despite the city being a rich habitat, various species and their habitats are vulnerable.

Urban nature encompasses a broad design spectrum, ranging from planning an ecological framework for the entire urban area to taking small measures in one’s backyard. Subtasks vary from transforming urban greenery into a more natural state to creating green roofs or facades. Addressing these challenges cannot occur in isolation. Even simple actions, such as installing a nest box, require attention to food availability, safe foraging routes, and the suitability of the environment. Moreover, certain animal species, like bats, require different types of shelters for various life stages, such as mating, giving birth, and hibernating. (Vink et al., 2017)

Different scales

When designing urban nature, a thorough inventory of the existing situation and an understanding of the interconnections between species and biotic and abiotic factors at the local level are crucial. Creating an entirely new ecosystem is practically impossible and, in fact, undesirable given the complexity of ecosystems with numerous subsystems. Sometimes, it is not about creating something but rather leaving things undisturbed. In certain cases, the outcome may even be better or comparably achieved with less effort by letting nature take its course.

However, in the urban environment, it is not always possible to leave nature entirely undisturbed. Urban nature is constantly under pressure from urban dynamics, with habitats threatened, and crucial connectivity routes unintentionally disrupted. Although the city is a rich habitat, the various species and their habitats are vulnerable.

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Points, surfaces & lines

In a nature-inclusive design, points, lines, and surfaces play an essential role, characterizing the ecological structure of a city at a more abstract design level. Points represent specific locations where individuals or subpopulations of species thrive, such as an amphibian pond or a decaying tree hosting an insect population. When these points come together in larger entities, like city parks, they form surfaces on the ecological map of the city. The lines act as connecting pathways between these surfaces and between the city and the surrounding rural areas. In an urban environment, where habitats are often small and isolated, these connections are crucial for the resilience of the ecosystem.

Urban structures, such as roads, railways, and canals, can serve as infrastructural lines and provide opportunities for both human and ecological transportation. Integrating naturally vegetated verges or nature-friendly banks along these lines is a logical choice to create or enhance ecological connections. Even small areas, like points, can act as stepping stones, allowing animals and seeds the opportunity to move within the city. For instance, a series of small front-yard gardens can establish a connection even if they are not entirely contiguous.

Similar to the architecture of the city, the ecological structure cannot be fully described in two dimensions alone; the third dimension, height, plays a role. On a small scale, vertical living layers can be observed, ranging from soil life to tree canopies. Both points, like a nesting box on a chimney, surfaces, such as a green roof, and lines, like a row of tree canopies, manifest themselves in this vertical dimension. (Vink et al., 2017)

Habitat requirements

A city becomes attractive for plants and animals when favorable habitat conditions exist at various scales. Food must be available, implying the presence of diverse plants or animals in close proximity. By connecting different areas, a bird, for example, can nest in one region and find food in an adjacent connected area. Suitable habitats, such as resting places, are essential, with the ability to create them, including the right conditions such as soil quality for plant growth. Safety also plays a role, with shelters or vegetated areas where grazing or walking is restricted, depending on the type of organism. This varies by species and scale; some require large, undisturbed areas, while others are content with greenery on a building facade.

For reproduction, facilities such as nesting and breeding sites, and a healthy gene pool are necessary. The proximity of different habitats for various life stages is crucial; these should be interconnected. This principle works through different layers, where a newly hatched bird benefits from a well-located nest, the surroundings around the nest become important as the bird takes flight, and the connection between green areas remains relevant as the bird matures.

All these factors fall under the umbrella of diversity, encompassing both life forms and communities, as well as spatial and biotic factors. Diversity is essential at various scales, from providing diverse habitats in the city as a whole to creating local microclimates through different gradients in smaller areas (Vink et al., 2017).

Design strategies

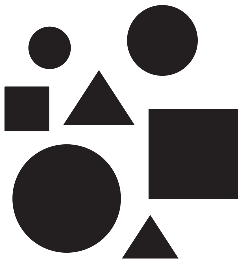
The collected information and knowledge have resulted in three design strategies that address the various scales of the city, namely the master plan, the building, and the building details. Not entirely coincidentally, these design strategies align with the requirements for a resilient and robust ecosystem. In the following paragraphs, we will explore how these design strategies can be applied at different scales to achieve a nature-inclusive design that leads to increased biodiversity. The design strategies that can be evaluated at various scales are:

Localization

Base interventions on the specific animals you aim to assist.

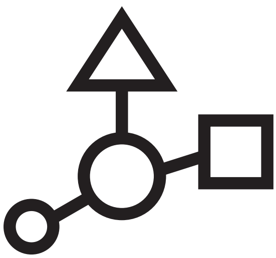
Variation

Variation in scale, Porosity, Height, Sun/Shade, and Much More: Embracing Diversity in Design



Connection(?)

Connection or the Lack Thereof: The Impact of Connectivity Across Various Areas, Elevations, and Scales



5.2 NATIONAL

The pursuit of a more nature-inclusive city begins with the policies of the national government. The nitrogen crisis and the increasing impact of climate change have compelled the government to contemplate effective solutions for these complex issues. In response, the government is formulating policies to address these challenges. A concrete example of this is steering the course of future developments in our urban environment by giving water and soil a leading role. Another example is the development of the 'Maatlat groene klimaatadaptieve gebouwde omgeving' (Measure Green Climate-Adaptive Built Environment), created through collaboration between the national government, municipalities, provinces, and water boards.

Water- en bodemsturend

With the ambition to realize a more sustainable future, the Dutch government has decided that water and soil must play a crucial role in our spatial policies. This innovative approach calls for a fundamental shift in our thinking and actions, taking profound consideration of the intrinsic qualities and vulnerabilities of these vital systems.

Current challenges, such as the nitrogen crisis, deteriorating water quality, climate change, and biodiversity loss, highlight the limitations of the manipulability of the Netherlands. Simultaneously, there is a growing demand for new housing and sustainable energy. In this context, a revision of our land use and spatial planning, with the water and soil system as a guiding principle, offers promising perspectives.

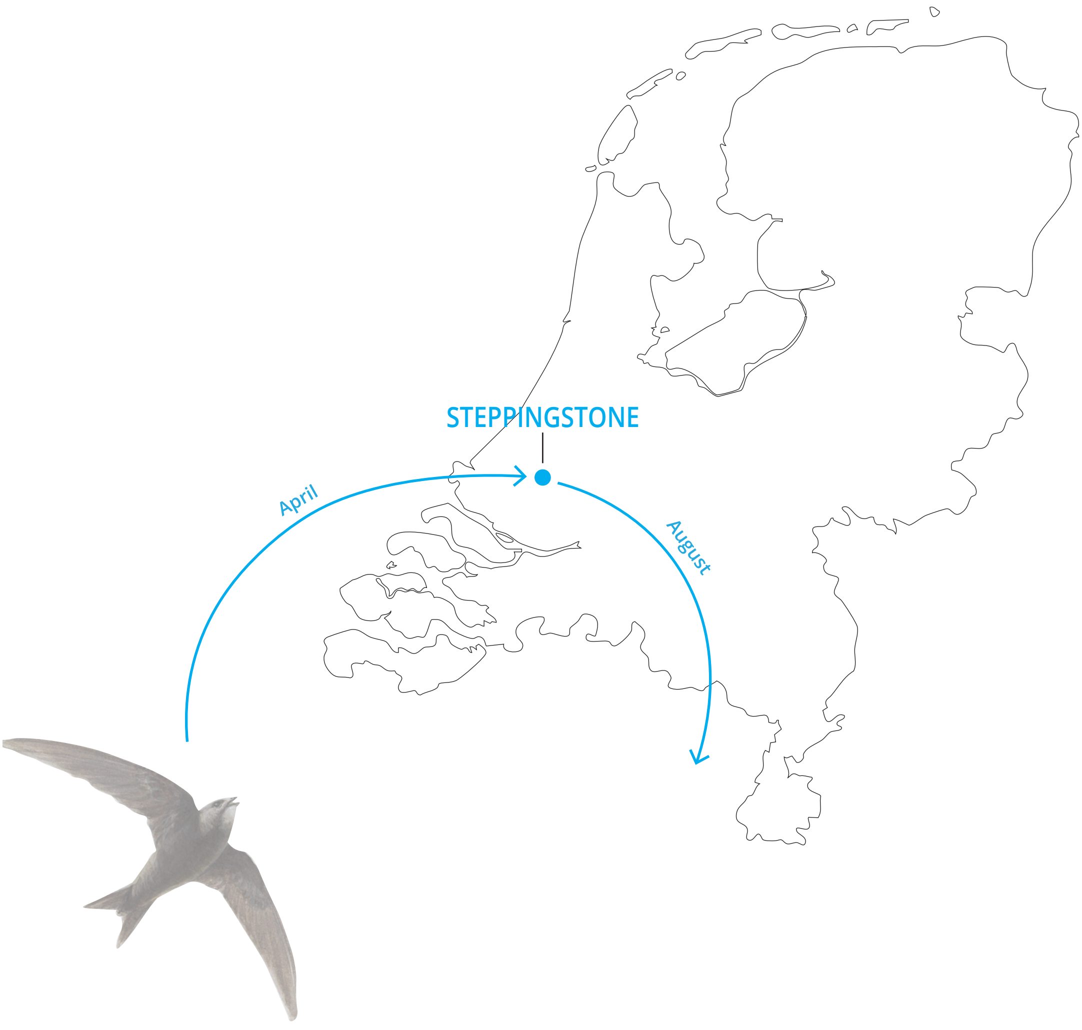
This concept does not advocate shaping nature to human needs but calls for a symbiotic relationship where we treat the natural carrying capacity with respect and intelligently harness its capabilities. Thus, the aim is to redesign the Netherlands, with a keen eye on the future, making the country not only more resilient against the challenges of climate change but also more appealing to future generations. (College van Rijksadviseurs, 2023)

Maatlat

The national adaptation standard emphasizes a necessary shift in our construction approach. It forms the basis for climate-adaptive construction, an essential requirement for sustainable development in the future. For new construction, the standard specifies criteria for climate-adaptive construction and design, focusing on themes such as waterlogging, drought, heat, biodiversity, soil subsidence, and mitigating flood consequences. The objectives, performance requirements, and guidelines of the standard provide a standardized national reference framework, enabling projects to be executed in a climate-resistant and green manner.

The standard does not provide specific regulations for measures, allowing governments,together with construction parties, to autonomously decide on necessary measures in a specific area or project. This approach encourages innovation and smart solutions from the market, as there is flexibility to meet the set goals.

In various regions, regional agreements have also been made in recent years to build in a climate-adaptive way, largely aligning with the national standard. These regional agreements provide additional details and refine the guidelines of the standard in some areas. Although not yet legally mandatory, it is encouraged to start working with these regional agreements.



National Ecological Network

Buildings with suitable nesting sites, like crevices for swifts (Apus apus), act as stepping stones in ecological networks. They connect fragmented habitats, supporting swift migration and breeding on a national scale.

URBAN NATURE AS STEPPING STONE - Own image

5.2 THE CITY

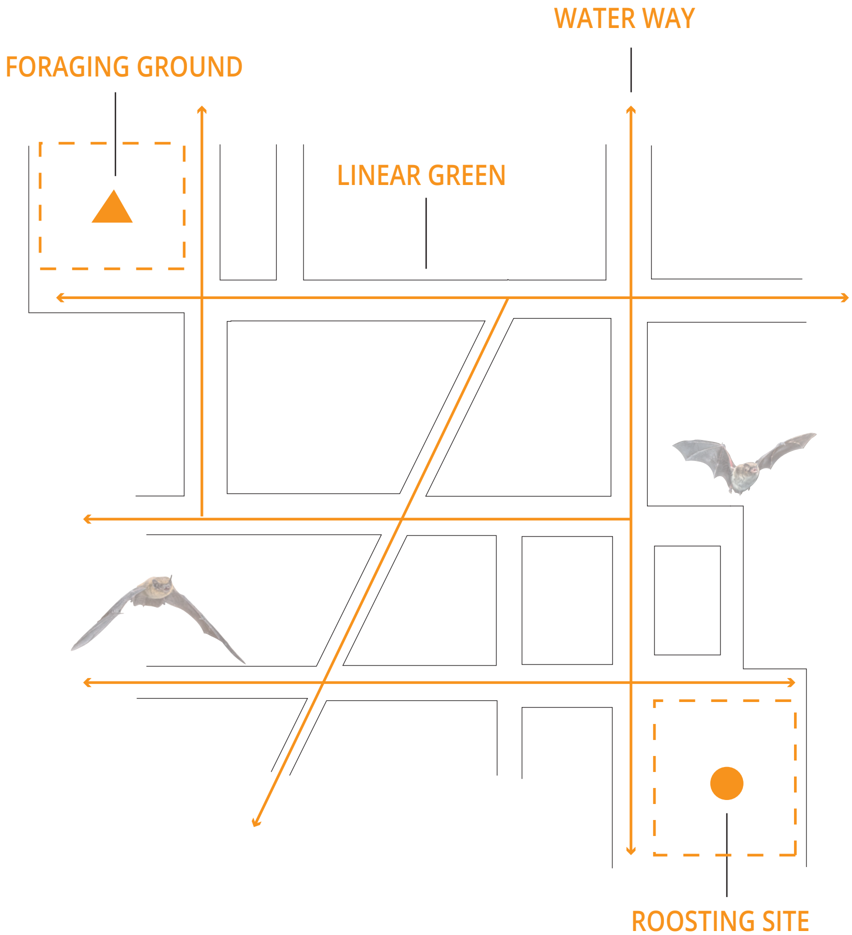
Location-Based Approach

At the urban level, it becomes intriguing to specifically examine the existing flora and fauna within the urban ecosystem, as observed in Rotterdam. The process commences with determining the ecological values and possibilities of the location. A street in the city center constitutes a different biotope than a residential neighborhood on the outskirts of the municipality. It is crucial to inventory the present species and determine whether and which additional measures can enhance the local nature. Mapping this out is essential to comprehend which animal species thrive in this city. This can be achieved by consulting observation websites, gathering information from ecologists, or local experts with knowledge of the regional nature. They can assist in answering questions such as which natural features need to be preserved or added, how to align with local ecological quality, whether there are specific species that need protection, and if there are ecosystem services that can be utilized. These principles are crucial and should not be considered optional; they must be incorporated into the requirements and ensured throughout the final design.

Sometimes, a municipality already possesses a green structure map, a map with ecological connections, or a policy document designating target species, indicator species, or however they may be termed, as animal species requiring extra attention in the municipality. Consider the initiative of the Rotterdam municipality: the "10 van 010" (10 of 010). This list encompasses mammals, plants, birds, insects, and fish. These species symbolize biodiversity across the entire city, from residential areas to harbor zones and from riverbanks to green roofs. Together, they narrate the story of the balance and interconnectedness between humans and nature, emphasizing the significance of a diverse environment. This symbolic value can strengthen the connection between humans and nature in the city and raise awareness of the importance of biodiversity.

Connection

Another crucial aspect at the city level is the connection between various green structures such as city parks and the natural landscape surrounding the city. The aforementioned research already emphasizes the importance of these green structures, not only to make the city's ecosystem resilient and sustainable but also to create connections for city residents to recreate and for animals to link different foraging areas, enhancing population resilience. An example of a green connection beneficial for both humans and nature is the proposal of "De Groene Marathon" (The Green Marathon). This is a recreational nature route of over forty kilometers cutting through the city. The route connects the most beautiful urban natural areas. Recreationists and athletes no longer need to leave the city for a clean, green environment, and children learn about plants and animals in their own surroundings. This strengthens, makes visible, and makes nature accessible to all residents of Rotterdam! De Groene Marathon is introduced with route markings, a website, apps, and walking maps. Less favorable parts of the route are improved with five nature projects, including a viewpoint pavilion on the Maas River and natural banks along the Rotte River. (de natuurlijke stad, 2017)

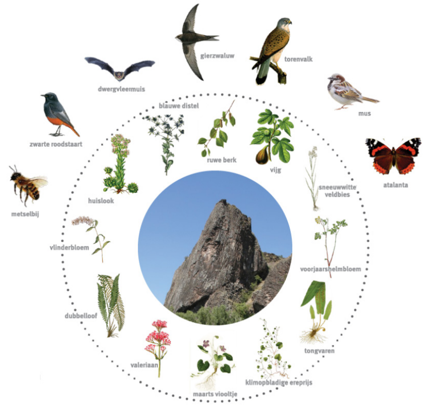


Ecological Corridors
Linear green structures, like tree rows, support bats by providing sheltered pathways for foraging and migration. These urban corridors connect habitats, ensuring species movement and biodiversity within cities.

ECOLOGICAL CORRIDORS- Own image

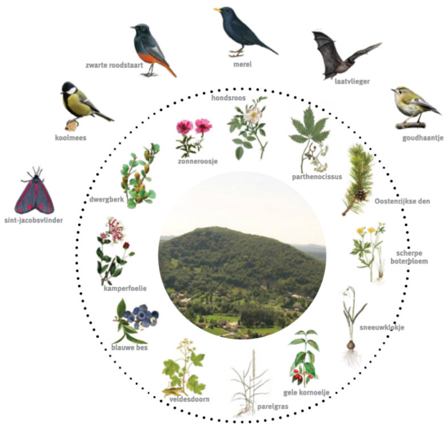
5.3 MASTERPLAN

The master plan represents the next phase in the hierarchy, introducing different aspects of nature-inclusive construction. Within this phase, various habitats, as described in previous chapters, are taken into consideration. Based on these habitats, the species inhabiting them can be integrated into the design process, directly influencing the master plan. Spatial layout is addressed, and questions arise regarding the settlement conditions that these species impose on their immediate environment.



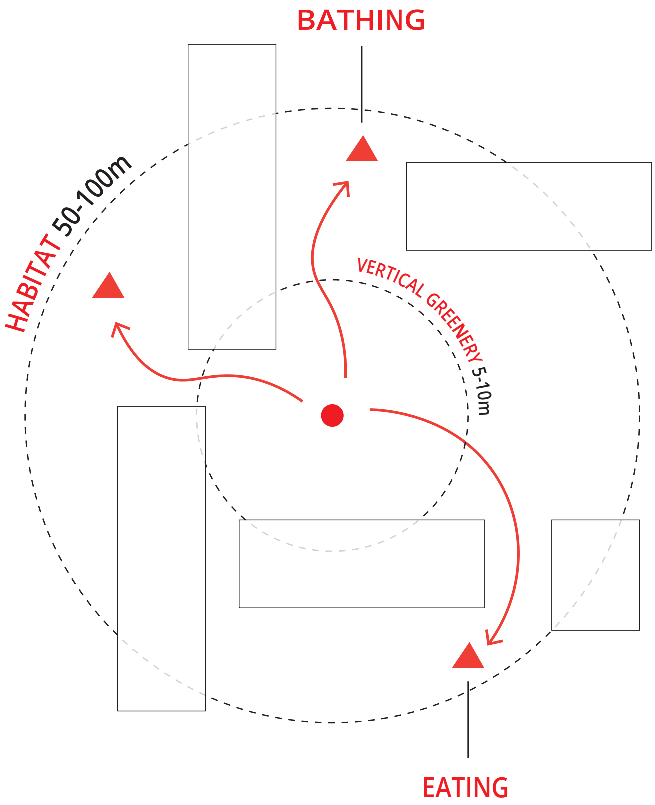
Biotopes

It is essential to investigate the biotopes present in the immediate vicinity of the planning area. An exemplary project that has implemented this in the final master plan is Vertical in Amsterdam. Various biotopes and habitats are present on the buildings in this master plan. These biotopes reflect those found in the surrounding environment. In this way, the buildings in the master plan can act as an extension or a stepping stone between different parks and landscapes.



Spatial layout

Once the biotopes and associated flora and fauna in the area are identified, an inventory can determine how these species influence the spatial layout of the master plan. This includes both two-dimensional ground-level planning and three-dimensional vertical design. By considering species' needs, such as movement, nesting, and feeding, the master plan can support biodiversity while aligning with human use.



LOCAL GREEN STRUCTURE - Own image

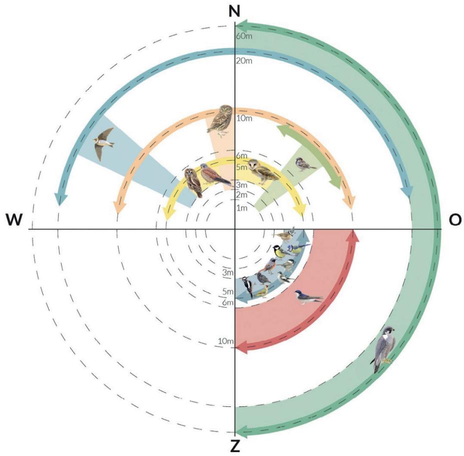
Local Green Structure
A masterplan can support house sparrows by ensuring food, water, and sandbathing spots are within 100 meters of nesting sites. This proximity creates a self-sustaining, localized ecological network.

Orientation & height

The orientation of buildings within the master plan can also be optimized by considering the ideal orientation and height of nesting sites and entrance openings, especially for birds.

With modern construction methods, natural openings for birds are often lost. Therefore, it is necessary to integrate nest boxes to preserve building-associated bird species in our living environment. Birds generally have specific preferences for the location of their nests, such as the height on the building, the dimensions of the nest box, and the entrance openings. At the master plan level, the orientation of the nest boxes is particularly important. In general, it is discouraged to orient nest boxes to the south due to the risk of overheating in the summer. With shade from, for example, trees or adjacent buildings, the southwest facade may also be suitable. For colony-nesting birds such as house sparrows and swifts, it is important to place multiple nest boxes together. The proximity of greenery for shelter is crucial; for example, sparrows thrive with a hedge at a short distance from their nests.

A house martin nest box works optimally when it hangs under an eave or gutter. The swift does not stack nests and prefers a low entrance opening, but it should not be too low to prevent chicks from falling out of the opening.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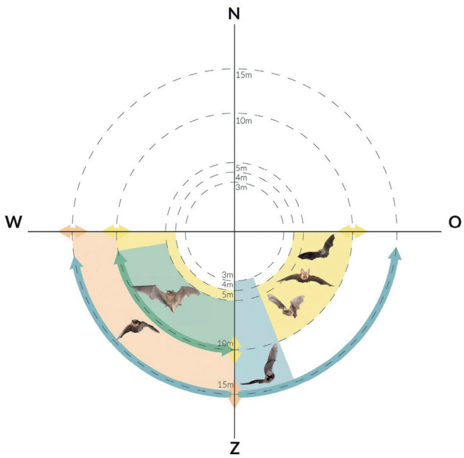
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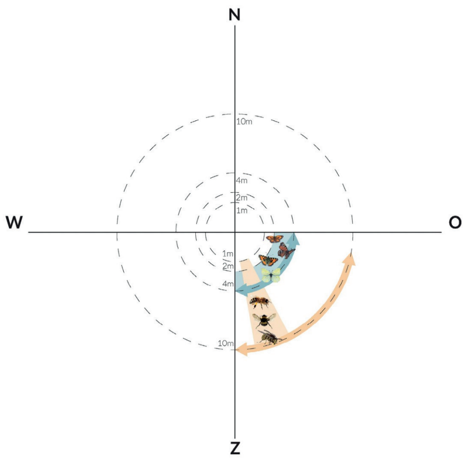
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5.4 THE BUILDING

Buildings constitute a significant portion of our urban environment, forming the vertical dimension of our cities. While some cities advocate or even mandate nature-inclusive building practices, integrating nature onto and into buildings presents a more intricate challenge compared to public spaces like parks, canals, road verges, viaducts, and harbor basins, which already provide substantial areas with authentic, living soil.

Nevertheless, compelling arguments support the imperative to design buildings with a nature-inclusive ethos. In a world where human and natural realms are intricately entwined, evading responsibility for our cities and structures becomes not only morally questionable but also perilous for our own well-being in the long run. The restoration and enhancement of ecology in both urban and rural landscapes pose a comprehensive challenge, spanning various societal domains, operating at all scales, and encompassing areas where human intervention intersects with the ecological system. Architecture must embrace and uphold this responsibility. In densely populated cities, the available space for nature is rapidly diminishing, elevating the significance of cities in ecological systems and biodiversity preservation. Consequently, buildings must be viewed as integral components of the urban ecological system.

The primary form of a building significantly influences the nature and extent of potential nature-inclusive measures. To facilitate discussions during the design process regarding the embodiment of the main form, common combinations of form and function have been categorized into typologies such as office towers, terrace buildings, daylight and patio houses. When focusing solely on form, typologies like tower, terrace building, strip construction, and closed building blocks serve as morphological descriptors. Each of these types entails specific nature-inclusive measures. However, it is important to note that, as with all typological classifications, many buildings ultimately exhibit a blend of forms (Vink et al., 2023).

Tower

The façade surface of a tower offers opportunities for incorporating green elements, achieved either through upwardly climbing vegetation from the base or by installing balconies equipped with planters or tree containers. Roof possibilities are often constrained due to limited surface area, exacerbated by the need for space for installations or solar panels. One viable solution involves maintaining the building in a compact form, thereby maximizing space for nature and greenery surrounding the structure.

Raised ground level

The land occupied by the building is compensated with greenery on the roof. Such roofs are among the most common examples of nature-inclusive buildings, both in urban areas, where they serve as stepping stones in the ecological network, and on city outskirts and in rural areas, where they connect to the surrounding natural environment.

Raised landscape

The land occupied by the building is offset by the introduction of greenery on the roof. Such roofs stand as prevalent examples of nature-inclusive buildings, found extensively in inner-city regions, serving as stepping stones within the ecological framework. They also extend to the outskirts of urban areas and rural settings, seamlessly connecting with the surrounding natural environment.

Vertical landscape

The surrounding landscape seamlessly transitions into a green facade, with the base of the building merging harmoniously with the vertical surface. This typology is applied in contexts where the surroundings provide space for green elements at ground level directly surrounding the building.

Landscape over the building

In this typology, the building is situated beneath the landscape, allowing nature to effortlessly ascend. This approach is predominantly employed outside densely urbanized areas due to its relatively extensive spatial requirements.

Terracebuilding

De buitenruimten van woningen zijn terrrasvormig uitgwerkt. De relatief kleine hoogteverschillen vergemakkelijken de uitwisseling van soorten en mogelijk ook van zaden tussen terrasssen onderling.

Stepstone building

This architectural concept comprises multiple volumes, each featuring a rooftop garden. The manageable height differences between these gardens facilitate the exchange of green structures.

Rock building

The fragmented facade construction of this building block results in an extensive surface area for both the facade and the roof. This configuration fosters a diverse range of microclimates, consequently creating varied habitats.

Height

Birds, bats, and insects impose specific requirements on the height and orientation of nesting sites, influencing the architectural configuration of buildings. Bats, in particular, exhibit diverse preferences for their varied roosting habitats.

Advantages of Building Roosts

Utilizing buildings as roosting sites offers advantages, notably a higher temperature compared to the external environment. This proves beneficial during hibernation when bats enter a winter rest to survive in the cold months with limited food availability. Additionally, warmth is crucial in spring for pregnant or nursing females, enhancing the survival chances for both mothers and their young. The maternity period is a vulnerable phase for bats, and its significance is crucial for the species' survival. Buildings provide protection against weather conditions, similar to tree hollows used by other bat species. Older structures with heat-retaining features such as insulated walls, heated spaces, draft-free attics, and roofs play a vital role in minimizing bats' energy consumption, a critical factor for their survival in cold periods. Beyond temperature, maintaining an optimal humidity level is essential, given bats' susceptibility to dehydration due to their large wing surface area relative to their body size. A draft-free residence, such as a spousal or bat box with minimal airflow, is crucial. In winter, bats prefer environments with high humidity, as found in forts, ice cellars, and bunkers.

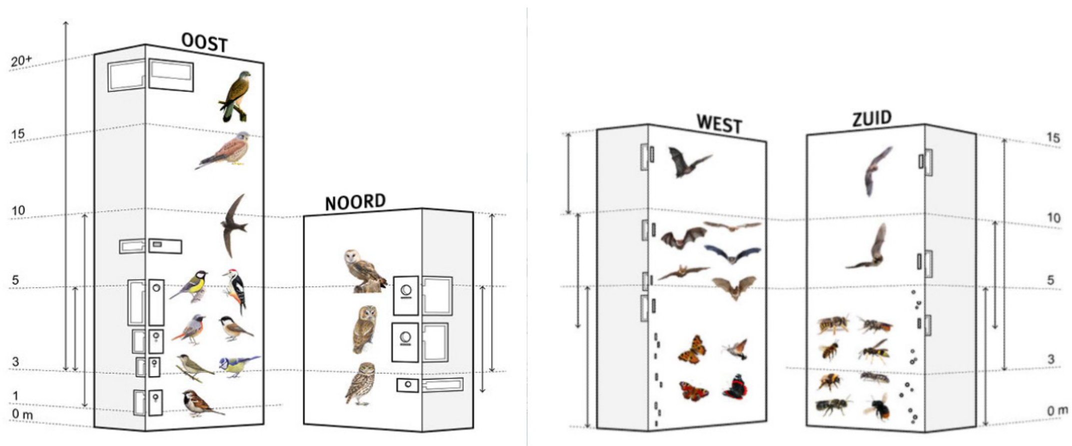
Overwintering in Urban Dwellings

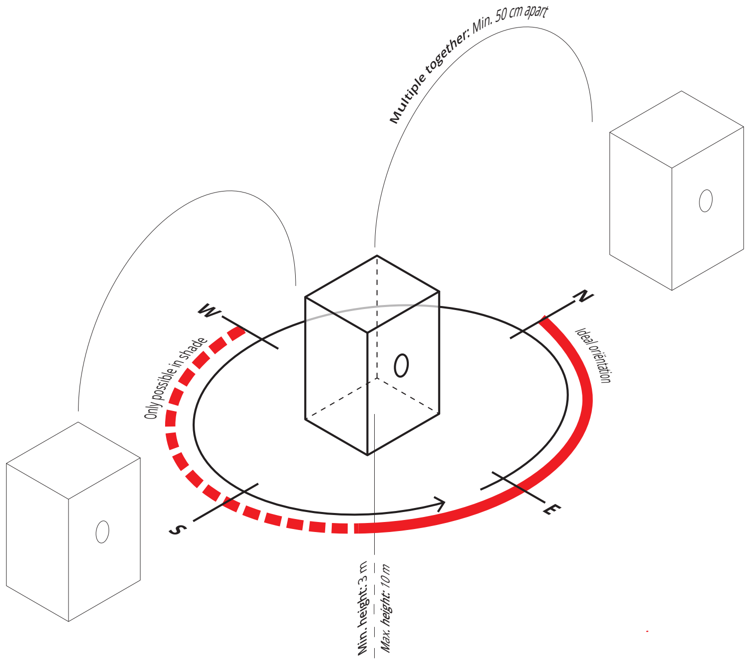
Various bat species utilize residential buildings for overwintering, contingent on compliance with specific environmental conditions. Due to their sensitivity to indoor climates, offering multiple shelter options within a building becomes imperative. These shelters should differ concerning orientation to various wind directions and exposure to sunlight. The provision of diverse roosting spaces with distinct microclimates significantly enhances the bats' chances of survival.

Architectural Considerations

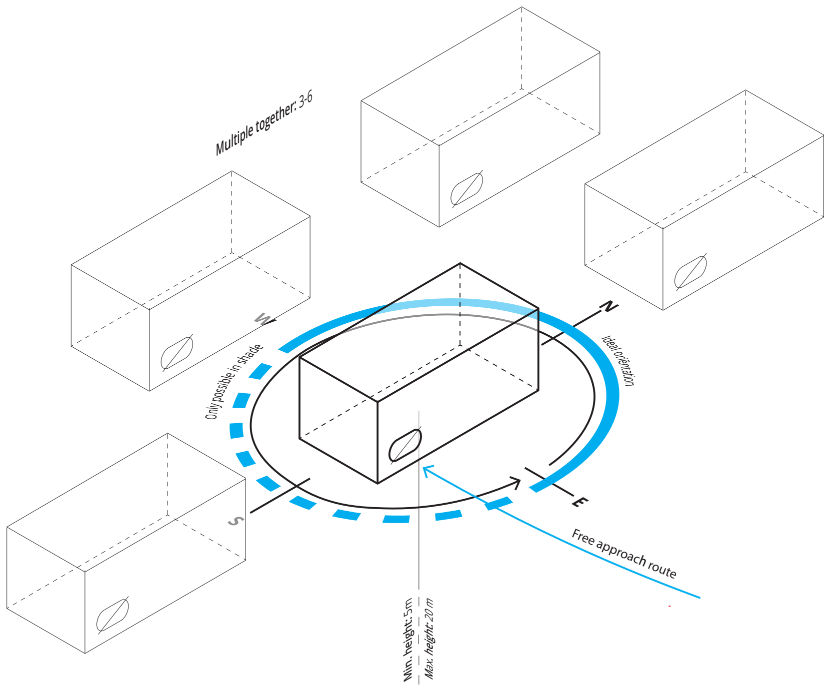
When creating bat roosts within blind walls, it is crucial to ensure that facade greenery is kept at a sufficient distance to maintain clear flight paths. Lighting around the building should be limited or absent, as nocturnal animals like bats are negatively affected by permanent illumination. If lighting is necessary, motion-sensor lamps can be employed to discourage bats. The chosen lighting should avoid causing light pollution and maintain a low lux level.

Concerning built-in features and entry points, the height can vary, ranging from a minimum of four meters to approximately 25 meters, depending on the bat species. In certain cases, certain species may prefer heights of up to 50 meters. Placement on window sills, eaves, or gutters is quickly located by bats and is considered more crucial than achieving an exact height, according to experts. Bats prefer interconnected roosting sites, allowing them to select from various microclimates at any given moment. Offering a diverse range of roosts significantly enhances bats' chances of survival.





HOUSE SPARROW REQUIREMENTS- Own image



SWIFT REQUIREMENTS- Own image

5.5 IN DETAIL

The building detail level is predominantly characterized by the specific requirements that different species have for their nesting sites.

Nature based enveloppe

The question of creating habitable spaces for birds and bats has become increasingly urgent, given the scarcity of suitable habitats due to modern construction methods and retrofitting of existing homes. In the facades of the future, it is imperative to establish functional ecosystems to accommodate these species, driven by both legal obligations and moral responsibilities. The realization of this objective will significantly transform the appearance of the facade and, consequently, the architectural landscape. This transformation stems not only from a more permeable, diverse, and layered fundamental form of the building but also from a shift in visible enclosed surfaces, which will increasingly incorporate living materials rather than predominantly consisting of concrete, wood, or brick. Consequently, architects will need to relinquish some control over the facade's appearance since nature is dynamic and inherently unpredictable.

Nesting place

The size, height, and material choice of habitats determine whether species will establish themselves in, for example, nest boxes or cavity walls. For birds, the size of the entrance hole is crucial, with smaller species preferring narrower openings. For bats, the conditions for establishment are largely similar, although the size of the access to the habitat may vary based on the species.

Birds

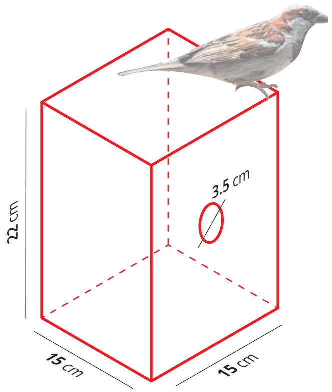
The entrance holes of bird boxes are specifically tailored to the size of the birds. For example, a low box is not suitable for blue tits due to their tendency to stack nesting material. For house martins, the nest box should be under an eaves or gutter, while swifts prefer low entrance holes to prevent chicks from falling out.

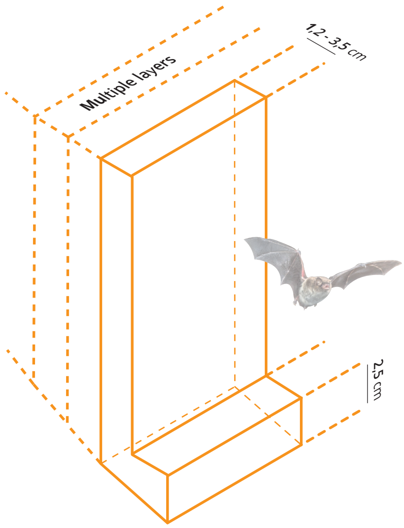
Bats

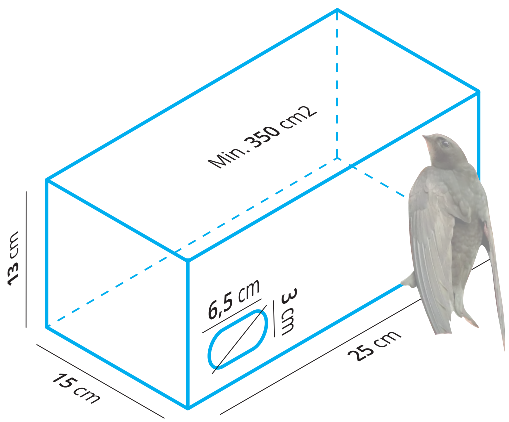
In the construction world, where modern building methods and insulation techniques increasingly displace the natural shelters of birds and bats, the search for suitable habitats becomes more pressing. The future façade of buildings will not only alter architecture but also provide functional living space for these animals, both due to legal obligation and moral awareness.

For bats, the requirements for a suitable habitat are crucial. Although these requirements broadly align for different species, varying in size, each has its own nuances. A shared preference for cavities and crevices connects all species, with buildings serving the same function as natural rock and cave openings.

During the summer period, bats often prefer smaller habitats used by solitary males or non-pregnant females. A network of habitats is essential for flexible use. Winter habitats differ from summer, maternity, and mating habitats. During winter, bats enter deep torpor, making them extremely vulnerable. Therefore, winter habitats must meet specific requirements, including heat buffering and high humidity. All types of habitats are necessary, with the most critical being winter and maternity habitats, followed by slightly less demanding mating and summer habitats. Variation in what is installed in or on a building is, therefore, crucial. The access openings to different habitats must be appropriate, not too small for entry and not too large to admit other animals. Providing varied, suitable habitats is vital to increase the survival chances







NESTING REQUIREMENTS - Own image

of bats. From special constructions to ordinary building components, the construction sector can play a crucial role in preserving these fascinating nocturnal creatures in our increasingly modern environment.

Roofs & facades

Various biotopes and their associated species influence the choice of roof and facade forms. The biotope directly impacts the material selection for facades; for example, species in the garden biotope prefer materials such as brick and roof tiles, commonly used in old city centers. Additionally, certain species in the garden biotope benefit from evergreen shrubs as part of facade vegetation. In contrast, greenery is often absent on facades in the rock biotope, favoring the species found there.

Concerning roofs in the rock biotope, specific species thrive on brown roofs, mimicking the appearance of vacant lots in urban areas where some birds build their nests. In the hill biotope, intensive green roofs play a crucial role since the species there thrive in trees and tall shrubs. Thus, each biotope, driven by the diverse needs of flora and fauna, acquires a unique atmosphere and appearance.

5.5 REALIZATION & MANAGEMENT

The Necessity of Monitoring

Nature-inclusive construction is in its infancy, with some strategies delivering tangible results while others remain experimental. Monitoring these interventions, whether for plants, birds, bats, or insects, is vital to measure their effectiveness and refine future approaches. Traditionally, this monitoring requires substantial time, resources, and input from specialized ecologists. However, it is often treated as an incidental task rather than a core component of project planning. This oversight highlights the need to embed monitoring as a fundamental aspect of nature-inclusive projects.

The Role of Technology and Citizen Science

The future of monitoring is likely to be transformed by technological advancements, such as sensors, smart cameras, and AI-driven tools. These innovations promise to reduce labor intensity and increase scalability, making monitoring accessible even for smaller projects. Additionally, citizen science initiatives, where local communities contribute observations and data, have proven highly effective. Tools like the AI app "ObsIdentify" enable individuals to accurately document species, generating valuable datasets for urban biodiversity studies. In the Netherlands, platforms like this already collect millions of observations annually, offering architects and urban planners profound insights into species distribution and habitat dynamics.

The Importance of Adaptive Management

Realizing nature-inclusive designs requires more than implementation; it demands adaptive management strategies to respond to evolving ecological and urban conditions. As species migrate or adapt to changing environments, built structures and green spaces must also evolve. Adaptive management involves continuous feedback loops where monitoring data informs ongoing maintenance and design modifications. For example, if a green roof intended for pollinators is underperforming, adjustments to plant diversity or microhabitats can restore its functionality.

Engaging Communities and Stakeholders

A critical, often overlooked component of realization and management is stakeholder involvement. Engaging local communities and ecological experts ensures the long-term success of these projects. Residents can become stewards of biodiversity-friendly initiatives, while ecologists provide the scientific backing to optimize habitat integration. Collaborative maintenance plans, co-created with stakeholders, can align ecological goals with practical urban living needs.

Scaling Nature-Inclusive Practices

For nature-inclusive construction to move beyond pioneering phases, it must become scalable and mainstream. Policies that incentivize biodiversity-focused designs, coupled with frameworks for monitoring and adaptive management, can bridge this gap. Urban planning authorities and developers must integrate nature as a non-negotiable component of new and existing projects, ensuring alignment with broader sustainability goals.

In summary, successful realization and management of nature-inclusive designs hinge on a blend of innovative technology, community engagement, and adaptive strategies. By embedding biodiversity at the heart of construction and maintenance practices, we can ensure that these projects not only support ecological resilience but also foster long-lasting, vibrant urban ecosystems.

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THE CTIY REIMAGINED - SLA Design Studio

CONCLUSION

This research focused on integrating biodiversity and architecture in urban contexts, aiming to design a regenerative living landscape where humans and nature can coexist harmoniously. By combining theoretical insights with a case study in Groot-IJsselmonde, this study provides a framework for redefining architecture's role as a connecting element between human and ecological systems. The research emphasizes the importance of considering biodiversity as a full-fledged stakeholder in the design process, not only to enhance ecological resilience but also to add social and spatial value.

Research Question
The central research question of this study was: Which regenerative design principles for the renovation and densification of a post-war building contribute to the densification of biodiversity within the ecologies of the urban fabric? This question reflects the dual challenge of addressing urban densification while simultaneously enhancing biodiversity—a task that requires rethinking the role of architecture in both ecological and social systems.

The findings of this research demonstrate that regenerative design principles can bridge the gap between human needs and ecological requirements. By focusing on the renovation and densification of post-war buildings, this study explores how architecture can transform existing urban structures into vibrant ecosystems. This transformation requires a shift from seeing densification as a threat to biodiversity to viewing it as an opportunity to create layered, interconnected habitats that enhance ecological and social resilience. Key regenerative principles identified in this research include:

I***ntegration of Biotopes:***
By introducing biotopes such as the Garden, Hill, and Rock Biotope, architecture can cater to diverse species and ecological niches while providing tailored living environments for human residents. For instance, the Garden Biotope supports active gardening spaces and

habitats for species like house sparrows and insects, whereas the Rock Biotope reflects the density and connectivity of urban areas, accommodating species that thrive in high-density environments.

Variation and Connection:
Variation in spatial configurations, housing typologies, and ecological elements is essential to creating resilient ecosystems. This includes the integration of ecological corridors that connect fragmented green spaces, enabling species to migrate and adapt within the urban fabric. These corridors not only support biodiversity but also enhance urban livability by providing accessible green spaces for residents.

Borders and Conflicts
An additional insight explored in this research is the importance of borders and conflicts in designing spaces where humans and animals coexist. Hard borders, such as noise barriers or light shields, can protect sensitive species from disturbances caused by urban life. Conversely, soft borders—like shared green spaces or permeable edges—encourage interaction and symbiosis between people and nature. This dual approach acknowledges that urban environments are inherently spaces of friction, where the needs of different species sometimes conflict. For example, light pollution impacts nocturnal animals, while bird droppings on balconies can create challenges for residents. Addressing these conflicts through careful design allows for coexistence while minimizing negative impacts for both humans and wildlife.

A critical insight from this research is that regenerative design must go beyond isolated interventions to address systemic challenges in urban environments. Post-war buildings, with their repetitive and often monolithic structures, represent both a challenge and an opportunity for biodiversity enhancement. Renovating these structures with regenerative principles transforms them from barriers into catalysts for ecological and social enrichment.

Ultimately, this research highlights the potential of regenerative design principles to contribute to biodiversity within the ecologies of the urban fabric. By focusing on renovation and densification, these principles offer a scalable approach to creating urban environments that are not only livable but also ecologically vibrant. This requires a paradigm shift in architectural thinking, treating post-war buildings not as static relics but as dynamic components of a larger, interconnected ecosystem.

Limitations of the Research
While this research provides a comprehensive framework for integrating biodiversity into the renovation and densification of post-war buildings, certain limitations must be acknowledged. These limitations highlight gaps that could influence the applicability and effectiveness of the proposed principles, as well as opportunities for improvement in future studies.

Lack of Real-World Testing
One significant limitation is the theoretical nature of the proposed design principles. Although the strategies,

such as ecological corridors and biotope integration, are grounded in rigorous research, they have not been tested in real-world settings. This absence of practical application means that the effectiveness of these interventions in supporting biodiversity remains speculative. Implementation and long-term evaluation in pilot projects would be essential to validate these concepts and refine their scalability and adaptability to various urban contexts.

Limited Stakeholder Engagement
Another notable gap is the lack of direct input from local stakeholders, including residents, ecological experts, and municipal authorities. Engaging with residents of Groot-IJsselmonde could have provided valuable insights into their relationship with nature and their expectations for urban green spaces. Similarly, collaboration with ecologists and species experts familiar with the area could have ensured a deeper understanding of local ecological dynamics. The absence of these perspectives may have limited the design's ability to fully address site-specific needs and challenges, potentially reducing its effectiveness and community acceptance.

Scarcity of Measurable Data
The broader field of nature-inclusive design still suffers from a lack of measurable data on the long-term ecological impact of green architecture. This limitation extends to this research, which could not draw on robust case studies to evaluate the proposed strategies. While many green architecture projects incorporate features like green roofs or vertical gardens, few include mechanisms for tracking their contribution to biodiversity over time. This lack of data hinders the ability to identify best practices and refine regenerative design approaches.

Challenges in Balancing Social and Ecological Goals
The socio-economic context of Groot-IJsselmonde adds another layer of complexity to the project. Balancing ecological interventions with the social and economic realities of the area proved challenging, particularly in ensuring that designs remain accessible and beneficial to all residents. Without input from the community, there is a risk that some interventions may not align with residents' needs or priorities, potentially undermining their success. This highlights the importance of participatory approaches that engage stakeholders throughout the design process.

Scalability and Contextual Variability
While the research aims to offer scalable principles, the specific context of Groot-IJsselmonde may limit the direct transferability of the findings to other urban environments. The unique characteristics of the neighborhood, such as its post-war housing stock and socio-economic challenges, shaped the proposed solutions. Applying these principles to areas with different urban fabrics, cultural contexts, or ecological conditions would require careful adaptation.

Future Directions for Addressing Limitations
To address these limitations, future research should prioritize pilot projects that

implement and monitor the proposed strategies in real-world settings. This would provide valuable data on the ecological and social impacts of regenerative designs, enabling further refinement and validation of the principles. Engaging local residents and experts through participatory design processes is another critical step to ensure that interventions are contextually appropriate and widely accepted. Additionally, integrating monitoring technologies, such as sensors and citizen science platforms, could bridge the data gap and provide insights into the long-term performance of biodiversity-focused designs.

By acknowledging these limitations and identifying pathways for improvement, this research lays the groundwork for more robust and actionable regenerative design methodologies. It underscores the importance of iterative learning and collaboration in advancing the field of nature-inclusive architecture.

Implications of the Research

This research emphasizes the transformative potential of treating biodiversity and animals as fundamental stakeholders in the architectural design process. Rather than introducing nature-inclusive elements as an afterthought, this approach integrates ecological considerations from the earliest stages of planning and design. By doing so, architecture becomes a proactive tool in restoring ecosystems and supporting species within urban environments.

One critical implication is the need to consider the requirements of specific species—such as nesting, feeding, and movement patterns—during the initial phases of design. This ensures that buildings and landscapes function as ecological assets, actively supporting biodiversity rather than merely mitigating harm. Such early integration aligns ecological needs with human-centric goals, creating spaces where both can thrive.

The research also highlights the importance of moving beyond fragmented approaches. To create meaningful impact, biodiversity-focused strategies must permeate every layer of design, from material choices to spatial layouts and urban connectivity. Monitoring and adaptive management are essential for tracking the success of these interventions, allowing for refinement based on real-world outcomes.

Involving local communities and stakeholders early in the process is equally critical. Engaging residents and ecological experts ensures that interventions are both socially relevant and ecologically effective, fostering a sense of ownership and long-term stewardship.

Ultimately, this study underscores that addressing biodiversity loss requires a paradigm shift in architectural thinking. By embedding the needs of animals and ecosystems into the core of the design process, we can create cities that are not only livable for humans but also regenerative ecosystems supporting diverse life forms.

Recommendations for Future Research

Future studies should focus on the implementation and monitoring of nature-inclusive designs, evaluating their ecological and social impact. Combining ecological monitoring with social assessments, such as resident interviews, could provide a more comprehensive understanding of how these designs function.

Additionally, integrating new technologies such as AI-driven sensors offers opportunities to monitor biodiversity efficiently. Developing methodologies that combine these technologies with participatory tools like citizen science could expand the reach and impact of monitoring efforts.

Finally, the connection between urban and regional biodiversity deserves further exploration. Designing buildings and landscapes that function as nodes in larger ecological networks offers an opportunity to support biodiversity on a much broader scale.

Final Thought

This research has fundamentally changed my perspective on architecture. It has taught me that architecture is not just a tool to meet human needs but also a powerful instrument to facilitate the interaction between humans and nature. By considering biodiversity as a full stakeholder, we can create cities that are not only sustainable but also contribute to a future where urban areas function as vibrant, regenerative ecosystems.

I hope this work inspires others to incorporate biodiversity into their projects from the very first sketch, contributing to a world where urban areas are not only homes for people but also sanctuaries for nature.

B

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