MUTUALIST URBANISM

Achieving mutualism between urban development and strengthening biodiversity through nature-inclusive urban planning and design: the case of het Zomerhofkwartier in Rotterdam

P5 report - Linde Jorritsma - MSc Urbanism TU Delft

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PREFACE

This report is the result of graduation within the Masterprogram Urbanism at the University of Technology in Delft. In this project I combined my passion for cities with a passion for nature, through which I discovered the interesting worlds of urban ecological research and nature-inclusive design and how these worlds can enrich the practice of urban planning and design.

ACKNOWLEDGEMENTS

I would like to thank, first of all, my mentors Leo van den Burg and Nico Tillie. Thank you Leo, for all our interesting, fruitful talks and especially for helping me get all the way to the finish line. Thank you Nico, for your enthusiasm and for answering many urban ecology and landscape architecture related questions.

Furthermore I would like to thank all helpful and interesting people that took the time to talk to me about urban ecology and nature-inclusive design. These talks and their books, research and designs have helped me in better understanding urban nature and how to design for it: Jacques Vink from ruimtelab en De Natuurlijke Stad, Rens de Boer and Niels de Zwarte from Bureau Stadsnatuur, Nina Ravestein from P.A.D. landscape and Maaike van Stiphout from DS landschapsarchitecten.

Last but certainly not least, I would like to thank my family, boyfriend, friends and colleagues at work, that have given me great advice, creative ideas and most of all a lot of mental support.

ABSTRACT

RQ - How can the urbanist provide conditions for strengthening biodiversity within urban development?

Biodiversity in the Netherlands has been under alarming pressure for many years. Historical drivers of biodiversity loss have been agriculture and urbanization, through causing environmental pressure, loss of natural habitat and fragmentation of habitat for numerous species and ecosystems (PBL, 2014). Pressure on biodiversity remains high today as the limited amount of land in the Netherlands is used intensively and densely inhabited.

Biodiversity ensures the health and resilience of ecosystems (Vink, Vollaard & de Zwarte, 2017): it influences its functioning and ability to react and adapt to changes. People are dependent upon the world's ecosystems through the ecosystem services they provide, but at the same time their actions are affecting the health and resilience of these ecosystems in a negative way. This relationship has to change fundamentally in order to ensure a healthy future for the worlds ecosystems and each species involved.

Although biodiversity is generally higher in cities than in the rural areas around (Pötz, 2016; Vink, Vollaard & de Zwarte, 2017) many species are still under pressure. There is a lack of biodiverse and connected green spaces, disturbances such as light and maintenance are negatively affecting urban ecosystems and nesting opportunities for species that have become dependent upon the city are disappearing (Dramstad, Forman & Olsen, 1996; Vink, Vollaard & de Zwarte, 2017; CBS, PBL, RIVM, WUR, 2018). This in turn also negatively affects the ecosystem services available for people living in cities. Future urban development, such as inner-city densification, are expected to further contribute to these pressures, as nature is still largely excluded from urban planning and design processes (Snep & Opdam, 2013, Pötz, 2016; Vink, Vollaard & de Zwarte, 2017; Weisser & Hauck, 2017).

This graduation project researches how knowledge from biodiversity, urban ecology and nature-inclusive design can be translated to urban planning and design. This is done by researching theory and at the same time studying the spatial aspects within the case study location of the Zomerhofkwartier in Rotterdam. The aim is to reach mutualist urbanism: a way of urban planning and design that provides conditions for strengthening biodiversity within 'habitats' that will also benefit people greatly. The found methods for a mutualist urban planning and design process consist of facilitating an 'interwoven urban mosaic through strongly interconnected landscape elements' (Forman, 2014) by designing for animals and people simultaneously (target species and target groups). Design principles that are then applied in design are: use, 3d connectivity, porosity, microclimate and time. Using these methods and design principles four mutualist habitats are designed for the Zomerhofkwartier that integrate within the ecological network of Rotterdam: a multi-level street, a public courtyard, a collective rooftop network and a collective garden. These mutualist environments provide a new relationship between the city and urban nature, between built structures and urban nature and between people and urban nature.

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1. introduction to the research

Figure 1.
Source: Dorfman (2018)

CHAPTER 1.
INTRODUCTION TO THE RESEARCH

''NATURE'S DANGEROUS DECLINE 'UNPRECEDENTED'

SPECIES EXTINCTION RATE 'ACCELERATING'

CURRENT GLOBAL RESPONSE INSUFFICIENT;

'TRANSFORMATIVE CHANGES' NEEDED TO RESTORE AND PROTECT NATURE''

The citation above shows the statements made in a media release on the May 5th of 2019, from the UN Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES). The citation summarizes some of the main conclusions from the IPBES Global Assessment Report on Biodiversity and Ecosystem Services: a critical assessment of research done over the past five decades regarding the relationship between nature and economic development. The report alarms that nature is declining worldwide, leaving 1,000,000 species threatened with extinction, but that ''through 'transformative change' nature can still be conserved, restored and used sustainably'' (IPBES, 2019).

This statement is deliberately used as an introduction to this research and design graduation project. It clarifies the wider context and emphasizes the urgency to act, in relation to the theme and problems addressed in this graduation project: biodiversity, and how pressure on biodiversity can be fundamentally shifted to strengthening biodiversity. This thematic is researched through the subject of urban development in the Netherlands using inner-city densification in Rotterdam as a case study. From this, lessons can be learned on what transformative changes are needed to strengthen biodiversity in the process and product of urban development. As this graduation project is done as part of the Masterprogram Urbanism at the TU Delft, the focus will be on the changes that are needed to be implemented by an urbanist.

Chapter 1 introduces the project by explaining the theme of biodiversity, the state of biodiversity in the Netherlands and the theme of biodiversity in the city. It will then explain the relationship between densification and biodiversity and the role of biodiversity in urban planning and design. The chapter concludes with the problem statement for this research.

1.1
A FIRST INTRODUCTION TO BIODIVERSITY

If we talk about biodiversity, what exactly are we referring to? And how does it relate to nature? As both terms, and many other related concepts, are fundamental within the thematic of this graduation project, a brief introduction will be given here with the help of theory. A journal article by Finnish researchers Haila and Kouki published in 1994, titled 'The phenomenon of biodiversity in conservation biology' is used as a starting point for this. Haila and Kouki (1994) acknowledge that 'biodiversity' is an umbrella term but they provide a general understanding to the term by introducing meaning and significance as ways to look at the term. They distinguish that: ''The meaning of 'biodiversity' is the phenomenon the term is supposed to stand for. The significance of 'biodiversity' is the total argument given in support of the urgency of biodiversity preservation.''

MEANING AND SIGNIFICANCE OF BIODIVERSITY

First of all, biodiversity can be seen as a general, descriptive term that is often used to refer to '**biological diversity**', which is the universal observation that animals, plants and micro-organisms appear diverse (Haila & Kouki, 1994). However, this description does not cover the exact significance of the concept 'biodiversity' yet. This significance depends on the discourse and context in which the word is used.

We start of by looking at biodiversity from the discourse of biology. In biology, different levels of biological hierarchy are recognized. Biological diversity appears at each of these levels (Haila & Kouki, 1994). There is diversity within species (variation in **genes**), between species (variation in **species**) and between **ecosystems** (communities of species within their living environments functioning as a system with non-living factors) (Gaston & Spicer, 2004). The significance of diversity at these different levels can be related to the connection between biodiversity and nature. Similar to the term biodiversity, there are many ways to define nature and innumerable significances that can connected to nature in different discourses and contexts. Often the term is used to describe the natural environment and natural processes, that occur without human intervention and/or occur despite human intervention in the world (Environment and Ecology, n.d.). Simple examples would be a forest, as well as the weather. Animals, plants and micro-organisms are the living elements of nature and biodiversity thus is a characteristic of nature. The significance of biodiversity in nature, as illustrated in Figure 2, can be explained by clarifying how the variety at different biological levels relate to **resilience** (Solbrig, as cited in Haila & Kouki, 1994).

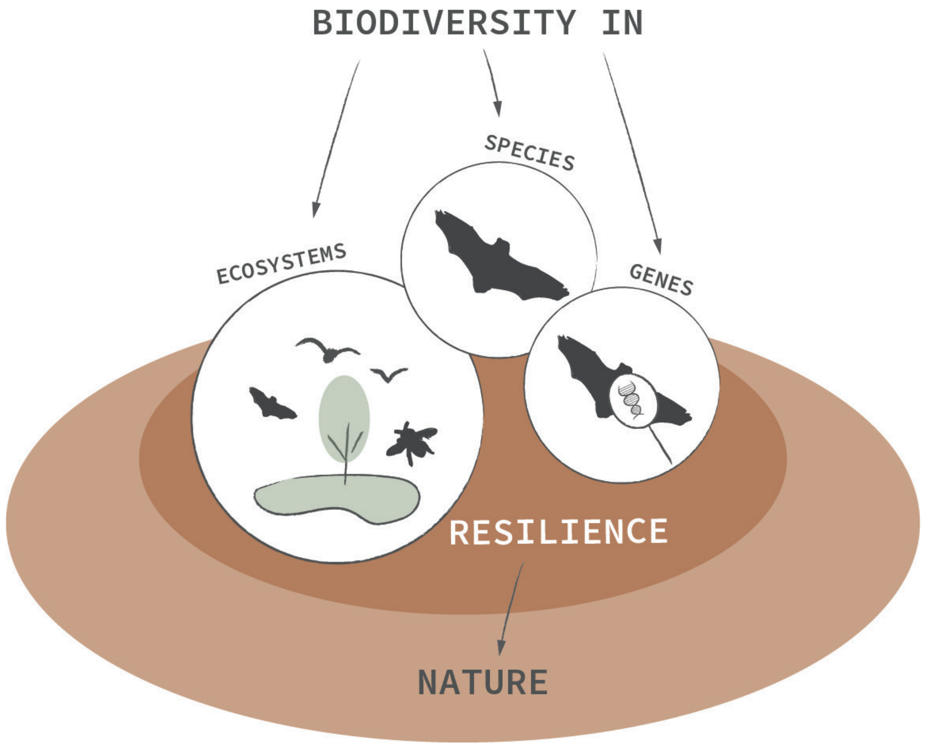


Figure 2. Significance of biodiversity in relation to nature in a biological context
Figure by author

Resilience is a system's ability to react and adapt to disturbances. This is needed for the system in order to retain the same function, structure, identity and feedback systems (Vink, Vollaard & de Zwarte, 2017).

Biodiversity in an important factor for the resilience of natural systems. For example, variety in genes enables a population to withstand diseases and it provides material for evolution of species as a mechanism to adapt to changes. Furthermore, different species together form an ecosystem and are interdependent upon each other through relationships of for example predation (to eat or be eaten). A variety of species can provide more opportunities for these processes to happen, therefore providing a more healthy, functioning ecosystem. And in turn, a variety of ecosystems is important as different species need different environments with different circumstances (warm, cold, wet, dry and so on) to live in (Vink, Vollaard & de Zwarte, 2017).

BIODIVERSITY ENTERING NEW DISCOURSES

Haila and Kouki (1994) describe how biodiversity has become commonly used in society and broader scientific fields, especially since the UN conference on the Environment and Development held in Rio de Janeiro in June 1992. At this conference, the first global agreement titled 'convention on biological diversity' was signed with the goal of promoting sustainable development, where conservation of biodiversity and sustainable use of natural resources were mentioned as preconditions (Secretariat of the Convention on Biological Diversity, 2019). This convention was the one of the first global acknowledgements that conservation of biodiversity was ''a common concern of humankind'' (Secretariat of the Convention on Biological Diversity, 2000, p. 8) as we as humanity depend upon it.

As biodiversity and conservation have become a concern of society as a whole, the significance of biodiversity broadens. For example, it has now entered the 'economic discourse' (Haila & Kouki, 1994). This is highlighted too by the organization that was quoted in the chapter introduction: the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services as their report concerned the relationship between nature and economic development. The term 'Ecosystem Services', that is used in their name, is a concept that is increasingly being used to give insight into the benefits people experience from nature. ''Ecosystem services are the direct and indirect contributions of ecosystems to human wellbeing.'' (TEEB, 2013b). Another association, The Economics of Ecosystems & Biodiversity, divided these services into four categories: Provisioning Services, Regulating Services, Supporting Services and Cultural Services (TEEB, 2013a). Figure 3 shows the categories and the corresponding services, such as the provisioning service of providing us with food or the cultural service of providing places for recreation.

Concepts such as Ecosystem Services provide more understanding for people of a wide public as to why nature and biodiversity are important and why they should be treated sustainably. However, as this acknowledgement is becoming clearer and clearer (sources from 1990 until today have been used here), the citation of the IPBES in the chapter introduction has showed that we are still in need of transformative changes to conserve, restore and sustainably use nature.

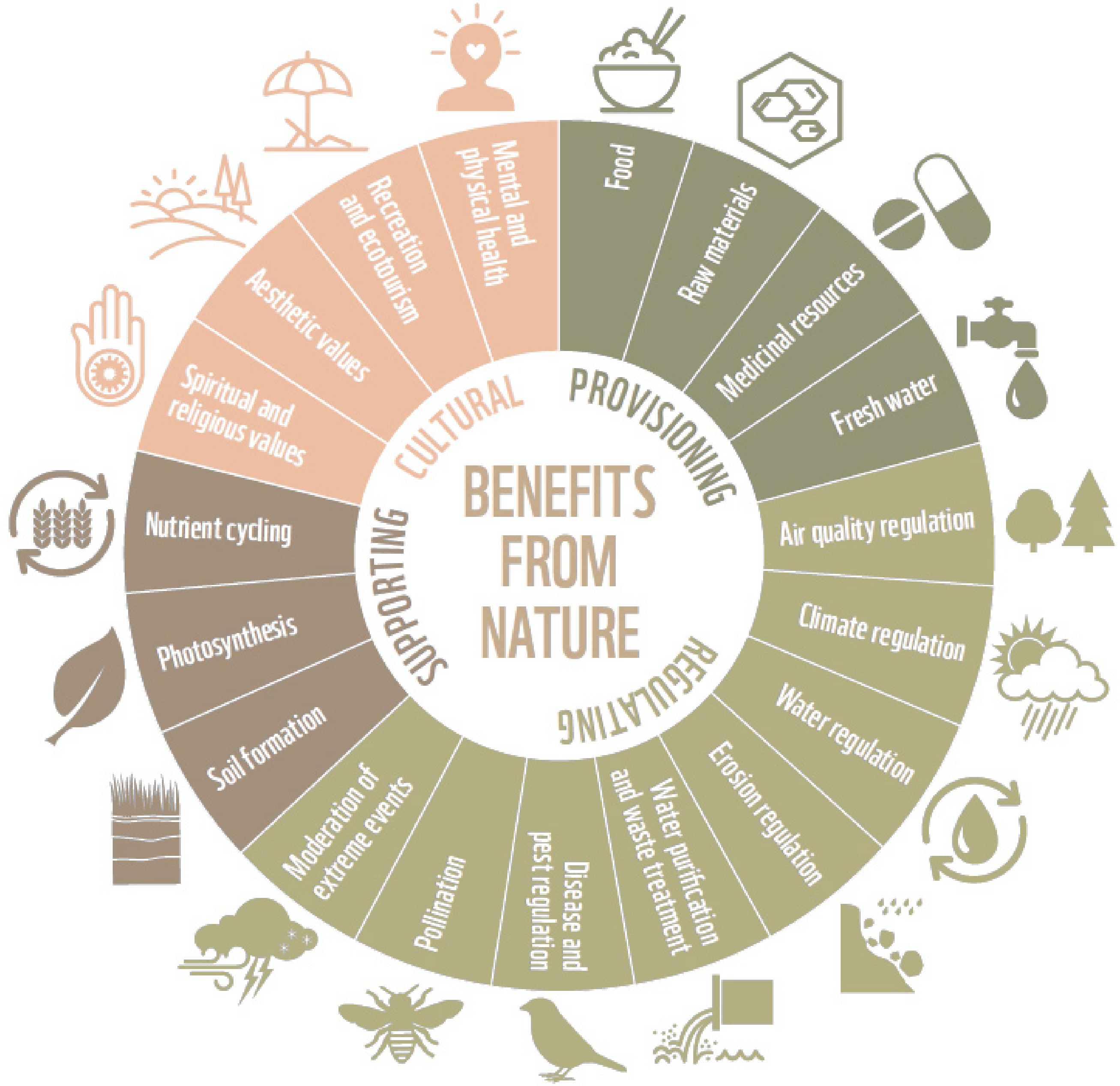


Figure 3.
Ecosystem services
Source: WWF (2018)

OPERATIONALIZING BIODIVERSITY CONCERN

Before it is possible to achieve transformative change in relation to biodiversity, it is necessary to define where exactly this change should happen. The IPBES (2019) mentioned the following brief definition of transformative change: ''By transformative change, we mean a fundamental, system-wide reorganization across technological, economic and social factors, including paradigms, goals and values.''. This is very broad, logically following from the fact that the IPBES target audience is global and we are dealing with ecosystems that are often by definition open systems that do not follow borders (Schilthuizen, 2016).

In relation to operationalizing the term biodiversity in urban settings Savard, Clergeau & Mennechez (2000) discuss several 'biodiversity concepts', such as '**hierarchy of scales**'. ''Biodiversity concerns can occur at any level of organization. Levels of biological organization often correspond to specific spatial and temporal scales and must be addressed at their appropriate scale'' (Savard, Clergeau & Mennechez, 2000, p. 132). These spatial and temporal scales could for example be related to a country, a city or a specific area in a city and measures could be targeted within a specific time horizon. Choosing specific scales to focus on can be helpful, but it is very important to consider the interdependency of scales by using a multi-scalar approach that considers effects of an action at different scales (Allen& Star, as cited in Savard, Clergeau & Mennechez, 2000).

So, first it is essential to realise that biodiversity is context-, level- and scale-dependent (Haila & Kouki, 1994; Savard, Clergeau & Mennechez, 2000). It is therefore crucial to research the context in relation to the scale(s) of intervention and effects on other scales. Furthermore, as mentioned, focussing on a specific level of biological organization can be related to the scales. However, deciding to for example focus on species diversity is still very general. Savard, Clergeau & Mennechez (2000) state that in fact not all species are equal, as specific species might have bigger roles and impact in a community than other species.

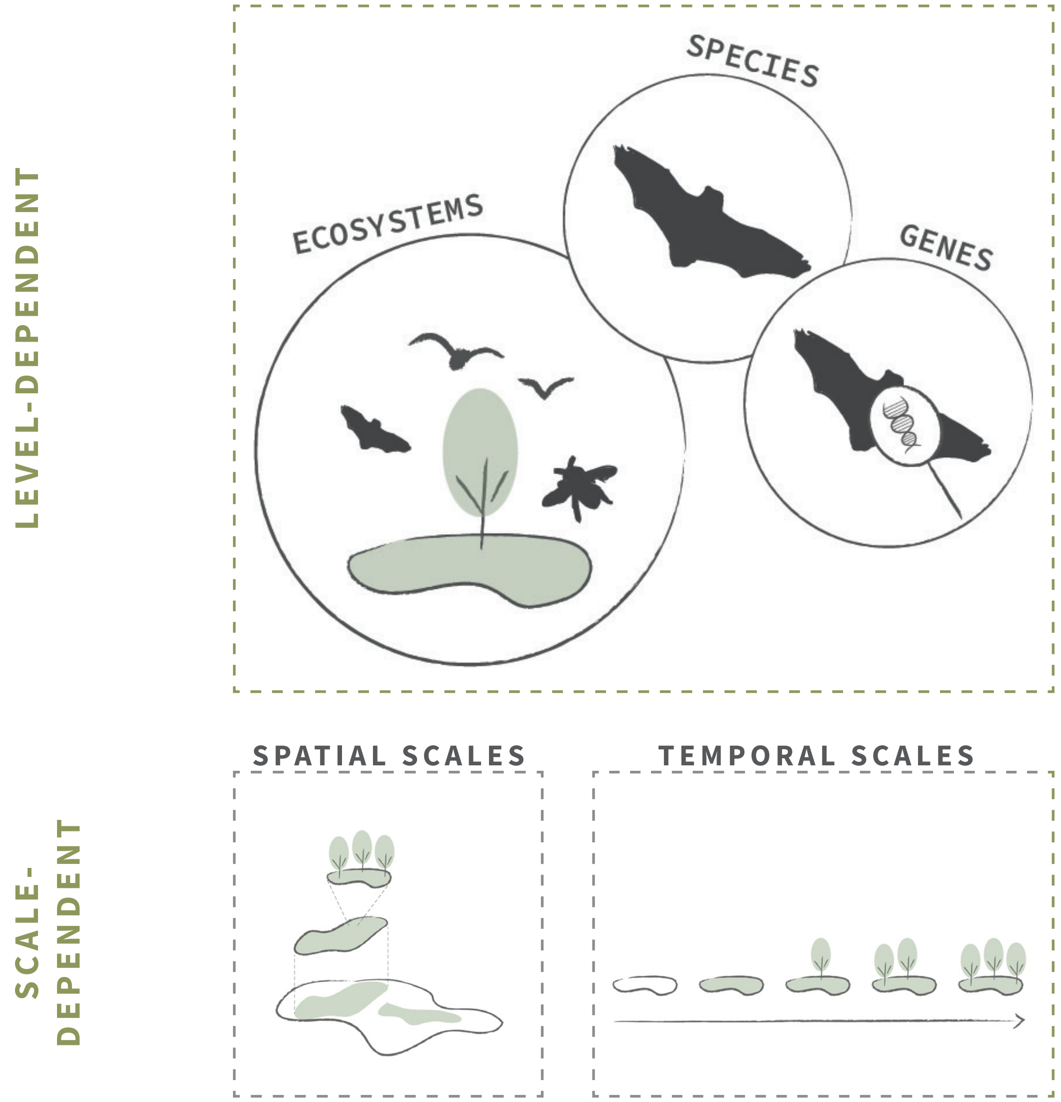


Figure 4.
Level- and scale dependency
Figure by author

BIODIVERSITY ENTERING THE DISCOURSE OF THE CITY - AND THIS GRADUATION PROJECT

So, what is the significance of biodiversity (and nature) in relation to cities? And how do we continue from the first starting points as named above to bringing about transformative change? Questions like these form a relatively new discourse around the topic of biodiversity and the discourse of this graduation project. Figure 5 illustrates this. To start with, the broader context, the state of biodiversity in the Netherlands, will be briefly explained. This is followed by a general exploration of the state of biodiversity in cities and why we should work on biodiversity in cities specifically. With this information this chapter forms a basis for this graduation project by providing insight as to what transformative change is needed in relation to biodiversity and cities.

The first introduction to biodiversity has very briefly touched upon a definition of nature and very briefly into the significance of biodiversity and nature, through introducing the concept of ecosystem services. In the text it was mentioned the significance depends upon the discourse in which the terms are used. Through researching how to reach transformative change towards biodiversity in an urban development area (the topic of chapters 3 and further) the significance of biodiversity and nature in relation to the city will also be addressed.

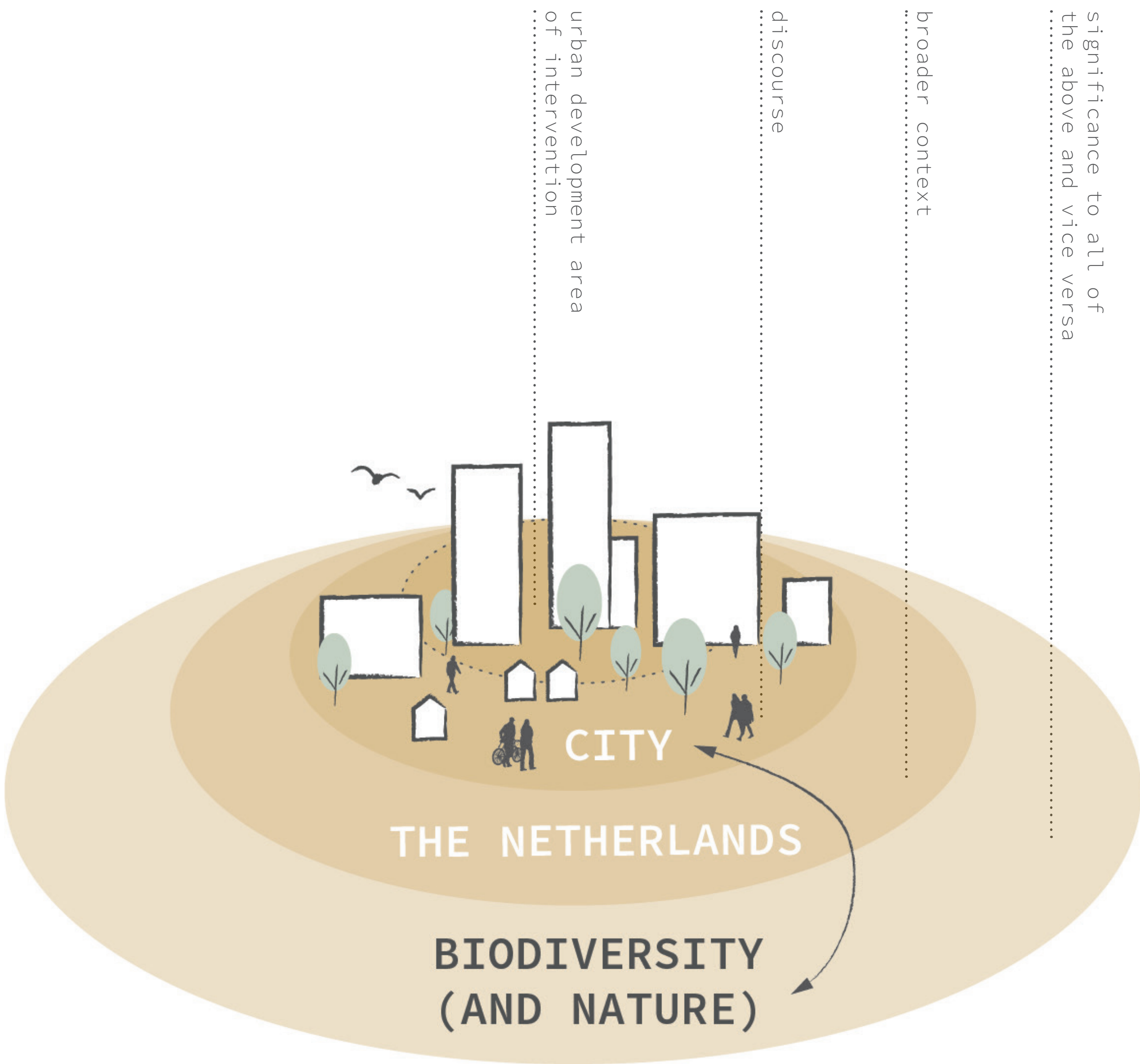
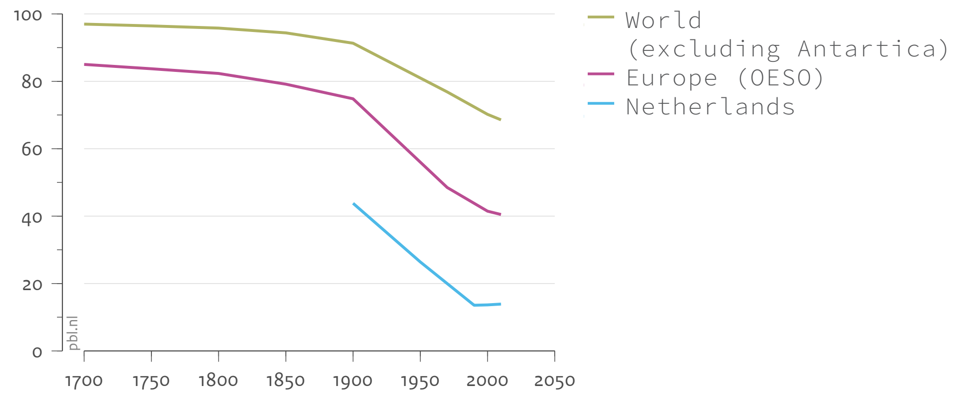


Figure 5.
Discourse of this graduation project
Figure by author

1.2
BIODIVERSITY IN THE NETHERLANDS

When looking at the state of biodiversity in the Netherlands, it becomes clear that this has been under alarming pressure for many years. As biodiversity encompasses diversity in genes, species and ecosystems there are multiple ways to measure it. One way to measure biodiversity is by examining the diversity in species using Mean Species Abundance (MSA). This indicates the percentage of the size of the population of native plant- and animal species that is left when comparing it to the original, natural situation. In the Netherlands the MSA was 15% in 2010, coming from 40% in 1900 (PBL, 2015), as shown in Figure 6. This percentage is also significantly lower when comparing it to the European and global percentage.

Figure 6.
Biodiversity
(Mean Species
Abundance)
Source:
Compendium voor
de Leefomgeving
(2014)



DRIVERS OF HISTORICAL BIODIVERSITY LOSS

As the Mean Species Abundance relates to the natural state of species it is not surprising that this has changed enormously in the Netherlands. The Dutch landscape as it is today is the result of centuries of landscape alterations by people, such as reclaiming land (Cey & Brugmans, 2014). Landscape changes between 1900 and 1980 are illustrated in Figure 7, showing "processes of reclamation of land, (de)forestation, industrialisation, agriculture reformations and increasing urbanization" (Knol, Kramer & Gijsbertse, 2004, p. 9). The Dutch Environmental Agency (Planbureau voor de Leefomgeving) found that agriculture and urbanization are the main causes for biodiversity loss (2015). First of all, both land uses have resulted in area loss of natural habitat, therefore changing biodiversity. Second, both developments cause fragmentation of habitat. Lastly, agriculture creates environmental pressure through for example the use of pesticides and emission and deposition of too high concentrations of substances, such as nitrogen and ammoniac, that end up in nature causing harm to numerous ecosystems (PBL, 2018).

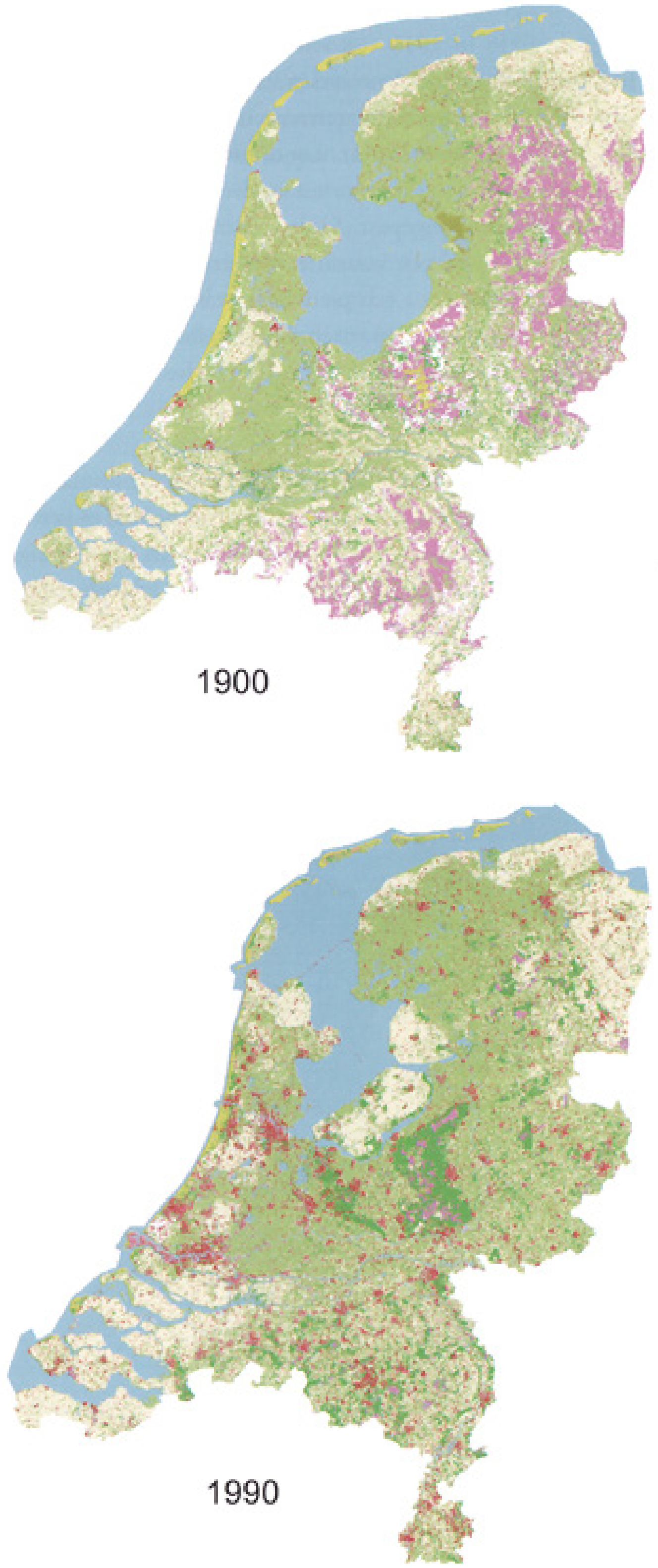


Figure 7.
Historical landscape types/land use
Source: Alterra (Knol, Kramer & Gijsbertse, 2004), edited by author

Legend
- (Agricultural) grassland
- (Agricultural) fields and bare land
- Heath and high bogs (heide en hoogveen)
- Forest
- Buildings and infrastructure
- Water
- Reed marshes (rietmoeras)
- Dunes (stuifduinen)
- Built area

Figure 8.
Current main land uses in the Netherlands
Source: PDOK & CBS bestand bodemgebruik (2019), edited by author

Legend

- Natura 2000 area (on land and water)
- Agricultural land
- (Sub)urban area
- Infrastructure (road)
- Industrial area

CURRENT PRESSURE ON BIODIVERSITY

Figure 8 shows the current main land uses in the Netherlands. As visible, the Netherlands is characterized by mostly agricultural land (70%) (PBL, 2015), with a continuous network of urbanized land and infrastructure running through it (Vink, Vollaard & de Zwarte, 2017). Protected nature reserves, called Nature 2000 areas, are limited. Around 14% of the Netherlands (land and marine) is classified as Nature 2000, which is under the European average (PBL, 2015) and lower than the expected 17% as noted in the biodiversity convention of the UN (Joosten, 2017). Pressure on biodiversity remains high today as the limited amount of land in the Netherlands is used intensively and is densely inhabited, creating pressure in these areas and Natura 2000 areas that surround them (PBL, 2015).

SPECIFIC SPECIES UNDER PRESSURE

The Netherlands has unique landscape features, such as the water richness, that are essential to some species, for example to the migration and hibernation of aquatic birds and to fish that migrate to countries upstream (CBS, PBL, RIVM & WUR, 2017). Therefore the state of biodiversity in the Netherlands is also of international importance. Furthermore, there are specific species that are under more pressure than others. In 2017, a scientific study in Germany found that since 1989 76% of the total biomass of flying insects was lost in German nature reserves with comparable environmental circumstances to the Netherlands (Deltaplan biodiversiteitsherstel, 2018; PBL, 2018). Currently there is no insight into the exact state of such developments in the Netherlands, but there is consensus among researchers that the population of Dutch insects is declining. Not only vulnerable, rare species are threatened to extinct, but also more common species are under pressure. Researchers alarm that action should be undertaken (Kleijn et al, 2018). Insects are an important group in many ecosystems and can function as an useful indicator for biodiversity (Vink, Vollaard & de Zwarte, 2017; Wageningen University & Research, 2017). When conditions positively or negatively change in a certain area, insects respond to these changes in a short time: making them easy to monitor (Vink, Vollaard & de Zwarte, 2017). Furthermore, there are multiple reasons why decline of insects can impact other species profoundly. Firstly, they are at "the basis of the food chain for many species such as >80% of birds, and other animals (mice, bats, fish)" (Wageningen University & Research, 2017). On top of that, their ecological functions include pollination of plants (agricultural and other plants), cleaning up of organic matter and preventing plagues in nature and agriculture (Wageningen University & Research, 2017).

1.3
CITIES AND BIODIVERSITY

Now we know what the main drivers of historical biodiversity loss in the Netherlands are, and that urbanization was one of them. As pressure on biodiversity remains high today, due to the limited amount of land in the Netherlands being used intensively and being densely inhabited, it is of importance to understand how to prevent future biodiversity loss in urbanization. So, what is the current state of biodiversity in cities? And what species are under pressure here?

CITY AS AN UNIQUE ECOSYSTEM

The city can be seen as an ecosystem consisting of different biotopes that in turn provide a variety of habitats. In ecology, the word biotope is used to describe ''a distinct landscape, uniform in environmental conditions'' (Vink, Vollaard & de Zwarte, 2017, p. 33). A biotope provides different habitats for different species. Cities provide unique biotopes and thus habitats that cannot be found outside cities. The combination of paved and unpaved surfaces, a diversity of microclimates, often warmer temperatures, dominant human presence, the dynamics of cities: this combination of features makes cities unique (Pötz, 2016; Vink, Vollaard & de Zwarte, 2017). Many species even migrate from the surrounding areas into cities (van Stiphout, 2019), or adapt (evolution) to dynamic city life (Schilthuizen, 2016). Biodiversity is often even higher in cities, especially when comparing it to the rural areas around (Pötz, 2016; Vink, Vollaard & de Zwarte, 2017).

THE IMPORTANCE OF CITIES FOR BIODIVERSITY

In 2014 researchers of Wageningen University published an article titled ''The importance of urban areas for the biodiversity of the Netherlands''. They used a sample of species from the national biodiversity register (Nederlands Soortenregister), taken from the approximately 36,000 native species registered at the time. From their research they extrapolated the following: ''a total of 3,900 species that are confined to urban areas for survival of the population'' (Lahr et al., 2014, p. 202), which corresponds to more than 10% of the species living in the Netherlands.

Urban species are not a new phenomenon: as cities have developed, plants and animals have settled and adapted to them (Snep, Kwak & Kramer, 2005; Schilthuizen, 2016). However, what stands out is that more and more species are becoming hemerophile (cultuurvolger): they benefit from opportunities provided by people (Vink, Vollaard & de Zwarte, 2017). They have either chosen the city as their main habitat or have become fully dependent upon the city (Lahr et al., 2014; Vink, Vollaard & de Zwarte, 2017). Some animals, such as the common swift and the peregrine falcon are now using the buildings in cities as a landscape similar like that of a mountain landscape (van Stiphout, 2019), providing them with mountains with different heights, alcoves and ridges.

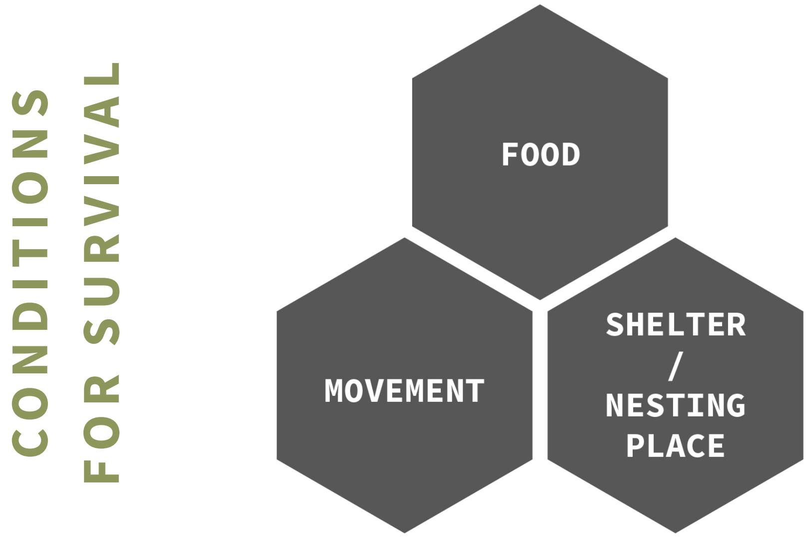


Figure 9. Conditions for survival By author

CONDITIONS FOR SURVIVAL

Many species have chosen the city as their main habitat or have become fully dependent upon the city, which means that the city provides a number of conditions or all conditions for their survival and that of the population they are part of. Most of the time efforts to protect and enhance biodiversity are directed towards animals in the city. Similar to the needs of animals in non-urban contexts, there are a few simple conditions that should be provided in cities. The first condition is the presence of food, thus the presence of plants and other animals. The second condition is providing opportunities for movement, which enables foraging (the act of searching and finding food) and provides chances for reproduction. The last condition is providing a place for shelter and/or nesting. This is important because not all (urban) species built their own nest or are dependent upon the presence of specific plants as a shelter or nesting place (Vink, Vollaard & de Zwarte, 2017). Dealing with different species in a city means that there is a variety of different needs that must be provided, specified to species or a species group. In general for most urban animals we can see urban green space as one of the most important providers of these conditions for survival (Pötz, 2016).

URBAN GREEN SPACE AND BIODIVERSITY

Urban green space includes all the 'green elements' of the city such as parks, public and private gardens, trees and plants, urban agriculture, green roofs and green facades. Urban green also plays an essential role in the water system of cities, as it retains, stores and drains water. (Pötz, 2016). Preserving, improving and increasing green spaces in cities is one of the basic factors for facilitating plant and animal diversity.

SPECIFIC SPECIES UNDER PRESSURE

Even though cities already provide unique biotopes and habitats, and that biodiversity is often higher than in the rural areas around, the ecosystem city can still improve a lot for many species. For some species conditions for survival in the city are not facilitated (enough) to maintain the population at a certain level, resulting in a decline of these species. For some species there is monitoring data available that gives an insight into the state of biodiversity for these groups. For example, Figure 9 shows that urban fauna, here representing summer birds and butterflies, in Dutch cities has decreased to 50% in 2017 compared to the 100% as measured in 1990 (CBS, PBL, RIVM, WUR, 2018). 13 of 20 typically urban birds have a decreasing population (van den Berg, 2018). Numbers like this alarm us that action should be taken.

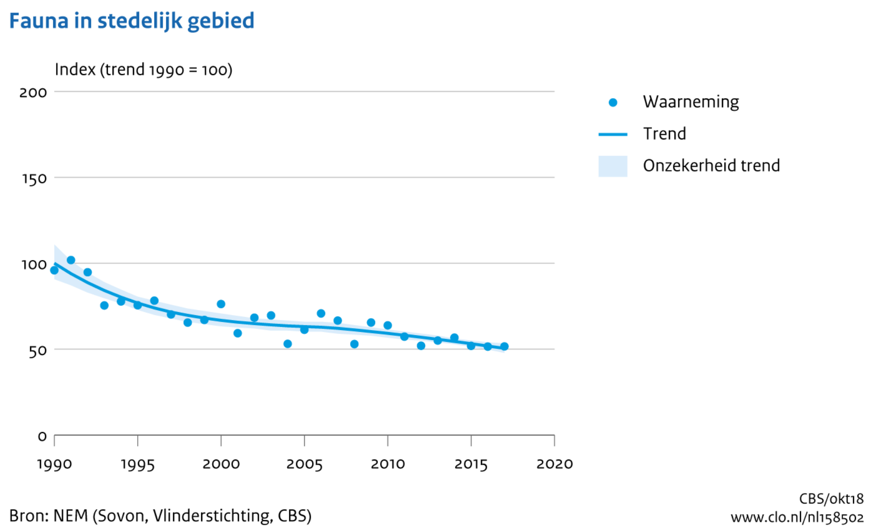


Figure 10. State of urban fauna (birds and butterflies) Source: CBS, PBL, RIVM, WUR, 2018

deVolkskrant

Voorpagina Nieuws & Achtergrond Columns & Opinie Video Wetenscha

NIEUWS STADSVOGELS

Ook stadsvogel kampt met woningnood: populatie van 13 van 20 stadsvogelsoorten flink afgenomen

De merel, de spreeuw en de huismus: zogeheten 'stadsvogels' zijn het. Maar juist in de stad hebben ze het moeilijk. De populaties van dertien van de twintig stadsvogelsoorten zijn tussen 1990 en 2017 in stedelijke omgeving fors afgenomen.

Jurre van den Berg 7 december 2018, 0:00

Een spreeuw, een van de stadsvogels waar het slechter mee gaat. Beeld ANP

Figure 11. Newsarticle ''Ook stadsvogel kampt met woningnood'' (Volkskrant, 7 December 2018)

GENERAL CAUSES OF PRESSURE ON BIODIVERSITY IN THE CITY

Not all urban species are monitored within cities and it can be hard to point to direct causes for change in biodiversity for each species. However, there are certain characteristics and developments within today's Dutch cities that can affect (specific) urban species in a negative way. These causes influence provision of food, movement and shelter/nesting place. For example birds and bats use holes and cracks in buildings to nest, which cannot often be found in buildings developed under current regulations (CBS, PBL, RIVM, WUR, 2018). As urban green space has such a vital role for the survival of species, many characteristics and developments related to biodiversity decline can be linked to quality and/or absence of these green spaces and weak interconnections (fragmentation and isolation) of urban green spaces (Dramstad, Forman, Olsen et al., 1996). Furthermore many problems relate to disturbances in cities, such as light, frequent maintenance and mowing of vegetation (Vink, Vollaard & de Zwarte, 2017). If biodiversity in the city is considered to a greater extent, solutions towards these pressures can be provided in future urbanization.

AIRTIGHT BUILDINGS WITHOUT HOLES AND CRACKS

LACK OF URBAN GREEN SPACES

LACK OF BIODIVERSE VEGETATION

FRAGMENTATION AND ISOLATION OF VEGETATION

DISTURBANCE

1.4
URGENCY CAUSED BY DENSIFICATION

These pressures and how we currently deal with them in cities have underlying problems that become clear when examining the way we develop and use our cities. The ecological importance of preserving and improving biodiversity in cities already shows the urgency to change this in regard to 'nature'. Through the concept of ecosystem services that has been introduced before, it also becomes clear that people experience many benefits from urban nature. The Dutch housing demand shows that more and more people want to live in cities in the upcoming years. In future urbanization it therefore becomes even more important to preserve and improve urban nature in the city.

THE DUTCH HOUSING DEMAND

In 2017 ABF research published a prognosis that showed that there is a need for 1 million new houses in the Netherlands until approximately 2035 (ABF Research, 2018). News considering the housing market has been dominated by this number ever since. It can be debated if as much as 1 million houses are necessary, but in any case the trend is that more and more people want to live in cities (PBL, 2018). Shortages in housing in and around big cities, resulting in increasing rent and housing prices (PBL, 2018) illustrate that in many new houses are needed here. Apart from meeting current demand, there is a need to replace housing that will be demolished due to renewed quality standards for example. It is expected that 25% of the 1 million houses is needed to replace this (Faessen et al., 2017).

WHERE TO DEVELOP THE DEMAND

The highest demand lies in and around cities in the Randstad such as Amsterdam, Rotterdam, The Hague and Utrecht (PBL, 2018). These cities are already the biggest cities and have limited amount of space available for development. The question therefore is, how can large housing demands be realized here? Since the 1990s spatial development in the Netherlands has been characterized by compact city development: new housing developments are realized within existing city boundaries or close to big cities. This is guided by the idea to stimulate city amenities and driven by sustainability arguments such as limiting loss of green or agricultural space and discouraging car use (and thus emissions) (van der Wouden et al., 2015). The national government used to be the main leader in compact city development through the Ministry of Housing, Spatial Planning and the Environment (Ministerie van VROM). Their policies and plans spatially led to the development of large quantities of new housing through key-projects (*sleutelprojecten*) and VINEX neighbourhoods within existing city boundaries and as extensions to existing cities. In 2010, this Ministry was abolished as part of decentralization measures, resulting in urban development mainly being the task of provinces and municipalities up until today (Nabielek et al., 2012). Despite this decentralization, the national government is still involved in steering the development through visions, laws and guidelines. For example, it is stressed that the housing demand must be realized within existing city boundaries as much as possible (BZK, 2018). Furthermore, in society there are also debates on how further urbanization should take place. With (open) space becoming more limited, societal opposition towards developing outside existing city boundaries at the expense of (agricultural) green landscapes is increasing. Combining this with the trend of people wanting to live in cities, municipalities and provinces acknowledge the need for continuing compact city development mainly within the city, leading to urban densification (Nabielek et al., 2012).

DENSIFICATION

Urban densification can be defined as ''using land more efficiently and intensifying development and activity'' (Jenks, 2000, p. 242). Densification with the main goal being increasing housing mostly happens by developing housing in areas that were not built-up before (infill development), by transforming a built-up area to housing such as a former industrial area, by adding floors to existing buildings or by replacing low-rise buildings with more compact or high-rise buildings (Haaland & Konijnendijk van den Bosch, 2015). Increasing housing within the city interferes with existing urban functions, such as infrastructure, workplaces, shops and places for recreation. In this way adding housing comes with the necessity to develop other circumstances simultaneously. Densification can therefore also be an opportunity to increase the quality of the living environment (Nabielek et al., 2012). Through the concept of ecosystem services it becomes clear that densification of the city comes with an inevitable task of improving and increasing the ecosystem services provided in cities (Stache, Jonkers, & Ottelé, 2019). It can become a precondition to enable high qualitative and accepted densification of the city (Pötz, 2016).

1.5
DENSIFICATION AND BIODIVERSITY

COMBINING GOALS?

We have seen that both animals and people in Dutch cities are experiencing a housing shortage. It seems that despite increasing awareness around the importance of and state of biodiversity and urban green spaces, structural changes in the practice of urban planning processes cannot be found yet: they remain focused on ''division of labour, separation of functions and maximised land yields'' (Pötz, 2016, p. 22). This can be illustrated using the following examples.

Municipalities in the Netherlands have been becoming aware of the importance of especially green space the last few years, taking Amsterdam as an example. As a reaction they start to adopt goals to increase green space. However, when combining goals of densification and increasing green space in cities, it is often found that one excludes the other. A study by researchers from the University of Amsterdam has shown that despite municipal claims and policies directed to creating new urban green space, between 2003 and 2016 11% of the green space within the ring road of Amsterdam has disappeared, mainly due to development of housing (Giezen, Balikci, & Arundel, 2018). Developments like this are further underlined in research on other cities where repeatedly it is stressed that despite good intentions, the effective integration of green space development and preservation in urban densification processes is not at all standard (Haaland & Konijnendijk van den Bosch, 2015; Pötz, 2016; Snep & Opdam, 2013). Evidence is growing that urban green space is disappearing particularly in high-density environments, but Haaland and Konijnendijk van den Bosch (2015) argue that this is a significant problem as well in less dense areas, to which Dutch cities can be categorized. One of their findings was that in European cities urban green space decreases particularly due to infill development. The start of these infill developments is often characterized by the clearance of vegetation on the building site. There is little to no (economic) incentive for developers to preserve green and little to no regulations to ensure preservation (Brunner & Cozens, as cited in Haaland & Van den Bosch, 2015). Furthermore, in most cases these new developments are surrounded by a minimal amount of newly developed green space and the green that is developed often merely consists of patches of grass that serve no multi-functional purpose: they do not contribute to biodiversity or provide multiple uses for people (Beer, Delshammar, & Schildwacht, 2003).

1.6
ROLE OF BIODIVERSITY IN URBAN PLANNING AND DESIGN

THE ROLE OF BIODIVERSITY IN URBAN PLANNING AND DESIGN

As shown through the pressures on biodiversity, many but not all problems relate to green space. Often animals are used in renders and impressions in urban planning and design processes, but not all professions involved in the process of planning and design have the knowledge to facilitate all conditions needed for these animals (Weisser & Hauck, 2017). Conditions needed for preservation of certain species, such as birds and bats, are only considered once the final design is submitted for building permission. ''The presence of a protected species may than require a costly modification of the project (or the removal of the species from the site), a lose-lose situation'' (Weisser & Hauck, 2017, p. 5).

CHANGING URBAN PLANNING AND DESIGN

As biodiversity is linked to an ecosystem, including this ecosystem and its plants and animals in development should be taken into account early on in the process of urban planning and design. This can enrich urban development for people and all other species of nature. Once the most important decisions have been taken without early consideration of biodiversity, the constraints of the design will then limit the potential and effectiveness of these (Snep & Opdam, 2013).

PROBLEM STATEMENT

This leads to the following problem statement for this project:
Nature is excluded from urban planning and design, resulting in loss of biodiversity and unused potential for an improved, liveable environment for people through the ecosystem services provided by urban nature.

2.
research methodology

CHAPTER 2.
RESEARCH METHODOLOGY

Chapter 1 has introduced the theme and problems addressed in this graduation project. In chapter 2 the research methodology will be clarified. First, the scope and aim of the research will be explained, with the corresponding research questions. This is followed by the conceptual framework, theoretical framework and an explanation of the case study approach. The chapter ends with an overview of the used research methods.

Figure 12.
From urban development to nature-inclusive urban development
Photograph by author and edited by author

2.1

OVERVIEW METHODOLOGY

On the right, an overview of the entire methodology of the project is shown. In this chapter each of the elements is explained.

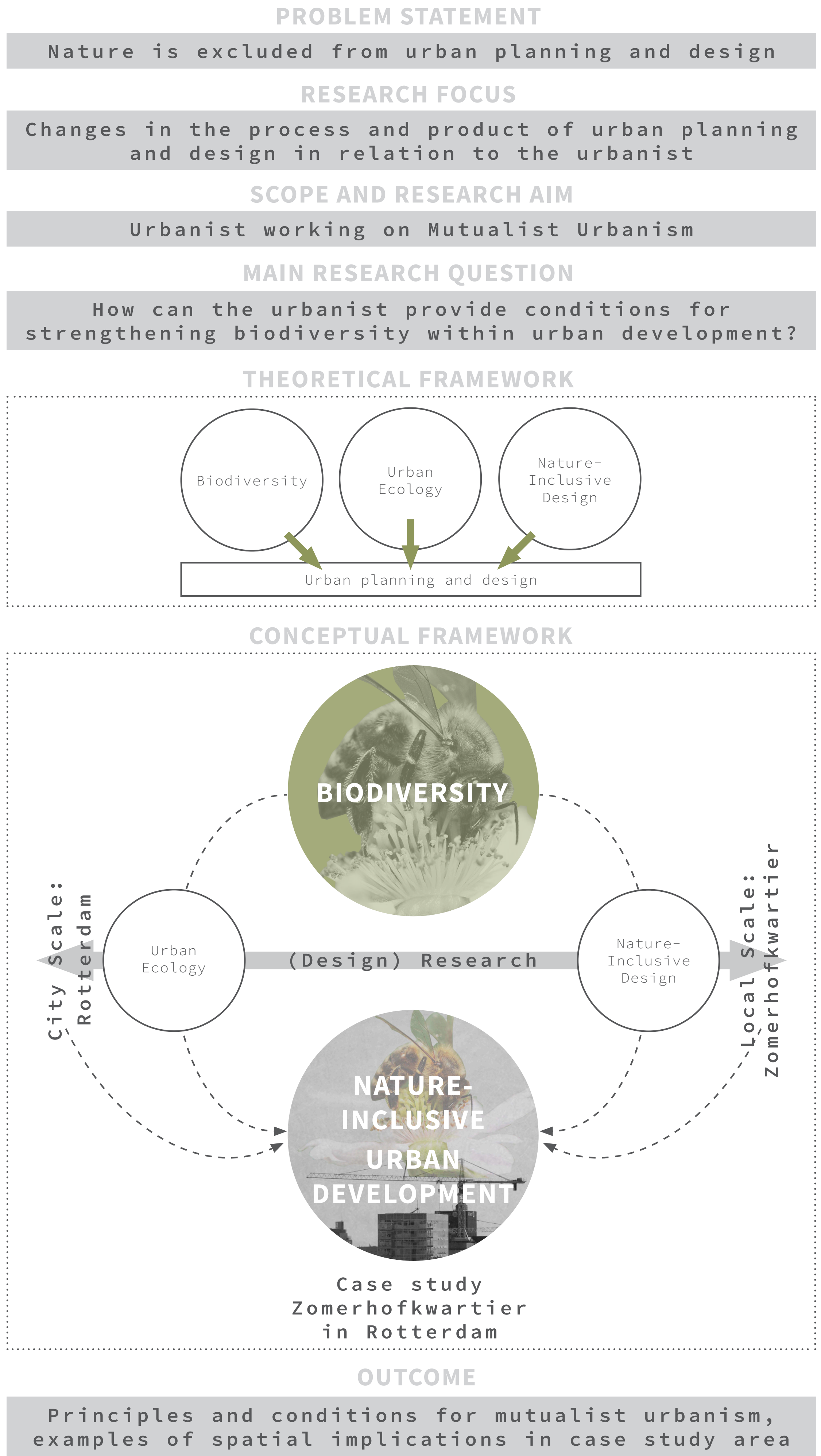


Figure 13.
Overview of the methodology for graduation project 'Mutualist Urbanism'
By author

MUTUALIST URBANISM

In nature, processes of mutualism occur: an ecological interaction where species benefit from each other. Pollination is a good example: the bee is fed and plant is enabled to flourish (Bronstein, 2015). What if mutualism is used as an inspiration for the development of cities? If we think of biodiversity as the bee, and urban development is the plant...

Through nature-inclusive urban development, cities and the people living in them will flourish greatly while conditions for strengthening biodiversity are provided simultaneously.

2.2

RESEARCH AIM AND SCOPE

INSPIRATION FOR THE AIM OF THE PROJECT

The page on the left shows the title of the project and describes how mutualism is used as an inspiration for this project to move from urban development to nature-inclusive urban development. This illustrates the research aim of the project:
To find out how to reach mutualist urbanism: a way of urban planning and design that, through providing conditions for strengthening biodiversity, aims at redefining the relationship between the city and urban nature. This in turn will result in redefined relationships between built structures and urban nature and between people and urban nature.

SCOPE: STRENGTHENING BIODIVERSITY

There are different ways to approach the topic of improving biodiversity in the context of cities. Savard, Clergeau and Mennechez (2000) describe three groups of biodiversity concern: ‘‘(1) those related to the impact of the city itself on adjacent ecosystems; (2) those dealing with how to maximize biodiversity within the urban ecosystem and (3) those related to the management of undesirable species in the ecosystem.’’ (p. 132). The research of this graduation project belongs in group 2. Strengthening biodiversity here refers to preserving local biodiversity and, within the local ecosystem, providing conditions for survival (food, movement and breeding/nesting places) for different local species.

SCOPE: THE URBANIST

This research focuses on the urbanist. An urbanist, referring to an urban planner and/or designer, can be involved in different approaches and can take upon different roles in the process of urban development. One of those can be to research and design the potential and desired conditions of urban development at different scales. In most cases people, and urban processes linked to people, are the focus of this research and design. The question of this research is how to include biodiversity in this.

2.3

RESEARCH QUESTIONS

MAIN RESEARCH QUESTION

The problem statement, research aim and scope have resulted in the following main research question:

How can the urbanist provide conditions for strengthening biodiversity within urban development?

SUB RESEARCH QUESTIONS

The sub research questions, as shown on the right, are related to:

1) the process of urban planning and design
2) the spatial implications of nature-inclusive planning and design (at the case study location Zomerhofkwartier Rotterdam)

THE PROCESS OF URBAN PLANNING AND DESIGN

SUB RQ1:
What basic knowledge from biodiversity, urban ecology and nature-inclusive design is needed to enrich the urbanist with an ecological point of view during the planning and design process?

SUB RQ2:
What are the analysis and design methods can be used for nature-inclusive planning and design?

THE SPATIAL IMPLICATIONS OF NATURE-INCLUSIVE PLANNING AND DESIGN (ZOMERHOFKWARTIER

SUB RQ3:
What are the main principles for nature-inclusive planning and design?

SUB RQ4:
What are the spatial implications of nature-inclusive planning and design of the Zomerhofkwartier in Rotterdam?

2.4

THEORETICAL FRAMEWORK

THEORETICAL FRAMEWORK

Figure 14 shows the theoretical framework of the research with the main research themes of biodiversity, urban ecology and nature-inclusive design. The main sources consulted are shown here.

NATURE-INCLUSIVE DESIGN AND URBAN ECOLOGY

Nature-inclusive design is a pioneering practice that integrates ecological principles with design, for example the design of cities (Vink, Vollaard & de Zwarte, 2017). From urban planners and designers this asks for gaining knowledge from the field of ecology. Ecology is a broad scientific field in which the relationships among different species and their living environment are studied. This is done in many ways, thus resulting in numerous fields and approaches within ecology. Urban ecology is one of those fields. This again is a broad concept but can be seen as the study of ecology within the urban context (Niemelä, 1999). This means studying all species and environments in the urban context and thus studying ‘‘an urban ecosystem where the built, the bio physical and the social interact’’ (Stockholm Resilience Centre TV, 2013). Urban ecology therefore does not only focus on the natural elements in the city but rather on the relationship between the natural system and all other systems, such as social and economic systems. Often the goal of urban ecological studies is to translate the scientific findings to urban planning, for example applying it to planning and management of urban green areas (Wittig and Sukopp as cited in Niemelä, 1999). Nature-inclusive design is a part of this, using a systemic approach that considers processes and the component of time and translating this to design interventions (Vink, Vollaard & de Zwarte, 2016).

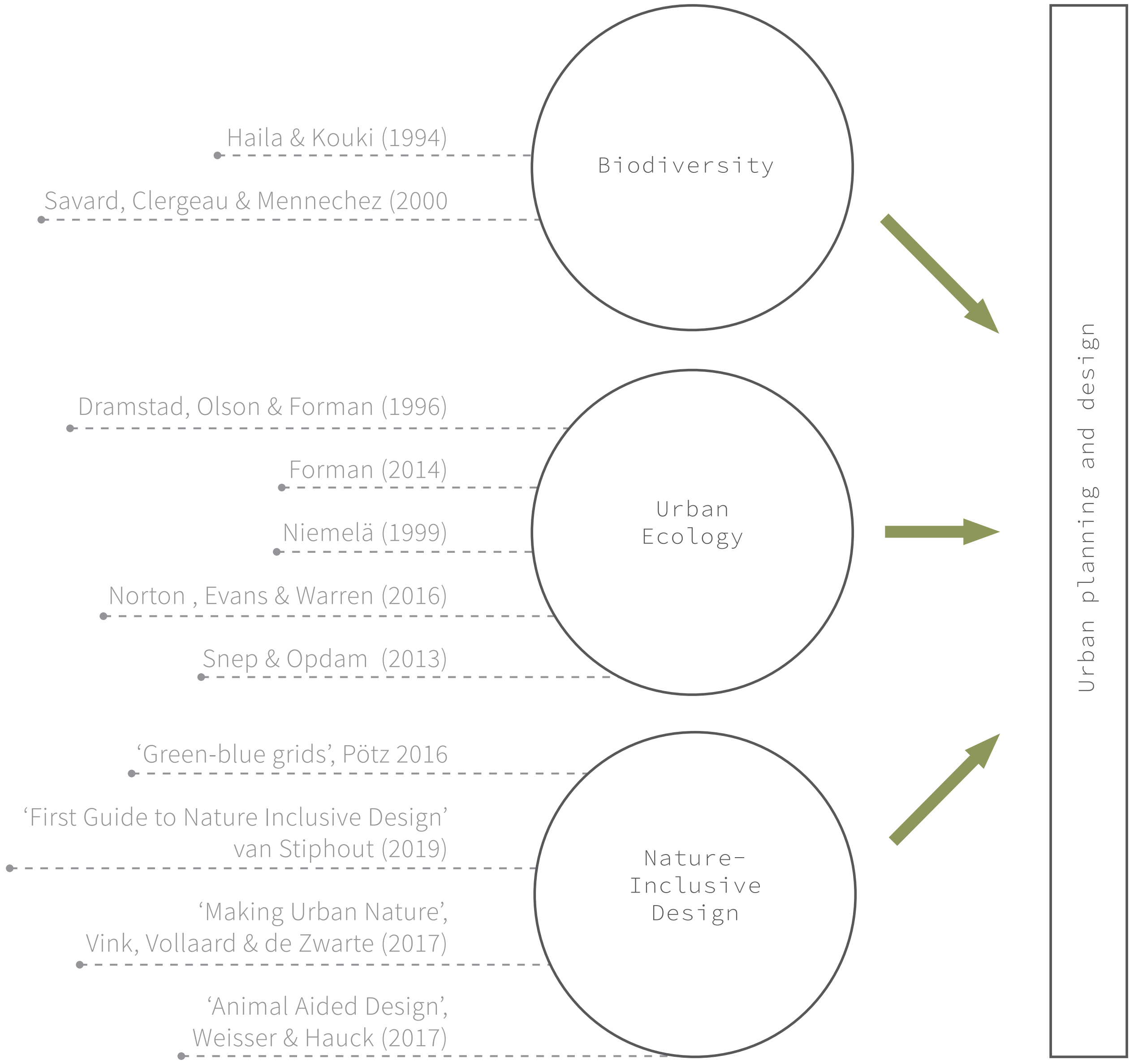


Figure 14.
Theoretical framework for ‘Mutualist Urbanism‘
By author

2.5

CONCEPTUAL FRAMEWORK

The conceptual framework shows the main research themes in this graduation project and shows the approach to this. The (design) research consists of a theoretical approach researching biodiversity, urban ecology and nature-inclusive design combining this with a case study approach, by applying knowledge to researching the Zomerhofkwartier in the context of Rotterdam.

CASE STUDY APPROACH

As mentioned before, nature-inclusive design is a pioneering practice. It is a topic that is increasingly discussed and written about, but there are limited examples (that have been realized) (Vink, Vollaard & de Zwarte, 2017). Mutualist urbanism is defined as the aim of this project. Urban planning and design are spatial practices, which means that research through a case study location can provide valuable results as it is concerned with the spatial implications. Densification serves as an interesting case in this for redefinition of the relationship between the city and urban nature, between buildings and built structures and urban nature and between people and urban nature.

The location that was chosen is the Zomerhofkwartier in Rotterdam, a central location that will be densified in the upcoming years. The location will be further introduced in chapter 3.

OUTCOME

Through (design) research using the themes of the theoretical framework in combination with the case study the following will be formulated: principles and conditions for mutualist urbanism with examples of spatial interventions in the case study area.

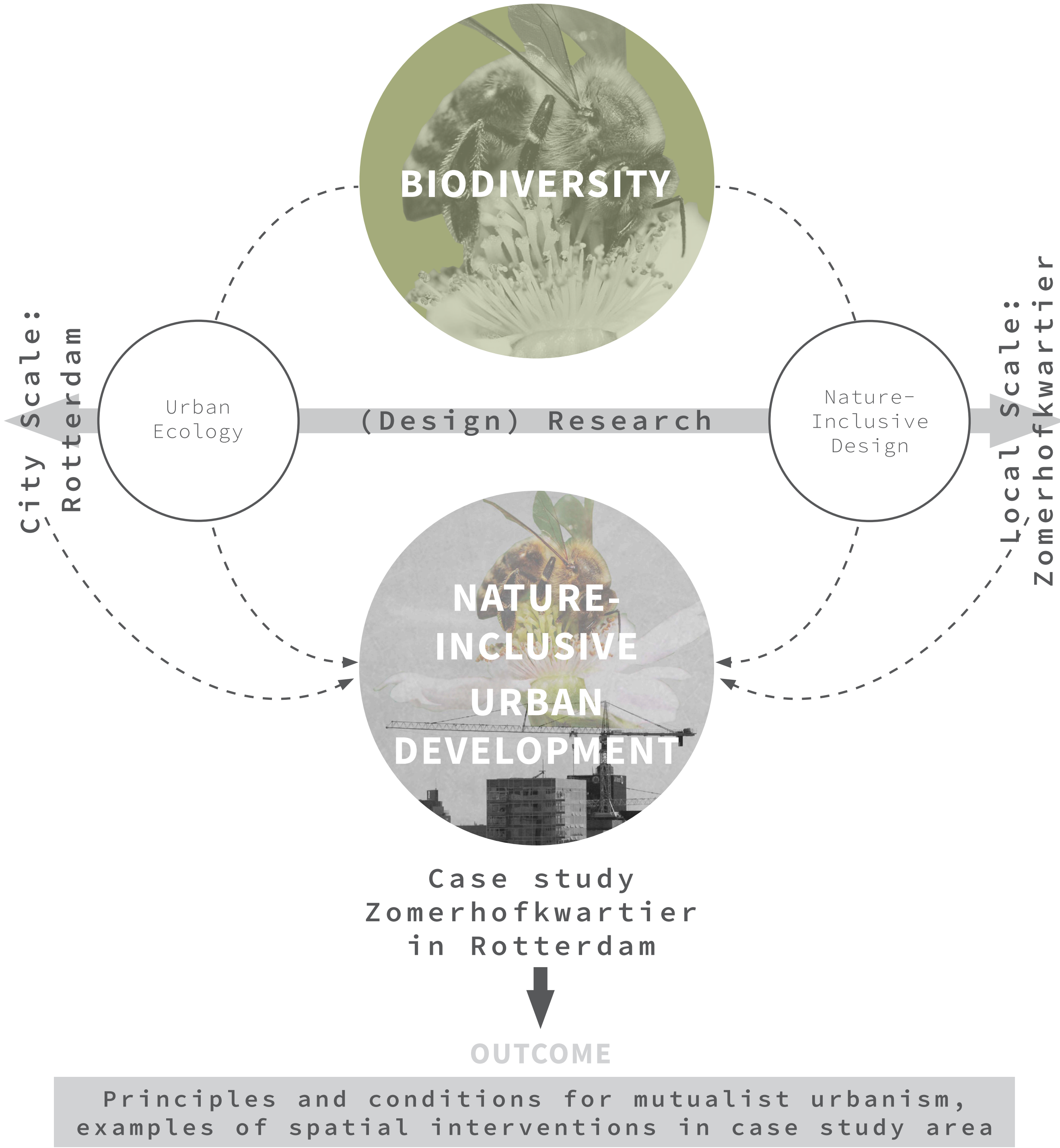


Figure 15.
Conceptual framework for 'Mutualist Urbanism'
By author

2.6
RESEARCH METHODS

To be able to answer the research questions, different methods to conduct research are used.
This part will elaborate on the chosen methods:

A. LITERATURE REVIEW
B. EVENTS AND (ONLINE) LECTURES
C. EXPERT CONSULTS
D. MEDIA STUDY
E. SPATIAL ANALYSIS
F. FIELDWORK
G. RESEARCH BY DESIGN

A. LITERATURE REVIEW

Aim:
Gaining theoretical knowledge, understanding the problems and developments input for planning and design solutions.

Process:
A very important method continuously used throughout the whole research, is literature review. Before being able to contribute anything with the research and to identify the knowledge gap, it is crucial to get an overview of research that has already been done concerning the relevant themes such as: densification, biodiversity, urban ecology, nature-inclusive design and all of these themes in relation to each other. The theoretical research is very important to formulate ecological points of view and principles needed in nature-inclusive design (see sub research questions). The theoretical research also serves as input for the research and design of the case study location.

Resources/tools:
- books
- papers
- reports
- websites

See theoretical framework.

B. EVENTS AND (ONLINE) LECTURES

Aim:

Gaining theoretical knowledge, understanding the problems and developments and using the opportunity to speak to experts.

Process:

Because of the current relevance of both densification and biodiversity of cities and themes such as urban ecology and nature-inclusive design, lectures and events around these topics have been and are being organised in and outside the faculty. Attending these lectures and events has already been very useful input and have provided contacts with several experts.

Lectures and events:

12/02/2019	Groenbouw Location: Pakhuis de Zwijger, Amsterdam
13/02/2019	Wereld zonder Insecten Location: Pakhuis de Zwijger, Amsterdam
06/05/2019	Research week 2019: 1 Million Homes Research Group Location: faculty of Architecture and the Built Environment TU Delft
22/05/2019	Natuurinclusief ontwerpen / Dag van de Biodiversiteit Location: Architectuurcentrum Amsterdam
29/05/2019	Lecture Jacques Vink, writer book Stadsnatuur maken Location: faculty of Architecture and the Built Environment TU Delft
05/09/2019	De waarde van groen Location: Pakhuis de Zwijger, Amsterdam
19/09/2019	Natuurinclusief ontwerpen in de stad Location: Het Nieuwe Instituut, Rotterdam
25/09/2019	Symposium Natuurinclusief Bouwen Location: faculty of Architecture and the Built Environment TU Delft
27/09/2019	Festival We Love Public Space Location: Zomerhofkwartier, Rotterdam
21/01/2020	Seminar 1 visiting professor Florian Boer Topic: biodiversity and radical greening Location: faculty of Architecture and the Built Environment TU Delft

Online lectures:

Many lectures and explanatory videos (related to specific events or held within universities in and outside the Netherlands) have been published on Youtube or other platforms and can therefore easily be used to learn about especially urban ecology and nature-inclusive design.

Lectures and videos:

- Robbert Snep (researcher green cities, Wageningen University): several lectures and videos related to urban ecology
- Jelle Reumer (Dutch biologist): Stadsnatuur maken and several other videos
- Charles Waldheim (Professor of Landscape Architecture at Harvard Graduate School of Design): Landscape as Urbanism
- Mohsen Mostafavi (architect, educator, Dean of the Harvard Graduate School of Design Harvard School of Design): Ecological Urbanism

C. EXPERT CONSULTS

Aim:
Gaining theoretical knowledge, understanding the problems and developments and input for planning and design solutions.

Process:
Interviewing experts in the field of nature-inclusive design and urban ecology will be another useful method to improve understanding and underpinning, and to receive input from experts from practice on spatial planning and design solutions. This has been done in both an informal setting (asking questions during lectures and events) as well as more formally with an appointment.

Experts consulted:
- Jacques Vink, architect working on nature-inclusive design and co-writer of book Making Urban Nature (appointment)
- Olaf van Velthuijsen, city ecologist municipality of Rotterdam (appointment)
- Maike van Stiphout, landscape architect, writer book First Guide to Nature Inclusive Design (consulted at different lectures and events)
- Jip Louwe Kooijmans, Vogelbescherming (consulted at different lectures and events)
- Niels de Zwarte & Rens de Boer, Bureau Stadsnatuur Rotterdam (appointment)
- Nina Ravestein, PAD Landscape, nature-inclusive consultancy and design (appointment)

D. MEDIA STUDY

Aim:
Understanding the problems and developments

Process:
Because of the current relevance of both densification and biodiversity and growing interest in themes such as urban ecology and nature-inclusive design, almost daily something is published in the media about this topic. Paying attention to the news and (subscribing to) other media platforms is crucial to understand the problems and current developments that can be built upon.

Resources/tools:
- newspapers
- websites related to the building sector (such as stadszaken.nl)
- magazines
- podcasts

E. SPATIAL ANALYSIS

Aim:

Understanding the manifestation of the main problems in the chosen case study location, finding potential for solutions and start the process of generating ideas for spatial planning and design solutions.

Process:

Spatial analysis is a key method to understand the spatial manifestation of the problems in Rotterdam and in the Zomerhofkwartier and to help coming up with ideas for planning and design solutions. This method mostly consists of mapping data.

Resources/tools:

- GIS data
- maps made by the municipality and other sources
- information and plans concerning densification/greening and biodiversity found in (municipality) documents
- historical analysis

F. FIELD WORK

Aim:

Understanding the manifestation of the main problems in the chosen case study location and to start the process of generating ideas for spatial planning and design solutions.

Process:

Fieldwork is an empirical form of research that will be used in this project to understand the spatial implications of the problem and solutions. This is done on both the scale of the city and on the scale of the Zomerhofkwartier. It consists of observations on site and documentation through photography.

H. RESEARCH BY DESIGN

Aim:

Providing a spatial, contextualized example on how to achieve nature-inclusive densification

Process:

To research the spatial implications of nature-inclusive planning and design, research by design is an important method. This will be a synthesis of all the knowledge obtained through the more theoretically related research methods and will provide context specific insights on how to achieve nature-inclusive densification. Combining the theoretical research and the research by design results in the formulation of the ecological points of view and main principles for strengthening biodiversity in urban development.

Resources/tools:

- mapping
- drawing
- 3d models: maquette and in Rhino

3.
introduction to the case study location

CHAPTER 3.
INTRODUCTION TO THE CASE STUDY LOCATION

Chapter 3 introduces the case study location. It will discuss densification plans in Rotterdam and the topic of green space and biodiversity in Rotterdam. The choice for the Zomerhofkwartier will be explained.

Figure 16.
Zomerhofkwartier
Photograph by author

3.1
DENSIFICATION IN ROTTERDAM

HOUSING DEMAND IN SOUTH HOLLAND AND ROTTERDAM

Between 2010 and 2017 80.000 houses have been built in the province of South Holland, as a part of the demand that takes up 230.000 new houses in South Holland until 2030. Furthermore, it is expected that there are an additional 60.000 houses needed between 2030 and 2040 (De Zwarte Hond, 2017). The prognosis is that between 2020 and 2040 47.500 new houses are needed in and around Rotterdam (Provincie Zuid-Holland, 2016).

DENSIFICATION IN ROTTERDAM

In the 'Stadsvisie 2030' that was published in 2007, Rotterdam decided that new housing demands should be realized within existing city boundaries (Verkenning Omgevingsvisie Rotterdam, 2018). Increasing housing in especially the center area has been a focus in this. In 1940 this area was bombed during the Second World War, almost completely erasing all buildings in the area due to resulting fires. After the war, the reconstruction was characterized by modernist principles of separation of functions. This resulted in developing housing elsewhere (Tillie et al., 2016). Since 2000 the municipality has been working on incorporating more housing in the center. The goals formulated in the 'Stadsvisie 2030' meant that the population of the center had to increase from 28.000 in 2007 to 56.000 inhabitants in 2030 (Verkenning Omgevingsvisie Rotterdam, 2018). However, in the 'Verkenning Omgevingsvisie Rotterdam the municipality (2018) recognizes that densification is not happening fast enough. Planned and potential densification locations are shown in Figure 17.

Figure 17.
Building functions and planned and potential densification locations
Data source: BGT, Verkenning Omgevingsvisie Rotterdam 2018

3.2
GREEN SPACE AND BIODIVERSITY IN ROTTERDAM

RELEVANCE OF ROTTERDAM AS A CASE STUDY FOR DENSIFICATION AND BIODIVERSITY

As densification is an urgent topic, it is interesting to see if there are plans to combine this with improving green spaces and biodiversity in Rotterdam. In some recent documents such 'Verkenning Omgevingsvisie Rotterdam' (2018) the municipality is already addressing the fact that green space in Rotterdam should be increased and improved. The 'Omgevingsvisie' mentions the need to align densification and greening, but does not yet give an answer to how. Then the newer 'Actieplan groen' mentions several ways to possibly achieve 20 hectares of extra green space mostly on and around existing buildings, but it does not mention anything about green space development in combination with densification. It does mention a subsidy for green roofs.

Figure 18. Verkenning Omgevingsvisie (2018)

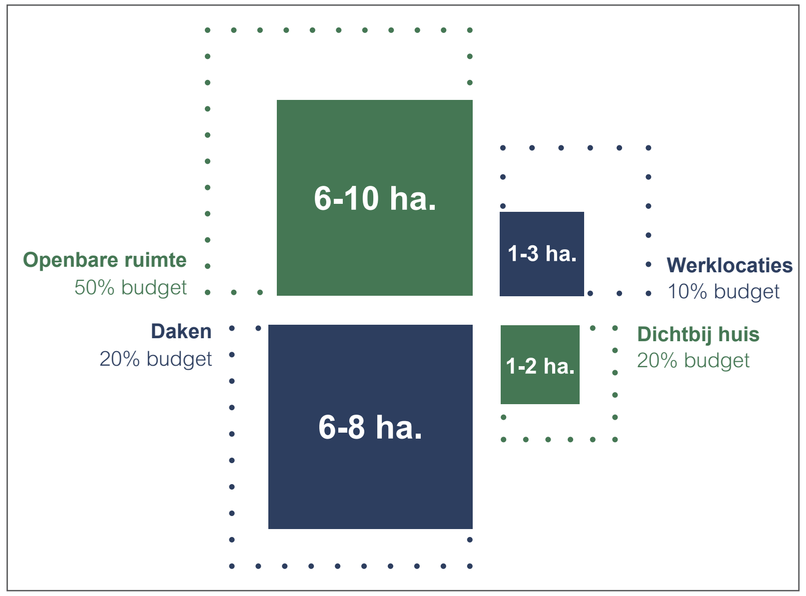


Figure 19. Rotterdam gaat voor groen: 20 hectare extra. Actieplan. (April 2019)

Several ecologists have expressed critique on how the city deals with biodiversity. The city ecologist of Rotterdam, Olaf van Velthuijsen, acknowledges that the city can improve a lot in the field of biodiversity (Resilient Rotterdam, 2018). Other ecologists are critical towards two things: nature-inclusive design and development is not obligated in Rotterdam and there is limited protection of the green network within the city and connections are limited, see Figure 20 and Figure 21.

Rotterdam: ontwikkelaars hoeven de natuur niet te faciliteren

stadsnatuur Het Rotterdamse college wil bouwbedrijven niet verplichten om rekening te houden met de natuur, de gemeenteraad vindt dat wél belangrijk

Figure 20. Newsarticle ''Rotterdam: ontwikkelaars hoeven de natuur niet te faciliteren'' (NRC, 10 October 2019)

Die vleermuisaantallen worden gebruikt om te kijken of er in de buurt voldoende alternatieven zijn voor de dieren. Is het niet makkelijker als de bouwer zorgt dat er in het nieuwe of gerenoveerde gebouw weer voldoende plek is voor vleermuizen? „Ja, we proberen dat zogeheten natuurinclusief bouwen ook te promoten", zegt De Zwarte. „Op andere plekken is dat al verplicht, maar in Rotterdam lopen we heel erg achter." In 2017 heeft de gemeenteraad een motie aangenomen over natuurvriendelijk bouwen, maar die is nog niet uitgevoerd, zegt hij. „Misschien dit najaar?"

De egeltjestest

Het is nog erger, zegt De Zwarte. „Rotterdam heeft in wezen geen natuurbeleid. Er is geen bescherming en onderlinge verbinding van de groene structuur van de stad." Neem het Kralingse Bos, waar vroeger de rode eekhoorn leefde, zegt hij. „Dat bos is volkomen geïsoleerd geraakt, die eekhoorns konden nergens heen. Als er een aaneengesloten bomenlaan over de Oudlaan naar De Esch was geweest, dan waren ze misschien behouden".

Figure 21. Newsarticle ''Niet de dieren en planten, maar de stadsecologen zélf in beeld'' (NRC, 12 September 2019)

DENSIFICATION LOCATIONS IN RELATION TO BIODIVERSITY OF ROTTERDAM

The 'Natuurkaart Rotterdam' (2014) is a document that shows Rotterdam's main ecological areas and connections, thus areas of high importance to Rotterdam's biodiversity. A map showing these areas can be found on the next pages.

3.3
ECOLOGICAL CORE AREAS AND CONNECTIONS IN ROTTERDAM

Figure 22 shows the ecological core areas and connections in Rotterdam. Rotterdam is intertwined with the Deltariver system of the Maas. Each category on the map shows different types of available nature or areas that could provide ecological opportunities, such as linear elements, ribbons, in the landscape such as

Figure 22.
Data source: Natuurkaart
Gemeente Rotterdam (2014)
Edited by author

3.4

LOCATION CHOICE

Densification locations that lie close to the ecological core areas and connections can provide interesting cases for studying the possibilities for strengthening biodiversity while densifying this area. The Zomerhofkwartier, shown in the circle in Figure 23, is such a location.

Figure 23.
Densification locations in relation to core ecological areas and main ecological connections.
Data source: Natuurkaart Gemeente Rotterdam (2014), Verkenning Omgevinsvisie (2018)

GREEN SPACES AND HIGHLY PAVED AREAS

As shown in Figure 24 the Zomerhofkwartier is also an area that is marked as a highly paved area that lacks green space, which means that it can improve in biodiversity and in ecosystem services provided for people.

Figure 24. Areas categorized as ‘highly paved, lacking green space’
Data source: Kaart van de Stad (2016)

3.5
DENSIFICATION ASSIGNMENT ZOMERHOFKWARTIER

ZOMERHOFKWARTIER
The Zomerhofkwartier itself is a central location in the city, close to the central station. The area was almost completely bombed in the Second World War. After the war it was developed into an office area, but eventually it slowly deteriorated. In 2005 there were plans for redevelopment, but these were paused due to economic crisis in 2012. What followed were years of bottom-up urbanism initiatives within the Zomerhofkwartier and its surroundings. (ZOHOcitizens, 2017).

FUTURE PLANS
The future plans for the area are to develop it into a mixed urban area that forms a connection between Rotterdam Noord and Rotterdam Center.
The program consists of:
• Residential program: around 54.000 m2 (500-600 houses)
• Commercial and other program: around 13.000 m2
The current users of the area came up with themes that should receive attention, including sustainability, experiment and innovation and attention to ecology and biodiversity (Aanbestedingsnieuws.nl, 2018).

Figure 25.
Zomerhofkwartier
Source: Google Maps (2019)

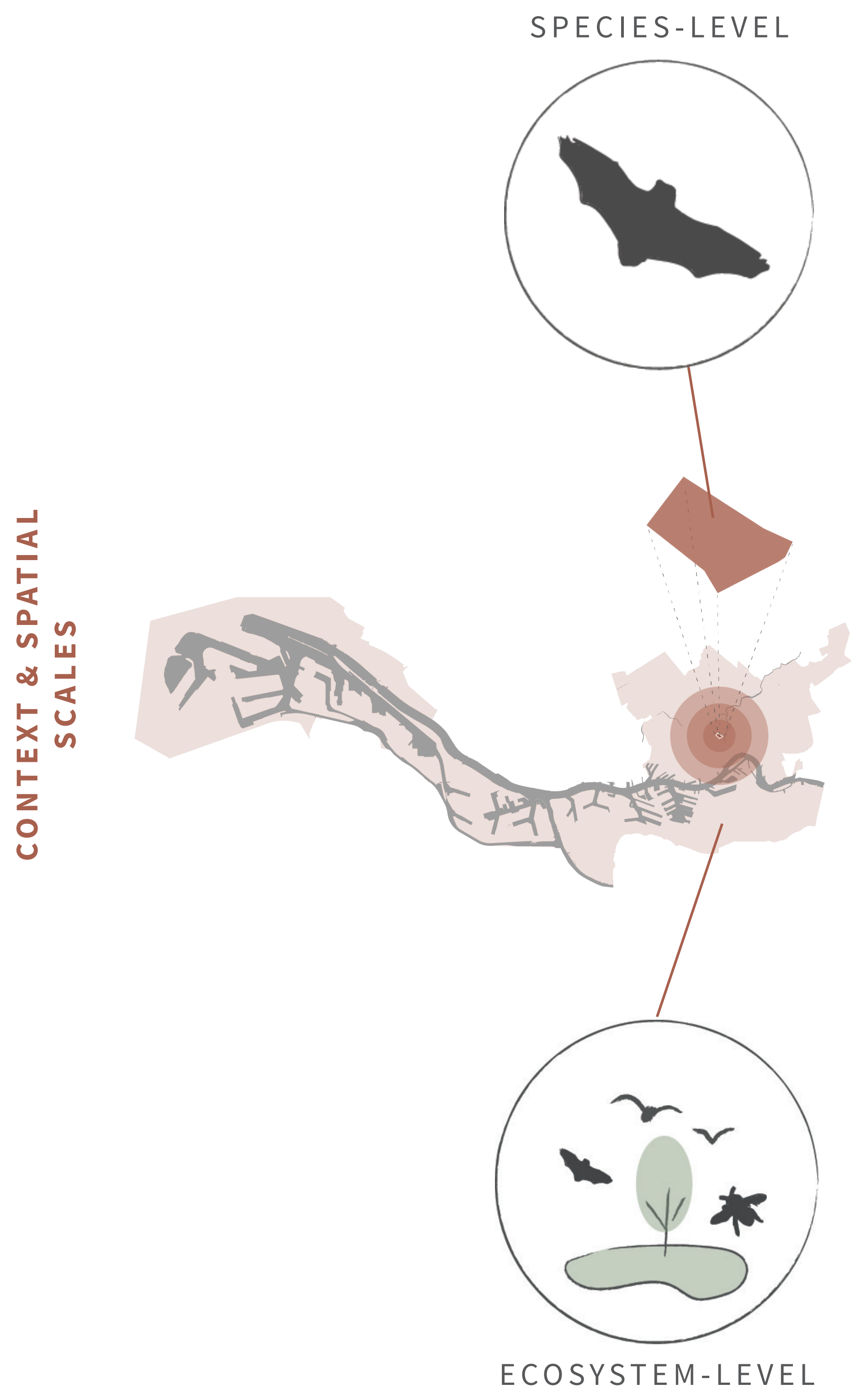
3.6

STRENGTHENING BIODIVERSITY IN THE ZOMERHOFKWARTIER

As explained in the main research question strengthening biodiversity is the topic of this research. The case study of the Zomerhofkwartier provides an opportunity to investigate spatial implications that relate to this. In chapter 1 strengthening biodiversity was defined as ‘‘preserving local biodiversity and, within the local ecosystem, providing conditions for survival (food, movement and shelter/nesting places) for different local species’’. This links to the multi-scalar approach that was also discussed in chapter 1. When talking about biodiversity, what happens at one spatial scale is interdependent with what happens at another spatial scale.

As a consequence before being able to propose interventions for strengthening biodiversity in the Zomerhofkwartier it is necessary to:
• understand the local ecosystem of Rotterdam
• understand the current role of the Zomerhofkwartier within the local ecosystem
• from there formulate the ecological potential of the Zomerhofkwartier targeted at local species, in relation to the densification assignment

This chapter already provided starting points for this, by for example providing insight into the proximity of the Zomerhofkwartier to the ecological core areas and connections and by showing that the area lacks green space. However, there is more knowledge needed from the research themes of biodiversity, urban ecology and nature-inclusive design to know **how** to understand the ecosystem in a city and its species and how this relates to urban planning and design. The next chapters will go more into depth in this.



4. translating ecological knowledge to urban planning and design

CHAPTER 4.
TRANSLATING ECOLOGICAL KNOWLEDGE TO URBAN PLANNING AND DESIGN

To be able to achieve nature-inclusive development, it becomes essential for professionals involved in the process of urban development to gain an understanding of some concepts, theories and spatial models related to biodiversity, urban ecology and nature-inclusive design. It also becomes essential to understand how this ecological knowledge can be applied to the planning and design process. This chapter describes this theoretical knowledge and uses the case study to provide insight how this translates to the scale of the city and to the scale of a densification development.

How findings can be translated to the process of urban planning and design is concluded throughout the chapter, resulting in methods for analysis and design and design principles for mutualist urbanism.

Figure 26.
A nature-inclusive process of urban planning and design?
Photograph by author and edited by author

4.1
SPATIAL MODELS TO UNDERSTAND THE URBAN ECOSYSTEM

For this research the biodiversity within the city, also referred to as intra-urban biodiversity (Beninde, Veith & Hochkirch, 2015), is of relevance. A way to study intra-urban biodiversity is by researching the relationship between biodiversity patterns and the spatial variation in a city (Norton, Evans & Warren, 2016). This is also directly relevant to urban planning and design. Studying spatial variation in and around a development area is needed to formulate planning and design interventions that answer for example social and environmental challenges. Studying biodiversity in relation to spatial variation can help an urbanist in understanding how current and future spatial variation will affect biodiversity and how that can merge with solving other planning and design challenges. Spatial models can be helpful in this as they provide a conceptualization for easy understanding and application (Forman, 2014).

PATCH-CORRIDOR-MATRIX MODEL

In urban ecological studies the patch-corridor-matrix model (or land mosaic model) introduced in 1995 by Richard Forman, professor in Landscape Ecology, is often used to understand the ecological functioning of landscapes in relation to spatial elements. The city can be considered as a specific type of landscape.

A patch or habitat patch is a specific area, relatively distinct from its surroundings, that provides habitat for a species or for a collection of species (Forman, 2014). Often this means that a patch consists of vegetation. The patch can be ''as large as a national forest, or as small as a single tree'' (Dramstad, Olson & Forman, 1996, p. 19). As highlighted when discussing pressures on biodiversity in cities in chapter 1, green spaces and elements (thus vegetated patches) in cities often are fragmentated. This can lead to loss and isolation of habitat (Dramstad, Olson & Forman, 1996) and thus may decrease the number of conditions for survival provided for certain species.

Corridors are linear elements in the landscape that actually counteract fragmentation and instead provide connectivity between different patches (Dramstad, Olson & Forman, 1996). Examples of corridors are aquatic corridors such as rivers and streams, terrestrial corridors such as vegetated areas (also called greenways) and aerial corridors provided through tree canopy (Savard, Clergeau & Mennechez, 2000; Martin, n.d.). Corridors are present as linear elements or can be formed through a collection of small patches that form a line through the landscape, which are referred to as stepping stones (Vink, Vollaard & de Zwarte, 2017). The aerial corridor is an example of this. Apart from connectivity between habitat patches, corridors can also provide additional habitat area, such as those stepping stones or a vegetated corridor (Savard, Clergeau & Mennechez, 2000). If a corridor actually provides connection depends upon the species that is considered. What may act as a corridor for one species, may be a barrier or filter to other species' movement (Dramstad, Olson & Forman, 1996). Aquatic corridors are a good example of this.

The matrix is considered as 'the background' and most dominant component of the landscape, thus most influential in the functioning of a landscape (de Vries et al, 2017). Figure 27 illustrates the patch-corridor-matrix model.

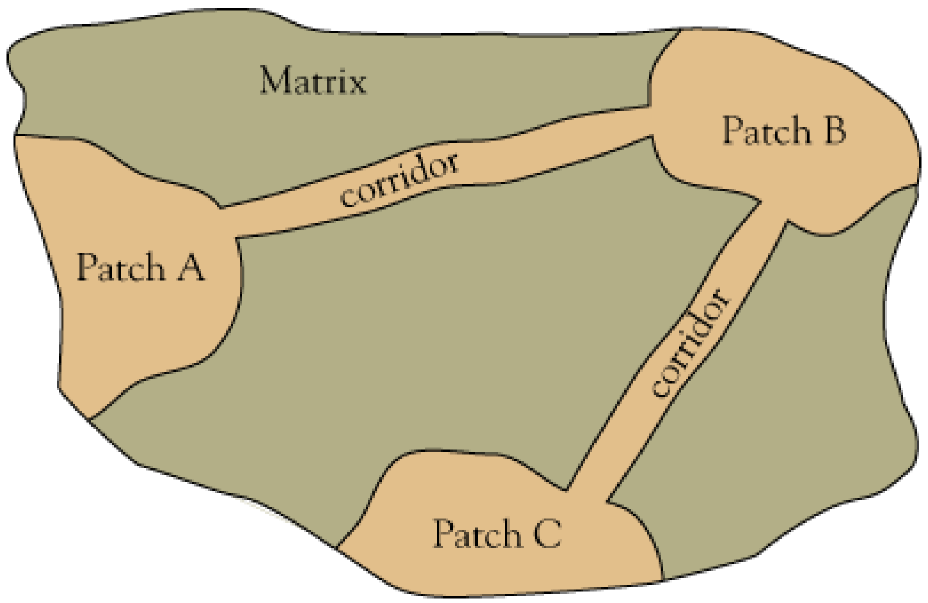


Figure 27.
Patch-corridor-matrix-model
Source: Barnes (2001)

To understand the ecology of cities, the patch-corridor-matrix model as illustrated above is often reflected on the spatial scale of a whole city. The ecological core areas and connections map of Rotterdam, see Figure 28, essentially illustrated the patches and corridors in Rotterdam. The areas in grey then represent the matrix.

Figure 28.
Data source:
Natuurkaart
Gemeente
Rotterdam (2014)
Edited by author

In many ecological studies the matrix is considered to be inhospitable, but for cities this conception is too simple (Norton, Evans & Warren, 2016). Following the example of a line of trees forming an aerial corridor through tree canopy and a single tree that can function as a habitat patch, it becomes clear that when zooming in, habitable patches and corridors can be found on smaller scales. The patch-corridor-matrix model on a city scale does explain the main ecological network of a city, but further understanding the urban matrix becomes highly relevant when researching possibilities to strengthen biodiversity at the spatial level of a densification development. This goes further than zooming in to patches and corridors at smaller scales and consider them by themselves. Instead, it is necessary to investigate how patches, corridors and the matrix work together as a so-called 'mosaic'

LAND MOSAIC CONCEPT

'The land mosaic concept' is described in the book 'Landscape Ecology Principles in Landscape Architecture and Land-Use Planning' by Dramstad, Olson, Forman et al (1996) and the book 'Urban Ecology' by Forman (2014). At several different scales landscapes can be seen as mosaics: ''composed of relatively distinct objects with boundaries'' (Forman, 2014, p. 32). In cities these 'urban mosaics' have been created through the spatial interaction of natural processes and human interactions. Each mosaic has unique characteristics that result in specific available habitats and land use for that mosaic (Forman, 2014).

To understand an urban mosaic three characteristics can be recognized:

1 Structure

The structure of a mosaic (in urban ecology also referred to as pattern) is its spatial pattern, which means the spatial configuration of landscape elements (Forman, 2014). Landscape elements can be natural, such as a tree or a plant, or anthropogenic, such as a building or a road. Natural elements can grow spontaneously or can be purposely planted by people. Natural landscape elements such as street trees and other vegetation can make up patches and corridors that can provide conditions for survival for different species. Anthropogenic landscape elements can form barriers or obstacles, but they are also capable of providing ecological opportunities. An example is buildings with cracks and holes in facades that provide nesting opportunities to specific bats and birds (van Stiphout, 2019).

2 Function or functioning

The function or functioning of a mosaic (in urban ecology also referred to as process) describes the flows and movements of wind, water, animals, people and transport in a mosaic (Forman, 2014). These flows and movements link the elements of the mosaic together. With strong interactions between elements, a mosaic is considered to be tightly interwoven with land uses and habitats that are strongly interconnected. This makes for an actively functioning mosaic and probably provides stability for functioning in the future (Forman, 2014)

3 Change

Change (in urban ecology also referred to as dynamics) describes ''the alterations in structural pattern (and functioning over time, as in a changing mosaic'' (Forman, 2014, p. 44). In the case of urban development, analysing the change of a mosaic can provide insights into understanding the functioning of the mosaic as it is today. It can also give an insight into the possibilites of what elements in the mosaic are (not) likely to change in the future.

MAPPING THE URBAN MOSAIC

The structure, thus spatial pattern, of the urban mosaic can be mapped. This is similar to mapping that an urbanist would do. For example, buildings, green spaces and infrastructure are components that can be mapped to understand the spatial pattern of a city on different scales. From here, an urbanist can also understand how this structure provides opportunities for the movement of people, thus functioning of the urban mosaic. For a mutualist urbanist however, it becomes important to consider how animals move through the structure of an urban mosaic and how they interact with it. Through this mapping, it can be identified where strong interactions within the mosaic can be found that should be preserved and where weak interactions occur that can be improved. From here landscape elements can be proposed that accommodate a strongly interwoven mosaic.

The urban mosaic of the case study location will be mapped in chapter 5, but first additional information is needed about animals in cities to be able to relate the urban mosaic to the local ecosystem.

4.2
UNDERSTANDING ANIMALS IN URBAN ENVIRONMENTS

If landscape elements facilitate a strong interwoven mosaic is completely dependent on the type of animal that is considered. The functioning of larger corridors and patches is more easily understood, but when zooming in to finer scales ‘‘highly complex spatial patterns of grey and green spaces’’ (Norton, Evans & Warren, 2016, p. 182) can be observed. Not all species have the same capacities and mobility to connect patches that are disconnected by impervious surfaces. Furthermore, suitability or quality of a habitat can differ greatly for different species at finer scales (Nortan, Evans & Warren, 2016). Radius of action and habitat quality will be discussed here as two themes that provide a basic understanding of the relationship between urban landscape elements and animals, to translate this to the case study location.

RADIUS OF ACTION

Radius of action in this case refers to the possible, performed or limited movement of animals in a city. Forman (2014) describes four types of movement: territory, home range, animal dispersal and migration. Territory refers to movement related to the protection of the nest. Home range refers to the daily movements made by a species from their nest to for example in search for food (foraging). Animal dispersal refers to the movement of animals that leave their home range to mate and develop a new home range, from a different nest for example. Migration refers to animals moving due to for example winter. All of these or some of these movement types establish the radius of action for different species relevant to a particular landscape element or location. In combination with either possibility or impossibility for specific movement (the ability to fly for example), this is one of the factors that determines the presence of species in specific areas.

Some examples that provide insight into the radius of action of some species are shown on the right:
- many wild bees can only fly a limited distance to minimize energy loss, resulting in the need to place nesting opportunities and food not more than 200 m apart
- a house sparrow does not move more than 1 km away from the place of its birth
- a hedgehog can move up to 1 km at night for foraging, if obstacles do not limit them on the way
- a common pipistrelle (a type of bat) alternates between places of shelter often, but once settled it only forages in a radius of 2 to 6 km

In the case of analysing the potential for strengthening biodiversity in urban development, it is necessary to consider radius of action in two directions:
1 as seen from the city to the urban development area
2 as seen from the urban development area to the city

This links to the concept of hierarchy of scales described in chapter 1, theat highlighted the necessity to considers effects of an action at different scales (the interdependency of scales) by using a multi-scalar approach (Allen& Star, as cited in Savard, Clergeau & Mennechez, 2000). Taking the example of the common pipistrelle in relation to the Zomerhofkwartier: if suitable foraging areas are found in a radius of 2 to 6 kilometers from the Zomerhofkwartier, it might be an option to facilitate places for shelter in the Zomerhofkwartier. Reasoning in the other direction, these places for shelter will only work once functionally connected to foraging areas within those 2 to 6 kilometers.

Projecting the examples of radius of action on the map of het Zomerhofkwartier (see Figure 30 on page 84), this gives an idea what to keep in mind when considering the interdependency of scales.

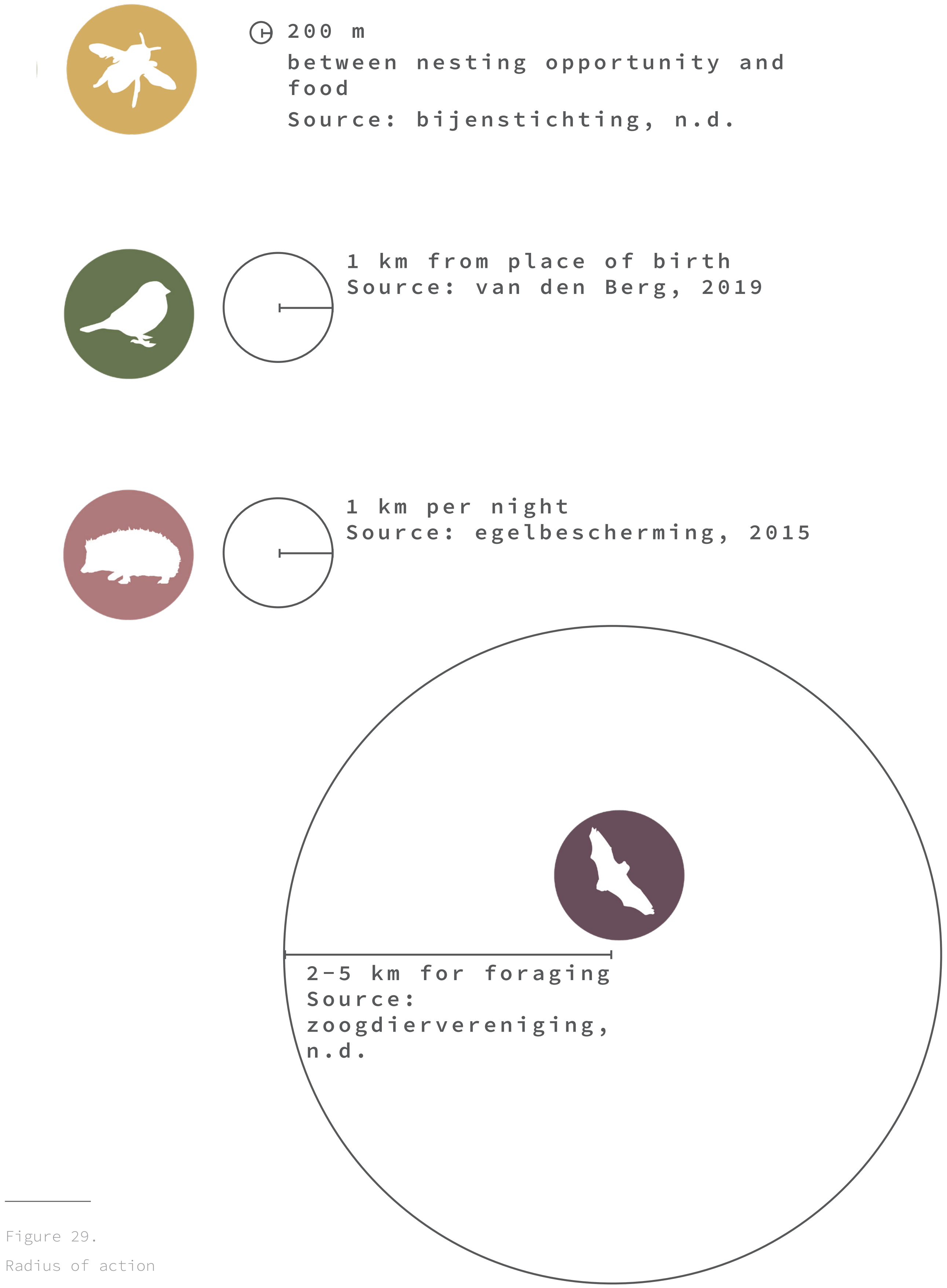


Figure 29.
Radius of action
Figure by author

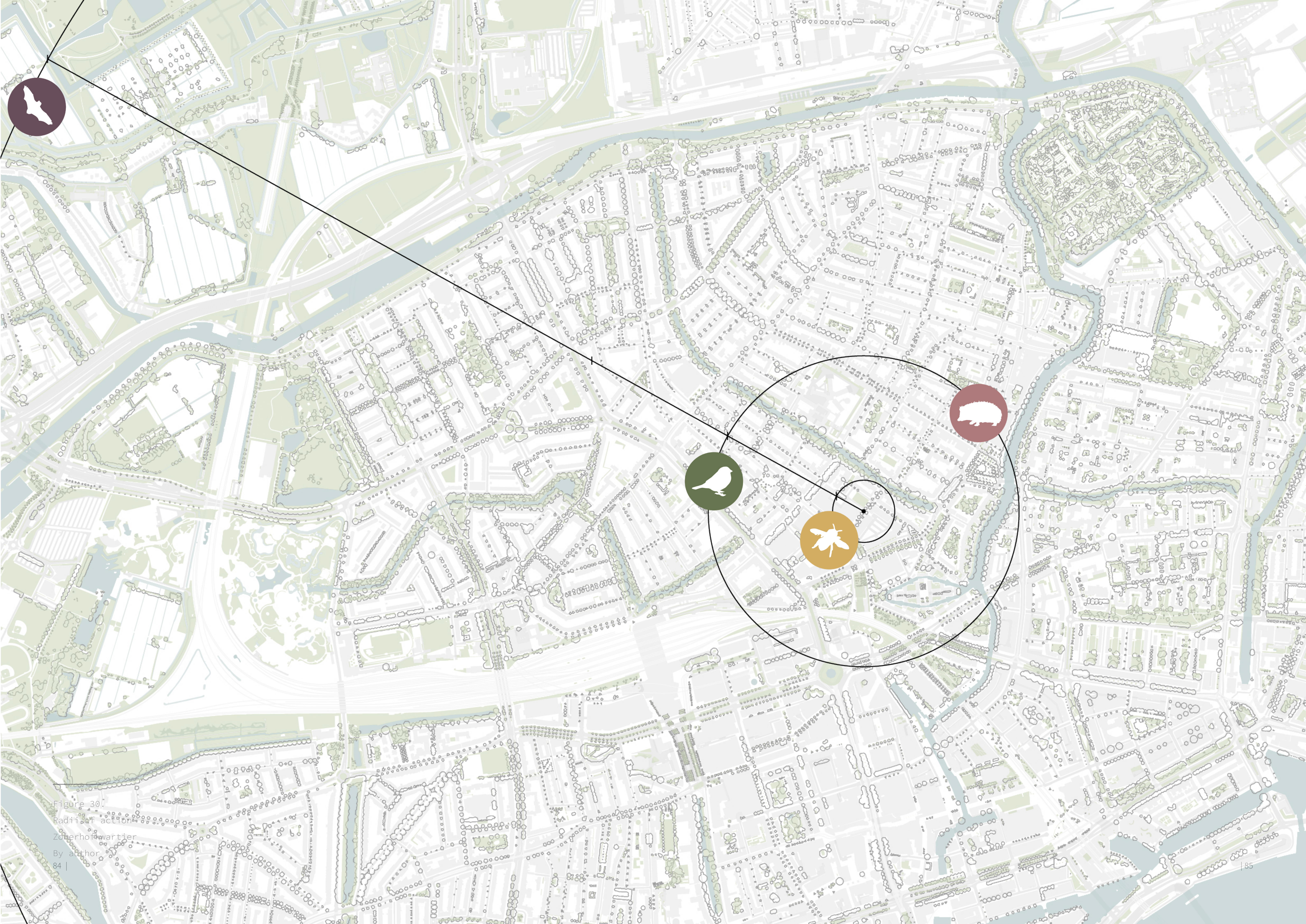


Figure 30.
Radii of action
Zomerhofkwartier
By author

RADIUS OF ACTION - IN 3D

Acknowledging the radius of action of different species is important, but it is even more important in a city to consider the radius of action of species **in 3d.** People built mostly horizontal and vertical structures, and themselves are able to use them in horizontal and vertical movement patterns. Many animals however, such as birds and insects, do not use these horizontal and vertical movement patterns, but instead fly through space obliquely (Forman, 2014).

A direct result of considering species' radius of action in planning and design is by providing connectivity. First of all, connectivity to city scale corridors and connectivity within an area through corridors or stepping stones has shown to be important. The oblique movement patterns of certain species show that connectivity in 3d has a potential, connecting different levels and layers in the urban landscape, see Figure 31.

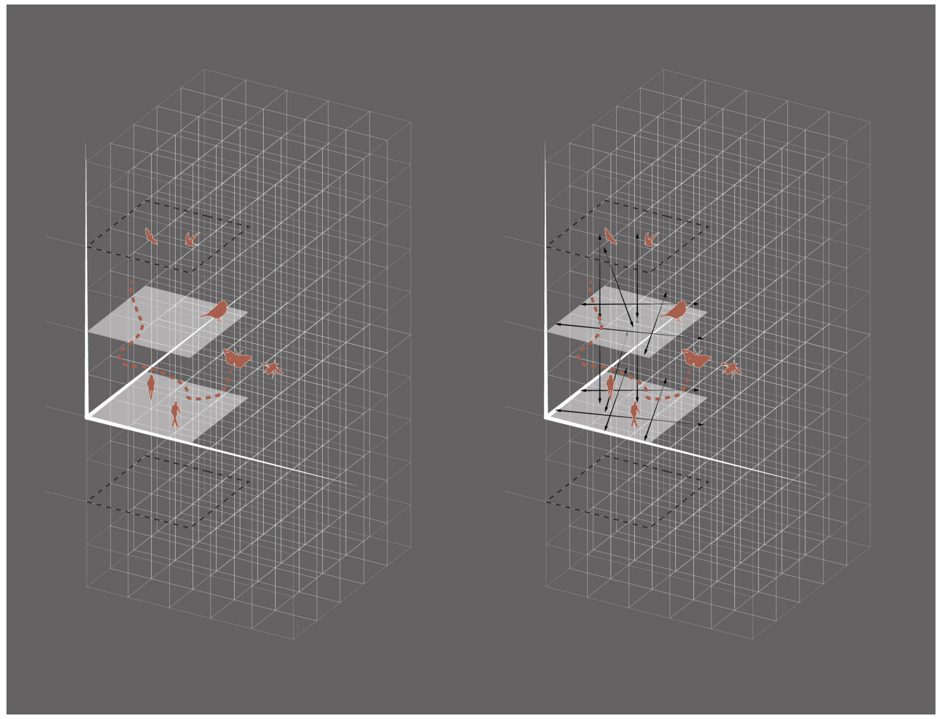


Figure 31.
Connectivity in 3d
By author

Connectivity in 3d means using buildings and other structures that have height, as opportunities for providing conditions for biodiversity. These landscape elements that often form obstacles have the potential to be incorporated in the ecological network of a city as stepping stones. In the case of buildings this can be done by realizing green facades and roofs. Green roofs and facades can succesfully be connected to the ecological network of the city when they are accessible for animals and provide food and/or shelter and nesting opportunities for animals (de Boer, 2019). In the same way especially green roofs can also be an addition to the green spaces and network used by people in cities (de Boer, 2019), once people can access these roofs and can use them, for example as places for recreation or for urban farming.

The less mobile species are, the more difficult it becomes to access green roofs. Insects are an example of less mobile species. Research has shown that bees, butterflies and dragonflies can reach roofs that are at heights of 30 meters (de Boer, 2019). Furthermore, a connection between the ground floor and the roof itself through a green facade and a three dimensional network of green roofs surrounding the green roof will provide accessibilty for more species (de Boer, 2019).

Other research has shown that plant species richness and substrate depth on green roofs are determining factors for the variety of insects on the roof (Drukker, 2019). These factors are especially important when green roofs are constructed above 30 meters. As insects are a source of food for many other animals (Wageningen University & Research, 2017), insect richness on a roof can attract other animals such as birds and bats.

HABITAT QUALITY

The structure of the urban mosaic on a city scale determines the permeability of the surrounding landscape for species movement, but local features of on a finer scale determine the habitat suitabilty or quality for species (Beninde, Veith & Hochkirch, 2015). This was already shown in the discussion of green roofs that highlighted plant species richness and substrate depth as important factors for the diversity of insects on green roofs. These factors are local features that determine the habitat quality and thus if they provide conditions for survival for certain species (Beninde, Veith & Hochkirch, 2015).

Habitat quality can be directly linked urban landscape elements, which means that it can provide starting points for planning and design for the urbanist. Some general starting points will be discussed here.

Vegetation

It has already been mentioned that vegetation provides food, enables movement and facilitates nesting or shelter to many different species. For example, nectar (and pollen in the case of bees) from plants provide food for bees and butterflies and fruits and seeds from plants provide food for birds (Vink, Vollaard & de Zwarte, 2017). Diversity in plants will provide diversity in food and nesting and shelter for different species. Native trees and plants are especially important in this, as local species will recognize these trees and plants and eat them (Vink, Vollaard & de Zwarte, 2017). Native species therefore are important in planning and design, but they can be complemented by exotic species that are known to have positive effects on species, for example through nectar or fruits (Tillie, personal communication, March 24, 2020).

Vegetation can be categorized as trees, shrubs, herbs and mosses (Vink, Vollaard & de Zwarte, 2017) and each category forms a vegetation layer in height named from highest (trees) to lowest growing (moss). When these vegetation layers are incorporated in design from low to high, they provide more opportunities for species richness (Mouwen, Vink & Vollaard, 2013).

(Artificial) opportunities for nesting and shelter

The way in which species breed and their preferences for nesting ad shelter are species-specific. However, some generalisations can be formulated.

First of all, a variety of **vegetation layers** in cities will provide a variety of nesting opportunities for small mammals, insects and birds (Gemeente Amsterdam, 2018). Some insects nest or find shelter in soil ('bodemnestelaars') (EIS Kenniscentrum Insecten, n.d.), in plant debris (such as fallen leaves), in dead wood and in artificial insect hotels (Vink, Vollaard & de Zwarte, 2017).

Second, it has been mentioned before that cracks and holes in facades and roofs are used by some urban species to nest in. These are **cavity-nesting species**. In Dutch cities different types of bats and birds are cavity-nesters (Vogelbescherming, n.d.). They will nest in cavities they find in buildings, trees and other tall structures or they can nest in artificial nesting boxes (Vink, Vollaard & de Zwarte, 2017). These nesting boxes can be placed in gardens (the well-known bird houses), hung on facades or can be integrated within the design of facades. Integration within facades is most future-proof. It will lead to permanent (as long as the building is there) nesting opportunities and certain microclimatic conditions can be met that cannot be met with external nesting boxes (Korsten & Limpens, 2011).

Some species use multiple nesting and shelter places (also called roosts), such as common pipistrelles (bats). In general, during the day a common pipistrelle needs a roost as a shelter and as a place to sleep in. Throughout the year the roosts should provide additional functions: bats need a matingroost, a maternity roost, a roost for summer stay and a roost for winter stay. The common pipistrelle will therefore move between different roosts that provide the right microclimatic conditions for the desired function (Korsten & Limpens, 2011; Vink, Vollaard & de Zwarte, 2017; Zoogdiervereniging, 2020). This shows that it is important to consider multiple opportunities for nesting and shelter and specifically aimed at certain species.

Lastly, some cavity-nesting species that use buildings breed in colonies, such as house sparrows and common swifts. This means that for breeding success, they will also need multiple nesting opportunities close together (Gemeente Amsterdam, 2018). Proximity to other conditions for survival such as food is also an important precondition for the succesful use of many nesting opportunities.

Microclimate

Abiotic factors such as wind, sunlight, temperature and the presence of water are all important non-living factors that affect plants and animals (Vink, Vollaard & de Zwarte). These factors also interact with urban landscape elements such as buildings: a south facade is warmed up by the sun or the building itself creates shade from the sun. This can be reffered to as a microclimate (Pötz, 2016). Because each plant and each animal has particular requirements, generally speaking a diversity of microclimates will be beneficial for species richness. Planning and design should take into account different microclimates and even create or use them to provide specific conditions. An example is shown in appendix 3 by the preferred facade for nesting for different species.

Life-cycle of species

Different species have different requirements throughout their life that have to be provided in a habitat (Weisser & Hauck, 2017). A butterfly is a good example. The butterfly itself needs nectar for survival, but in the caterpillar stage it has different requirements. The main food source for caterpillars are plants, often these plants are specific so-called hostplants. This hostplant is also used by butterflies to deposit eggs on (Vink, Vollaard & de Zwarte, 2017). Furthermore, different butterfly species hibernate in different forms, some hibernate as a caterpillar, some as a pupa or some as a butterfly. The caterpillars and pupas need vegetation for this and wintering butterflies need splits in walls, insecthotels or dead wood (Vlinderstichting, n.d.). These requirements have to be available in the right time (winter) or throughout the year (nectar plants) to ensure survival.

For many species food and shelter all your round is a precondition for survival, which mainly relates to the type of plants available in an area (Mouwen, Vink & Vollaard, 2017).

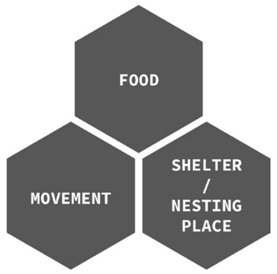
ORGANISM-BASED APPROACH THROUGH TARGET SPECIES

It becomes clear that generalisations can be formulated with regard to needed connectivity within the urban mosaic and factors that are likely to positively influence habitat quality. In planning and design an organism-focused approach is often used to be able to propose real spatial interventions (Savard, Clergeau & Mennechez, 2000; Norton, Evans & Warren, 2016). 'Target species' are chosen for an urban development area, just as target groups of people will be chosen. These target species are 'representive focal species' that provide an essential ecological function . It is assumed that with this approach other organisms will also benefit from the interventions targeted at those species (Norton, Evans & Warren, 2016). These target species can be found through analysis of the urban mosaic.

INTEGRATING WITH LANDSCAPE ELEMENTS FOR PEOPLE

An interwoven mosaic can be facilitated by landscape elements with strong interactions. In urban development these landscape elements will mainly be chosen for their functions in the 'human habitat' and it is therefore important to seek intergrations with these landscape elements and their functions. A good example is a building, which can provide a home for people but can also be designed in such as that it also provides nesting opportunity for animals. This can enhance the experience of nature
Another example is a street tree. This tree can bring many benefits to people through for example its aesthetic, by cleaning the air and providing shade. At the same time this particular street tree might not benefit the ecosystem as much. Instead a type of tree can be chosen that brings the same benefits to people, or even more benefits such as growing fruits, and at the same time greatly benefit biodiversity by providing food for different species. These examples show that landscape elements can be chosen, configurated and designed in such a way that enables mutualist environments. These landscape elements can vary from big to small: facades, roofs, balconies, trees, a paving-stone and so on. Together they can form environments such as streets, parks, buildings and so on.

4.3
NATURE-INCLUSIVE PLANNING AND DESIGN PRINCIPLES



Underpinned by theory and inspired by exemplary works about nature-inclusive design (Vink, Vollaard & de Zwarte, 2017; Weisser & Hauck, 2017; van Stiphout, 2019) the following main principles have been composed. These planning and design principles can be used to translate the knowledge about urban species as described before (radius of action and habitat quality) to spatial interventions. These principles can be applied to landscape elements, such as buildings, facades, street pavings etc. This will then lead to providing conditions for survival. Chapter 6 will show the use of these principles in the Zomerhofkwartier.

USE

Refers to integrating conditions for animals and humans in landscape elements. Succesful nature-inclusive design in the city enriches urban functions instead of frustrating them (Vink, Vollaard & de Zwarte, 2017). Nature-inclusive design interventions have to be proposed within urban development, so design decisions should be integrated with the design challenges for people. Places where people and other species meet can be designed, as well as seperated areas if necessary due to unwanted disturbance. Lighting, paving materials and maintenance can be included in the design (Vink, Vollaard & de Zwarte, 2017; van Stiphout, 2019).

(3D) CONNECTIVITY

Refers to providing connectivity between the conditions for survival, horizontally and vertically. Connectivity between all conditions needed for survival (food, movement, shelter/ nesting place) on different scales and in all direcions is the key to success.

POROSITY

Refers to providing open spaces between and in landscape elements to enable movement for animals, nesting for animals and a grow site for plants. Enabling a grow site for plants (whether plants will be planted or conditions for spontaneous growth are provided) is a starting point for nature-inclusive planning and design. Holes and cracks in facades and roofs provide nesting conditions for certain birds, bats, butterflies, bees and other insects (van Stiphout, 2019). Porous surfaces in streets, public spaces and on vegetated roofs have the same effect and also enable water to enter the soil.

TIME

Refers to the consideration of time, through day and night, through the seasons and through the life cycle of species. Succesful integration of species requirements' involve considering the entire lige cycle of species from birth to adult, including breeding requirements and providing food all your round for example (Weisser & Hauck, 2017).

MICROCLIMATE

Refers to configuration and orientation of landscape elements which can create optimal microclimates. Cities already provide a high diversity of microclimates and gradients. When designing, considering the potential to provide additional conditions for species in existing or newly made microclimates is important. Sun, shadow, wind and (rain)water are examples of factors that can be thought about in design.

5.
the urban mosaic

CHAPTER 5.
THE URBAN MOSAIC

This chapter is an exploration of the ecological potential of het Zomerhofkwartier, alongside the densification assignment of the area. This is done by analysing the urban mosaic, providing an insight to the structure and functioning of the Zomerhofkwartier and its direct surroundings and in relation to (the ecological network of) Rotterdam. Historical maps are the starting point for this as they provide a systematic approach to understanding the build up of the urban mosaic as it is today. This is combined with information and maps from the 'Natuurkaart Rotterdam'. Through combining this information an understanding can be provided of the relationship between the urban mosaic and species present. This results in a selection of target species (animals) and target groups (people) are discussed. The chapter ends with a proposal for change in the mosaic.

Figure 32.
The ecological role of the Zomerhofkwartier in Rotterdam
By author

5.1
HISTORICAL DEVELOPMENT

1854 WATERPROJECT ROSE

Figure 33. Waterproject Rose, W.N. Rose 1854

INFLUENCE ON THE URBAN MOSAIC TODAY

Singels in Rotterdam. Noordsingel is Northern boundary of the Zomerhofkwartier. The singel as well as the buildings along the singel are protected ('beschermd stadsgezicht') therefore not likely to change. The Noordsingel itself functions as a corridor.

1900/1925 RAILWAY AND HOFBOGEN

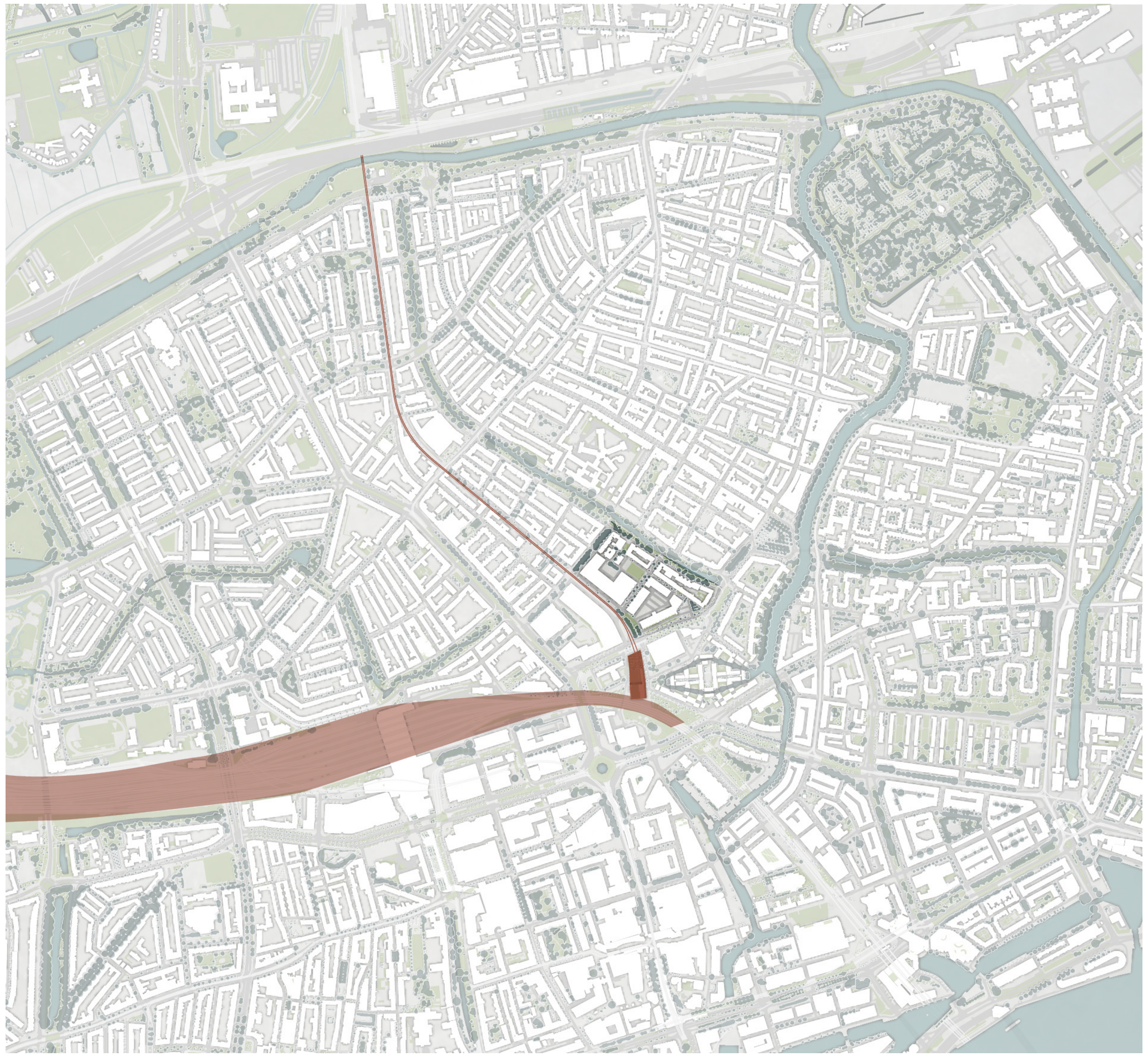
The Hofbogen is a former railviaduct that used to provide a connection from Rotterdam to The Hague.

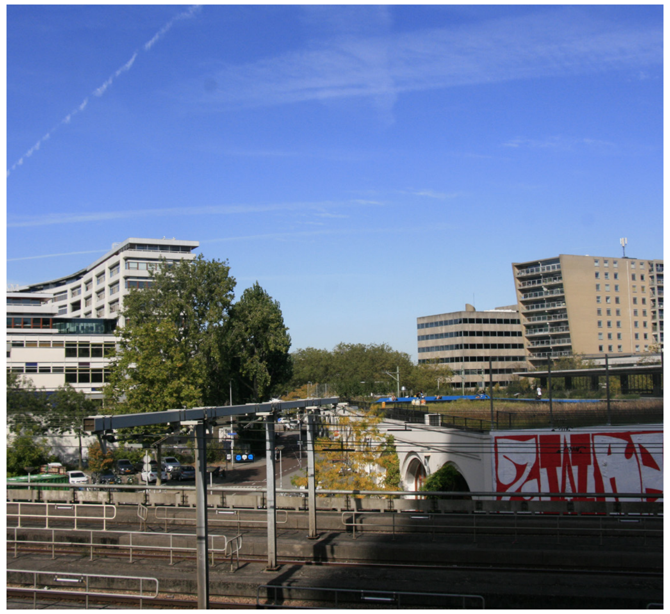
Figure 34. Plattegrond van Rotterdam in 1925, J. Treffers 1925

INFLUENCE ON THE URBAN MOSAIC TODAY

The main railway station Rotterdam centraal is close to the Zomerhofkwartier. The railway tracks however form a barrier between the center and Rotterdam Noord. Ecologically seen, the railway is a corridor for certain species (see ecological map).

The Hofbogen is the western boundary of the Zomerhofkwartier. There are limited possibilities on ground level to pass it. The Hofbogen is a monument as well, which also means that it is unlikely to change structurally in the future.





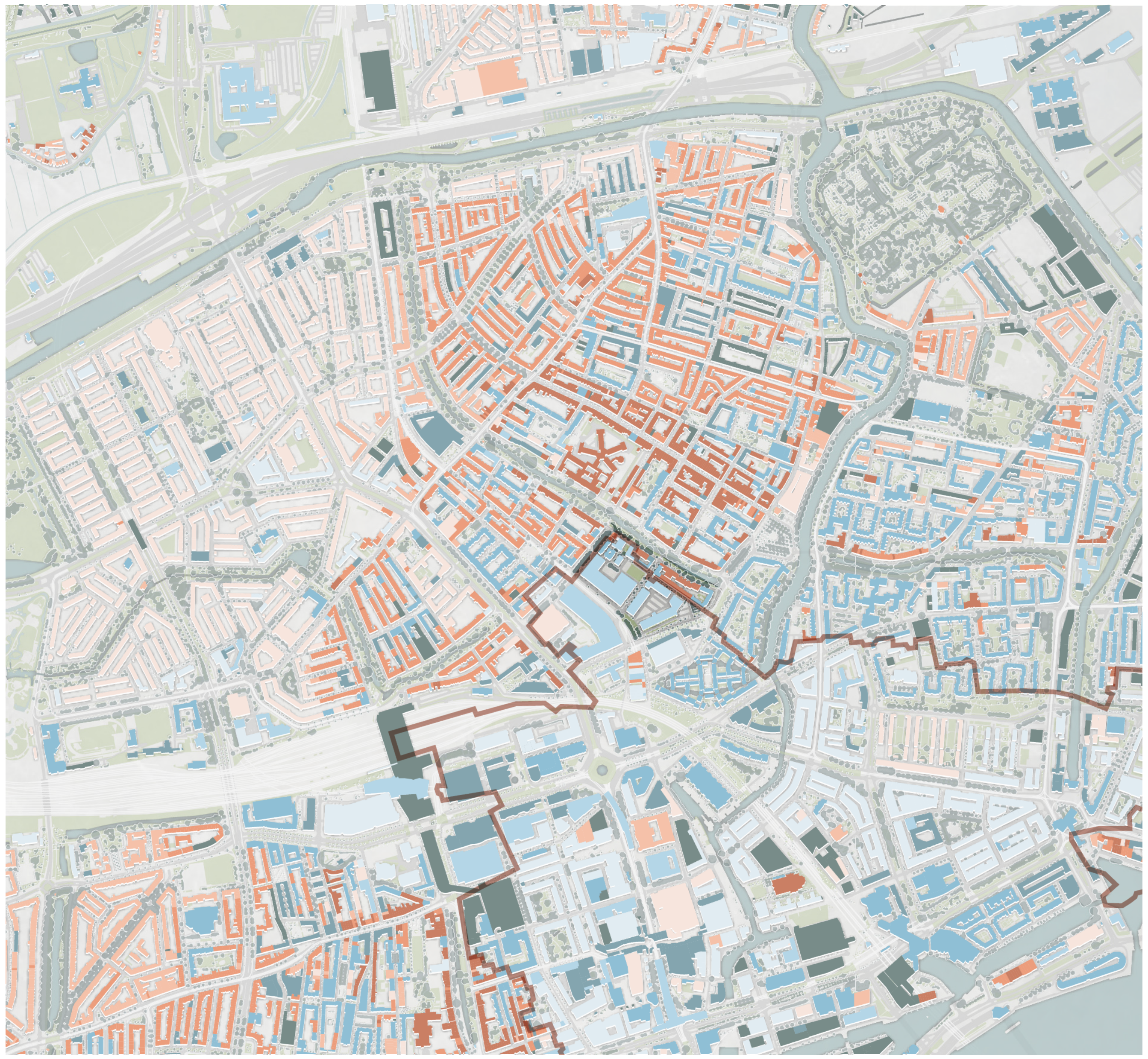
1940 BRANDGRENS

In the Second Worldwar Rotterdam was bombed resulting in fires burning down parts of the city.

Figure 35. Bombardement 1940 (2017)

INFLUENCE ON THE URBAN MOSAIC TODAY

As seen from the building age (red-blue shows old-new), the 'Brandgrens' (fire boundary) runs through the Zomerhofkwartier. This results in a combination of different architectural typologies within the area.



1960 BESTEMMINGSPLAN ZOMERHOFKWARTIER

Area was named Zomerhofkwartier. Became an area for companies and offices after the war, which slowly deteriorated.

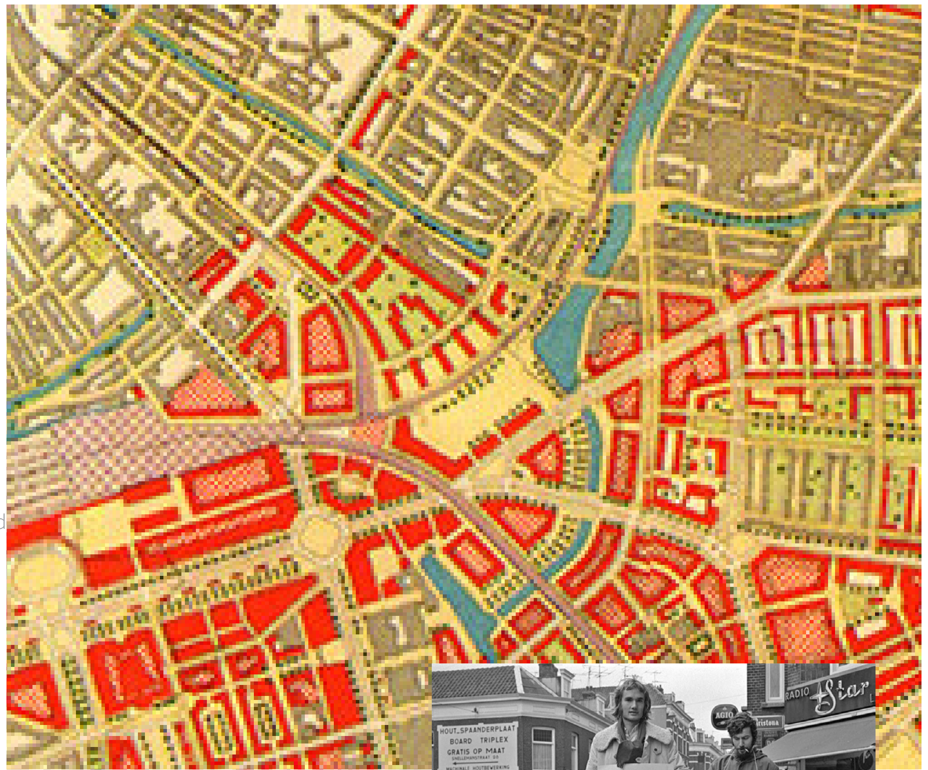
Figure 36. Plattegrond van bouwbestemmingen in het Zomerhofkwartier, Gemeente Rotterdam 1960

INFLUENCE ON THE URBAN MOSAIC TODAY

Most of the buildings in and around the Zomerhofkwartier originate from the 70s. These buildings are much larger then the surrounding building typologies, visible when comparing their form and building height (yellow-blue shows low-high) as shown in the map. Since the 70s some of the buildings in the Zomerhofkwartier were replaced, but most of them have remained. Due to the detoriation of the area, plans for redevelopment were made in 2005. These were paused due to economic crisis in 2012. Since then area is characterized by bottom-up urbanism initiatives by creative companies and other users in the area.

1900/1925 ROTTETRACE AND HEER BOKELWEG

Proposed main infrastructural connection along the Rotte that eventually was not developed as such.



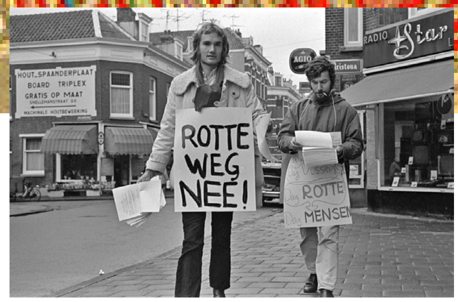
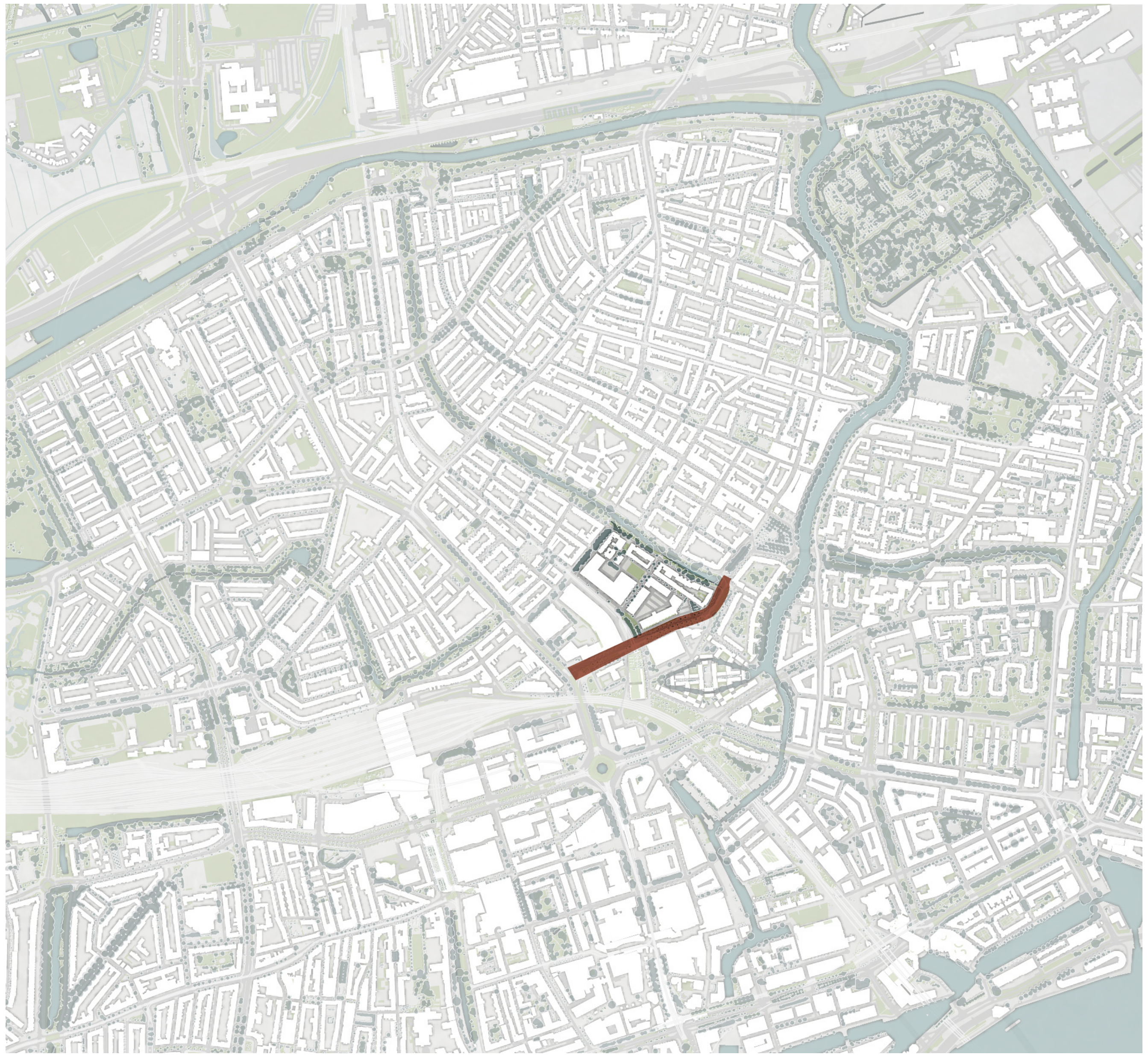


Figure 37.
a. Basisplan herbouw Binnenstad Rotterdam, Cornelis van Traa 1946

b. Photo source: Groeneveld (n.d.)



INFLUENCE ON THE URBAN MOSAIC TODAY

De Heer Bokelweg is the southern boundary of the Zomerhofkwartier. It was developed as the start of the Rottetrace, which is the reason why it has a very wide streetprofile accentuated with large building typologies surrounding it.

5.2

URBAN GREEN SPACES

Legend

- Grass
- Shrubs
- Plants
- Rosebush
- Trees
- 1 Noordsingel
- 2 Rotte
- Recent developments

The Zomerhofkwartier and its surroundings is a highly paved area. Most vegetation within public space in the area is found in the form of trees or small patches of grass. These patches of grass are quite isolated form each other. There is very limited availabilty of other types of vegetation. The next page will show the diversity in trees.

CORRIDORS

The Noordsingel is functions as a corridor due to availability of water, trees and green space. The Rotte also functions as a corridor through the water and its trees. It does have a paved quay.

RECENT DEVELOPMENTS

A The ZOHO raingarden to enable infiltration of rainwater and designed with attention to biodiversity
B Urban farming by restaurant Gare du Nord
C Small facade gardens planted by residents in Rotterdam Noord
D Dakakker: urban farming on top of the roof of het Schieblok
E Heemtuin at Dakpark Hofbogen: garden with native trees and plants
F Initiative to transform the Hofbogen railviaduct into a long, green roof

Legend

- Platanus (Plane tree)
- Robinia (False acacia)
- Tilia (Linden)

See appendix 2 trees and biodiversity

The singels show most diversity in trees (picture A). Within the Zomerhofkwartier there are not a lot of trees that provide many conditions for biodiversity (see appedix 2). Tilia trees normally do provide a lot of conditions for biodiversity, but the tilia trees south of the Zomerhofkwartier at the Heer Bokelweg are extremely small in size for example (picture B). The most common tree in the area is a platan (picture C), as it is a typical urban street tree. The Zomerhofstraat has bigger and smaller robinia trees (picture D). Both the platanus and the specific cultivars used of the false acacia's do not provide many conditions for biodiversity for different species.

CORRIDORS

Lines of trees can function as aerial corridors (Savard, Clergeau & Mennechez, 2000) for birds and bats due to their tree canopy. In this way the plane trees do have an important function for bats. The platans along the roads and along the Rotte (and the structure of the water) are used as such by bats.

5.3
INFRASTRUCTURE

Legend

- Pedestrian areas
- Main cycling routes
- Train railway
- Tram railway
- Luchtsingel for pedestrians
- Roads and streets
- Opening in Hofbogen

The zomerhofkwartier and its surroundings are quite dominated by infrastructure. A train station nearby, a frequently used cycle network and connected road and tramrail infrastructure enable easy movement for people in this area. Some of these infrastructures possibly create barriers for animals, such as the Heer Bokelweg (picture A). Limited connections through the Hofbogen (B and C).

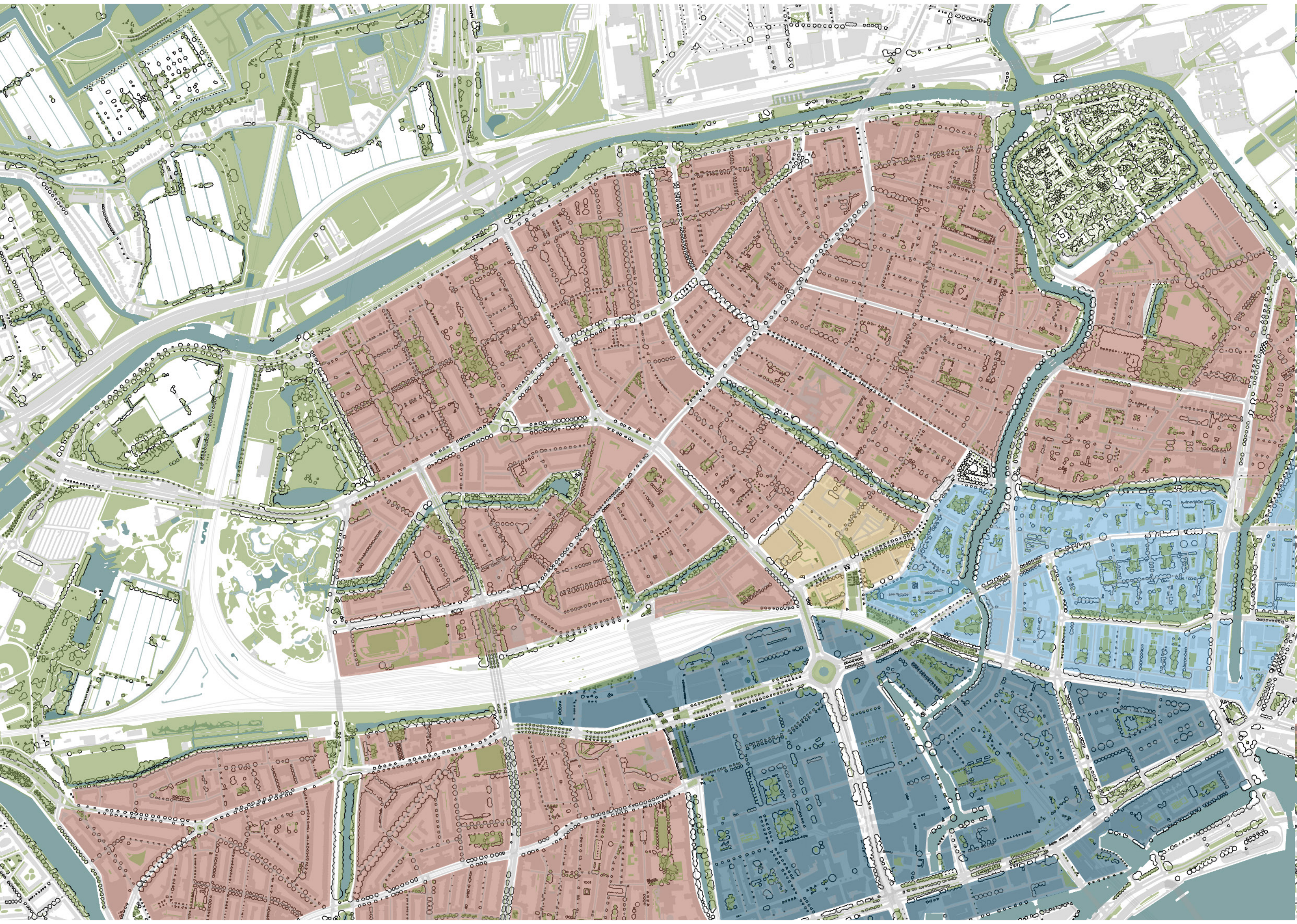
A

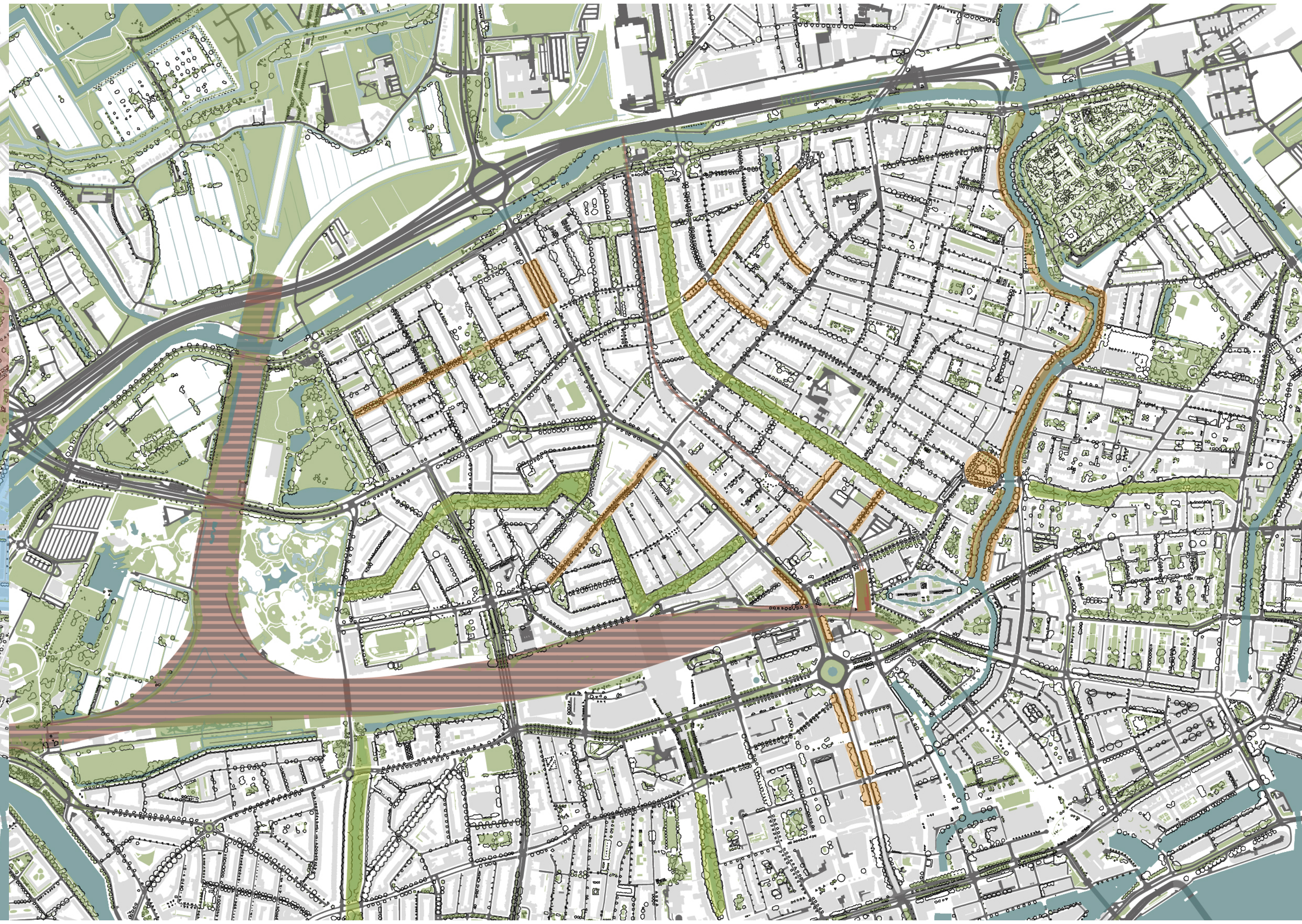
B

C

5.4

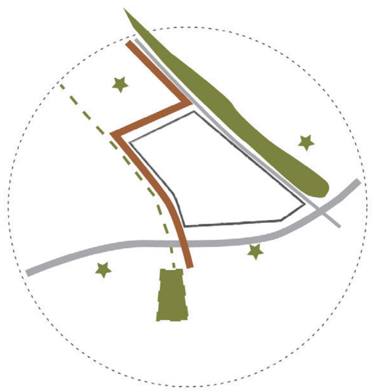
CONCLUSION URBAN MOSAIC





STRUCTURE

The Zomerhofkwartier lies at an intersection within the urban mosaic. The borders of different spatial patterns with their own urban morphology and building typologies meet here. These differences in morphology and typology likely result in the presence of different species in each of the distinguished areas of the mosaic.



FUNCTIONING

A train station nearby, a frequently used cycle network and connected road and tramrail infrastructure enable easy movement for people in this area. Some of these infrastructures possibly create barriers for animals, such as the Heer Bokelweg. Ecological corridors such as the Noordsingel and the tree canopies provide movement of animals. Interaction between small green patches is likely to be limited.

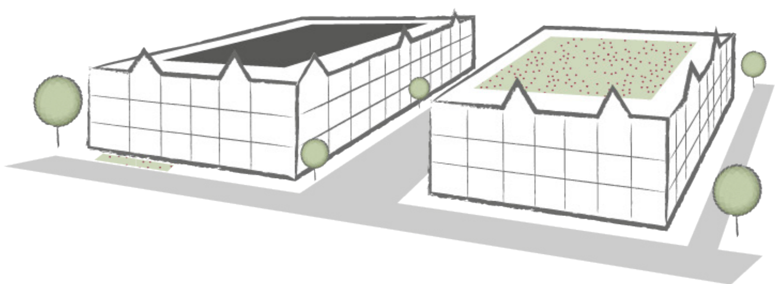
Legend

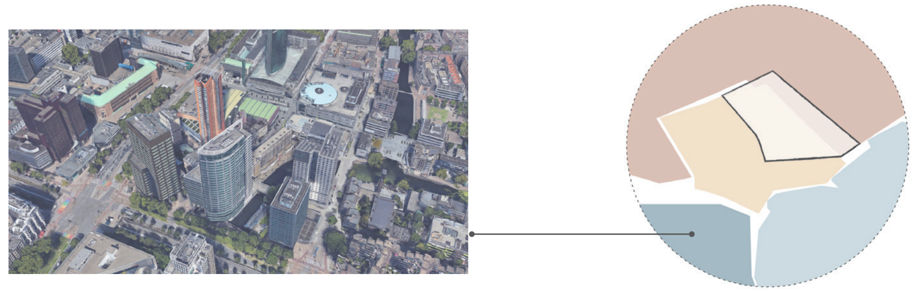
- park (patch)
- waternetwork (corridors and patch)
- singels (aquatic corridor and diversity of trees)
- street trees forming aerial corridors (such as platans)
- infrastructural line (often obstacle to cross on ground level, but potential linear connection)
- small vegetated patches (often grass)

5.5
STRUCTURE OF MOSAIC AND PRESENCE OF SPECIES

URBAN NEIGHBOURHOODS BUILT BEFORE THE WAR:

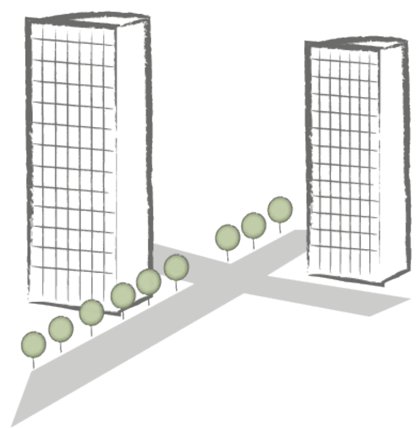
Characterised by closed building blocks with green inner gardens, highly paved streets and a lack of public green spaces. The houses dating from the 19th century provide nesting opportunities for bats and birds (Natuurkaart Rotterdam, 2014). Some facade gardens planted by residents provide conditions for birds, bees and butterflies.





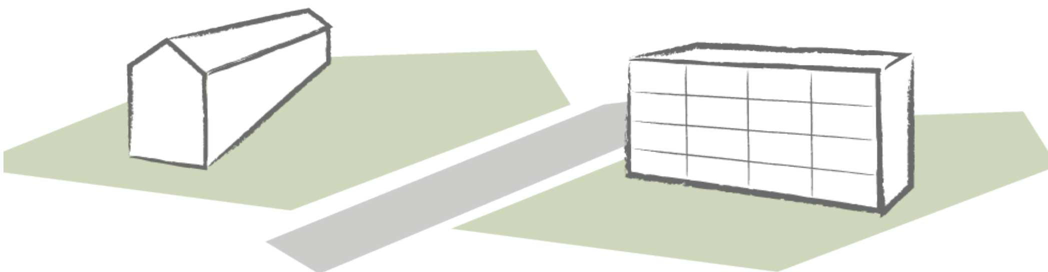
CENTER:

The center of the city is characterized by highrise buildigs surrounded by highly paved areas with typical urban street trees such as the platan. The common swift, bats, peregrine falcons and pigeons thrive in areas like this. There are limited optimal conditions for bees, butterflies and insects, mainly because of the lack of (flowering) green space providing for food and movement (Natuurkaart Rotterdam, 2014).



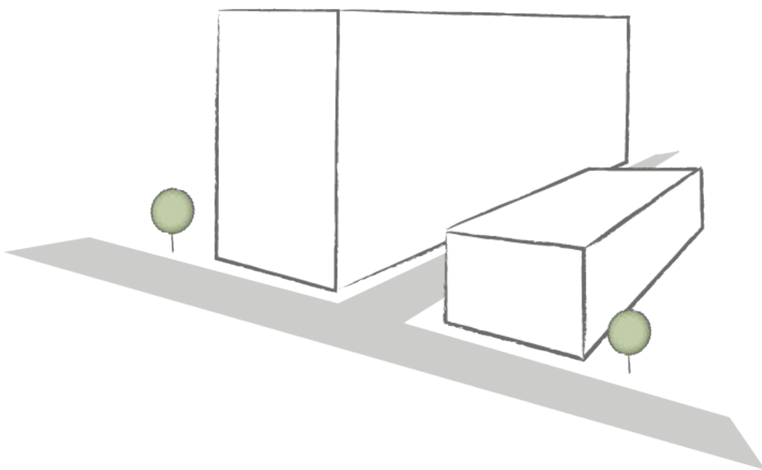
URBAN NEIGHBOURHOODS BUILT AFTER THE WAR:

Variety of building typologies with a mix of single family homes and multi-storey residential buildings. Often without a private garden or one that has been paved. The buildings itself are also low in ecological potential. In the Natuurkaart the municipality describes the ambition for these areas to provide smaller green elements within these neighbourhoods and to improve the routes to the green areas of the city.



ZOMERHOFKWARTIER AND DIRECT SURROUNDINGS:

The large-scale office and commercial buildings in combination with highly paved streets make this an area that mostly consists of impervious stone. Limited green space and trees that do not provide many conditions for biodiversity, such as plane trees and false acacias. Some initiatives to improve biodiversity have been realized in close surroundings, but do not link through green spaces in Zomerhofkwartier. Hofbogen provide a lot of future potential if developed into a green corridor.



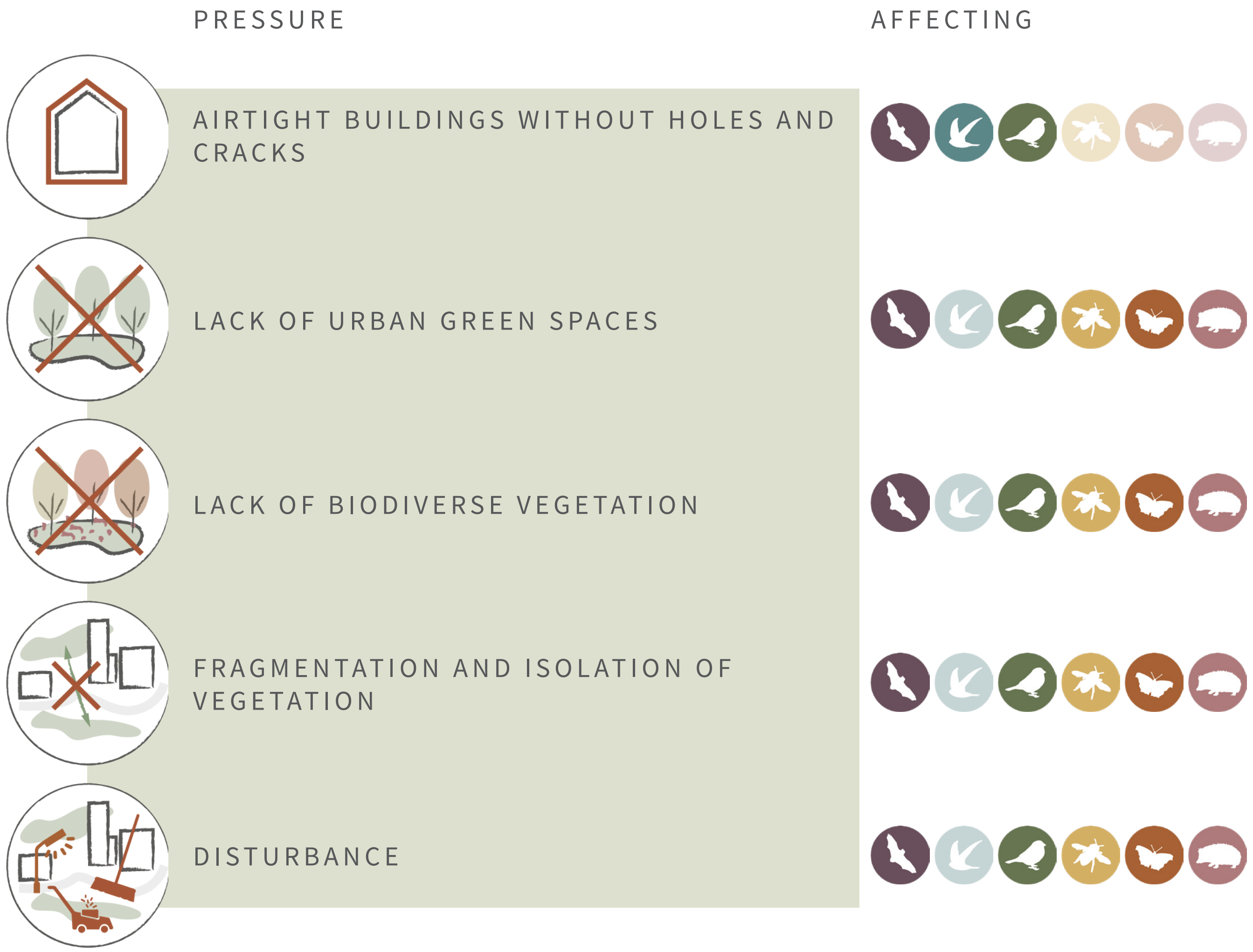
5.6

TARGET SPECIES CHOICE

The species and species groups that will be used as ‘target species’, shown on the right, for spatial interventions in the Zomerhofkwartier have been chosen through the analysis on the previous pages as well as considering their radius of action discussed before.

These species relate in one or more ways to the pressures on biodiversity as discussed in chapter 1. They are expected to struggle in Rotterdam in the future, and due to similar reasons in other cities as well. They are therefore symbolic: when designing for these species it is likely that a basic quality for biodiversity within urban development will be provided, of which more than just these species can benefit. These species also relate to different scales and different landscape elements of the urban environment, which help to show a variety of design interventions.

Additionally, insects automatically will be included in the design process, because they are a main food source for bats and birds.



5.7
TARGET GROUPS PEOPLE

FUTURE ASSIGNMENT FOR THE ZOMERHOFKWARTIER

- Mixed urban area
- Connection between Rotterdam Noord and center
- Housing: around 54.000 m2 (500-600 houses)
- Commercial and other: around 13.000 m2

TARGET SPECIES: PEOPLE

The idea is to propose conditions for strengthening biodiversity that can integrate with urban functions that need to be provided for people. For the categorization of target groups the groups considered will have a specific relationship with the urban nature due to the buildings, public and collective spaces they use. These groups are: people living in ZOHO, people working in ZOHO, people visiting ZOHO and people passing by or through ZOHO.

People living in ZOHO

People working in ZOHO

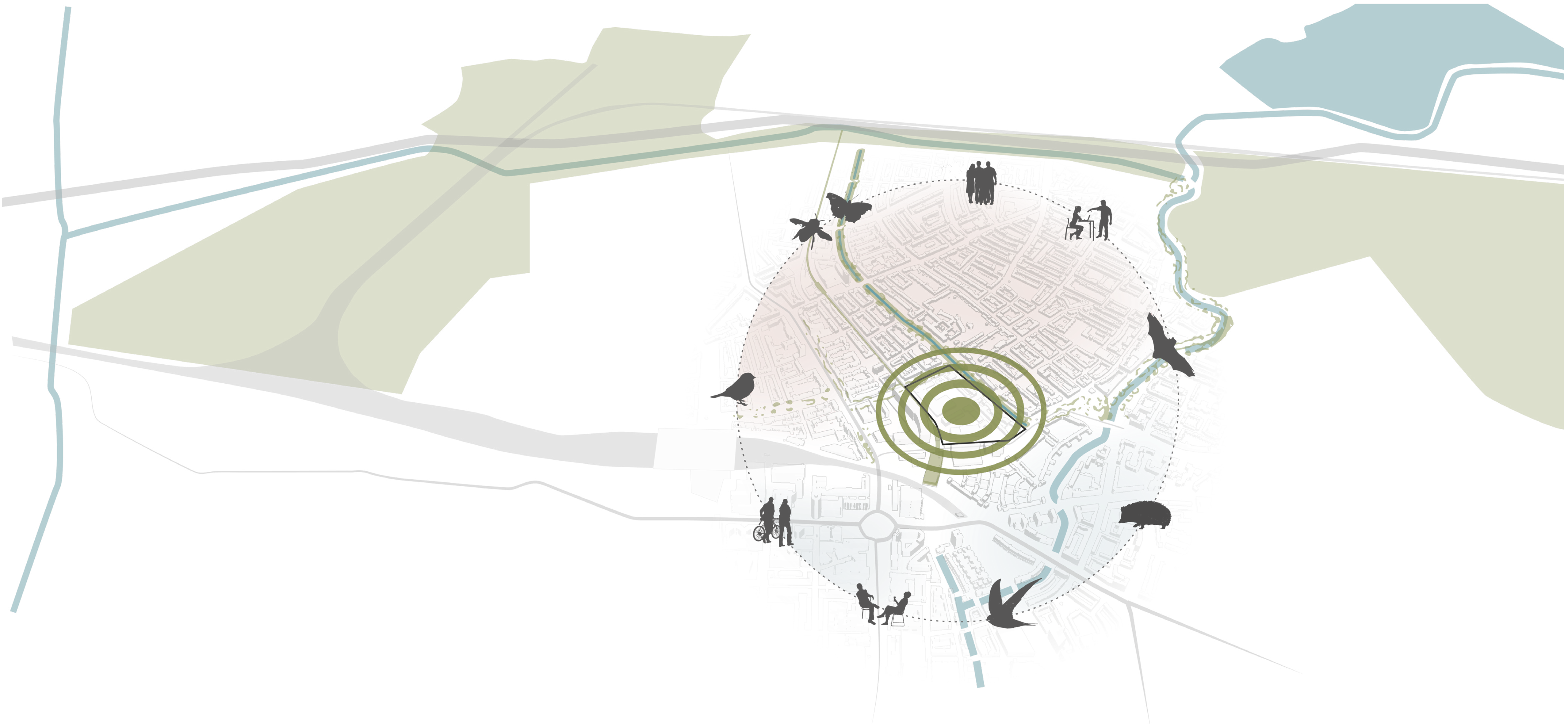
People visiting ZOHO

People passing by/through ZOHO

5.8
PROPOSED CHANGE IN THE MOSAIC

Facilitating a more interwoven mosaic which makes the Zomerhofkwartier a stepping stone within the larger ecological network of Rotterdam, functioning as a link within the urban mosaic.

The interwoven mosaic will be facilitated through a combination of built and vegetated landscape elements, that seek connection with the current urban context and provide valuable additions to that. Thereby answering spatial urban design challenges as well as providing conditions for strengthening biodiversity. This will lead to mutualist environments for the target species and target groups as described.



6. spatial interventions

CHAPTER 6.
SPATIAL INTERVENTIONS

Using all theory and findings from previous chapters, this chapter explores spatial interventions for the Zomerhofkwartier.

6.1
FOCUS OF DEVELOPMENT

Figure 38 shows the current situation of the Zomerhofkwartier. From the analysis of the urban mosaic the area as highlighted is likely to be the focus of development in the future. The buildings along the Noordsingel are protected ('Beschermd Stadsgezicht'). The area as highlighted has therefore been used to study a possible configuration of landscape elements that can fit the future program as well as promote nature-inclusive, mutualist living environments for people and other species.

Figure 38.
Current situation
Zomerhofkwartier
By author

6.2

3D DENSIFICATION STUDY

A 3d model (physical and digital) were used to study possible spatial configurations for future development.

The main ideas that were developed to promote nature-inclusive development:

1 A green structure integrated within the public and collective spaces of the buildings that connect the Noordsingel corridor to the future elevated Hofbogen corridor. Space between buildings has to be reserved especially to be able to plant bigger trees.

2 Buildings will be integrated into the ecological network by becoming stepping stones through their vegetation and integrated nesting opportunities. The suggested building typologies react to the surrounding building typologies in the urban mosaic, resulting in combined building volumes: closed building blocks with height accents through residential towers, combined with smaller building volumes towards the Noordsingel. In the plinths the commercial functions can be found. Parking spaces can be integrated within the larger building volumes and some parking spaces can be provided within public space. These combined building volumes enable a division between unique outdoor public and collective spaces that will be the spaces that support the ecological network and at the same time provide high qualitative spaces for people to use, interact with other people and interact with urban nature.

3D CONNECTIVITY AND USE

3D connectivity and use were the main principles integrated in this 3d study. These principles will be main determinants of success towards the integration of the Zomerhofkwartier within the existing ecological network.

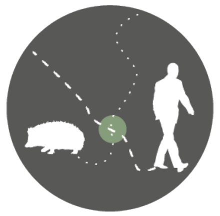
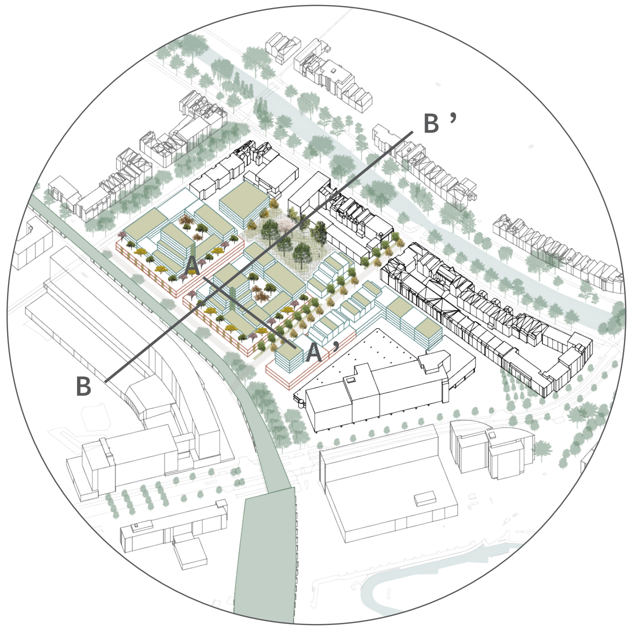


Figure 39.
3d study of possible future use of space in the Zomerhofkwartier
By author

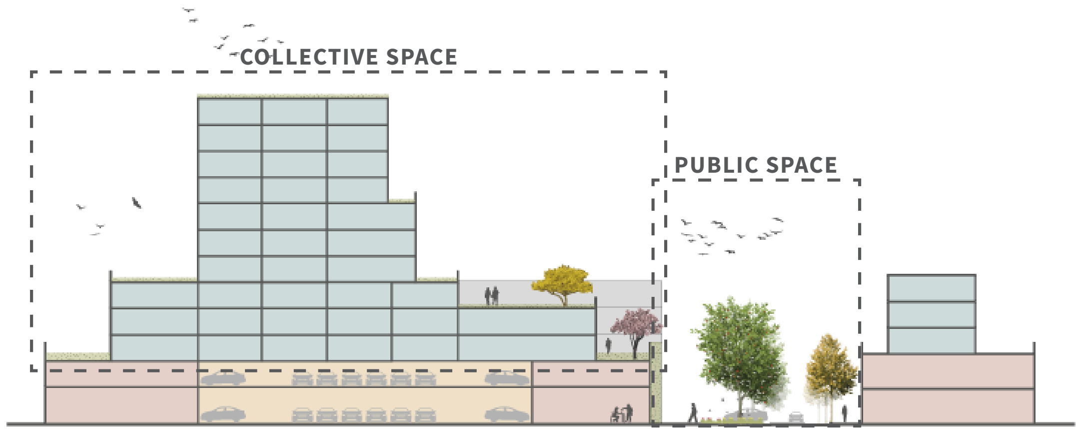
6.3

PUBLIC AND COLLECTIVE SPACES

The sections show how residential (blue), commercial functions (red) and parking (yellow) are combined in the building volumes, and how that results in public and collective spaces.



SECTION AA'



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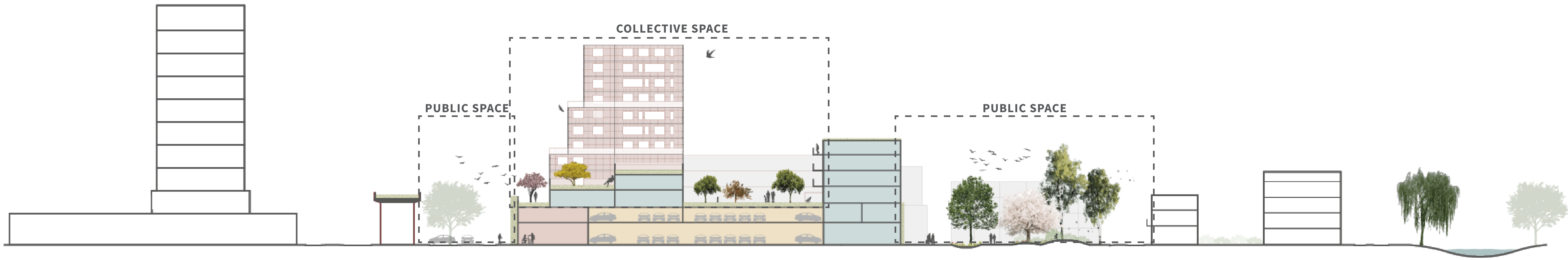
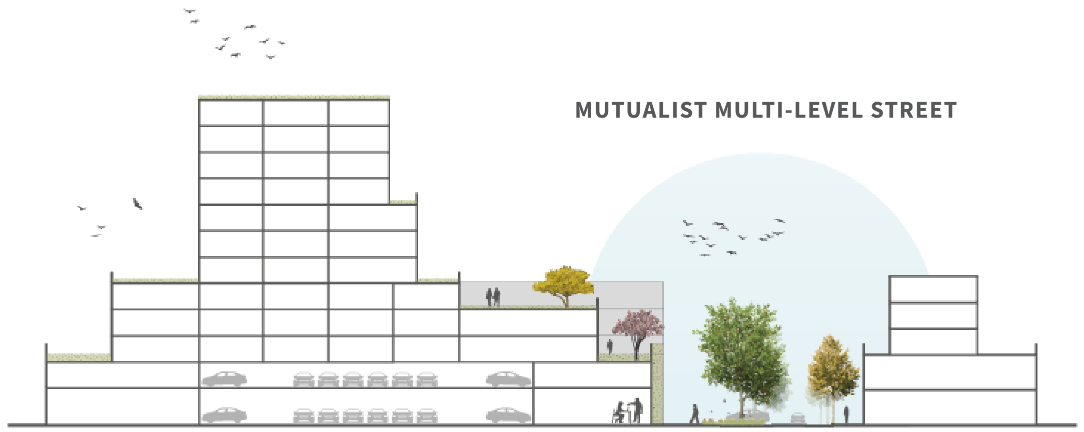


6.4
4 MUTUALIST HABITAT TYPES

The focus of further design interventions has been on 4 mutualist habitat types:
- mutualist multi-level street
- mutualist public courtyard
- mutualist collective rooftop network
- mutualist collective garden

SECTION AA'



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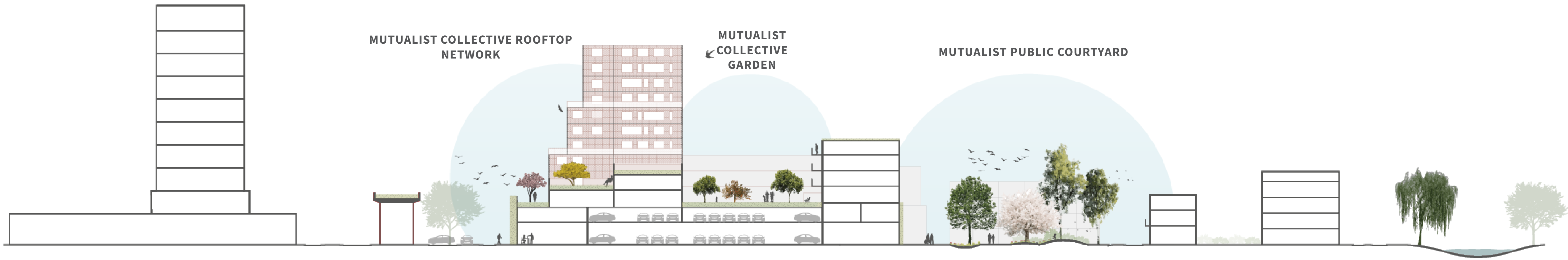
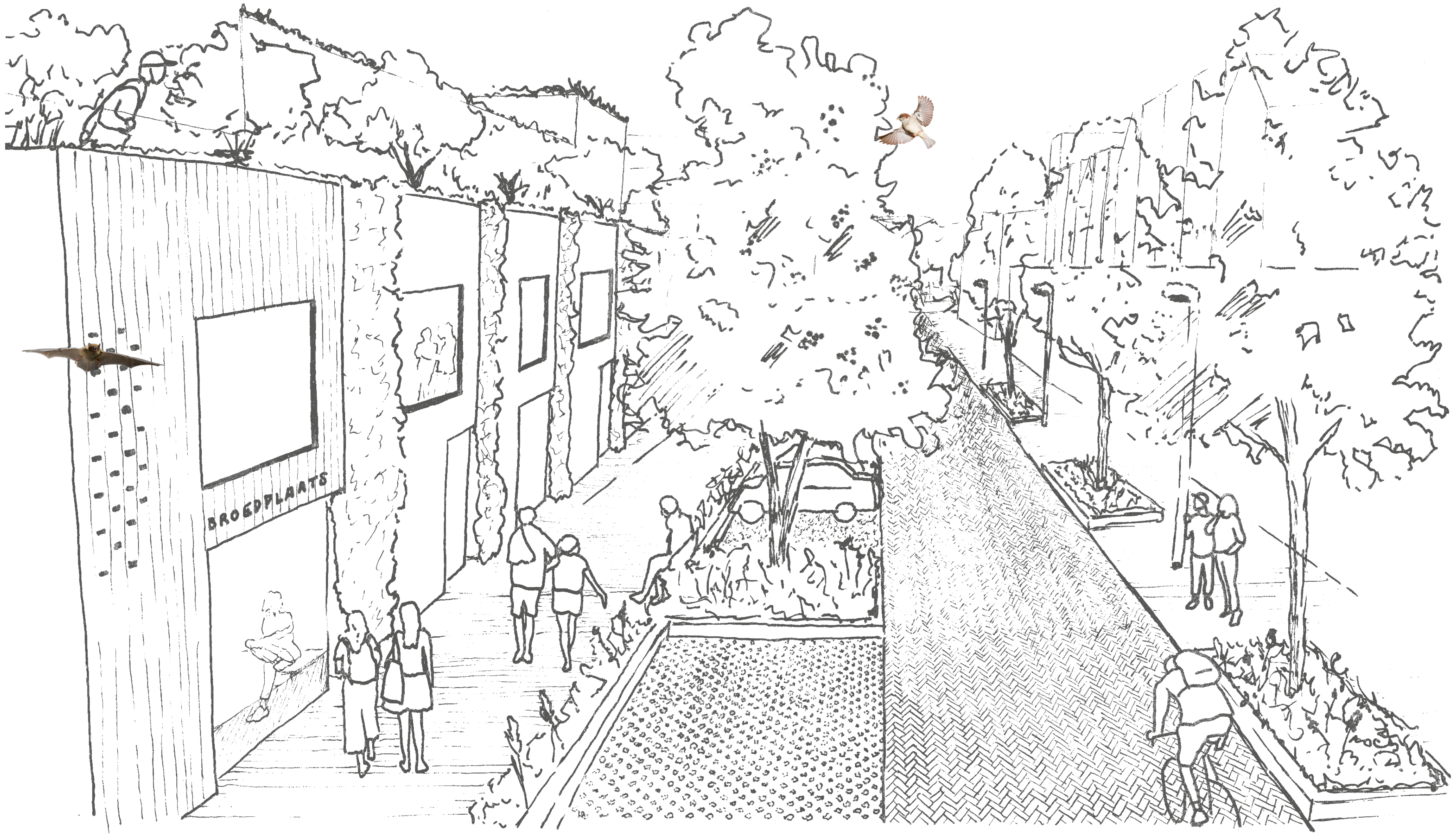
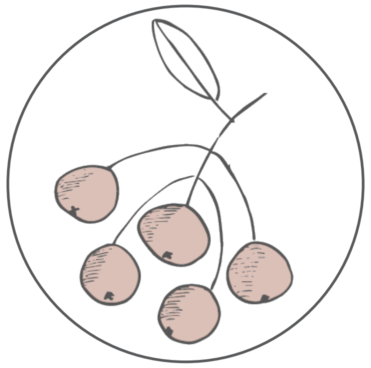
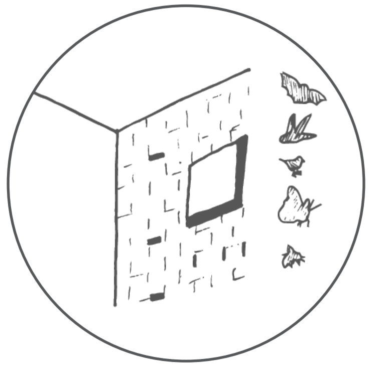


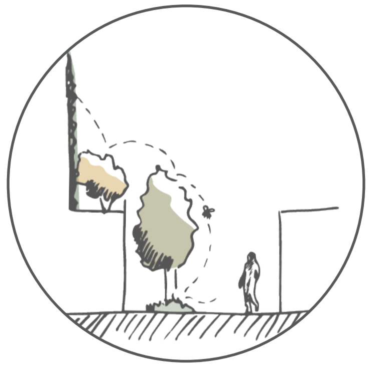
6.5
MUTUALIST MULTI-LEVEL STREET

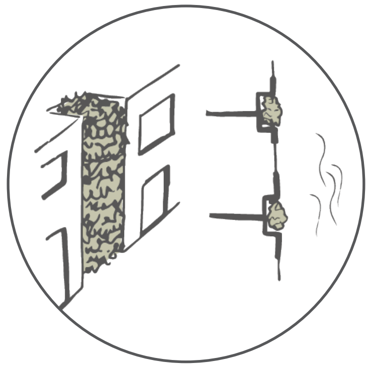
The multi-level street enables movements of people and animals, but also becomes a nice place to stay and enjoy nature. Inhabitants of the residential towers can use the elevated collective street around their houses. These elevated streets are characterized by multi-stemmed trees and other vegetation. From the elevated street inhabitants can look down to the ground level public street which enables experiencing nature from multiple levels. The public street at ground level is surrounded by active plinths with commercial functions. Vegetation and nesting opportunities are integrated within the facades. Native trees with fruits and a beeline (bijenlint) with nectar plants determine the streetview and enable people to enjoy a green walk through the area while also being able to observe the local wildlife. This green structure also benefits the hedgehog that can use it to move and forage. Parts of the streets that are not alway intensively used, the parking spaces, are paved with open pavement patterns that enable plants to grow and let water enter the soil. Lighting is placed in such a way that it will minimize disturbance for animals such as bats and insects at night.

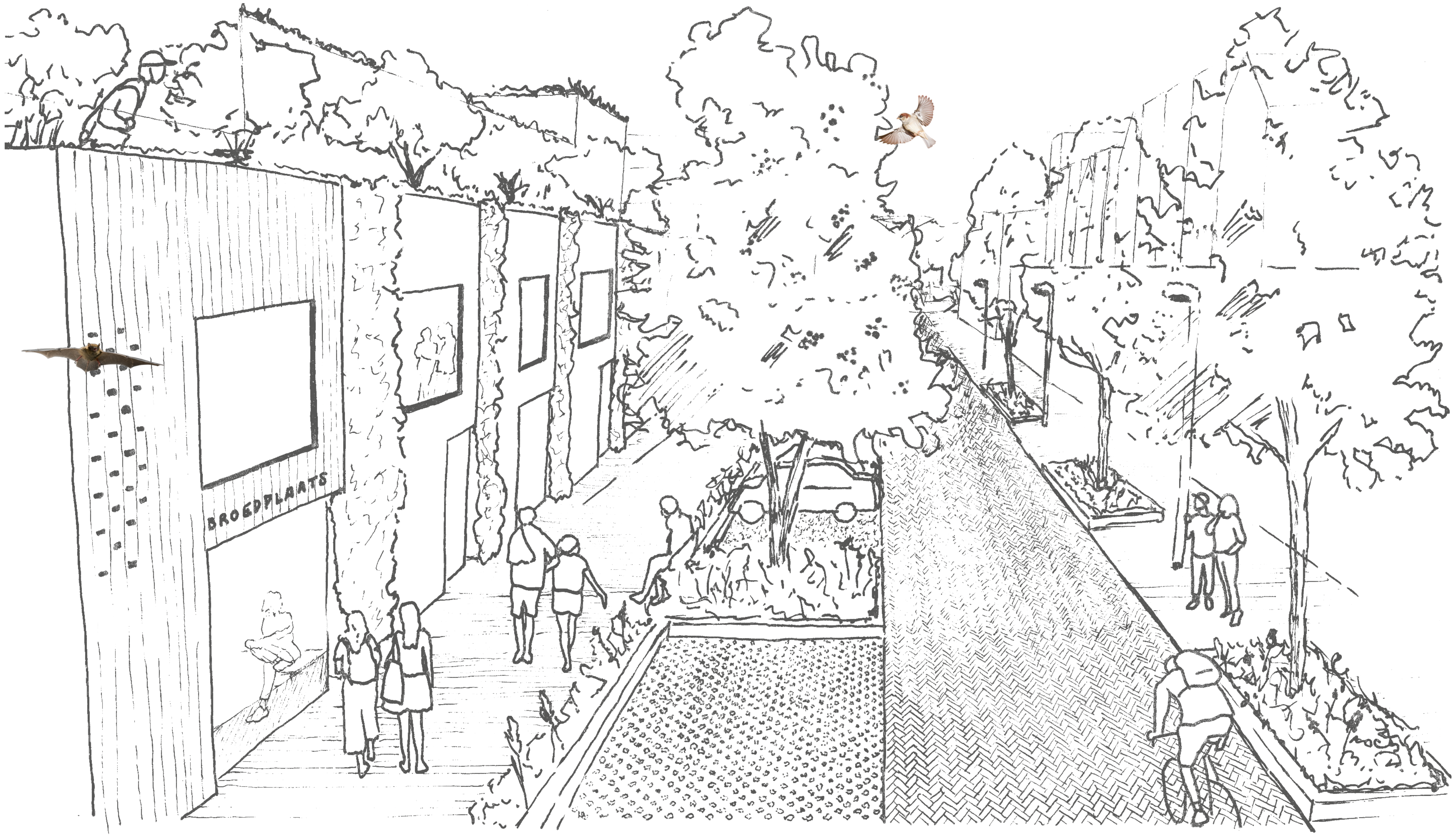


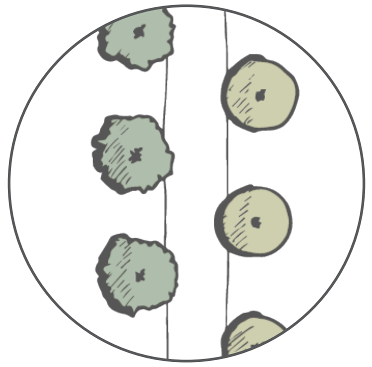


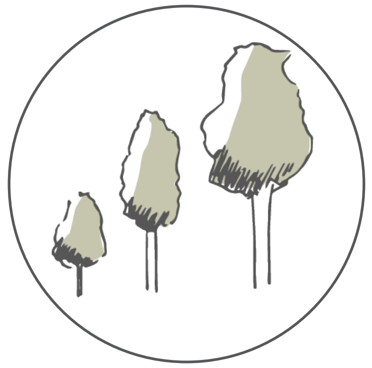


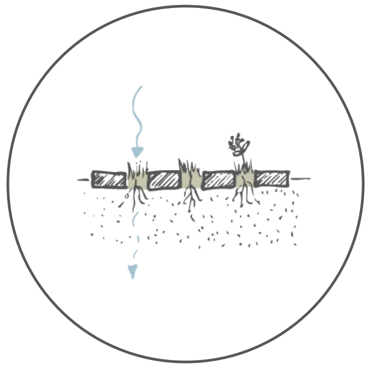


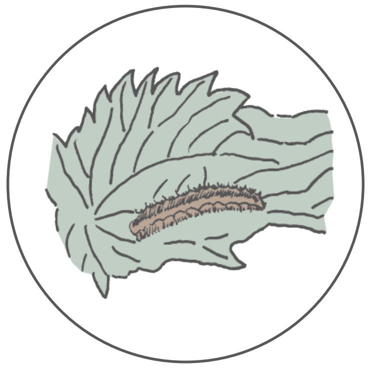



BROEDPLAATS









6.6
MUTUALIST PUBLIC COURTYARD

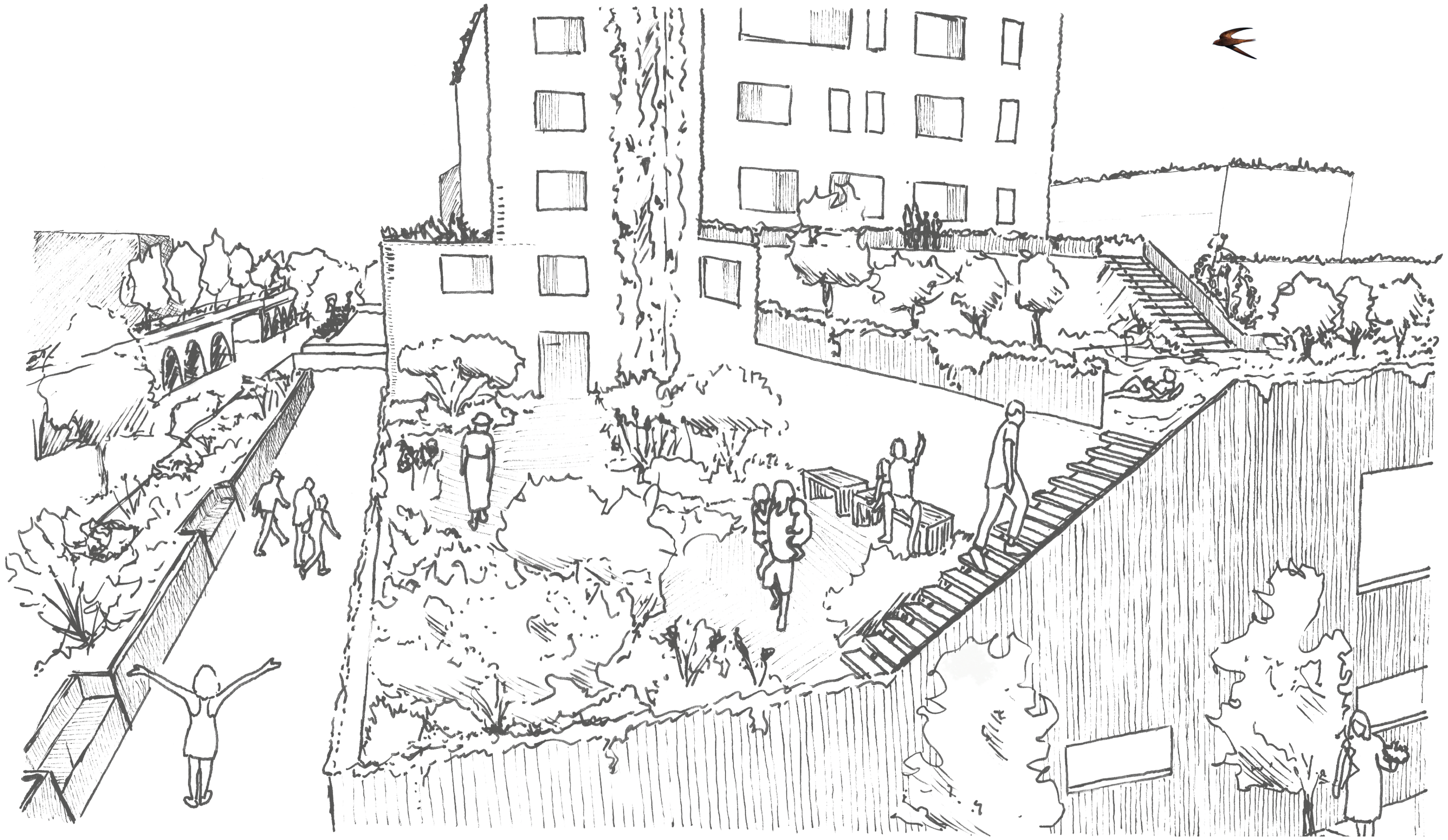
The public courtyard can be found between the new buildings volumes of het Zomerhofkwartier and the exisitng buildings along the Noordsingel. The courtyard serves as a green heart for the Zomerhofkwartier that can be used by inhabitants, people that work in the area or people that come to use the commercial functions, but it can also be used by commuters that found the courtyard during a walk around the Noordsingel or the Hofbogen. It is characterized by open paving patterns and vegetation with different heights. In the vegetation, the lower parts enable temporary storage of rainwater, while the higher parts provide opportunities for children to play and people to relax in the grass. Due to the use of native trees and abundance of nectar plants all year round people will be able to observe many bees, butterflies and other insects here as well as birds such as the house sparrow. The house sparrow, the common swift and the common pipistrelle can nest in the area as nesting opportunities are provided within the northeastern facades of the residential buildings. Bees, butterflies and other insects are also given opportunities to find shelter in the courtyard for nesting or wintering. The hedgehog also profits from shelter and food provided within the vegetation of the courtyard.
From the courtyard residents can walk up the stairs that bring them to the elevated collective streets as describes before.


1
2

6.7

MUTUALIST COLLECTIVE ROOFTOP NETWORK

On top of the building volumes, a network of collective green roofs can be found. These roofs function as stepping stones between the Noordsingel and the Hofbogen. They are accessible for the inhabitants of the residential buildings. The roofs connect to the elevated street as described before or can be entered from the residential towers. These green roof landscapes provide inhabitants with places to relax, to meet each other and to enjoy nature. Green facades that can be found at multiple places, from the ground floor up to the tower, provide additional connections for birds and insects to reach the roofs. The roofs are characterized by a variety of nectar plants and multi-stemmed trees. These multi-stemmed trees are used, because they can withstand wind and they will break the wind to ensure a good microclimate for people and animals. At night, these roofs can form forage habitats for common pipistrelles. The common pipistrelle finds nesting opportunities in the residential tower, just like the people do.

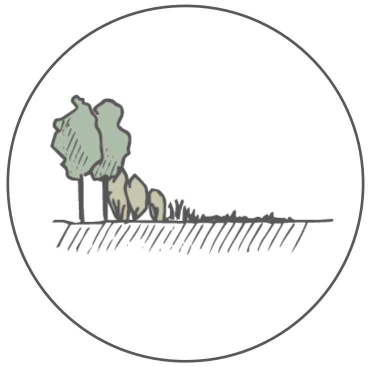


6.8
MUTUALIST COLLECTIVE GARDEN

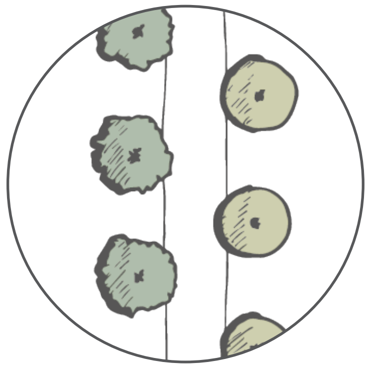
Within the building volumes, a collective garden can be found for the residents of the surroundings houses. In this garden, residents have their own private and collective outdoor areas that provide opportunities to enjoy nature. The collective area can be used for urban farming and fruit trees, such as an apple tree, grow on the roof. Because of the availability of nectar plants, bees and butterflies will visit the garden to pollinate the crops and plants. This process provides the residents with food, while also providing conditions for biodiversity. Residents with a private outdoor space can receive seeds for their small garden or balcony when they move in. With these seeds they can grow plants in their private outdoor spaces that will also contribute to the local ecosystem.

6.9

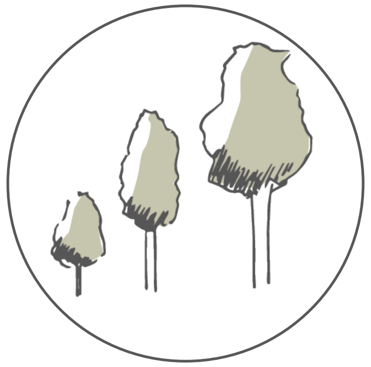
INTERVENTIONS AND LANDSCAPE ELEMENTS EXPLAINED



Vegetation layers - vegetation layers applied from low to heigh provide a diversity of conditions for a variety of species (Mouwen, Vink & Vollaard, 2013)



Diversity of trees - the street on ground floor level is characterized by lines of trees of two species: rowan trees (sorbus aucuparia) and european linden (tilia cordata). Using different trees provides a diversity of conditions for different species. Rowan trees provide food for bees, butterflies and birds and european linden for bees and butterflies. If one tree species is cought by disease, the other tree line will ensure that a green corridor is still in tact (Vogelbescherming, n.d.)

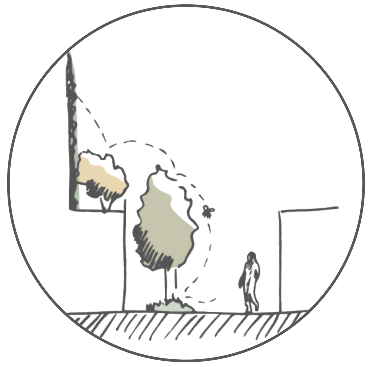


Making space for trees - each tree has specific requirements. Generally speaking, to make space for trees the following is required (Tillie, personal communication, April 1, 2020):
> 15 m height - around 30 m3
10-15 m height - around 24 m3
<10 m in height: around 15 m3

Native trees - are recognized by local species. Example: birch can be used by 200 different types of insect (Vink, Vollaard & de Zwarte, 2017).
Native trees used in the plan: common silver birch, rowan tree, european linden, cornelian cherry, european ash, mazzard cherry and appletree.

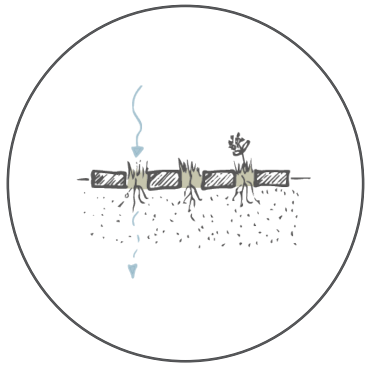
Vegetation that remains green - vegetation that remains green is needed to provide shelter and nesting opportunities and food to a variety of species all year round. Ivy (Hedera helix) is a good example that benefits birds and insects.

A flowering grow site for trees - trees have better growing opportunities when they are not packed in imperveous materials. Flowering grow sites (bloemrijke boomspiegel) will provide even more benefits as they can provide food and shelter for birds, bees, butterflies and hedgehogs.

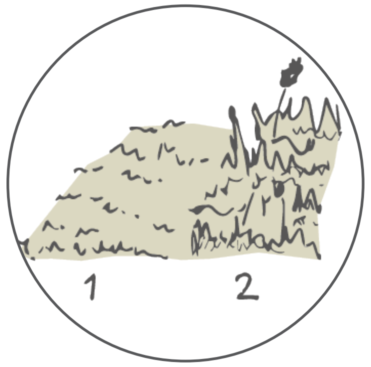


3d connectivity of the landscape elements on buildings - trees and plants on different levels vertically and horizontally connect the ecological strcuture throughout het Zomerhofkwartier.

Multi-stemmed trees - multi-stemmed trees such as service berry (amelanchier lamarckii) and cornelian cherry (cornus mas) are suitable for green roofs as they can withstand wind and will break the wind, benefitting the users (both relaxing people and foraging bats) of a green roof.

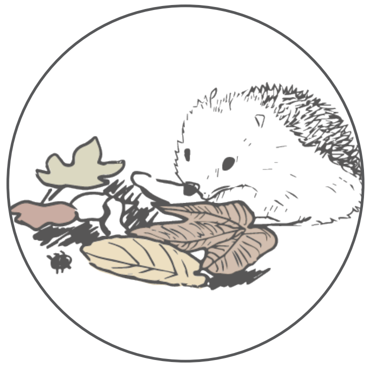


Open pavement patterns - open pavement patterns enable water to enter the soil, enabling a healthier soil(life). It also enables the growth of grasses, mosses and small plants that can provide food for insects and birds (Gemeente Deventer, 2019)



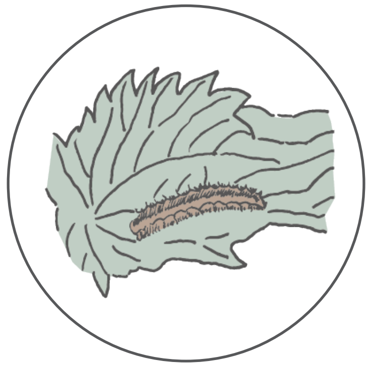
Ecological maintenance - the grass in the public courtyard will need maintenance once in a while. In ecological maintenance, grass is not mowed all together, but in different phases. This makes sure that food and shelter for especially insects

Lighting - bats can be highly disturbed by streetlights. Streetlights therefore are not placed close to nesting opportunities in facades and the courtyard and green roofs can remain relatively dark at night to also provide the common pipistrelle with a change to use them as foraging areas (Zoogdiervereniging, 2020)



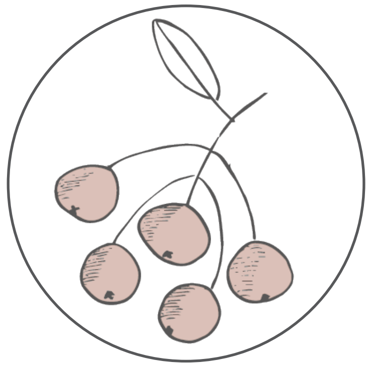
Plant debris - fallen leaves do not have to be cleaned up. They provide shelter and nesting opportunities for hedgehogs and insects. They also improve the soil once decomposed.

Nectar plants - nectar plants that flower at different times are included in every mutualist habitat. They provide food for bees and butterflies year round and as well as aesthetic year round for people.

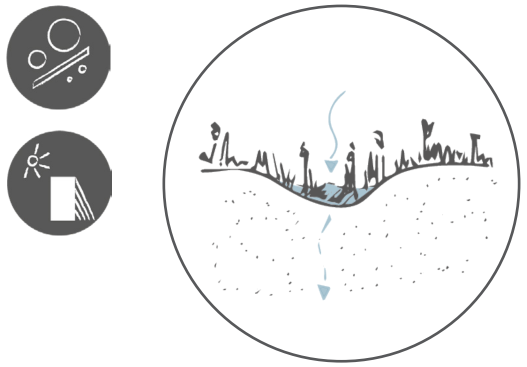


Hostplant - hostplants for butterflies are included in vegetation to contribute to the full life-cycle of the butterfly (Weiser & Hauck, 2017)

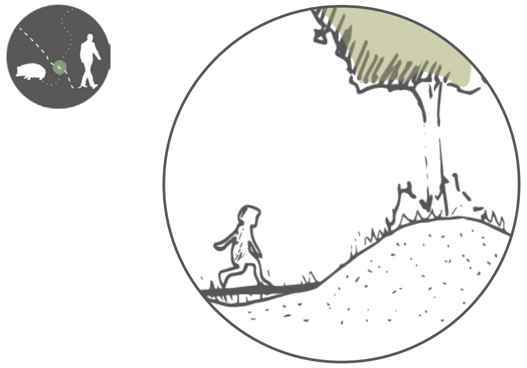
Seeds for birds - the vegetation in all mutualist habitats provides seeds that are eaten by for example the house sparrow.



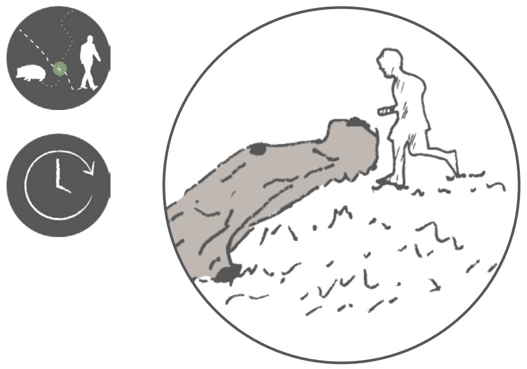
Fruits - fruits for birds are provided through trees such as the rowan tree (sorbus aucuparia) that can be found in the ground level street.



Height differences - low - the height differences in the public courtyard ensure temporary storage of rainwater. This water will slowly enter the soil, This also provides another microclimate, which can provide conditions for certain plants and insects.

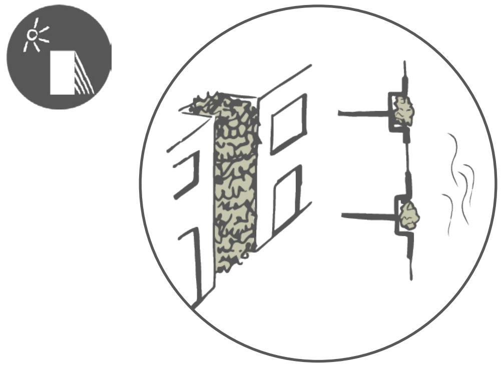


Height differences - high - higher areas also provide other microclimates and soil conditions, providing additional variety in public space. These height differences can also be used by children to play on or can form a nice place to sit or lie down.

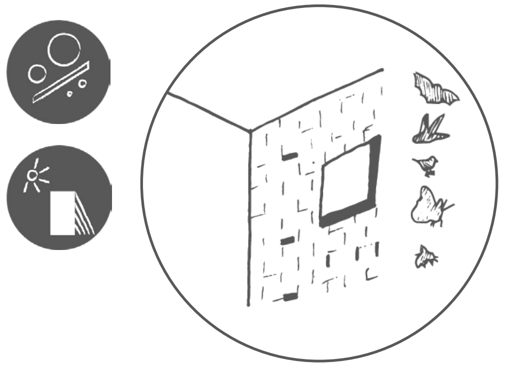


Dead wood - dead wood provides shelter and nesting opportunities for butterflies and other insects. It can also provide opportunities for children to play.

Beeline - a beeline is a line (continuous or close together forming small stepping stones) of nectar plants that provides bees, butterfles and small mammals such as the hedgehog to move through the area and forage. It also provides a green route for people.

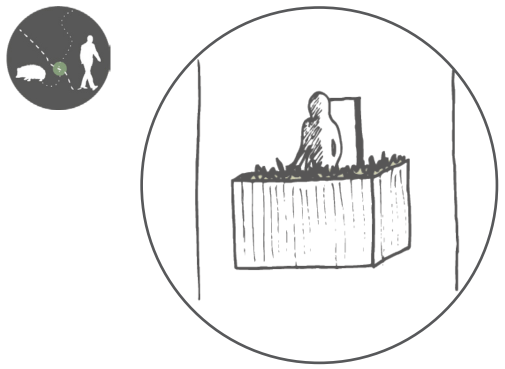


Integrated facade green (slangenmuur) - chances are higher that facade green will stay if it is integrated within facades. For integration of vegetation in the commercial plinths, a 'slangenmuur' or 'retranchementmuur' was used as an inspiration. By creating a small set back, a warmer, less windy microclimate is created that enables plants to grow. The left drawing shows a perspective, the right drawing is a plan view.



Nesting and shelter opportunities - nesting/shelter opportunities are included in each facade. The nesting opportunities can be used as a main design inspiration for the porosity and pattern of the facade.

North: common pipistrelle, common swift, house sparrow, butterfly and bee
East: common pipistrelle, common swift, house sparrow, butterfly and bee
South: common pipistrelle
West: common pipistrelle (see appendix 3)



Private gardens and balconies - to include private outdoor spaces in providing conditions for biodiversity, residents can be given seeds to plant when they move in that will contribute to the local ecosystem.

Urban farming and fruit trees - urban farming and fruits treets can be an addition to the local ecosystem while at the same time enabling residents to interact with nature.

7. conclusion and reflection

7.1
CONCLUSION

This chapter provides answers to the (sub)research questions as formulated in chapter 2. Theoretical research and (design) research by using the case study of the Zomerhofkwartier was conducted. The findings and lessons learned from this research answer the main research question, which was:

How can the urbanist provide conditions for strengthening biodiversity within urban development?

The reflection further reflects upon this research question by linking it to nature-inclusive design in practice.

SUB RQ1, SUB RQ2 & SUB RQ 3:

What basic knowledge from biodiversity, urban ecology and nature-inclusive design is needed to enrich the urbanist with an ecological point of view during the planning and design process? What are the analysis and design methods can be used for nature-inclusive planning and design? What are the main principles of nature-inclusive planning and design?

First of all, realising that the city already is a shared habitat among people and other species is a good starting point for nature inclusive planning and design. Currently many urban species are already using our cities as their (main) living environments. Although biodiversity is generally higher in cities than in the rural areas around (Pötz, 2016; Vink, Vollaard & de Zwarte, 2017) many species are still under pressure. To prevent added pressures by future development, it becomes essential to understand how to include nature in urban planning and design.

As an urbanist it is important to understand what biodiversity is. Biodiversity ensures the health and resilience of ecosystems (Vink, Vollaard & de Zwarte, 2017): it influences its functioning and ability to react and adapt to changes. People are dependent upon the world's ecosystems through the ecosystem services they provide. Biodiversity is context-, level- and scale-dependent (Savard, Clergeau & Mennechez, 2000) and therefore to be able to work on strengthening biodiversity, it is essential to consider interdependency of scales. This directly links to analysis and design methods: as a nature-inclusive urbanist it is essential to understand briefly how the local ecosystem works to be able to formulate how urban development can contribute to this. Analysing the urban mosaic is a method to understand the spatial pattern of corridors and patches of a city and understand how this links to the ecological functioning of the city, as well as providing insight into possibilities for movement and use by people. An interwoven mosaic with landscape elements that are strongly connected (Forman, 2008) is an urban mosaic with a strong ecological functioning. By learning about the radius of action of animals and by learning basics about habitat quality requirements an urbanist will understand urban species better. For habitat quality this involves knowledge about vegetation, (artificial) nesting opportunities, microclimates and life-cycles in relation to urban species. These requirements can be translated to spatial interventions by thinking about the following principles when choosing and configuring landscape elements: use, 3d connectivity, porosity, microclimate and time.

SUB RQ4:

What are the spatial implications of nature-inclusive planning and design of the Zomerhofkwartier in Rotterdam?

The Zomerhofkwartier was used as a case study to analyse the urban mosaic. Potential was found to improve the mosaic for a selection of target species: the common pipistrelle, the common swift, the house sparrow, wild bees, butterflies and the hedgehog. To develop the Zomerhofkwartier into a stepping stone within the larger ecological network of Rotterdam a 3d configuration was suggested:

1 A green structure integrated within the public and collective spaces of the buildings that connect the Noordsingel corridor to the future elevated Hofbogen corridor.

2 Buildings will be integrated into the ecological network by becoming stepping stones through their vegetation and integrated nesting opportunities. The suggested building typologies react to the surrounding building typologies in the urban mosaic, resulting in combined building volumes: closed building blocks with height accents through residential towers, combined with smaller building volumes towards the Noordsingel. In the plinths the commercial functions can be found. Parking spaces can be integrated within the larger building volumes and some parking spaces can be provided within public space. These combined building volumes enable a division between unique outdoor public and collective spaces that will be the spaces that support the ecological network and at the same time provide high qualitative spaces for people to use, interact with other people and interact with urban nature.

Four mutualist habitats were designed: a multi-level street, a public courtyard, a collective rooftop network and a collective garden. Considering the use and 3d connectivity provided in these habitats proved to be the most important factors for successfully providing integrated conditions for strengthening biodiversity. As a result these mutualist environments provide a new relationship between the city and urban nature, between built structures and urban nature and between people and urban nature.

7.2 REFLECTION

At the very first day of the graduation year I was asked what topic I wanted to research. A combined fascination between densification of Dutch cities and green living environments resulted in me answering ''the alignment of densification and greening of cities…'' followed by a doubtful ''… maybe also focussing on biodiversity in the city''. At the time I was doubting this decision, thinking ''I do not know enough about biodiversity'' and ''biodiversity is too far away from my discipline, it is not my job''. One year later I realised that this is exactly the problem within professions related to urban development.

SCIENTIFIC RELEVANCE: REALISING BIODIVERSITY IS PART OF THE JOB AND MAKING IT PART OF THE JOB

Traditionally urban planners and designers mostly focus on the built-up part of cities. For the integration of green space and other interventions aimed at increasing biodiversity very often ''the emphasis is on what is still possible within the constraints set by the design'' (Snep & Opdam, 2010). The ecological aspects are not always the focus from the start of the design process, or are left to a landscape architect or public space designer who comes in later in the design process. As an urbanist it is valuable to learn about the integration of urban ecological and nature-inclusive principles in the planning, design and decision-making process to be better capable of creating sustainable, liveable and biodiverse cities.

Nature-inclusive design is a pioneering practice. It is a topic that is increasingly discussed and written about, but there are limited examples (that have been realized) (Vink, Vollaard & de Zwarte, 2017). Moreover, ecology is very context-specific, so what works in one location does not always apply to other locations. Therefore there is a need to keep on studying the principles of urban ecology and nature-inclusive design in different contexts and types of development. Inner-city densification is an interesting case in this.

SOCIETAL RELEVANCE: ECOSYSTEM SERVICES

Since urban populations are increasing in the Netherlands (PBL, 2018), providing high quality of life in cities becomes increasingly important. Biodiversity ensures the health and resilience of the worlds ecosystems, on which people rely through the ecosystem services provided (Vink, Vollaard & de Zwarte, 2017). Addressing biodiversity and ecosystem services provided in cities is of high societal relevance to quality of life now and in the future.

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NATURE-INCLUSIVE PLANNING AND DESIGN IN PRACTICE

In practice including nature within the urban planning and design process early on, could benefit both biodiversity and development processes. However, in practice it will be quite challenging to incorporate every actor involved in the planning and design process, and ensure the right maintenance once a development is there. It means that, among other actors: municipalities, developers, architects, landscape architects and urbanists all have to work together to realize integrated nature-inclusive designs, especially because of the multi-scalarity of the matter. This research showed that strengthening biodiversity is concerned with interdependency of scales that looks at the city scale up to a facade detail or a paving stone in the street. That shows how many actors will eventually have influence on nature-inclusive results. The economic side might also be a hurdle, but by combining challenges (for example climate adaptiveness) this can be overcome. Also, if the concept of ecosystem services will be more commonly known and used, the economical debate around nature-inclusive design might also change in the future. Furthermore, residents and users of urban development areas can and should also be incorporated in nature-inclusive development, especially if nature-inclusive design is done in areas with more private green spaces instead of collective green spaces. All topics discussed in this section form interesting topics for further research.

A MUTUALIST URBANIST IN PRACTICE

An urbanist that wants to realise mutualist cities has to seek collaborations with architects, landscape architects and especially city ecologist to make successful interdisciplinary, multi-scalar designs together or to simply use each others advices. At the same time, a mutualist urbanist can educate him/herself with the books that already have been written (such as Making Urban Nature by Vink, Vollaard & de Zwarte) or consult associations such as de Vogelbescherming, Zoogdierverening and Vlinderstichting. In the design of the Zomerhofkwartier many interventions were suggested that traditionally would not be found in a regular urban design plan. Many small-scale interventions (facade detailing, specific types of plants) could be added to a 'Beeldkwaliteitsplan' to ensure that they will be seen in the end result. The nature-inclusive planning and design principles can possibly also be used to test if a design is nature-inclusive. It can be checked if 3d connectivity and porosity for example are applied to a design. Lastly, designing through a (physical or digital) 3d model can help greatly to bind together interventions (small tot big).

8.
bibliography

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9. appendices

Compact *and* Green: the New Sustainable City

Understanding alignment of urban green space planning and densification processes in cities in the context of the Netherlands

AR3U023 Theories of urban planning and design

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Abstract – Until approximately 2035, 1 million new houses have to be built in the Netherlands, mostly in and around the biggest cities. It is likely that compact city developments that have been applied since the 1990s will be continued, especially in the form of densification within existing city boundaries. With scarcity of space increasing, liveability standards have to be considered carefully as well as newer challenges such as climate adaptation and enhancing biodiversity. Urban green space could provide essential solutions to addressing these challenges through provision of ecosystem services, but urban green space planning involves numerous complexities resulting in lack of green space, low quality and fragmentation of green space. To reach sustainable urban development, urban green space planning and densification processes have to be aligned effectively. Strategies include early integration in the planning process through target setting and balancing the spatial layout of the city, considering alternative forms of densification, introducing rating systems and subsidies and cross-sectoral collaborations.

Keywords: urban green space planning, densification, compact city, sustainable cities, ecosystem services, the Netherlands.

1. Introduction

Sustainable urban development in the Netherlands: from compact to compact and green

Since the 1990s spatial development in the Netherlands has been characterized by compact city development: new housing developments are realized within existing city boundaries or close to big cities. This is guided by the idea to stimulate city amenities and driven by sustainability arguments such as limiting loss of green or agricultural space and discouraging car use (and thus emissions) (van der Wouden et al., 2015). The national government used to be the main leader in compact city development through the Ministry of Housing, Spatial Planning and the Environment (*Ministerie van VROM*). Their policies and plans spatially led to the development of large quantities of new housing through key-projects (*sleutelprojecten)* and VINEX neighbourhoods within existing city boundaries and as extensions to existing cities. In 2010, this Ministry was abolished as part of decentralisation measures, resulting in urban development mainly being the task of provinces and municipalities up until today (Nabielek et al., 2012).

In the Primos-prognosis of 2017 by ABF research, it was calculated that there is a need for 1 million new houses until approximately 2035 (Faessen et al., 2017). The highest demand of housing lies in and around the cities that are already the biggest: Amsterdam, Rotterdam, The Hague and Utrecht and development and granted building permits in each of these cities is not yet at the pace to meet current and future demand (Doodeman, 2019). The municipalities and provinces of these cities are therefore dealing with complex cases in places that are already limited in space.

To develop in a sustainable[1] way by considering current scarcity of space and preservation of green space around the city, Dutch cities choose to continue compact city development through densification processes within the city (Nabielek et al., 2012). However, since the 1990s the overall sustainability of these compact city approaches has received critique in different areas. Many critics have questioned if the quality of life for individuals is taken into account to a considerable extent. This is a sensitive point, especially in the Netherlands. In some cities, new developments might be built in higher densities than is common in those particular areas. The most common housing type in the Netherlands is the single-family row-house, which is culturally manifested in Dutch people's image of what a possible ideal house and living environment could be. Such views deeply embedded within culture as well as more general negative expectations that come with density, such as overcrowding (Jenks, 2000), often lead to dissatisfaction with densification among existing inhabitants. As a result, density is often negatively associated with liveability (Howley, Scott, & Redmond, 2009) Taking into account both the satisfaction of existing and new inhabitants becomes increasingly important when further densifying cities. It is found that integrating the development of urban green space[2] into densification processes and into the city in general, can contribute to a higher (perceived) liveability and mitigate the perceived negative

[1] The World Commission on Environment (1987) has defined sustainable development as ''development that meets the needs of the present without compromising the ability of future generations to meet their own needs.'' This can relate to factors of for example economic, social and environmental purposes.

[2] Urban green space includes all the 'green elements' of the city such as parks, public and private gardens, trees and plants, urban agriculture, green roofs and green facades. Urban green is often found in combination with water and plays an essential role in the water system of cities, as it can also retain, store and drain water. Together the 'green' and 'blue' elements form the urban green-blue structures of the city (Pötz, 2016).

effects of densification (Haaland & Konijnendijk van den Bosch, 2015). Urban green space provides places for recreation, play and social interaction and can improve health by cleaning the air, reducing stress levels and stimulating movement and exercise (Pötz, 2016).

Furthermore, urban green space is essential to dealing with other, relatively new challenges in cities. Due to climate change, extremes in weather conditions are occurring more often, again affecting the quality of life. Cities will have to be able to deal with more heavy rainfall and on the other side longer periods of drought (Planbureau voor de Leefomgeving, 2018). Urban green space can help to mitigate the effects of climate change through temperature regulation and water retention. Moreover, very recently the UN-platform for biodiversity has stressed in their published research how biodiversity decline forms a great danger for the future of the world and thus humanity and what the current severity of the problem is (IPBES, 2018). As urbanisation is one of the main reasons for biodiversity decline in the Netherlands (Planbureau voor de Leefomgeving, 2018), it is essential to enhance biodiversity through a different way of sustainable urbanisation.

Municipalities in the Netherlands are slowly becoming aware of these challenges and the necessity of preserving and developing urban green space linked to this. As a reaction they start to adopt green goals. However, when combining goals of densifying and greening of cities, it is often found that one excludes the other. A study by researchers from the University of Amsterdam has shown that despite municipal claims and policies directed to creating new urban green space, between 2003 and 2016 11% of the green space within the ring road of Amsterdam has disappeared, mainly due to development of housing (Giezen, Balikci, & Arundel, 2018). This is further underlined in research where repeatedly it is stressed that despite good intentions, the effective integration of green space development and preservation in urban densification processes is not at all standard (Haaland & Konijnendijk van den Bosch, 2015; Pötz, 2016; Snep & Opdam, 2013). To prevent that urban green space (with its indispensable functions) becomes subordinate to densification, there is a need for changes in the decision making, management and design of urban green spaces (Stache, Jonkers, & Ottelé, 2019).

Objective and structure of the paper

This paper is written as a part of the research conducted in a TU Delft MSc Urbanism graduation project titled 'Nature-Inclusive Densification', in which the alignment of densification and greening processes in the city of Rotterdam is researched by the author. The purpose of this paper in the context of the project is first of all to provide a general understanding of green space planning in cities and all the components related to it. This is described in part one of the body of the paper. Secondly, it provides an overview of the problems of green space planning in combination with densification processes in the Netherlands. This part ends with suggestions for strategies on how to align the processes. The paper is written by reviewing theories and results from research conducted around the topic of urban green space planning and/or densification as well as examining (recently) proposed strategies from practice (in the Netherlands) to align the two planning approaches. The paper sometimes uses a historical approach and an exploration of concepts to create a thorough understanding. The paper concludes with a summary of the findings, a reflection on the limitations of the research and recommendations for further research.

2. Green space (planning) in urban areas

Historical background on the role of nature in urban planning

The necessity and benefits of urban green space have already been introduced briefly. These benefits and being aware of their importance has not always been self-evident throughout the history of the development of cities and green in cities. The relationship between nature, the city and city development has been widely discussed in literature. Examining this creates an understanding of urban green space planning and the challenges it has to overcome in the future, because reasons for a minimum amount of green space in cities today cannot only be attributed to recent developments, but are rooted in development and planning decisions that go far back in time. This is pointed out strongly by Stache, Jonkers and Ottelé (2018) who conclude that ''cities were in fact built to protect humanity from nature and not to integrate with it''. Cities in the Netherlands are a good example of this, with an extensive history starting from approximately the 13th century of turning peatlands into habitable places, protected from flooding by an ingenious system of dykes and other water management measures. Green spaces in and around Dutch cities today are the result of centuries of landscape alterations by people (Cey, 2014).

Furthermore, Stache, Jonkers and Ottelé (2018) point out that the industrialisation of the 18th and 19th century was highly influential in this, by causing rapid urbanisation. Rural land changed into urban area or people moved from the rural area to the cities due to the economic opportunities created by industries. However, industrial activity and increasing transport activity linked to this, resulted in environmental pollution in cities, creating unhealthy living environments. As a reaction, improving unhealthy living environments was one of the objectives of urban planning approaches after the industrialization. Modernism since the 1920s did so by proposing 'the functional city' where functions such as working, living and recreation. This meant that substantial areas of green space were developed as separate entities. (Stache et al., 2019). Effects of these planning approaches are still visible in cities today. In the last decades there is an increasing awareness that including green in all parts of the city is important, fuelled by environmental movements and increasing interest in urban ecology[3] coming from universities. Despite this change in discourse, structural changes in the practice of urban planning processes cannot be found yet: they remain focused on ''division of labour, separation of functions and maximised land yields'' (Pötz, 2016, p. 22).

The value of urban green space

Especially land yields seem to be a determining factor when it comes to green space planning. The multi-functional nature and value of green space is not understood in planning processes and therefore not equally treated with respect to other infrastructural elements of the city. The dominating perception of green space in many European countries is that it is only recreational or aesthetic use of land (Beer, Delshammar, & Schildwacht, 2003). Other disciplines such as ecology and more specifically 'economical ecology' do acknowledge the multi-functionality of green space and the value related to this. In the field of economical ecology research has been conducted in the last decades on how people benefit from

[3] Urban ecology can be defined as an ecological research discipline within urban areas, aiming at integrating ecological research findings in planning urban green areas (Niemela, 1999)

services provided by ecosystems (*ecosystem services*[4]) and how this can be connected to economics (TEEB, 2010). Costanza et al. (1997) highlighted what is still relevant today in decision-making around urban planning: ''because ecosystem services are not fully 'captured' in commercial markets or adequately quantified in terms comparable with economic services and manufactured capital, they are often given too little weight in policy decisions.''. Looking at urban green space and its full economic value can be an effective way to change the attitude towards development. If ecosystem services are increased or existing ecosystem services are improved in the city, this can be of increasingly economic value by for example attracting investments from developers, entrepreneurs looking for a location for their business and tourists (Beer et al., 2003).

The performance of urban green space

Not only the current lack of green space in cities, but also a low quality of existing green space and fragmentation of green spaces (Snep & Opdam, 2013) result in a low performance in terms of the ecosystems provided (Stache et al., 2019) and thus low value. Adding more green and increasing ecosystem services through urban green space planning is necessary, but not always realistic in areas with limited space (Raats, 2019). Furthermore, green space can take time to develop before it can deliver the intended ecosystem services. An important task in urban green space planning in cities therefore is to look at the current urban green space (Haaland & Konijnendijk van den Bosch, 2015).

The quality of these green spaces can be improved from the point of view of usability for people and from the point of view of ecological performance. In the first case improvements can be made considering for example the program and accessibility (Beer et al., 2003). In the second case, improving the biodiversity could be a strategy, by for example adjusting and reducing maintenance to create space for spontaneous growth of wild flowers that attract bees, butterflies and insects (Pötz, 2016). Also, addressing fragmentation of the green spaces and elements proves to be effective for improving conditions: with linking ecosystems they can support each other (Opdam & Steingrover, as cited in Snep & Opdam, 2013). This network can also help in distribution green more equally across a city and therefore creating more equal accessibility to green spaces for each inhabitant. This is especially important since bigger green spaces such as city parks cannot substitute ecosystem services and performances that more local, accessible green space has (Beer et al., 2003).

Green space planning

Through exploration of the developments and concepts mentioned above, an understanding of a number of the challenges and aspects of urban green space planning become clear. To overcome the argument of green space being not profitable, it is important to connect values to green spaces for example by integrating the use of ecosystem services in planning practices. Spatially organising new green spaces and elements and improving existing green spaces in such a way that enhances the performance of the green structure as a whole, is one of the aims of green space planning. Considering

[4] Ecosystem services can be divided into ''provisioning services (raw materials, food and water supply), regulating services (urban temperature regulation, noise reduction, air purification, moderation of climate extremes, runoff mitigation, waste treatment, pollination, pest regulation and seed dispersal, global climate regulation), cultural services (recreation, aesthetic benefits, cognitive development, place values and social cohesion) and habitat services (habitat for biodiversity)'' (TEEB cited in Stache et al., 2019).

short and long term values and performances are important in this (Snep & Opdam, 2013). A clear understanding of this is needed to be able to align green space planning with densification processes.

3. Urban green space planning and densification processes

To now be able to formulate strategies on how to align urban green space planning and densification processes, densification processes in the context of the Netherlands have to clarified briefly. Especially since talking about the concept of density and thus densification in the context of Dutch cities, is significantly different than considering density and densification in for example Asian cities. As elaborately discussed by Berghauser Pont and Haupt (2010) there is not one accepted and broadly used definition of density. For example, density can refer to 'population density' with the number of people in a given area, or density can be defined as 'Floor Space Index (FSI)' or 'land use intensity' that relate to the number of dwelling units or building mass per given area. Population density and dwelling density per hectare are commonly used in urban development in the Netherlands and FSI is starting to become more commonly used (Berghauser Pont & Haupt, 2010). Density can come in a variety of urban forms and building patterns, and what is exactly perceived as high or low density is dependent on the context considered (Haaland & Konijnendijk van den Bosch, 2015). For example, the FSI of an area does not contain information about the height of buildings.

General knowledge about the concept of density is relevant for this research, but the shortcomings of the concept of density and density in relation to the urban form will not be elaborated further on. This general knowledge about the concept of density is needed to understand the concept of densification and how is related to urban green space planning. Different ways of densification and how densification processes generally take place in European and Dutch contexts is more relevant and will be elaborated on.

Urban green space planning and densification

Urban densification, or urban intensification, can be defined as ''using land more efficiently and intensifying development and activity'' (Jenks, 2000, p. 242). Intensifying development relates mostly to increasing the built form and intensifying activity relates more to the use of space and how many people use this space (Oxford Brookes University , 1998). In the case of increasing housing within the city it can relate to either of these forms: it can result in increased built form and/or an increased amount of people, depending on the way in which densification took place or the size of the newly introduced (smaller) households. Densification in cities to increase housing generally happens by developing dwellings in areas that were not built-up before (infill development), by transforming a built-up area to housing such as a former industrial area, by adding floors to existing buildings or by replacing low-rise buildings with more compact or high-rise buildings (Haaland & Konijnendijk van den Bosch, 2015).

Evidence is growing that urban green space is disappearing particularly in high-density environments, but Haaland and Konijnendijk van den Bosch (2015) argue that this is a significant problem as well in less dense areas to which Dutch cities can be categorized. One of their findings was that in European cities urban green space decreases particularly due to infill development. The start of these infill developments is often characterized by the clearance of vegetation on the building site. There is little to no (economic) incentive for developers to preserve green and little to no regulations to ensure preservation (Brunner & Cozens, as cited in Haaland & Van den Bosch, 2015). Furthermore, in most cases these new developments are surrounded by a minimal amount of newly developed green space and the green that is developed often merely consists of patches of grass that serve no multi-functional purpose (Beer et al., 2003).

Strategies for alignment

Problems like these can be addressed in different ways. First of all they can be addressed at the root: to prevent loss of green space due to infill development, different ways of densification can be encouraged, such as the discussed alternatives like transformation and replacing buildings with housing in higher densities. The last option could be a plausible strategy in the Netherlands, since 25% of the demand of the 1 million houses is needed to replace housing that needs to be demolished, because they do not meet quality standards anymore (Faessen et al., 2017). What is then built as replacement can be done in compact or high-rise forms, to also integrate some demand of the other 75% that is needed for growth in households and to solve the current shortage on the housing market (Faessen et al., 2017).

Furthermore, when infill development is the chosen method of densification, then preservation and development of green can be stimulated. In the case of the Netherlands several stakeholders can be identified in this. As noted before, the developer is often not (economically) incentivized to preserve green. First of all economic benefits should become clear for developers and be integrated in the exploitation process. The ecosystem services approach could help in improving this (TEEB, 2010; Beer et al., 2003; Costanza et al., 1997). From the side of the municipality regulations and subsidies could be introduced to stimulate green development. These could be aimed at preservation, but also at new development of green. An example is the municipality of The Hague who recently has developed a rating system with green and nature-inclusive measures in/on buildings, in the direct surroundings of buildings and in public space that is aimed at developers and architects. The municipality provides a list of green measures to choose from, for which points can be earned. The score that needs to be achieved depends on the scale and location of a project (Gemeente Den Haag, 2018). Other municipalities, such as Rotterdam, could translate it to the context of their city. Green developments could also be subsidized. This is already happening in the case of green roofs in Rotterdam with 15 euro/m2 (Gemeente Rotterdam, 2019) and could potentially be applied to other measures too.

In literature the early attention to green space in densification processes is emphasized repeatedly (Haaland & Konijnendijk van den Bosch, 2015; Pötz, 2016; Snep & Opdam, 2013). For example Snep and Opdam (2013) explain that these strategies should result in early target setting for green development in the planning, design and development process of densification place. This is important for example regarding the layout of densification development within the city. Once the most important decisions have been taken without early consideration of green space planning and the provided ecosystem services, the constraints of the design will then limit the potential and effectiveness of the green space. One of the undesired effects could be fragmentation of the urban structure, causing low ecosystem service performance as highlighted before. Pötz (2018) additionally emphasizes the necessity for cross-sectoral collaboration, where the stakeholders that have been discussed before and other parties related to advising, planning, designing and financing the development of cities join forces. Pötz has researched these collaborations by setting up 'living labs': sessions where stakeholders come up with solutions together, considering not only their point of view but becoming aware of others' approaches to reach the same goal. With the help of such sessions, common visions can be developed. Other collaboration processes described in literature include citizen participation. Especially with dealing with limited amount of space in densification processes, including the opinion of existing and

new residents to develop urban green spaces that provide desired ecosystem services from their point, can help in increasing acceptance of densification processes (Haaland & Konijnendijk van den Bosch, 2015).

4. Conclusions

This paper was aimed at creating an understanding of (the components of) green space planning in cities and what the challenges and strategies are when combining it with densification processes. It can be concluded that the role of green space planning throughout history has led to urban green spaces lacking from cities today and the development of undervaluation of green space in urban planning (Stache, Jonkers, & Ottelé, 2019). Maximizing land yields is an important argument to not integrate green space, but integrating the ecosystem services approach, where ecosystem services are recognized for their multi-functionality and broad (economic) value, could potentially help in changing this discourse (Costanza et al., 1997; TEEB, 2010). It is not only due to lack of green space, but also due to low quality and fragmentation of existing green space that provided ecosystem services are insufficient. Developing more green space as well as preserving and improving existing green space is essential.

Current densification processes prevent the success of exactly these goals of urban green space planning, particularly through infill development that does not preserve existing green and the limited amount of developed green space is of low quality and mono-functional (Beer, Delshammar, & Schildwacht, 2003). To better align urban green space planning and densification processes a number of strategies have been researched:

- considering alternative ways of densification as opposed to infill development
- making developers and municipalities aware of the ecosystem services approach
- introducing rating systems and subsidies

It is mostly important to emphasize on urban green space planning early on in densification processes through target setting and considering a spatial layout with the best performances in both processes. Furthermore, cross-sectoral collaborations through living labs (Pötz, 2016) and citizen participation (Haaland & Konijnendijk van den Bosch, 2015) can provide valuable input to reach sustainable and accepted thus compact and green urban environments.

Discussion

Due to the broad approach of this paper many components of urban green space planning and densification processes have been researched. As a result, not all components are discussed thoroughly, creating a quite general overview. Some components eventually have also been left out because of this reason. This is a limitation, but also provides a lot of interesting topics for further research. Components from the paper that could be researched further include the ecosystem services approach, more specifically in relation to densification processes for example. Components that have been left out in this research are ownership of green space and more specifically how strategies addressing private green spaces can help in urban green space planning. Including more aspects or focussing on specific aspects can result in very interesting strategies to find the way to alignment in urban green space planning and densification processes.

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APPENDIX 2 TREES AND BIODIVERSITY

LEGEND OF TREES IN ROTTERDAM, COMBINED WITH DATA
FROM VLINDERSTICHTING AND VOGELBESCHERMING

Bomen naar geslacht		Bijen	Vlinders	Hommels	Diversen	Vogels (bes/zaad)	Kleine zoogdieren	Schuil/ nestplaats	
Tilia	Linde	XX	X	XX	XX				←
Fraxinus	Es								
Platanus	Plataan								
Acer	Esdoorn	XX		X	X				←
Populus	Populier								
Salix	Wilg	XX	X	X	XX				←
Prunus	Kers sierkers	X(X)	X	XX	X	XX		X	← !
Aesculus	Paardenkastanje	XX		X	X		X	X	← !
Quercus	Eik					X	XX	X	←
Ulmus	Iep								
Robinia	Acacia (valse acacia	XX		X					
Alnus	Els					XX		X	
Sorbus	Lijsterbes	X	X		X	XX		X	← !
Betula	Berk					XX		X	
Crataegus laevigata/media	Meidoorn	X	X	X	XX	XX		XX	← !
Malus	Appelboom sierappel	XX		X	X	X		X	← !
Pyrus	Perenboom								
Corylus	Hazelaar						XX	X	
Carpinus betulus	Haagbeuk							XX	
Ailanthus altissima	Hemelboom	XX							
Styphnolobium sophora japonica	Honingboom	XX							
Gleditsia triacanthos	Christusdoorn valse	XX			X				
Ginkgo	Gingko								
Pterocarya	Vleugelnoot								
Fagus sylvatica	Beuk					X	XX	XX	←
Liquidambar	Amberboom								
Pinus	Den						XX	XX	
Metasequoia	Soort naaldboom								
Taxodium	Conifeer/cipres								
Magnolia	Magnolia (beverboom)								
Catalpa	Trompetboom	X		X	X				
Juglans	Walnoot								
Overige geslachten									

APPENDIX 3

OVERZICHT NATUURINCLUSIEF BOUWEN EN ONTWERPEN
FROM GEMEENTE AMSTERDAM (2018)

Overzicht natuurinclusief bouwen en ontwerpen