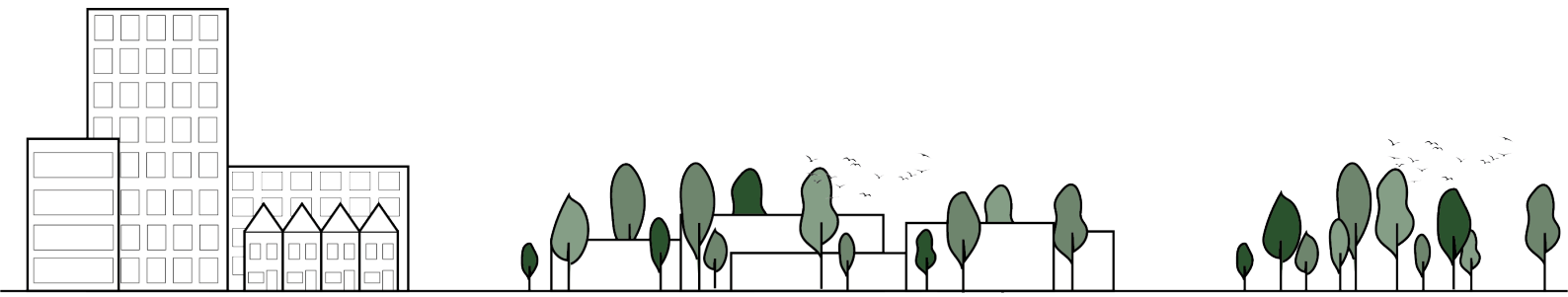
MAKING GREY GREEN

Redesigning business parks as an additional step to bringing back biodiversity in these areas



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PREFACE

This report is the result of the graduation project of the master track Urbanism in the graduation lab Urban ecology and ecocity. In this project, I focused on one of my interests which is the natural environment. Throughout my bachelors and masters, I have always found nature an important aspect that should be taken into consideration in every project. This is why my graduation project is about biodiversity and how to improve this.

ACKNOWLEDGEMENT

First of all, I would like to thank my mentors, Nico and Els, who have helped me through the process of this graduation project. With their enthusiasts and help during the meetings, they have helped me to the finish. Because of the corona, my graduation process went a bit different than it would normally go. The first half-year I had to work from home which makes it difficult to have contact with my fellow students. In this first half-year, Diego helped out with giving structure to the project. Luckily the second half-year I could work on the faculty again and this made a big difference having my peers right next to me. Thank you to all my peers which I could ask questions or with who I could discuss different topics.

Lastly, I would like to thank my roommates and my family who have helped me during this year by having tea breaks at home and motivating me and giving me creative advice even though they all have no background in architecture or designing.

ABSTRACT

Biodiversity is declining worldwide because of population growth and the rising demand for goods. Biodiversity is needed for our ecosystem services which provide us with fresh water and medicine which means people are dependent on a healthy biodiversity. Cities want to greenify to battle the urban heat island effect and the bad water infiltration. If these cities want to connect to nature on the outside of the city there are often business parks situated in between. These Business parks are large grey areas that create a barrier between the green and the city and add onto the urban heat island. To change a business park from a barrier to a corridor there is a need for change. This brings us to the question “What are design tools an urban designer can use to improve biodiversity and human well-being on a business site and how can this be implemented? Using case study location Spaanse Polder.” Twenty design tools have been created to enhance biodiversity and improve human well-being. These tools have been divided into three categories wherein each category biodiversity will be enhanced and human well-being will be improved. These categories are blue, green, and grey. To understand how these tools interact with each other and their surroundings and what effect these tools have they have been implemented on the location site. In conclusion, multiple elements should be taken into consideration if these tools will be implemented. These are combining design tools, effect on different scale levels, the size of the location, and it is still a business park with private properties. By implementing these design tools in the Spaanse Polder the Spaanse Polder will function as a corridor with multiple patches on its site which are connected to the ecological networks instead of the barrier it is now.

KEYWORDS – Biodiversity, human well-being, business parks, ecosystems, corridors, patch, Rotterdam, Spaanse Polder.

MOTIVATION

Figure 1. Own image

"We are so fond of being out in nature because it has no opinion of us"

(Friedrich Nietzsche)

I like this quote or Friedrich because I feel like this when I am in nature. When I go out into nature I feel at peace with myself. This is also why I wanted to do a graduation project which had a focus on the natural environment.

My parents always told me to go play outside and explore the outdoors. And only now I see the value of all the time I have spent outside in my childhood. From climbing trees to running through cornfields and finding insects under a stone, I have seen the variety of nature or actually just a fraction of the variety there is on Earth.

I grew up in a place where there was always a lot of nature around me. But when I moved to the city I got to know that stepping out of your house right into an area that is rich in green is not the norm. I have always loved to be in nature and enjoyed the plants and trees when they were in full bloom and to see all the animals being busy with their daily chores. But now there is a decrease in our biodiversity and we see our nature being cut down and replaced with buildings and agriculture. And because we rely on biodiversity for not only the enjoyment of nature but also for products like food, materials and medicine I want to find a way to bring back nature into the city and its surrounding areas (Millennium Ecosystem Assessment, 2005a).

During the time I have lived in the city, I noticed 2 things. These are the floodings in the city when there has been heavy rainfall for multiple days and there is the urban heat island. This is because in the city there is more concrete than there is green. The water can not infiltrate into the ground anymore and when there is heavy rainfall it will overflow from the sewer system. The sunlight is absorbed by the concrete which will make it very hot in the city. If you add more green in the city the heat can not be absorbed that easily anymore and the water can infiltrate into the ground.

Next to the fact I have seen what the lack of green does to a city I also saw the documentary of David Attenborough: A life on our planet. Which showed alarming numbers of the decline of our ecosystem and our biodiversity. He did give some reassurance that if we took good care of nature it could bounce back and repair itself, but this means we as humans need to do something to change our way of living and our built environment.

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1

INTRODUCTION

In this chapter, a first introduction to the thesis and the challenges we face are introduced. These challenges go from a global scale to the scale of the Netherlands. Firstly, it will start with the decline of biodiversity we see happening in the world. Secondly in the context of the Netherlands, the biodiversity decline together with the densification followed by the business sites. Lastly, this chapter will end with the problem field and the problem statement of this thesis.

Figure 2 DebraLee Wiseberg (n.d)

1.1 BIODIVERSITY

BIODIVERSITY UNDER THREAT

Our biodiversity is declining worldwide and one of the main reasons for the decline is population growth and the rising demand for goods (Millennium Ecosystem Assessment, 2003; Laverty et al., 2008). The variety of plants and animals are shrinking which makes the ecosystems more fragile for changes (UN Report). More and more animals are being added to the IUCN Red List from the 138.300 species on the list more than 38.500 species are being threatened with extinction (Background and History, 2021). This loss of biodiversity poses a real threat to our ecosystem which helps provide us with our ecosystem services which are important for our economy and our well-being (Summers et al., 2018). This means biodiversity is a key element that we need to protect and try to bring back. A step has been made by the United Nation who have created the 17 sustainable development goals. Goal number 15 states that they want a halt on biodiversity loss together with the halt and reverse of land degradation, the protection and the restoration of terrestrial ecosystems, the promotion of sustainable use, and the combat of densification (Sustainable Development Goals, n.d.).

There are five reasons which cause biodiversity loss next to the growing population and the rising demand for goods these are; habitat destruction, invasive species, overexploitation, pollution, and climate change (Laverty et al., 2008; Millennium Ecosystem Assessment, 2005b). These reasons will be explained how they cause biodiversity loss.

HABITAT DESTRUCTION

A habitat is a space which has all the environmental needs a certain species need to survive in (National Geographic Society, 2012b). These habitats can be split up because of agriculture and the construction of roads. Habitats consist of an interior habitat and an edge habitat where different species live. If a road will be placed through an existing habitat this is called habitat fragmentation because the habitat is split which has as a result a smaller habitat which can have as an effect the loss of certain species that needed a larger habitat (Millennium Ecosystem Assessment, 2005b). There should be green infrastructures that connect these habitats to enhance biodiversity which stretches from the urban areas all the way to the surrounding countrysides (Gill et al., 2007).

INVASIVE SPECIES

Planting or growing invasive alien species can have an enormous effect on the local habitat. These invasive species can bring diseases with them or will be competitors to the local species (Millennium Ecosystem Assessment, 2005b). Because travelling has become very easy the transportation of species around the world has also become easier. This is also the reason you are not allowed to bring species with you on a plane to an island because they do not want invasive species that can compete with their native species.

OVEREXPLOITATION

Overexploitation is happening because we are taking more resources than the earth can reproduce for us. But not only the natural resources are taken in large amounts animals are also hunted to the brink of extinction or they have even been completely extinct (Millennium Ecosystem Assessment, 2005b). The losses of these species and resources can have an ecological impact which can affect food security (Millennium Ecosystem Assessment, 2005b).

Figure 4. Spatial fragmentation
(Rijkswaterstaat, n.d.)

Figure 3. Overexploitation
(Conserve energy future, n.d.)

POLLUTION

One of the main polluters is carbon dioxide and greenhouse gasses but McNeely (1992) has listed five other pollutants; pesticides, acid deposition, the effect of CFC's, heavy metals, and plastic. Plastic is a common polluter we hear about in the news when a lot of plastic is found in the ocean and animals die because they get stuck on plastic or they get plastic in their belly.

CLIMATE CHANGE

Climate change is a phenomenon that is happening globally. Climate change has a lot of effect on the planet and on the environment. The main reasons for climate change are a large amount of CO2 emission from factories, our cars and together with the deforesting, these CO2 gasses alter the atmosphere (Hardy, 2003). Our planet is heating up and the sea level is rising because of the melting ice caps, more natural disasters, and there are more extremes in the weather like extreme rainfall, together with the densification, which causes floods. With the rising temperature and heatwaves, the cities are getting hotter.

All these reasons and the effects they have on the environment can be seen on every continent and at every scale level. Because this thesis is in the context of the Netherlands it is good to know what the situation is there.

Figure 5. Pollution
(Edie, 2020)

Figure 6. Flooding in the Netherlands
(ANP, 2016)

BIODIVERSITY IN THE NETHERLANDS

The landscape of the Netherlands consists of a lot of “green” space. Under “green” space falls; agriculture, forest, open natural terrain, and recreation space which is around 68% of the total surface of the Netherlands, where most of this green is agriculture (CBS, 2016). A lot of the land in the Netherlands is used for agriculture which makes the land look a bit like a “lappendeken” if you look from a plane down to the ground. Because of this intensive use of the land, the land has been fragmented where habitats have been cut into pieces which result in the loss of biodiversity. At the moment there is only 15% left of the original plants- and animal species that there were in 1900 (Birger, 2020). This is mostly because of land-use changes, habitat fragmentation, and environmental pressure (PBL & WUR, 2008).

In figure 7 the loss of biodiversity is shown for the world, Europa, and the Netherlands, as can be seen, is the Netherlands doing the worst in losing its biodiversity in comparison to the world. The biodiversity in this figure is measured through Mean Species Abundance (MSA) which shows a percentage of the original populations of plants and animals which is left (Begrenzing van Het Natuurnetwerk En de Natura 2000-Gebieden, 2017).

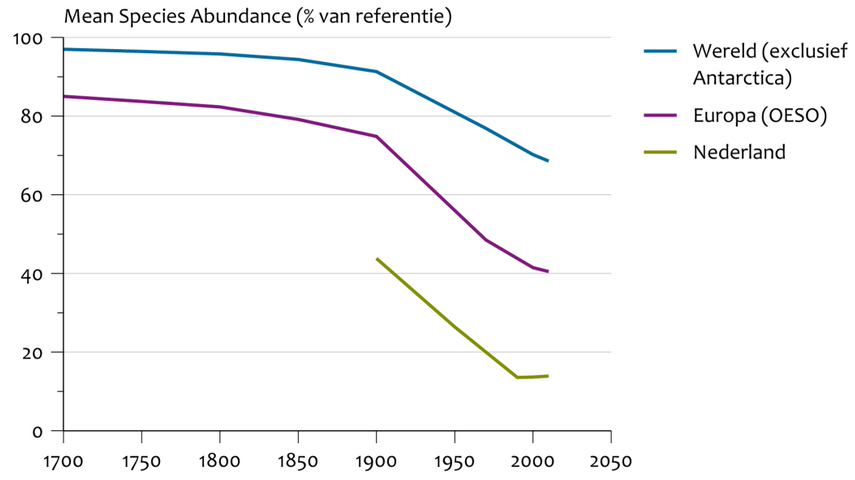


Figure 7. Decline in biodiversity
(Staat van instandhouding EU-soorten en habitattypen (2020), 2014)

Figure 8. Lappendeken
(Jan Adelaar, n.d.)

NATURA-2000

Because biodiversity loss is a global problem that needs to be tackled nationally and internationally in 1990 there was a nature policy made to improve this by connecting habitats with the Ecologische Hoofdstructuur (EHS) this name has changed in 2013 to Natuurnetwerk Nederland (NNN) in the Netherlands (Missler, 2020). The EHS was a frontrunner to the Natura 2000 network for threatened and rare species and habitats which stretches across 27 EU countries (Begrenzing van Het Natuurnetwerk En de Natura 2000-Gebieden, 2017). In the nature pact, it is agreed that in the period of 2011-2027 a minimum of 80.000 hectares of new nature should be added in the Netherlands to realise the nature network (Natuurnetwerk Nederland (2027), 2020). But how is this going till now? In 2020 the progress for the nature networks are disappointing, provinces are not doing enough to meet the requirements to improve their nature (Haas, 2020). In figure 9 the areas of NNN and the Natura 2000 are shown and the areas which are overlapping. As can be seen in the figure is that there is quite some overlap between the NNN areas and the Natura 2000.

Figure 9. Natura 2000 and the NNN areas in the Netherlands
(Begrenzing van Het Natuurnetwerk En de Natura 2000-Gebieden, 2017)

1.2 URBAN DENSIFICATION

Cities have been growing for a long time already, where more and more nature had to make place for the built environment. In image 11 there is a series of maps through time from 1950 to 2020 where Rotterdam, Delft, and The Hague can be seen and how these cities have grown. This densification of the cities is happening because our population is growing, the composition of households is changing, and people want to live in the cities because it is close to their work, historical monuments and cultural heritage (Broitman, & Koomen, 2019). As seen in the news there is a demand for housing in the Netherlands, right now there is a housing shortage of 300.000 according to onderzoeksbureau ABF Research (NOS, 2021). This means more houses need to be built and this most likely also means more of the natural environment has to make space for the built environment. This brings some negative effects like the loss of productive agricultural land, the destruction of biotopes and habitats, and the decline of ecosystem services (Pelczynski, & Tomkowicz, 2019). About 13% of the land in the Netherlands is part of the built environment, 68% is used for green space and the remaining 19% is water (CBS, 2016). 13% build environment consists of build terrains and infrastructure. Urban densification will happen but the way we will build these densified areas can be done with a green backbone. But also the already urban areas can be redesigned into areas that are rich in biodiversity and are connected to the ecological structures of the NNN.

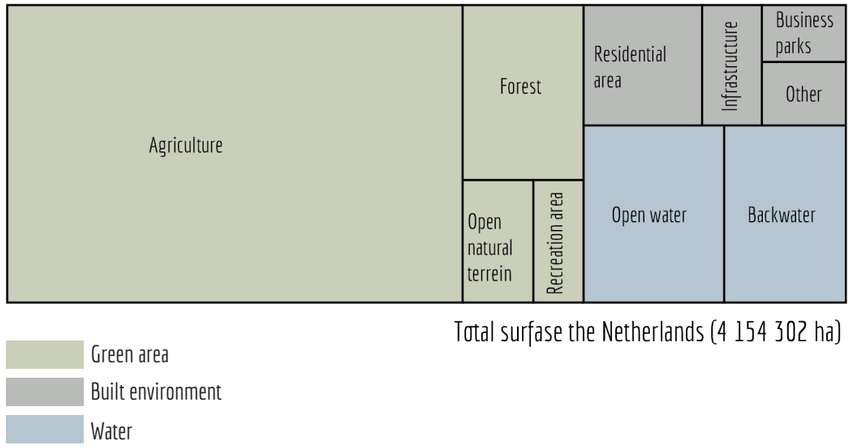


Figure 10 Bodemgebruik in Nederland 2012
(CBS, 2016)

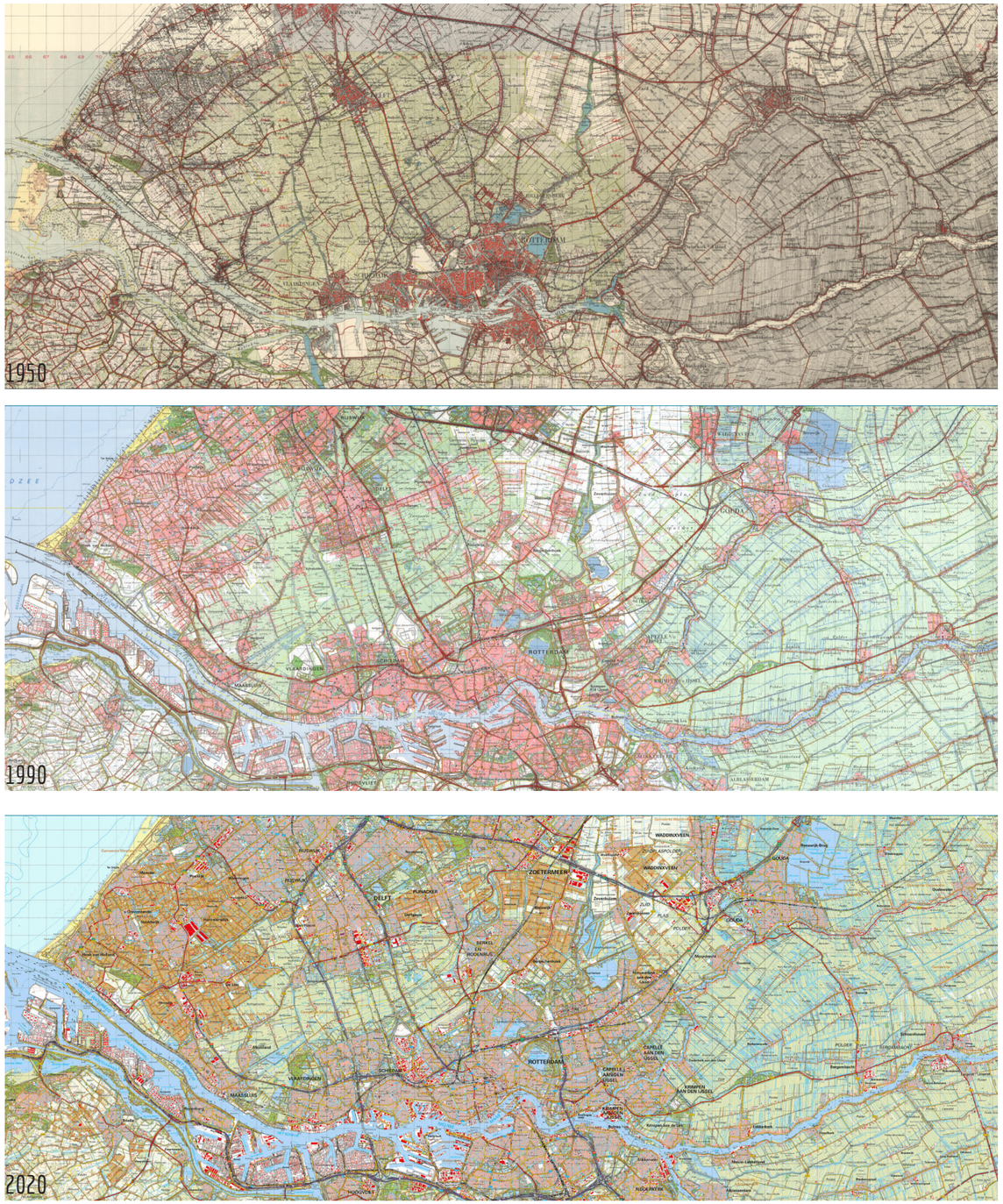


Figure 11 Time travel
(Topo tijdrijs, n.d.)

PRESSURE ON NATURE

Since the coronavirus the pressure on nature has gone up. More people went outside into our nature reserves which had negative effects on this nature with noise pollution, people leaving their trash, and damage people bring to this nature (Maas, 2020). People not only looked for the larger nature reserves but also looked for parks closer to their homes which meant that the city parks where also used a lot even to the point that some parks had to be cleared of the people. This meant the pressure on these areas went up. For a healthy environment in an urban area the availability of green is necessary not only for recreation for the people but also to lower the urban heat island and to improve the water infiltrations. Because we will experience more extremes in the weather from heatwaves to extreme rainfalls. this is why in the coming years the cities in South Holland need to greenify to tackle the urban heat island and to improve the biodiversity and the water infiltration (Koelewijn, 2021).

Figure 12 (Straver, 2020)

Figure 13 (NOS, 2021c)

Figure 15 (rtl nieuws, 2021)

Figure 14 (Verbunt & Oosterom, 2021)

Figure 17 (De Wit, 2021)

Figure 16 (NU.nl, 2021)

1.3 BUSINESS PARKS

If you think about a business park often your first thought would go to an area with large buildings where trucks come and go. You would not think of a green area where there is a lot of biodiversity. This is probably also because most of the business sites have not been built with attention to their appearance or their life span (Snep, 2009).

From 1920 new spatial planning concepts consisted of function separation this meant working and living were separated (Snep, 2009). Because business parks need a good connection with the infrastructure they were placed close to the highways and waterways on the border of the cities separated from the living functions, also because they were seen as polluters they had to be placed as far away from where people lived (van Velzen, 2019; Snep, 2009). Throughout the years more business parks were built and now these business parks take up about 2,5% of the surface in the Netherlands which is around 100.000 hectares (Bedrijventerreinen op de schop, 2021; CBS, 2016). From the total amount of the built environment in the Netherlands (13%) the 2,5% is a pretty large percentage (CBS, 2016).

At these business parks, it is mostly about profit and production. It is not that surprising that these business parks, harbours, and industries are of great importance for the economy of the Netherlands, it creates about 30% of the jobs (van Velzen, 2019). And because most people work between 32 and 40 hours per week this means a lot of people spend a lot of time on these business parks.

Because these business parks were placed at the border of the city they often form a barrier for the city and the nature which is on the other side of the business site. This nature can be agricultural land but it can also be a forest or a protected nature reserve.

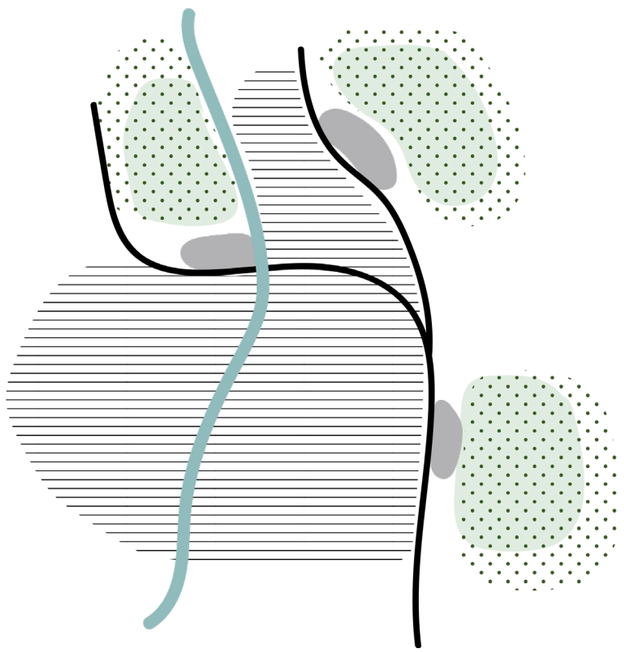


Figure 18 Placing of business park at the border of the city creating a barrier between the green and the city (own image)

Figure 19 Business parks in theNetherlands (Qgis eddited by author)

NATURE ON BUSINESS PARKS

Even though the business sites are grey areas there are still species that find these spaces good habitats. Flat roofs that have gravel on them are attractive nesting spaces for the Eurasian Oystercatcher (Scholekster) and spaces like brownfields are good spaces where Pluimraket (grijze mosterd) can grow (Gemeente Rotterdam, 2014). For species which like the silence in the evening after all the people have gone home it is very quiet on these locations because there is no housing or eventing spaces where people could go to.

As Robbert Snep has said Nobody would go to a business site for fun ('Niemand gaat nu voor de lol een bedrijventerrein op, 2021). These business sites are often enormous areas which are situated in between the city and nature reserve. In the Netherlands there are at least 500 business parks which are located next to a nature reserve ('Niemand gaat nu voor de lol een bedrijventerrein op, 2021). Now function these business sites as barriers but they could also be redesigned into a corridor and make it a place for people to go to for fun.

Figure 21 Grijze mosterd
(Grijze mosterd, n.d.)

Figure 20 Scholekster
(De Vries, n.d.)

HEATLY WORK ENVIRONMENT

A lot of the time people have is spend at work. This is why it is important to have a healthy work enironment not only inside the building buit also outside. The Dutch institute of sport and movement wants to promote everyone to take a lunch walk of at least 30 minutes for at least five days a week (Rombout, 2009). Going outside into the fresh air is healty for you not only for the movement but also for your mental healty and you will get new energy (Rombout, 2009).

There already initiatives like an app "ommetje" which promotes people to go for a walk every day and where you can share this with your colleagues. But if people are stimulated to go outside for a walk the location should also be inviting to go for a walk. If the compony is located next to a large park people will be stimulated to go outside but if the compony is located in a business site which is mostly grey this is not inviting to go outside for a walk.

TYPOLOGIES OF BUSINESS PARKS

There are different typologies of business parks but a definition of a business park in this thesis is "A site that because of its location is suitable for trade, business, commercial and non-commercial services and industry." (Wat zijn bedrijventerreinen, n.d.). In this definition business parks are not only defined as offices but there can also be different kinds of industry. In this thesis, there are five different types of business parks identified. Next to these five types of business parks, there are also the environmental categories. The environmental categories go from 0 to 6 where 0 has the least environmental pressure and 6 has the most (Bedrijven en milieuzonering, n.d.).

The five different types of business parks are (wat zijn bedrijventerreinen, n.d.):

- Heavy industry
- Harbours
- Mixed-use
- Distribution
- High tech

Heavy industry is a location where all different industry is allowed even the industries which have an environmental category of 5 or higher. Harbour is a site where large boats can load or unload their cargo. Mixed-use is a mix of different activities in business but with an environmental category not higher than 4. Distribution areas are locations that are specifically intended for transport and distribution. High tech campuses are mostly businesses that are in the IT industry.

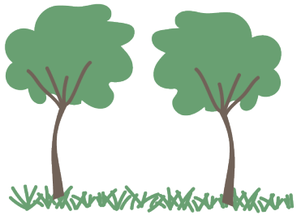
These five different types of business parks also have a different distribution of green available on their sites. Where heavy industry often has a little to nothing of green on their sites, have high tech business parks sometimes entire parks on their sites. For instance, the high tech campus of Eindhoven has made it its mission to be the Europa greenest campus (Sustainability Roadmap 2025, n.d.).

Because these different business site typologies all have very different aspects this thesis will only focus on the mixed-use typology.

HEAVY INDUSTRY

HARBOURS

MIXED-USE



DISTRIBUTION

HIGH TECH

Figure 23 Heavy industry
(Ajot, n.d.)

Figure 22 Harbours
(Haven van Rotterdam, 2017)

Figure 24 Mixed-use
(Plan viewer, n.d.)

Figure 26 Distribution
(ANP, n.d.)

Figure 25 High tech
(Emerce, n.d.)

1.4 CONCLUSION

The context of the thesis is very clear, the decline of biodiversity is mainly because of the population growth and rising demand for resources which cause densification and habitat destruction. But there are also other reasons for biodiversity decline like pollution, invasive species or habitat destruction.

Business parks are often situated at the border of the city between the city and the green. This green can be a nature reserve but this can also be agriculture. These business parks are large grey areas where people do not go for fun but to go to work. There is limited green available in the business parks and they form a barrier between the city and the nature reserve.

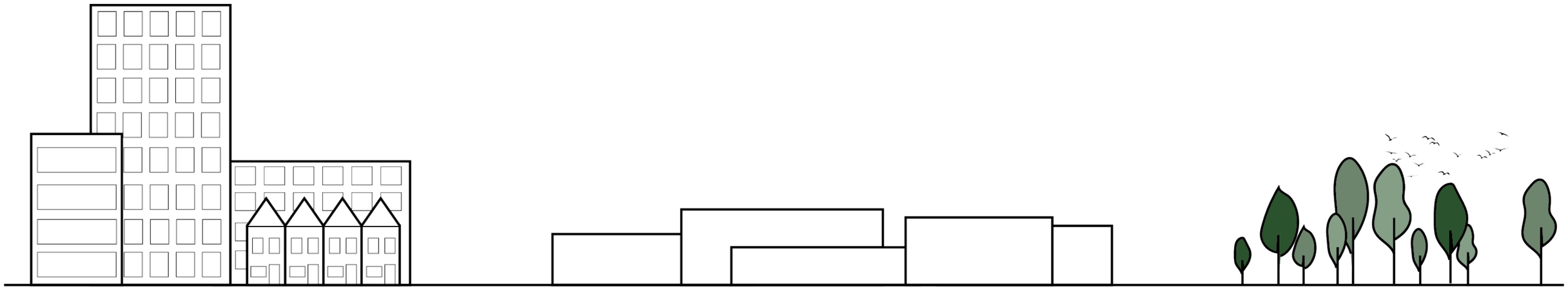
1.5 PROBLEM FIELD

Now the context has been explained together with all the problems which follow.

PROBLEM FIELD
Our population is growing, the demand for resources is rising and with this our cities are densifying and biodiversity is declining. Together with the densification there are business parks which are large grey areas that add onto the urban heat island and the floodings and which form barriers for the city and the green areas.

From this problem field which has been sketched the problem statement for this thesis can be written down.

PROBLEM STATEMENT
Business parks are not designed with the purpose of being a green park, there is only limited green which does not add to biodiversity. These business parks are now grey barriers for the city and the green.



CHAPTER 2

THEORY

Knowing how to tackle the problem statement there is first a need to understand what biodiversity is and why we need biodiversity. Biodiversity plays a lead role in this thesis so in this chapter biodiversity will be explained. Not only will be explained what biodiversity is and why we need it but also its connection to the ecosystem services and our human well-being. In this chapter the sub-question *"What is biodiversity and human well-being and how are they connected?"* will be answered. This chapter will end with principles for biodiversity and human well-being which will be used to give a score to the design tools.

Figure 27 WUR (n.d.)

2.1 BIODIVERSITY

WHAT IS BIODIVERSITY?

There are two environmental crises which are climate change and biodiversity loss but in literature and in the news climate changes has gotten more attention in comparison to biodiversity (Legagneux et al., 2018). Even though the amount of papers and attention is higher for climate change the number of researches has gone up from 1996 till 2016 for biodiversity which means this subject is getting more attention (Legagneux et al., 2018). But what is this biodiversity and why is it important for us?

"Biodiversity is the variety of life on Earth at all its levels, from genes to ecosystems, and the ecological and evolutionary processes that sustain it."

(Laverty et al., 2008, pp. 2)

Biodiversity is a very complex system because it goes through many scale levels from genes to entire ecosystems. Having a lot of species is part of biodiversity but there is still a lot unknown about the different species on Earth, it is estimated that between 5 million to 30 million species have not been discovered yet (Millennium Ecosystem Assessment, 2005b).

As mentioned goes biodiversity through different scale levels from genes to entire ecosystems. To understand a bit how biodiversity works the different scale levels will be explained and how they have diversity in them. To begin with, the smallest level is the genetic diversity which is ultimately responsible for the variation of the individuals of a species (Laverty et al., 2008). Genetic variation is important for the adaptability of a species, for instance, because of climate change the climate can change which means species need to be adaptable to these different circumstances (Millennium Ecosystem Assessment, 2005b). If every species would have the same genetic code and the climate would change drastically the possibility of extinction of the species would be larger in comparison to some species that would have a different genetic code that is more resilient to the different climate. The next levels are the communities and ecosystems where the relationship between the different species and their environments is important. Where ecosystems come in all different sizes from the pond in the back yard to the coral reefs (Millennium Ecosystem Assessment, 2005b). An ecosystem contains not only the living elements but also the non-living like rocks and temperature (National Geographic Society, 2012a). The largest level of the hierarchy is the biomes like; grassland, deserts, and savanna where different communities live. In these biomes, there is a broad representation of different habitats and the different types of vegetation that span across large areas (Millennium Ecosystem Assessment, 2005b). This hierarchy of biodiversity gives a basic understanding of how biodiversity at the smallest level is connected to the largest level of biomes. And where there is a variety of life in all these different levels (Noss et al., 1994).

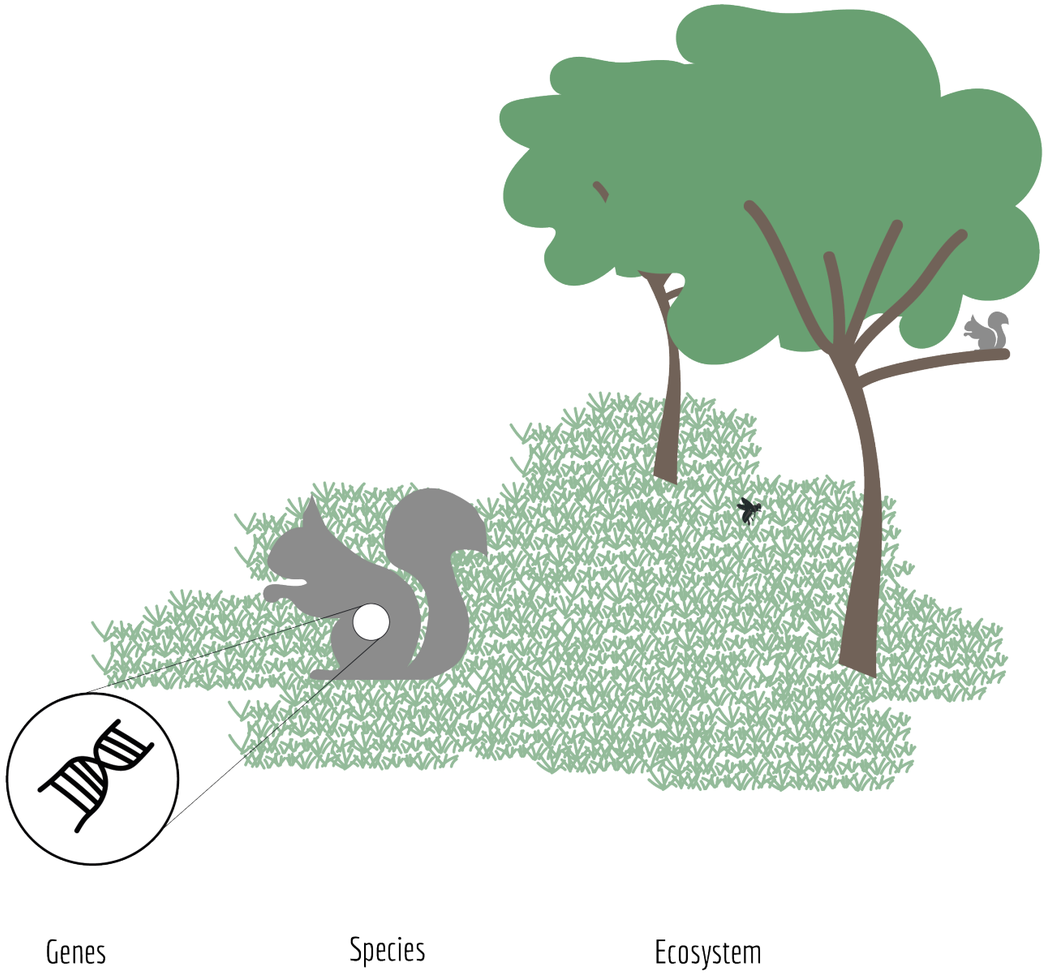


Figure 28 Hierargy of biodiversity (own image)

WHAT IS NEEDED TO HAVE RICH BIODIVERSITY?

Now it is clear what biodiversity is and that biodiversity is going through many scale levels the next question is to know what healthy biodiversity is. In chapter 1 it was explained that biodiversity is under threat because of multiple reasons like habitat destruction and climate change. Miller & Spoolman (2017) identified four components that are needed to have healthy biodiversity.

- Species diversity
- Genetic diversity
- Functional diversity
- Ecological diversity

Species diversity is the number and abundance of different kinds of species in an ecosystem (Miller & Spoolman, 2017). The number is the species richness like different kinds of species. The abundance is the species evenness, this is the distribution of the different species. This could mean you could have a large number of different species in an area but the evenness could be all of that of 1 of these pieces there are 100 and another species there is only 1. Both the number and abundance need to be diverse. Genetic diversity is the variety of the genetic material within a species or population (Miller & Spoolman, 2017). Having a large genetic diversity within species makes them more resistant to environmental changes. Ecological diversity is the diversity of different biomes there are in the world like wetlands, forests, rivers or desserts (Miller & Spoolman, 2017). Where in these biomes different kinds of species live because of the climate and availability of flora. Functional diversity is the diversity of different energy flows within an ecosystem (Miller & Spoolman, 2017). The greater the biological diversity there is in an ecosystem that also makes it more resilient to change.

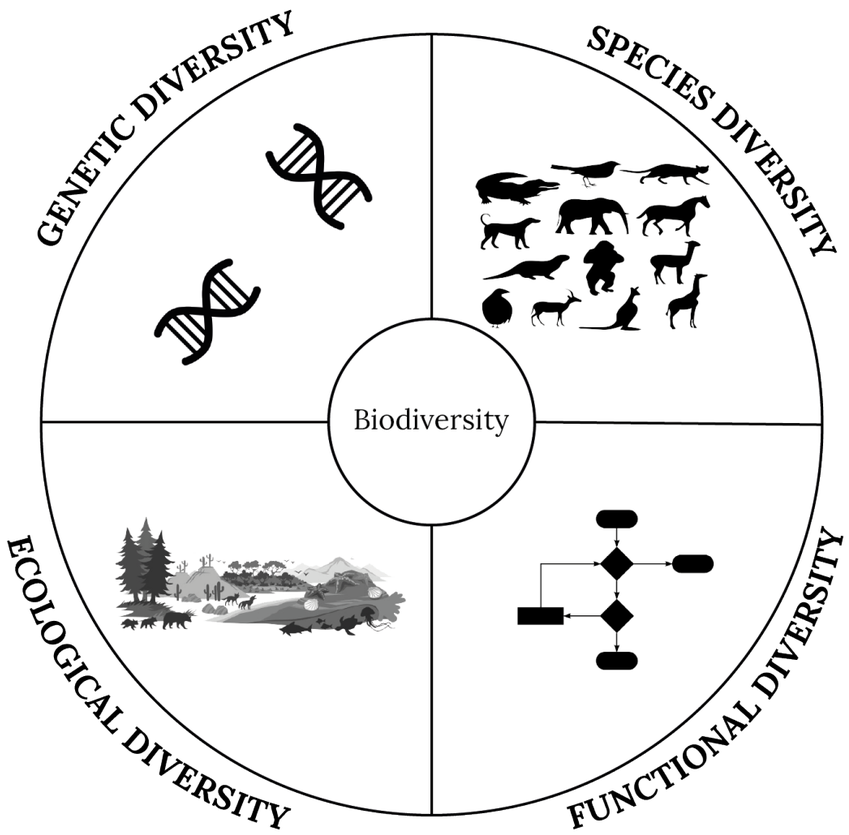


Figure 29 Biodiversity components (own image derived from Miller & Spoolman)

HOW CAN WE BRING BACK BIODIVERSITY?

As mentioned in the previous chapter biodiversity is declining but how can the biodiversity be brought back? To enhance biodiversity an important aspect is to connect habitats and ecological networks from a small scale to the networks on the larger scale which stretches from the countrysides to the urban areas (Gill et al., 2007). This can be done through corridors, these corridors should connect the green areas to each other (De Montis et al., 2016). For this, the patch - corridor - matrix strategy could be used.

It is known that only designing small pieces of land leads to the fragmentation of the landscape which is not good for the ecological network (Dramstad et al., 1996). This is why the patch - corridor - matrix model has been introduced which is built upon many different principles. The patch - corridor - matrix model can be used in any type of landscape and shows the ecological functioning in that landscape. The landscape can vary from the desert to an urban area (Dramstad et al., 1996). So what are the different elements of the patch - corridor - matrix?

A patch or a habitat is an area that holds specific properties where different species live. A patch can come in many different sizes from an entire forest to only a single tree (Dramstad et al., 1996). The number of patches can differ in a landscape and the placement of these patches can also vary (Dramstad et al., 1996). Every patch has an edge or a boundary these areas contain very different species than in the heart of the patch (Dramstad et al., 1996).

Corridors are the natural connections between different patches. Through these corridors animals can move from one patch to another patch. Stepping stones are a form of corridors these are smaller patches between larger patches that can be used by animals as stepping stones (Dramstad et al., 1996). If stepping stones are used to create a corridor it is important to know which species will make use of the corridor because different species need different distances between stepping stones (Dramstad et al., 1996).

And lastly, the matrix is the background in which the patches and corridors are placed. A matrix can be consistent out of all different types of landscapes and be in different scale levels.

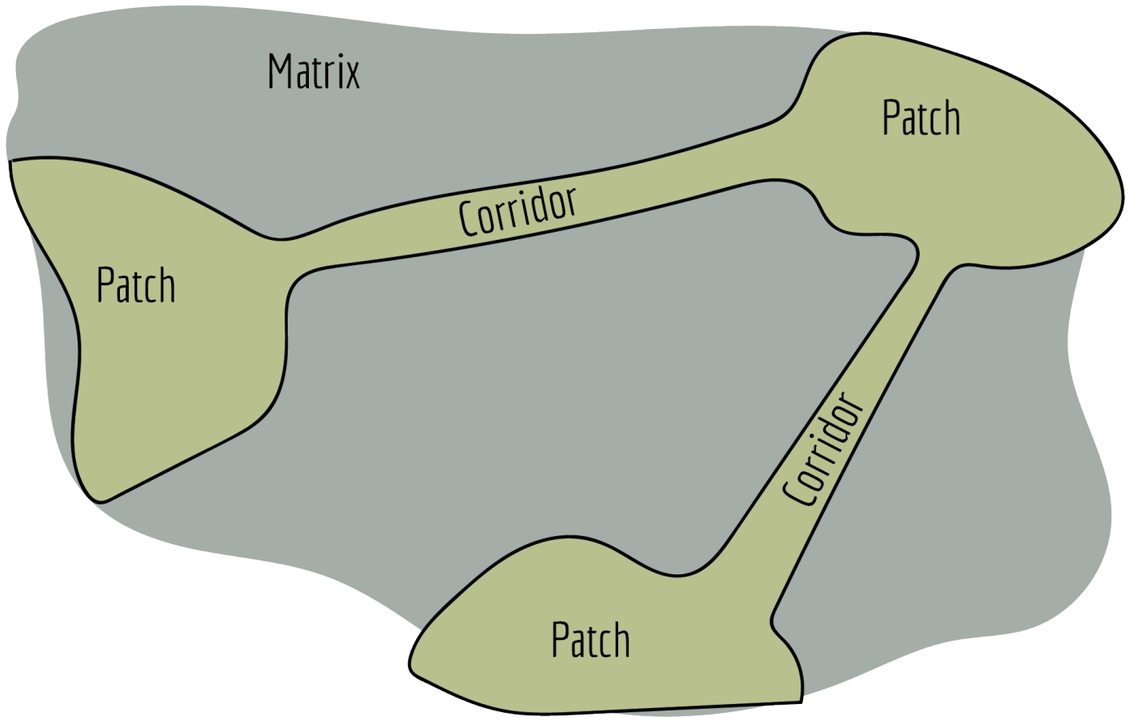


Figure 30 Patch-Matrix-Corridor scheme (Own image derived from Dramstad et al., 1996)

2.2 ECOSYSTEM SERVICES AND HUMAN WELL-BEING

ECOSYSTEM SERVICES

There are many different ecosystems in the world that are connected to each other and can vary in size (National Geographic Society, 2012a). "An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit and humans are an integral part of this ecosystem" (Millennium Ecosystem Assessment. (2005b) pp. 27).

"An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit and humans are an integral part of this ecosystem"

(Millennium Ecosystem Assessment. (2005b) pp. 27).

Our freshwater, the medicine at the pharmacy, and the wooden closet in the living room and other services are all benefits humans obtain from the ecosystem and are called the ecosystem services (Millennium Ecosystem Assessment, 2003).

The Millennium Ecosystem Assessment identified 4 different services which the ecosystem provides for us (Millennium Ecosystem Assessment, 2005a). The first service is the supporting services where we have the nutrition cycle and the soil formation. This service is mainly the support of the other services. The second service is the provision service which provides us with food, medicine, and freshwater. The third service is the regulating services like the purification of water or the climate regulation. The last service is the cultural service which includes recreation, and education. All these ecosystem services are linked to constitutes of human well-bing.

It is important to use the ecosystem services on a sustainable way because taking too much of the ecosystem can cause the decline of biodiversity. And the decline of biodiversity can cause a disruption of the ecosystems.

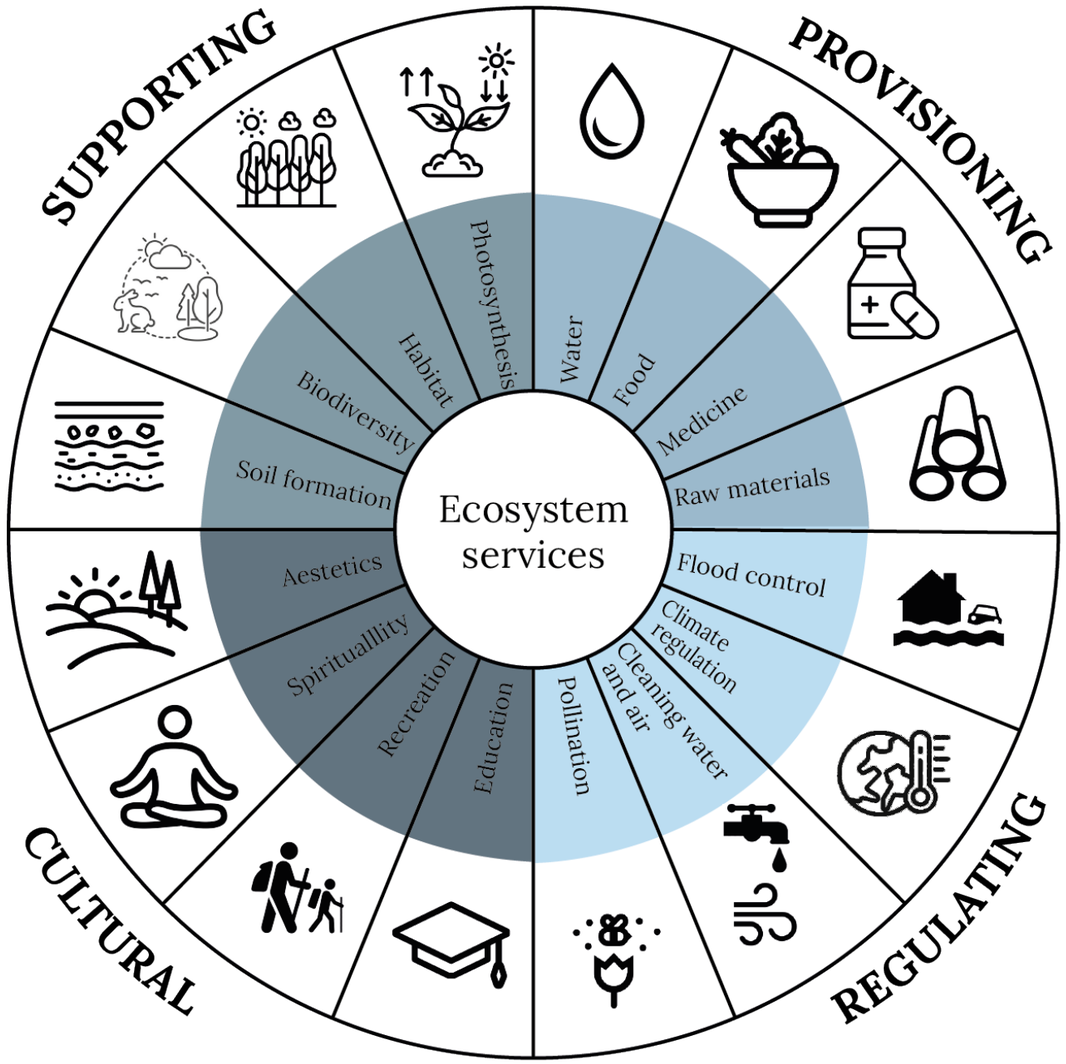


Figure 31 Ecosystem services (own image derived from Millennium Ecosystem Assessment2005a)

HUMAN WELL-BEING

It has already been mentioned that the ecosystem services provide for our human well-being but what is human-well being? Human well-being is the thoughts and feelings of a person about how they are doing in life, the material possession they have and the social relationships which can help in achieving their goals (Ashton et al., 2013).

Human well-being is perceived differently by people around the world but can be measured by the five constituents meantiond.

(Millennium Ecosystem Assessment, 2003)

Because human well-being is often based on how people are feeling and because well-being is perceived differently by people around the world it is difficult to measure this (Millennium Ecosystem Assessment, 2003). But this does not stop people from trying to measure human well-being. Well-being is measured in combination of facts and figures like the Gross Domestic Product (GDP) where occupation, housing, and wealth together with the quality of life indicators like employment, education, personal security, social connections, health, and environmental quality and from these facts and figures an idea of the human well-being can be given (Ashton et al., 2013).

As the Millennium Ecosystem Assesment (2003) has described that human well-being is connected to the ecosystem services they have five constitutes which are important for human well-being. They are; good social relations, health, security, freedom of choice and action, and basic material for good life. For this thesis only the first three constitutes will be used because they also match with the quality of life indicators.

Having good social relations is important for your well-being. Having a lack of social relations has a negative effect on our well-being as also can be seen with the social distancing during corona time (Umberson & Karas Montez, 2010). For security you have personal safety and safe from natural disasters. And lastly health which is divided into physical health and mental health.

As mentioned above our human well-being is linked to the ecosystem services which is linked to biodiversity. Kaplan & Kaplan (2011) explain that the natural environment also plays a direct role in human well-being. Where being in nature gives us a break from our daily routines and where nature contains aesthetically pleasing stimuli which help to take the mind of these daily routines and are good for our health (van den Berg et al., 2007). Having nature near is healthy for humans.

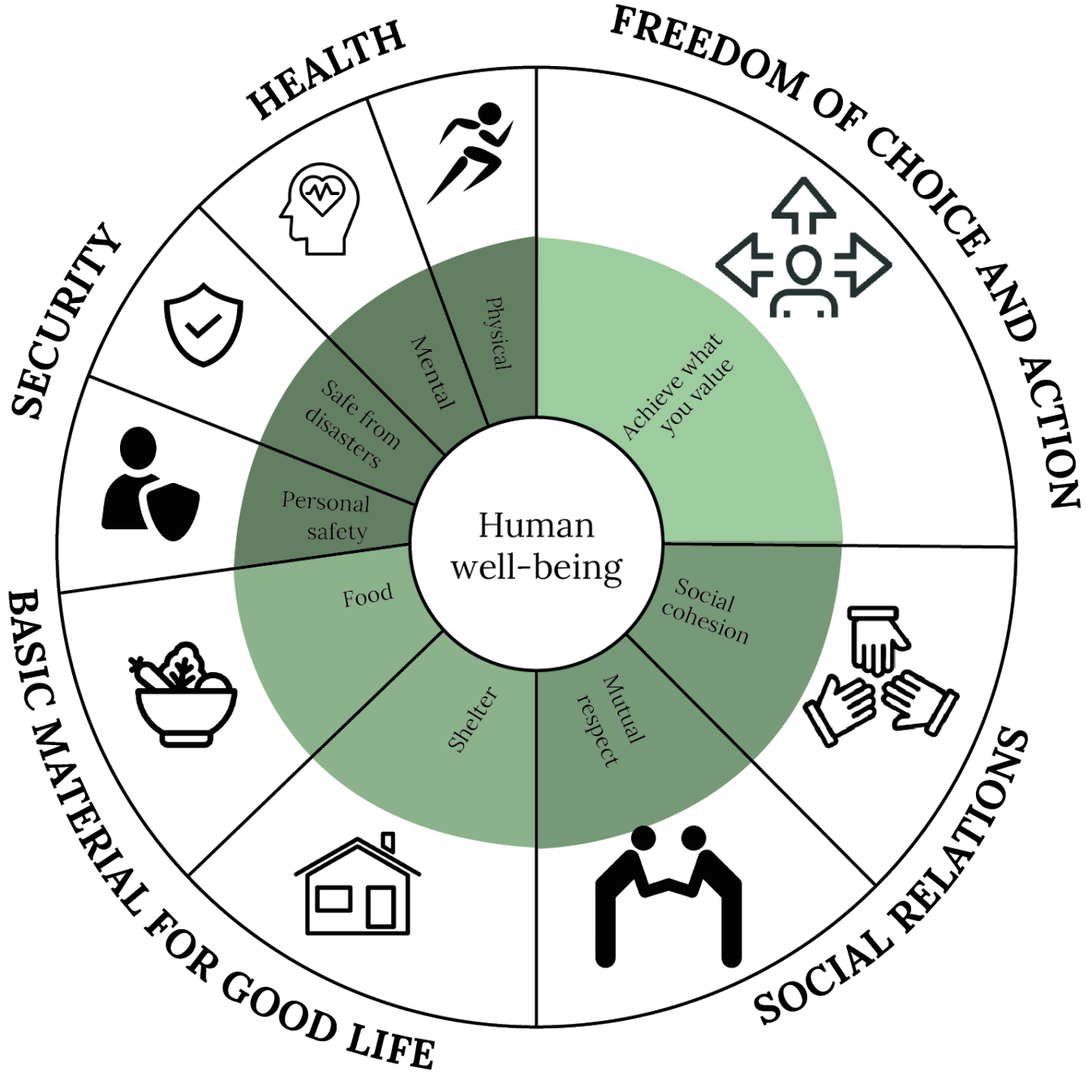


Figure 32 Human well-being (own image derived from Millennium Ecosystem Assesment (2003) & Ashton et al., (2013)

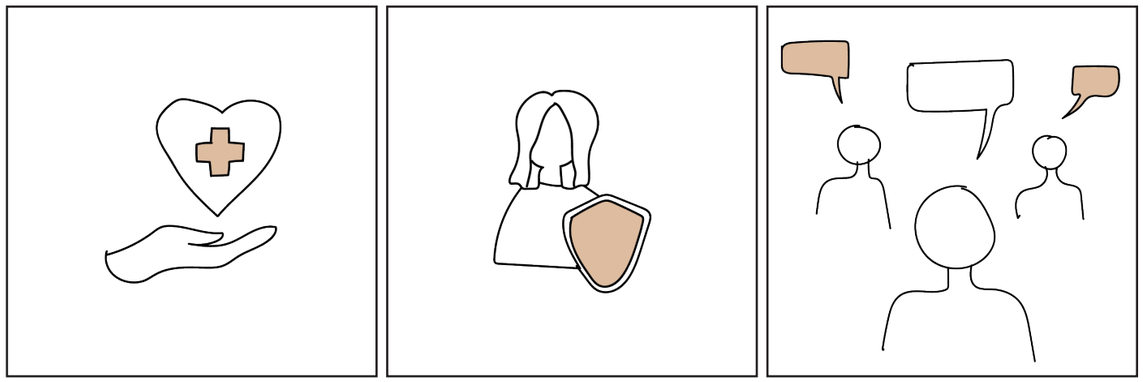
2.3 CONCLUSION

Having healthy biodiversity is important not only for human well-being but also for our nature. And because biodiversity is declining there is a need for redesigning urban areas to enhance biodiversity. To answer the question “What is biodiversity and human well-being and how are they connected?” we first start with the definition of biodiversity. “Biodiversity is the variety of life on Earth at all its levels, from genes to ecosystems, and the ecological and evolutionary processes that sustain it.” (Laverty et al., 2008, pp. 2). This means biodiversity goes through many different levels. Secondly, what is human well-being, human well-being are the thoughts and feelings someone has about how they are doing in life, meaning the possessions they have and the social relations they have (Ashton et al., 2013). But this human well-being is perceived very differently around the world (Millennium Ecosystem Assessment, 2003).

How are biodiversity and human well-being connected to each other? This is because biodiversity provides for the ecosystem and from this ecosystem people obtain benefits which are the ecosystem services (Millennium Ecosystem Assessment, 2003).

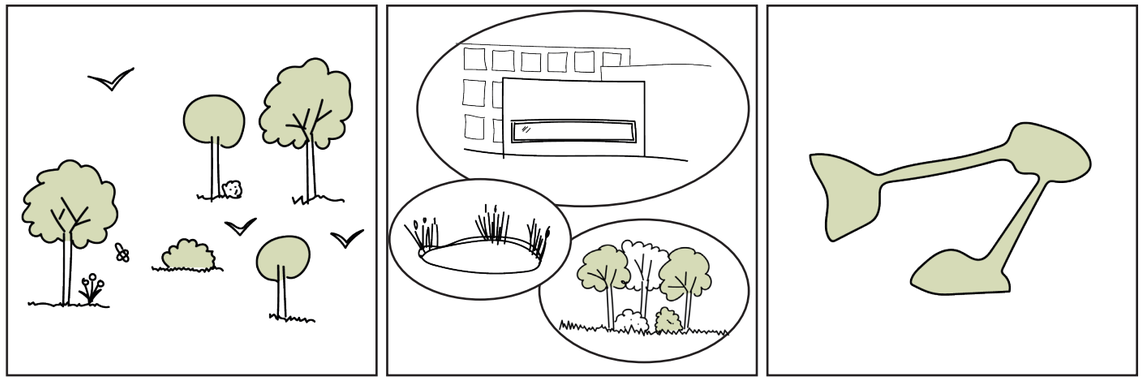
To know what is important for biodiversity and human well-being six principles have been selected for biodiversity and human well-being. These principles have an influence on biodiversity and on human well-being. In chapter 5 these principles will be used to give a scoring of the design tools on biodiversity and human well-being.

HUMAN WELL-BEING



Heatlh | Security | Social relations

BIODIVERSITY



Numbers and variety of species | Habitat diversity | Connecting habitats

CHAPTER 3

METHODOLOGY

Now the problem and the main theories have been explained in the first and second chapters of this thesis, the methodology will explain the methods which will be used to answer the main question. First, the conceptual framework explains the concepts in this thesis and how they relate to each other. Second the research approach will be explained where the research question and the sub-question are shown and lastly the methods and their advantages and limitations.

Figure 33 Walter (2021)

3.1 CONCEPTUAL FRAMEWORK

In the conceptual framework, the different concepts used in this thesis are shown and how they relate to each other. Firstly there is the business park which is the location on which this research is based. Now the business park is a barrier but by implementing the design tools and enhancing biodiversity and improving human well-being the business park can become a corridor.

Secondly, the design tools which will be introduced in chapter 5 are linked to biodiversity and human well-being. Every tool will be given a filled box if this tool adds to the principle chosen for human well-being and biodiversity.

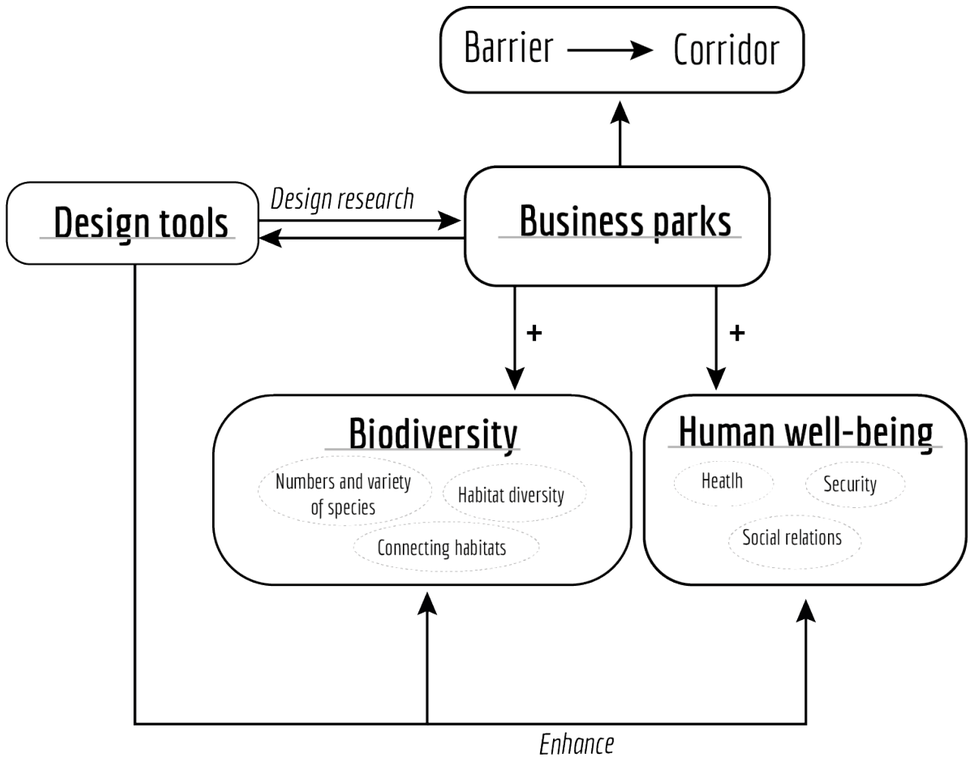


Figure 34 Conceptual framework (own image)

3.2 RESEARCH APPROACH

The research approach is shown in a diagram on the next page in figure 35. In this research framework, the main question is divided into four sub-questions which help to get to the outcome of the research question. But firstly the aim of the thesis.

THE AIM OF THIS THESIS IS TO IMPROVE BIODIVERSITY ON A BUSINESS SITE AND CHANGE THE BUSINESS SITE INTO A CORRIDOR TO CONNECT TO THE ECOLOGICAL NETWORK. AND WITH THIS ALSO IMPROVE HUMAN WELL-BEING.

From this aim the main research question is as follows:

RQ

"WHAT ARE DESIGN TOOLS AN URBAN DESIGNER CAN USE TO IMPROVE BIODIVERSITY AND HUMAN WELL-BEING ON A BUSINESS SITE AND HOW CAN THIS BE IMPLEMENTED? USING CASE STUDY LOCATION SPAANSE POLDER."

To answer the main research question there are four sub-questions. These questions will be answered in different chapters of the thesis. The first sub-question has already been answers in chapter 2 in the theoretical framework where six principles have been chosen which can 'measure' the design tools on how they improve biodiversity and human well-being.

SQ1

WHAT IS BIODIVERSITY AND HUMAN WELL-BEING AND HOW ARE THEY CONNECTED?

The second sub-question will show what the opportunities are to enhance biodiversity in a business site. For this question, the site location Spaanse Polder is used and analysed. Where the opportunities are linked to three categories of blue structures, green structures, and grey structures.

SQ2

WHAT ARE THE OPPORTUNITIES TO ENHANCE BIODIVERSITY AND HUMAN WELL-BEING IN A BUSINESS SITE?

From the third sub-question nature inclusive design tools are introduced. These tools are linked to the categories from the analysis in which area they can enhance biodiversity.

SQ3

WHAT ARE DESIGN TOOLS TO ENHANCE BIODIVERSITY AND IMPROVE HUMAN WELL-BEING?

In the last sub-question, the derived design tools will be implemented in the location site. Multiple locations have been chosen to tackle the different categories from the analysis of the Spaanse Polder. For this step research by design is an important method.

SQ4

HOW CAN THESE DESIGN TOOLS BE IMPLEMENTED IN THE CASE STUDY LOCATION SPAANSE POLDER?

During the implementation of the design tools in the location, the design tools will be reflected on for how they work in the location.

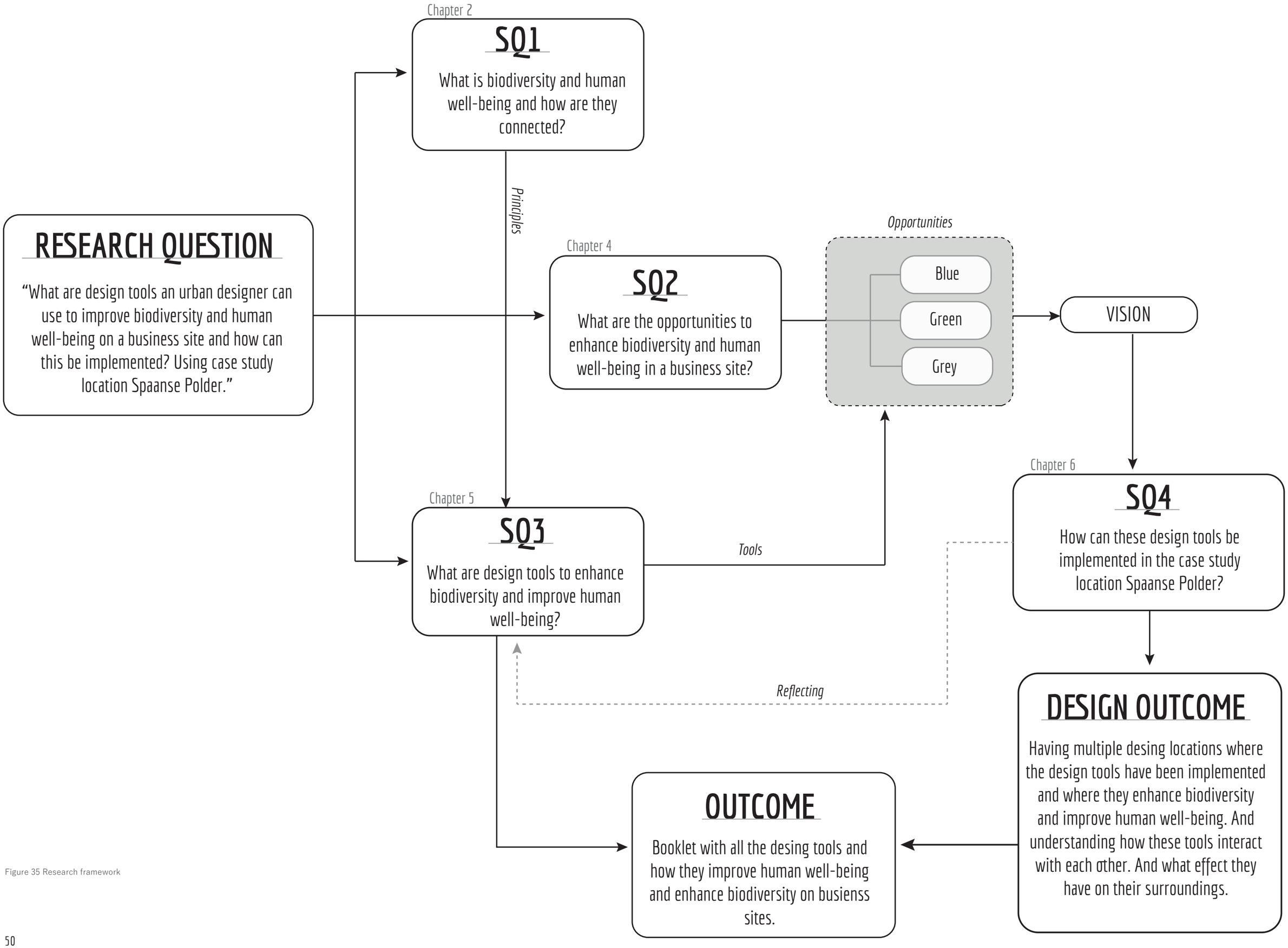


Figure 35 Research framework

3.3 METHODS

On the previous page in figure 35 the research framework is shown. In this framework, the four sub-questions, the main question, and the outcomes are shown and how these questions relate to each other and how do they give an outcome which is needed for another question. This process is an iterative process that has constant feedback back to the main question or other questions.

To answer these questions there are different methods used. There are many different methods that can be used to help answer the questions but for this thesis, there are five methods used. These methods can be seen in the table below and on the next page. In this table first, a small explanation of the method will be given and what tools have been used for this method. All the methods have their advantages and limitations, these are also shown in the table.

METHOD		ADVANTAGES	LIMITATIONS
Literature review	Through literature review a first introduction and explanation of subjects in this thesis can be given. Reading about your subject which has been researched by other researchers can give an idea of where the knowledge gaps are. It also helps for understanding certain subjects and its connection to other subjects. The tools used to do the literature review is mostly with papers, books, reports, and websites.	Because of the internet, a lot of information and papers can be found online. It is also an advantage that scientific papers are more trusth worthy than another source.	Not all information has been written down in papers or researches this means there is also a need for using different methodologies to get information. Another limitation of literature review is the enormous amound of information there is available. This could be seen as an advantage but in the case there is so mutch information about subjects that it is hard to know what is important for the research and what is not important.
Mapping	Analysing and creating maps for the site helps to better understand the structures and flows on a site location. This analysis will be done through different scale levels. Where the relation between the different scales can be explained. This mapping is also a preparation for designing, where the opportunities lay on the location or where the threats of the location are situated. Tools which where used for mapping the site is Qgis and google maps.	Advantages of this method is that you will understand the location and where its strengths and weaknesses are.	A limitation of this method is that there is only a limited amount of information you can get from a computer about the location. This limitation can be eliminated by visiting the location site and filling in the missing information.
Fieldwork	Fieldwork will give first-hand information about the site that will be investigated. It is a continuation of the mapping where the information is gathered and compared to the real situation on site. Fieldwork can give more specific details to the mapping method.	Seeing the location yourself is always better for understanding the typologies of the location. Because not everything can be seen on google maps from behind your screen.	The limitation of fieldwork is that you will only see what you can see. There are often more processes happening on a site which is not visible. Another limitation is the time you visit the location which can only give a snapshot, if it is beautiful weather in the summer it will have a totally different experience than if it is snowing in the winter.

METHOD		ADVANTAGES	LIMITATIONS
User analysis	Knowing who the users are of the location will give an understanding of what these different users might need and how these needs maybe overlap or are in conflict with each other. Often only users like people are mentioned but because nature plays an important role in this thesis animals will also be analysed and what they need. For this thesis personas are created which identify as the different users of the site which means they are not real people. Tools for analysing the users has mostly been interpretation of the users.	Understanding the users of the location helps with knowing what they want and what they need for their surroundings. Also implementing animals as users makes the connection to biodiversity closer.	Because the users which have been identified for this thesis are fictional there are limitations because they are not real people.
Research by design	The last method is research by design for this method the design tools which have been found in chapter 5 will be implemented on the location site. By doing this the tools will get a spatial feeling of the location. An important aspect of research by design is to reflect back to the design tools. If the tools have been implemented in the location they should be reflected on to see if they fit in the context.	Advantages of research by design is that it is an important tool for an urban designer to implement the tools on the location. Only having tools which enhance biodiversity does not say if this tool will actually help with improving biodiversity. By implementing them on the location the designer can see how it relates to its surroundings and to the other elements.	Because research by design is testing the design on a specific location this means it is often site specifiek. This means the design could fit in one location but maybe does not fit in another location.

CHAPTER 4

INTRODUCING THE LOCATION

In this chapter, the location which will be used as a case study location will be introduced and analysed. This chapter will answer the sub-question "What are the opportunities to enhance biodiversity and human well-being in a business site?" will be answered. The analysis is done with the help of three main structures. These are the blue structure which consists of all the water networks and the smaller water bodies, the green structure which consist of all the available green in the area from grass to the trees, and lastly the grey structure which are all the roads, paved areas, and the buildings on the site. From these analyses, an opportunities map can be made where there is a lack of biodiversity and where the opportunities lay to enhance it.

Figure 36 Nature (n.d.)

4.1 ROTTERDAM

Rotterdam is located in the province of South Holland and is one of the four largest cities in the Netherlands. The municipality of Rotterdam not only has a large city but is also the home of the largest port in Europe.

From 2014 to 2018 the sustainability trends of all the 380 municipalities in the Netherlands have been monitored and from this, the municipality of Rotterdam ended in spot 379 (Nationale monitor duurzame gemeente, 2018). This dramatic result has gotten Rotterdam into taking the challenge of making their municipality more sustainable and with this also adding more green into their city (Gemeente Rotterdam, 2021). Rotterdam is a city that has a high urban density which causes a high urban heat island in the city. And because of this density, there are also more floodings not only because the water can not easily infiltrate in the ground but because of all the pavement but also because there are more peak rainfalls which makes a gradual infiltration more difficult.

Because of this, the municipality wants to take action and make their city more green, the municipality wants to add 20 hectares of green to the city of Rotterdam before 2022; they started in 2018 (Gemeente Rotterdam, 2021). There is even a focus on business sites that also need to start to greenify their area because these areas also add to the urban heat island and the bad water infiltration (Gemeente Rotterdam, 2021). A first start has been made in the Spaanse Polder with the company SEW Eurodrive which added more green to their parking lots and added solar panels (Gemeente Rotterdam, 2019).

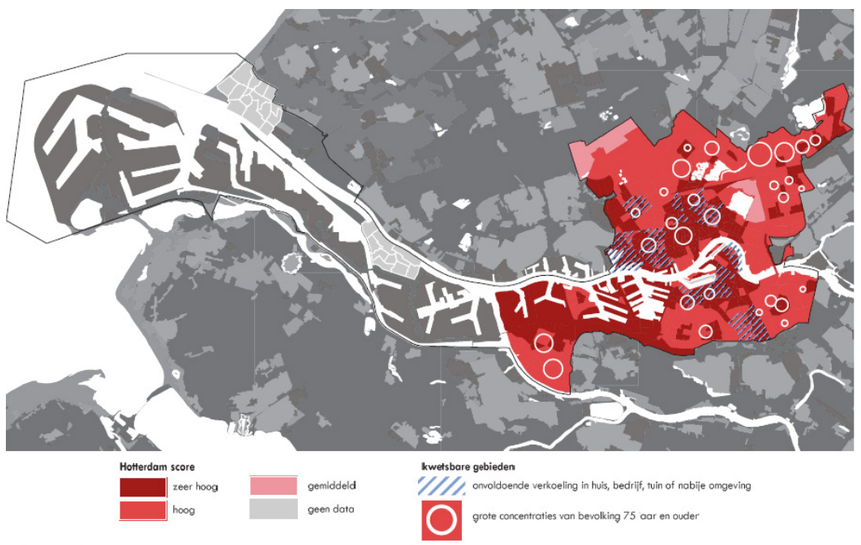


Figure 37 Urban heat island and flood risks (Gemeente Rotterdam, 2019)

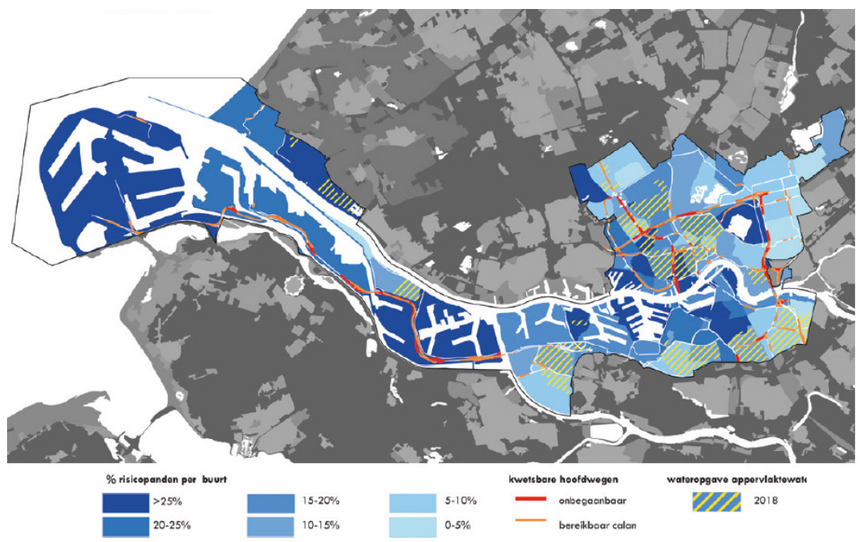


Figure 38 Paved and green area (Own image adapted from qgis)

NATURE MAP

The main reason for this nature map is to reverse the fragmentation of habitats which has been happening for years. And to do this ecological networks need to be made and connected. Not only in the city itself but also from the city to the surrounding areas. In this nature map of Rotterdam, you can see there are the green and blue networks shown. But also the dunes and the dune forests are part of the nature map. The ecological connections which exist to connect habitats are shown but also the opportunities.

To start with the most prominent green patch on the map is in the North of Rotterdam which is the polders, these polders are part of the nature monuments and are protected areas. The polder has a rich habitat for multiple animals and vegetation and is an open landscape with natural waterfronts where small animals like Common vole, European polecat, European hare and bats can be found. And because of the presence of these small animals, there are also birds of prey like the Montagu's harrier and the Little owl (Gemeente Rotterdam, 2014).

The water networks in Rotterdam are the Rotte and the Schie which connect to the Maas which is a tidal river. A water network has many ecological properties like the migratory fish who use it. At the places where the waterfront has a natural border, there is a diversity of plants that grow there like Lisdodde, Moerasspirea and Spindotterbloem (Gemeente Rotterdam, 2014).

As can be seen, there are some dry lint in the area these are mostly next to roads or train rails. These are spaces with just dry ground and some vegetation. These areas are often used by small mammals like a hedgehog or a Common vole (Gemeente Rotterdam, 2014).

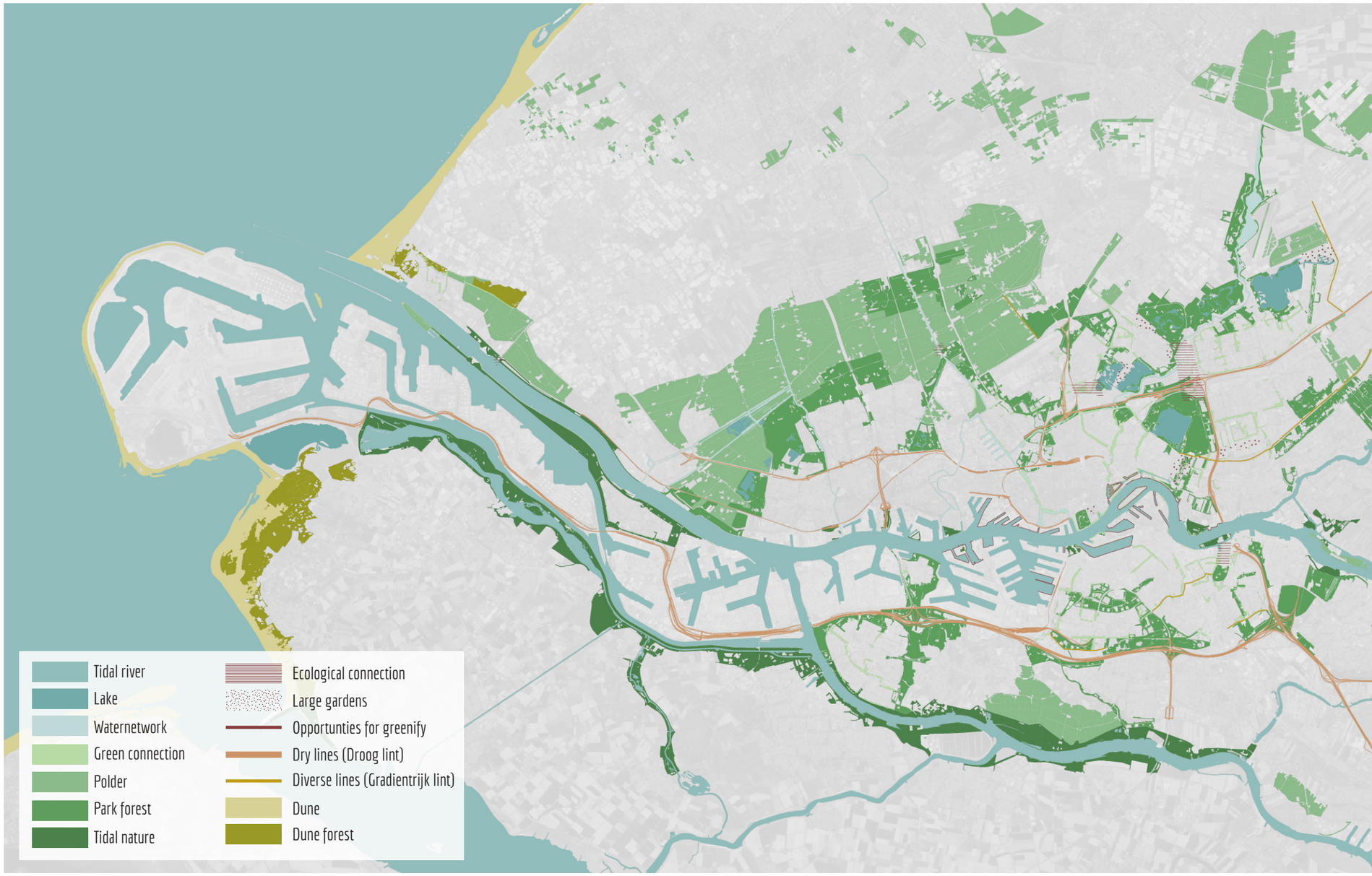
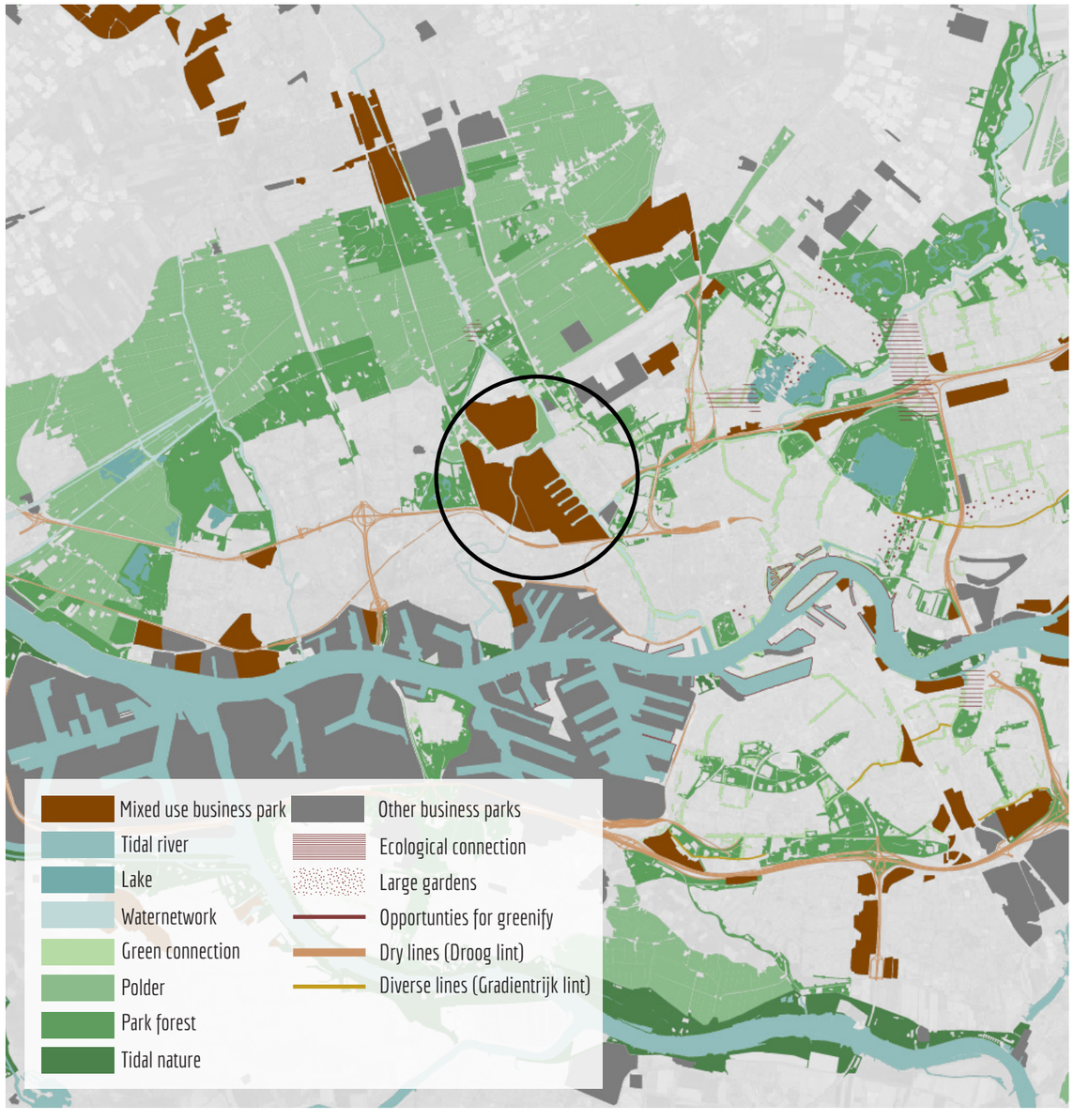


Figure 39 Nature Map Rotterdam (Own image adapted from qgis)

4.2 LOCATION CHOICE

In Rotterdam, there are many business sites to choose from in total there are 6000 hectares of business sites in the Municipality of Rotterdam which makes Rotterdam the number 1 with the most surface of business sites (Schellenburg, 2020). For this thesis, a site that is a mixed-use business park will be chosen for the case study. In the figure below the business, parks are shown and the mixed-use types are highlighted. There are quite a few business parks that are mixed-use but there is one that really stands out not only because of its size which is the Spaanse Polder and Rotterdam North-West. In a previous figure, the location Spaanse Polder has a very high urban heat island effect.

Because Rotterdam has some ecological networks like the Schie which goes right through the Spaanse Polder and Rotterdam North-West. Next to the water network the Schie there are also green networks. To the North of the Spaanse Polder and Rotterdam North-West there is the Midden-Delfland. This can mean that not only can an ecological connection be made on land with the Polder and the neighbourhoods but also the Schie goes through the location which also has ecological properties. This makes this location a perfect spot to research the possibilities of enhancing biodiversity and human well-being on the location. For the rest of the thesis, the location of Spaanse Polder and Rotterdam North-West will be called Spaanse Polder.



4.3 HISTORY OF THE SPAANSE POLDER

A business park has a very different character than a neighbourhood, this is mostly to thank of the fact that neighbourhoods are built for people and business parks are built for production and infrastructure for the fast traffic. But this was something the urban designers who had to design the Spaanse Polder wanted different they had the ambition to make the Spaanse Polder with a centrum, recreation fields, trees, parks and even a swimming pool (Crimson, 1998).

The first urban design of the Spaanse Polder was in 1941 which can be seen in figure x. In this first design, a large focus was placed on the connection with the water. As can be seen in de design there were a lot of harbour basins in comparison to the 5 there are now. After this design, there were 2 more designs made. One of the larger changes which had to be made is the placing of the highway A20. in the plan in 1943 the road was to the south of the location border but Rijkswaterstaat wanted to use the shortest route which meant the A20 had to go through the area (Crimson, 1998). As a consequence of the placing of an A20 there the Van Nellen fabriek was cut off from the rest of the area. The first plan of having a lot of harbour basins was with the intention a lot of products would be transported over water but after the war, this had changed and the harbour basins were cut shorter and there were made less (Crimson, 1998).

The focus for the Spaanse Polder which was the housing of industry could not only be on the economy but also had to be a safe and healthy environment for the people working there (Crimson, 1998). The plan was to use the Van Nellen fabriek as an architectural example to build the rest of the buildings with some strict rules for instance that it was not allowed to use red bricks.

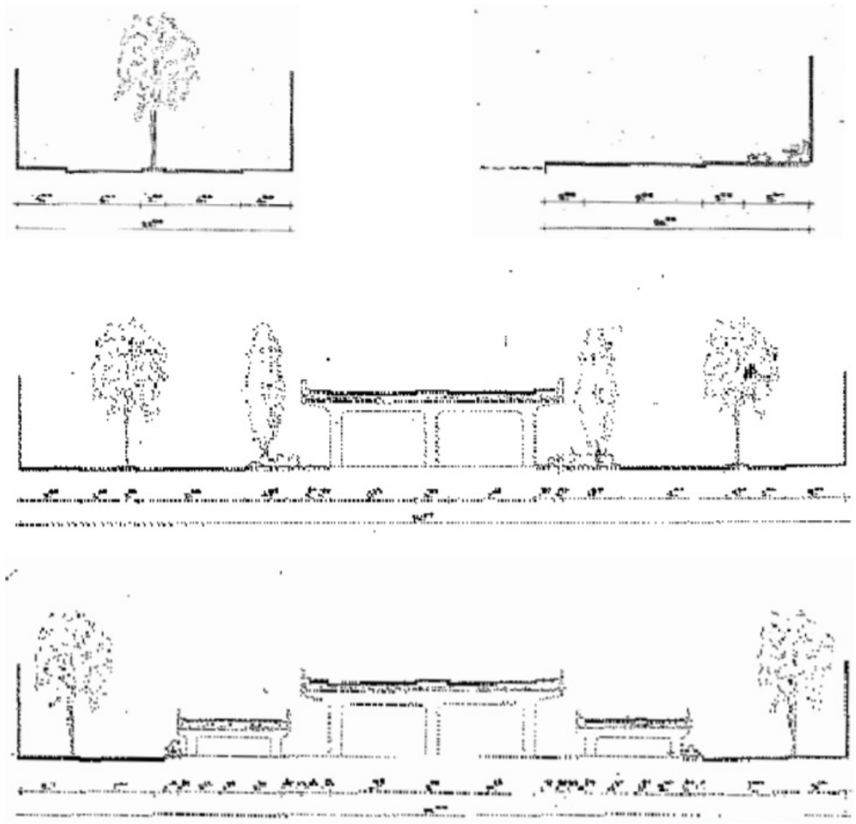


Figure 40 Sections of the plan of Spaanse Polder (Crimson, 1998)

In the plans for the Spaanse Polder, they had given a lot of attention to the landscaping which can be seen in the sections which have been made in figure x. Every road had three lanes and if you would enter the location in the south you would be embraced by tree lanes and grass fields. At the heads of the harbour basins, there would not be any buildings and this would be used as a space to sit down and have an excellent view of the water (Crimson, 1998).

When the first start of businesses were build there was almost no trace to be found of the strict architectural rules and the placing had gone all random in the plot the business was placed (Crimson, 1998). The planned train station next to the van Nellen fabriek did not come and the infrastructure went also very slowly which made the Spaanse Polder a lot less accessible than they had planned (Crimson, 1998). Also, the attention to the landscaping had made a place for bigger roads and parking space there are still some traced to be seen of the tree lanes but most of it has been lost (Crimson, 1998).

It is expected a change will happen from the larger factories to a smaller offices which will give the Spaanse Polder a different colour from blue collar to white collar (Crimson, 1998). It is important for the Spaanse Polder if they want to keep up they need a good connection with its surroundings (Crimson, 1998).

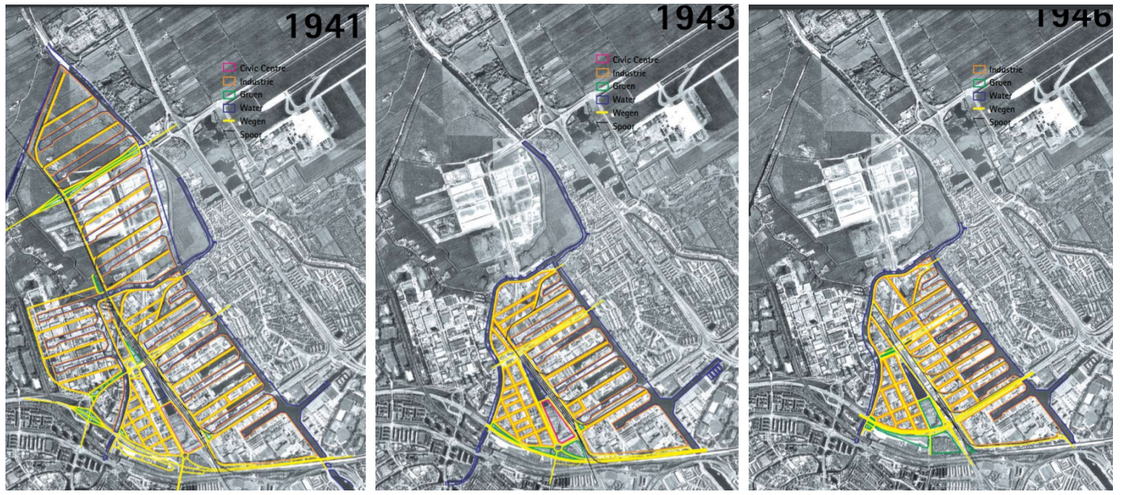


Figure 41 Plans throughtou tthe years (Crimson, 1998)

4.4 SITUATION NOW

CRIME
The Spaanse Polder has a long history that has changed in its plans throughout the years. But what is the situation now in the Spaanse Polder? The Spaanse Polder has had a lot of criminality in the past. In the past, there have been attempts to take out the criminality which has helped but after a while, the criminality found its way back to the Spaanse Polder (van Twist et al., 2017). Which meant that the criminality had to be taken out by the root. To take out the criminality once and for all the Municipality of Rotterdam has appointed a "stadsmarinier". The task for this stadsmarinier was to take out the criminality by its roots. After the stadsmarinier began his work he had taken out a lot of drug dealers and other criminal practices (van Twist et al., 2017). During large operations, stolen cars were confiscated and a lot of the car dealers which were a front for criminal practices left the site (Lewis, 2019). This rooting out of the crime has given positive effects to the location. But even though the site has gotten less crime there are still cases where the Spaanse Polder is involved in criminal practices. Where the Police will still occasionally intercepts money and even firearms in the Spaanse Polder (Politie Onderschept Nog "dagelijks" Geld in Spaanse Polder, 2021).

INNOVATING
The Spaanse Polder wants to innovate, they want to attract more innovative and young companies (van Twist et al., 2017). Because the Spaanse Polder lets businesses with an environmental category of 5.3 settle in the location it is a unique space for businesses that operate in these higher environmental categories (Kegel, 2020). It is an attractive location for discrete manufactories, food, construction, transport and logistics which are focused on delivering for the city because they are located right next to the city (Kegel, 2020).

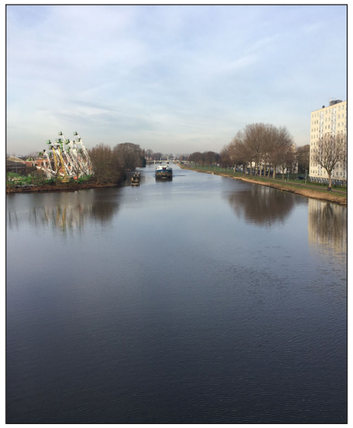
TOTAL SURFACE	320 hectares
WATER	26 hectares
LAND	295 hectares
BUSINESSES	minimum of 1400

Figure 42 Numbers (Spaanse Polder, 2020)

4.5 ANALYSIS

To really understand the site and its opportunities it is needed to do an analysis of the site. For the analysis, there are three subjects that will be analysed. Because this thesis is about biodiversity and human well-being and how to improve this on a business site the structures which should be analysed are firstly the blue networks and other water bodies in the area, next up the green structures from grass to trees in the area. And lastly, the grey structures which are all the roads but also the parking and the buildings.

GREY



BLUE

GREEN

4.6 BLUE STRUCTURE

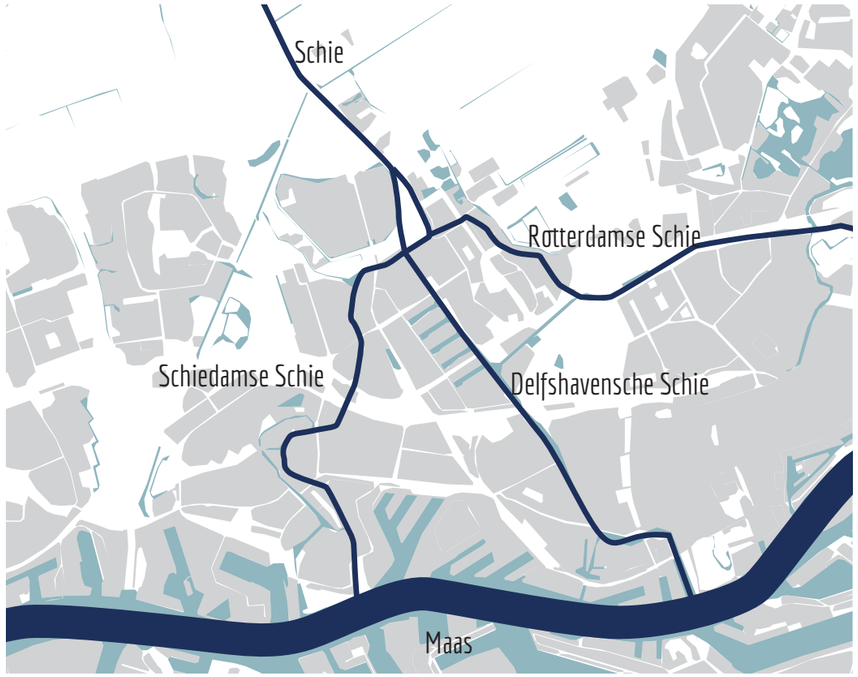
The Netherlands is one large Delta area and South Holland plays a big role in this because it has many rivers going through. These rivers are ecological connectors, for instance, the Rijn which goes through Switzerland, Germany, and France and eventually enters the Netherlands. The Rijn branches into many different rivers in the Netherlands where one eventually becomes the Maas which goes through the city of Rotterdam. The Delta areas have enormous ecological property especially for the birds is the Delta is an important habitat.

The Schie is the ecological water network that goes through the location site and is connected internationally. The Schie is connected to the maas which is connected to the Rijn and goes into Germany. The Schie goes also up North towards Delft and further up The Hague and Leiden where it goes over into the Vliet and eventually goes all the way to Amsterdam. This waterway is not only an ideal space for the birds but it is also a space for migratory fish species to live in. Next to the fact, the Schie has many ecological properties the Shie is used by inland fleets.

The ecological structure of the waterways in Rotterdam can be seen in the figure below. The Maas has three arms going up which are the Schie, the Rotte and the Hollandse IJssel. All these three arms have different ecological properties for instance the ecological properties of the Rotte are higher once you leave the city in comparison to the Schie which has limited ecological possibilities (Gemeente Rotterdam, 2014). This can also be explained because the Schie is used intensively by the inland fleets.

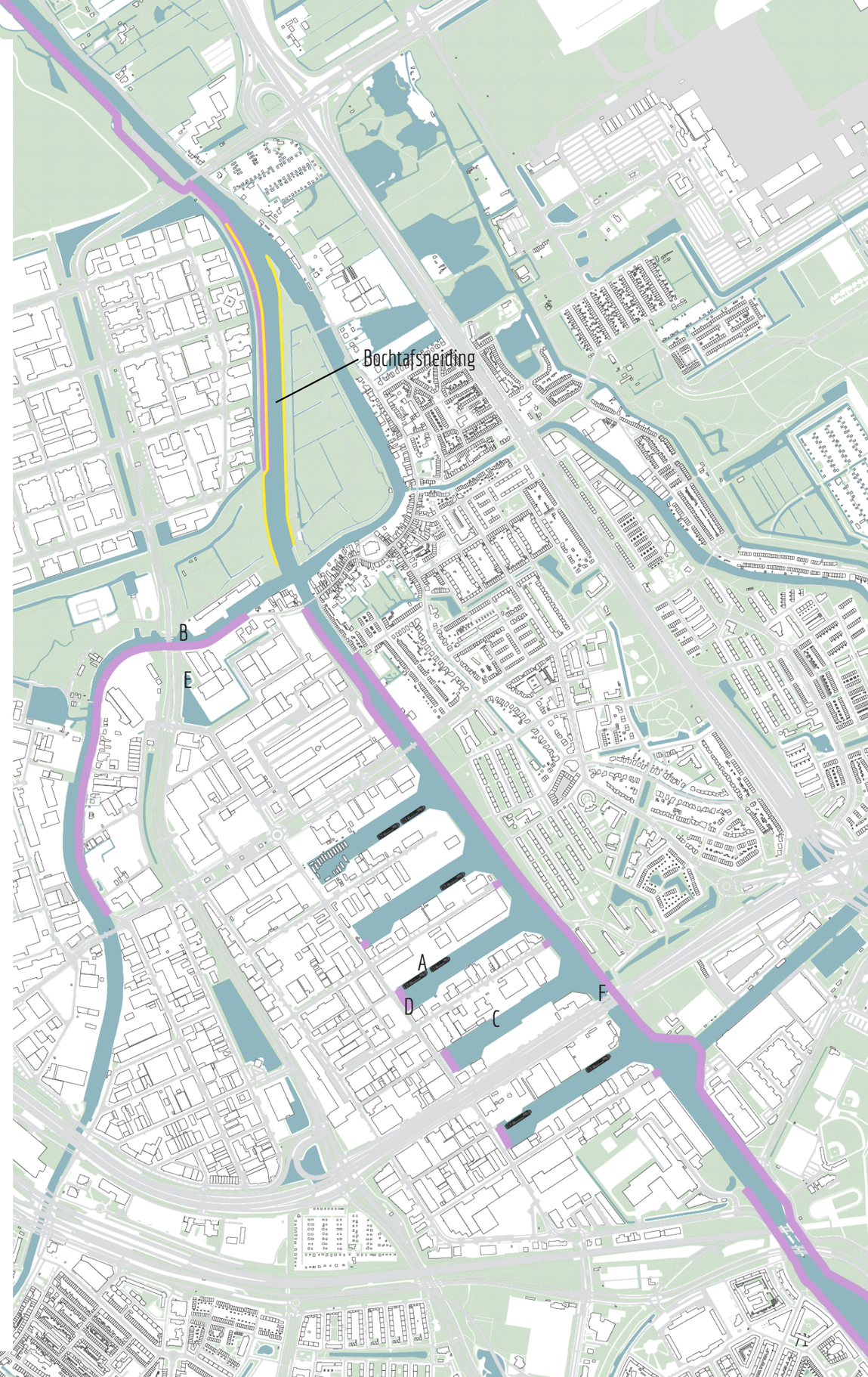
THE 3 ARMS OF THE SCHIE

This Schie has a rich history, around 800 the first people started settlements next to the side rivers which came from the now called the Maas (Abrahamse et al., 2016). The Schie going from Delft towards Rotterdam splits into 3 arms, the Rotterdamse Schie, Delfshavensche Schie, and the Schiedamse Schie. This is because Rotterdam, Delft, and Schiedam wanted to use the waterways for trade and they all created their own canal (Abrahamse et al., 2016). At the moment only the Delfshavensche Schie is used by inland fleets with cargo. The Rotterdamse Schie is not directly connected to the Schie anymore, boats can not go from the Schie towards the Rotterdamse Schie. And the Schiedamse Schie is only used for recreational boating where this arm will bring you inside the city centre of Schiedam.



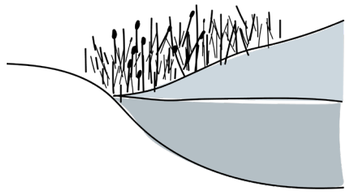
BLUE STRUCTURE

The Waternetwork in the Spaanse Polder is a leading element in the structures. The Schie embraces the Spaanse Polder on two sides on the one side the Delfshavensche Schie which has five harbour arms that go into the location and the Schiedamse Schie on the other side. Most of the waterfronts are not accessible to walk or bike next to and almost all of the waterfronts are hard waterfronts. In pictures A, B, C, and D all these hard waterfronts can be seen. Only picture E is a more natural waterfront and this one is taken in one of the other water bodies and not the Schie. On the next pages, the different typologies and their characteristics will be explained that can be found in the Spaanse Polder.

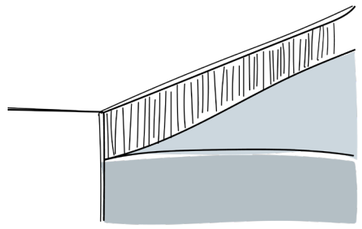


TYPOLOGIES

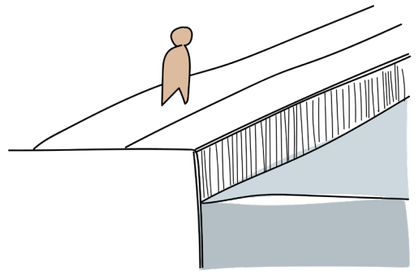
Natural waterfront
The Natural waterfront is the most nature friendly. There is a sloping ground into the water where plants and animals can live. There is only one place on the site where there is the natural waterfront and this is in the bochtafsneiding. A natural waterfront is good for biodiversity because it can house many different species (Gemeente amsterdam, 2018).



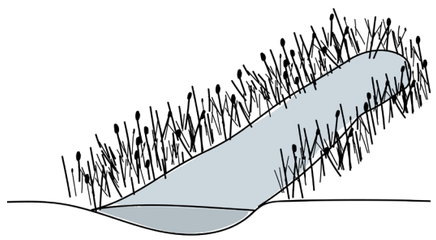
Hard waterfront
The hard waterfront is where there is almost no possibility for green to grow or for animals to get out the water which makes the connection of water to land hard. These hard waterfronts are situated in the location because it is a harbour area where boats need to be able to dock to load and unload.



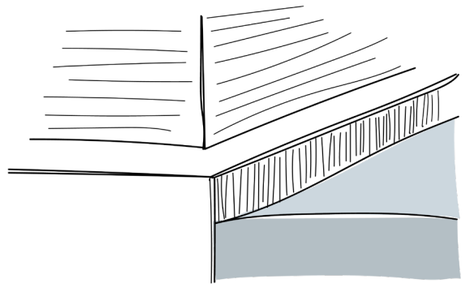
Walking/biking next to the Schie
Waterfronts are locations that are attractive for people to be. They can enjoy the views and the boats which come by. But in the area there are only a few places where you can walk or bike next to the water most of the area there are business situated next to the water.



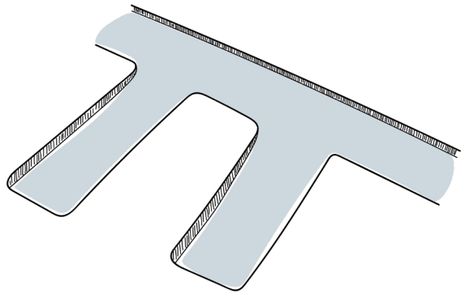
Other water bodies
On the location site, there are some other water bodies next to the Schie. These water bodies have often a sloping edge and planting around which creates a good habitat for small species like frogs or Narrow-winged damselflies.



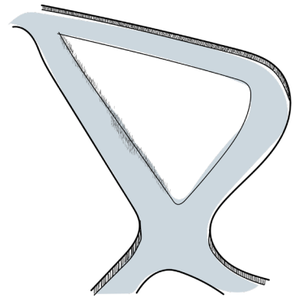
Backsides to water
In the location there are some businesses which use the waterfront for loading and unloading their products. But most of the businesses on the site have nothing to do with the water which results in having their backs towards the water and so people can not get to the waterfronts.



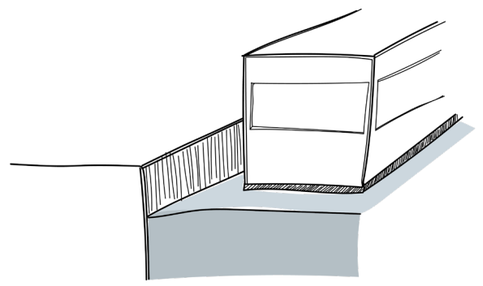
Port arms
The Spaanse Polder has a unique location because it is situated next to the Schie. There is still a lot of transport going over the water but in history, it used to be more (Crimson, 1998). The location has five harbour arms where some are in use but there are also companies who do not use the water anymore.



Bochtafsneiding
In 2019 the bochtafsneiding was opened this was a shortcut for the inland fleets which used to have to make 2 sharp turns. With the making of this bochtafsneiding they made the waterfronts soft and they even added a spawning ground for the migratory fish.



In use waterfronts
In most of the arms, there are businesses that use the waterfront to load and unload. But this is just a small amount of businesses. There is also one arm where there are house boats which is one of the view places where there are people living in the business park.



4.7 GREEN STRUCTURE

Most of the green structures in Rotterdam has already been shown in the nature map of Rotterdam in a previous section. These green structures can be seen as the second ecological structure next to the water network. There are some green structures in and around the Spaanse Polder. These vary from the polders in the North to sport fields in the South. But there are also roads where there is green in between them or on the sides. As mentioned in chapter 2 if you want to improve biodiversity, habitats need to be connected through corridors to make ecological connections and enlarge the habitats. The map shows where all the green structures are located, these structures can be patches of different sizes and there are even some corridors.

MISSING LINK

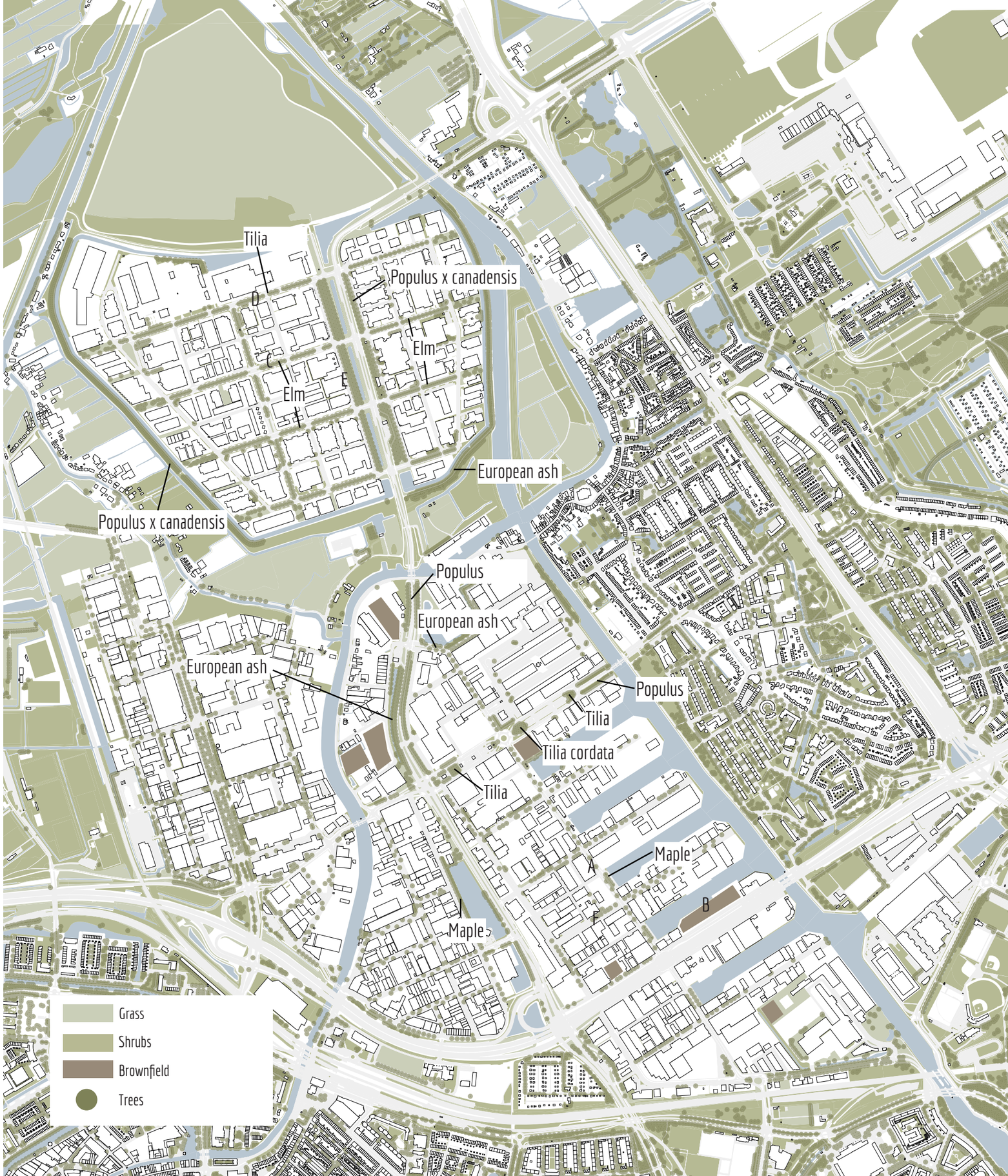
The problem statement states that the business site forms a barrier for the city and the nature on the other side of the business site. This means there are some missing links that could connect the existing green patches through the business park by creating corridors or stepping stones. These missing links go from North to South and from West to East. From North to South from the Middendelfland nature area to the Spangen neighbourhood. And from the West to East from the Prinses Beatrix park to the Sidelingepark which is located in the neighbourhood of Overschie.

CONNECTORS

These missing links can be made through two different types of green connectors, these green connectors are firstly the trees and secondly, there are the shrubs, flowers and grass fields. Both these connectors are used by different animals, the birds, bats, and some insects mostly use the tree lines. The shrubs, flower fields, and grass fields are mostly used by animals that have to be on the ground or other small insects.

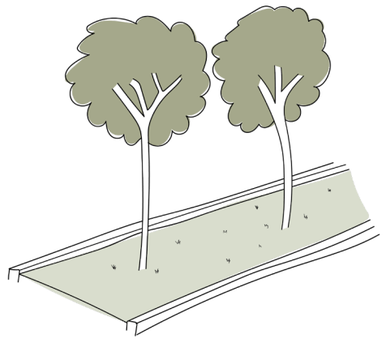
As explained there are two different green connectors the trees and the lower vegetation of grass, and shrubs. The green structures in the location all have different characteristics which make them all different habitats for species. But because the location is a business site these green spaces do not yet get a lot of attention. Most of the green which is situated on the location is public green next to the infrastructure. Businesses do not have green on their properties or have limited green. There are some brownfields (picture B) in the area that can be a habitat for some species but does not have a lot of diversity. The trees in the area are placed in rows and are in the same row of all the same species (pictures D, E). Most of the trees in the South are surrounded by pavement and do not have a healthy tree drip line like picture F. But nature is persistent so there are some spots in the area where there are some weeds coming through the paved areas (picture A).

Figure 43 (own images)

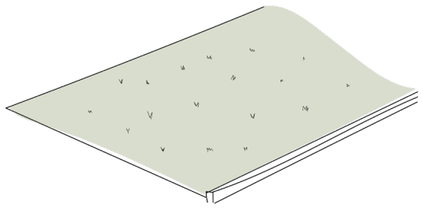


TYPOLOGIES

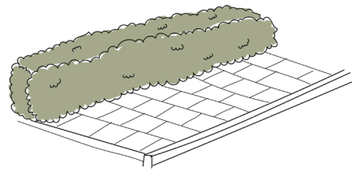
Tree lanes
There are in the location some tree lanes mostly situated near a road. These tree lanes are often of only 1 species. For instance, the tree lane in the North next to the Matlingeweg consists of all Populus x Canadensis trees. Diversity is needed to create more resilience to for instance diseases. These tree lanes are important as connectors for birds, bats and some insects.



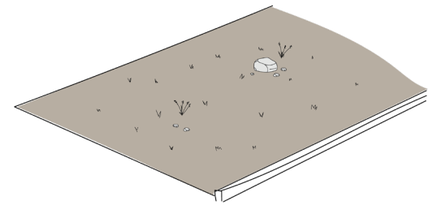
Grass
There are some open spaces that are not properties of business owners that are grass fields, these spaces can be found between buildings or next to roads. A grass field does not have a lot of diversity but can have the potential of becoming a space with more biodiversity.



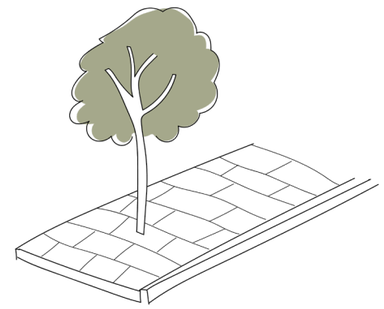
Shrubs
On the business site there are some places where there are shrubs these can be found between the sidewalk and the border of the plot of a business or close to the facade of a building. These shrubs can vary from just simple bushes of just one species to sometimes different species. Bushes are good places for animals to find shelter in.



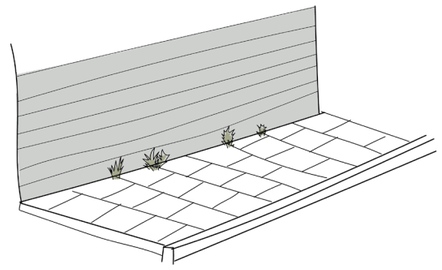
Brownfields
There are not many brownfields on the location but it can happen when a business moves and when the building is too old the building will be taken down. Because a brownfield is often not maintained a lot of different species can grow there. But most of the brownfields in the Spaanse Polder consist of mostly grass fields.



Trees in pavement
In cities but also on the business sites a lot of the trees are surrounded by pavement. These trees do not have a healthy tree dripline where plants can grow and insects can live. This often also means they do not have a lot of space to grow.



Weeds
Because nature is very persistent there are always some spots in the area where there are some weeds coming through the pavement. But mostly will these weeds be taken away eventually.



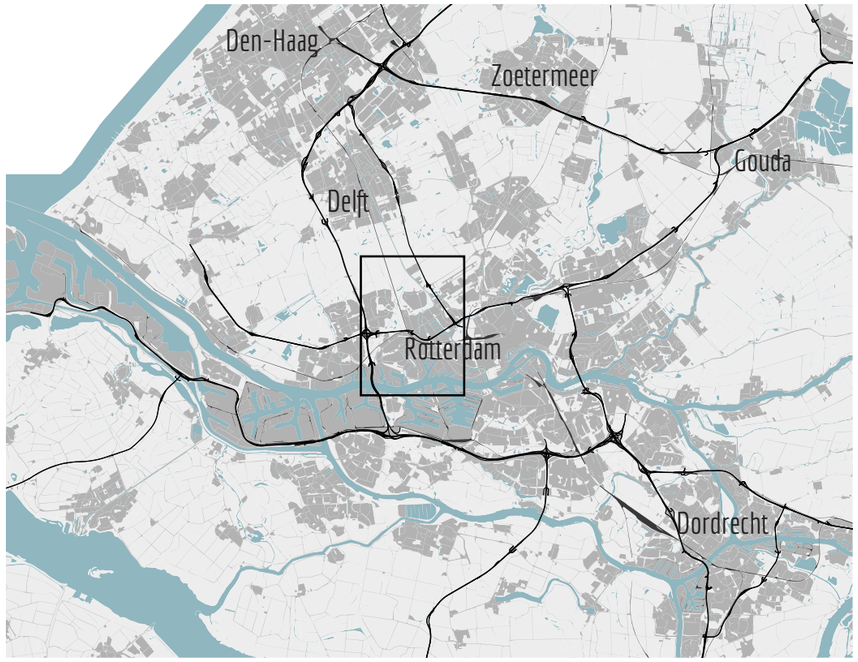
4.8 GREY STRUCTURE

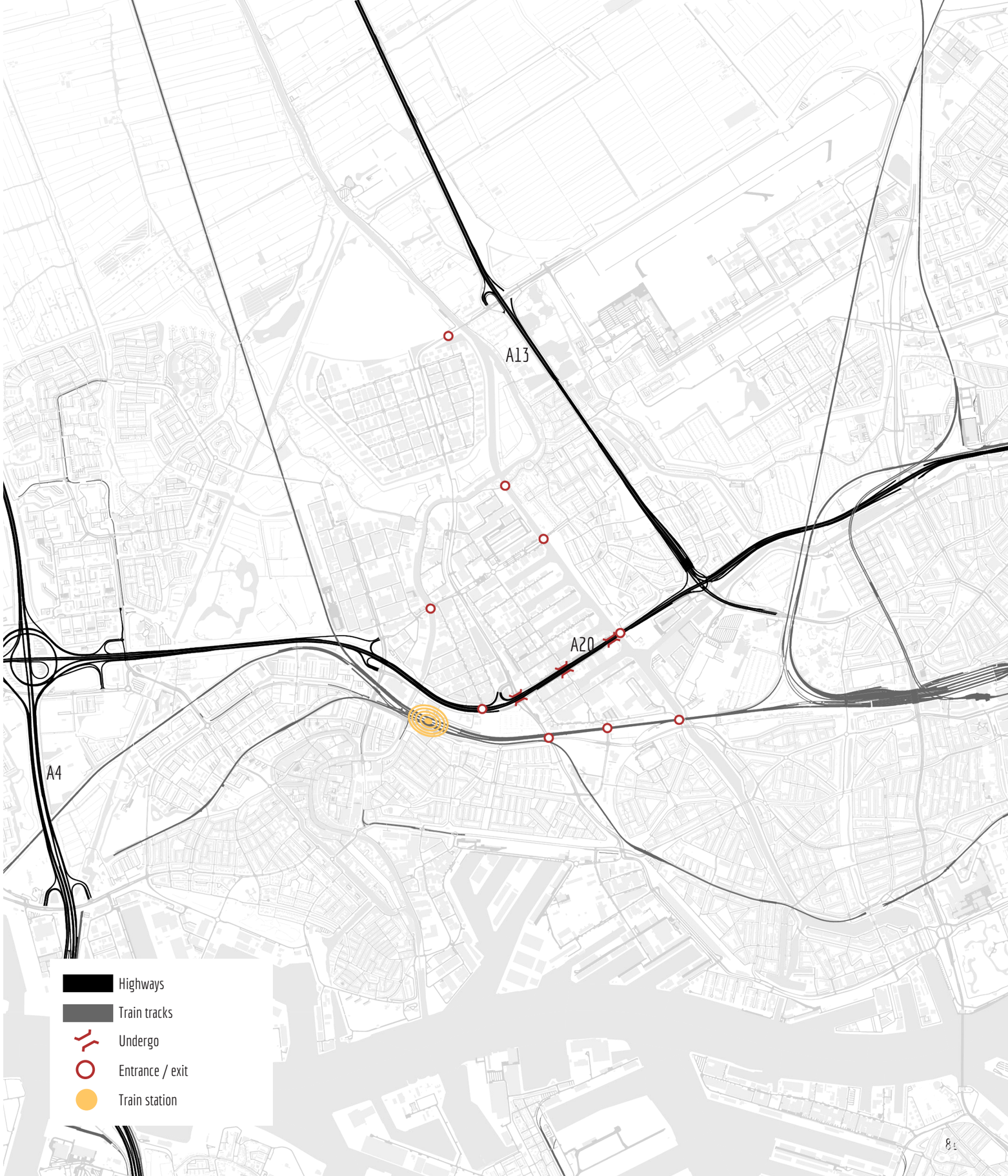
The grey structure is the infrastructure but it is also all the buildings and all the paved areas. The infrastructure is very important for a business site. A lot of businesses on the location make products which means these need to be shipped or transported. The Spaanse Polder has a very tactical location between 3 highways which can bring you everywhere in the Netherlands.

One of the highways the A20 goes through the location at this place where it goes through the location the highway is elevated. With this elevation, they have left the space underneath open and is now designated for parking.

There are multiple exits/entrances into the site from the North there is only 1 entrance which comes from the A13 or the N209. From the South, there are 3 entrances from which 1 is also the main road into the site which is the Matlingeweg. From West to East there is 1 main road going through the location with the exception of the highway.

Close to the Spaanse Polder there is the train station Schiedam centrum, this is also one of the only possibilities of the public transport which is close to the Spaanse Polder there is one bus line going through the location and that is about it.





On the business site there is a lot of grey areas. The roads which are not the main roads are often very brought with parking on the sides. There can be a large sidewalk like in picture E but there can also be no sidewalk or a very small sidewalk which can be seen in picture A. The Spaanse Polder is wrapped around the Schie as the waterway but also by the highway and the train tracks. To the East and South, there are residential neighbourhoods located right next to the Spaanse Polder.


A

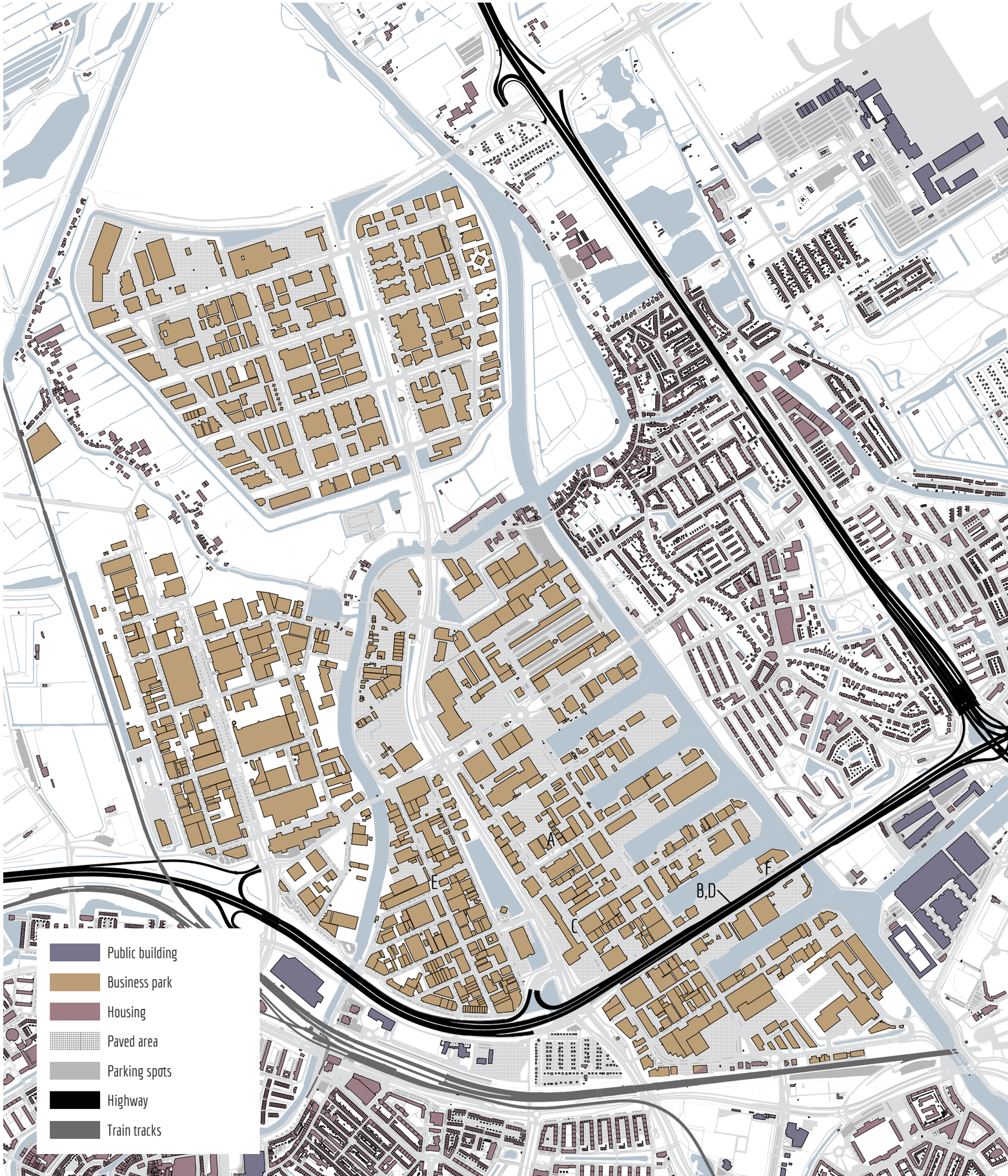

B

C


D

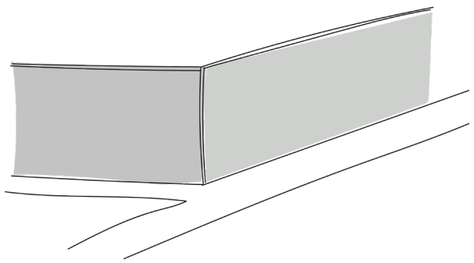

E


F

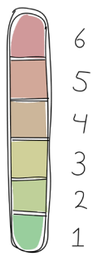


TYPOLOGIES

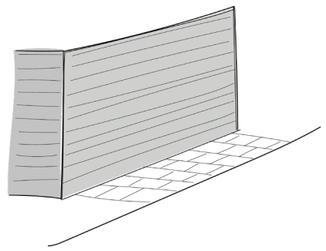
Large buildings
Very common in a business site are the large buildings. An entire building sometimes has the same measurements as a building block with multiple houses in a neighbourhood. This can make the human scale difficult to find in the location.



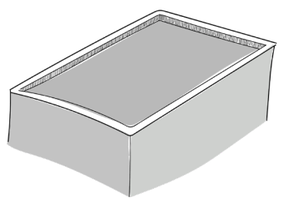
Environmental category
Business sites have different environmental categories which indicate how polluted they are allowed to be. This is also one of the reasons why these business sites have been placed on the border of the cities away from where people live. The environmental categories go from 1 to 6 and the Spaanse Polder lets businesses between 1 and 5.3 settle on its location (Kegel, 2020).



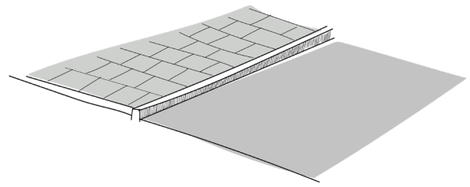
Closed facades
Because the businesses on the site consist of storage, make industry, and a few office spaces there is not a lot of need for windows. Office buildings have windows and shops that want to showcase their products have large windows but the majority of the buildings have closed facades and are made of a smooth surface which makes it hard for plants to grow on.



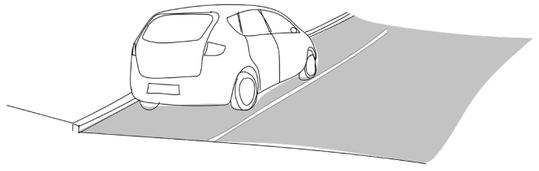
Flat rooftops
These large buildings do have an upside which is that many of them have flat roofs. Which means there are possibilities for these roofs. Some of the roofs have solar panels on them but there is not one roof that has a green, brown, or blue roof.



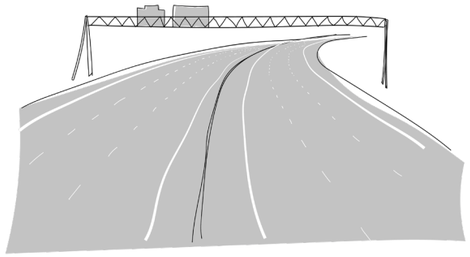
Paved areas
Not only all the roads and parking spots are paved but also the plots of the businesses are all paved. There is a lot of storage outside on these lots and all this outdoor space is paved.



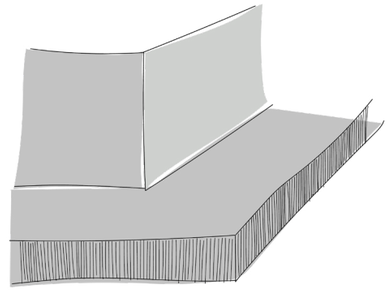
Parking
There is a lot of parking spaces on the business site. This means that most of the people working on the site take the car instead of the public transport or the bike. This can also be because the public transport is not the best in the area. The parking spots are not only used by cars but also a lot of trucks and vans which take up a lot of space.



Highway
The A20 is a highway that goes through the location. This highway causes a lot of noise pollution for the surrounding areas but because it is a business site there are buildings right next to the highway. The A20 is elevated going through the location and is filled with parking possibilities underneath.



Fences around properties
A lot of the businesses have fences around their property because they store their machineries or other products on their plot. But even a lot of the offices have fenced properties.

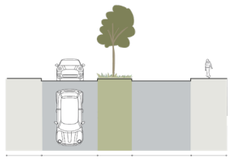


ROADS

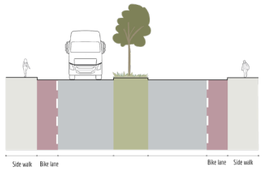
Because infrastructure is an important element for a business site the different roads have been analysed. What has been found is that there are two main structures where there are multiple variants off. These main structures are the green line and the grey roads. There are four variations to the road with the green line in the middle. And even the green line in the middle can differ from width but also if there are trees in the middle or if there is only grass. There are three variations to the grey roads, where in some cases there are trees but these trees are placed in pavement. The last variation of the grey roads is only accessible by car or trucks because the buildings or the fences are directly next to the road there is no space for a sidewalk or a biking path.

GREEN LINE

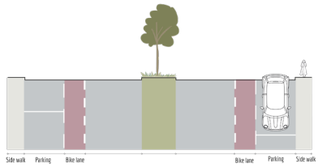
Sidewalk



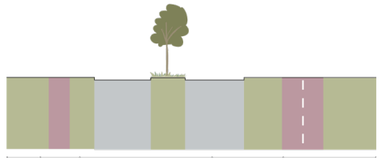
Sidewalk
Biking path



Sidewalk
Biking path
Parking

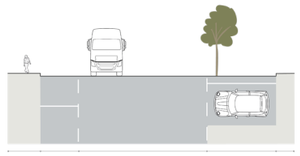


Green patch
Biking path

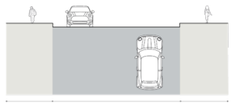


GREY

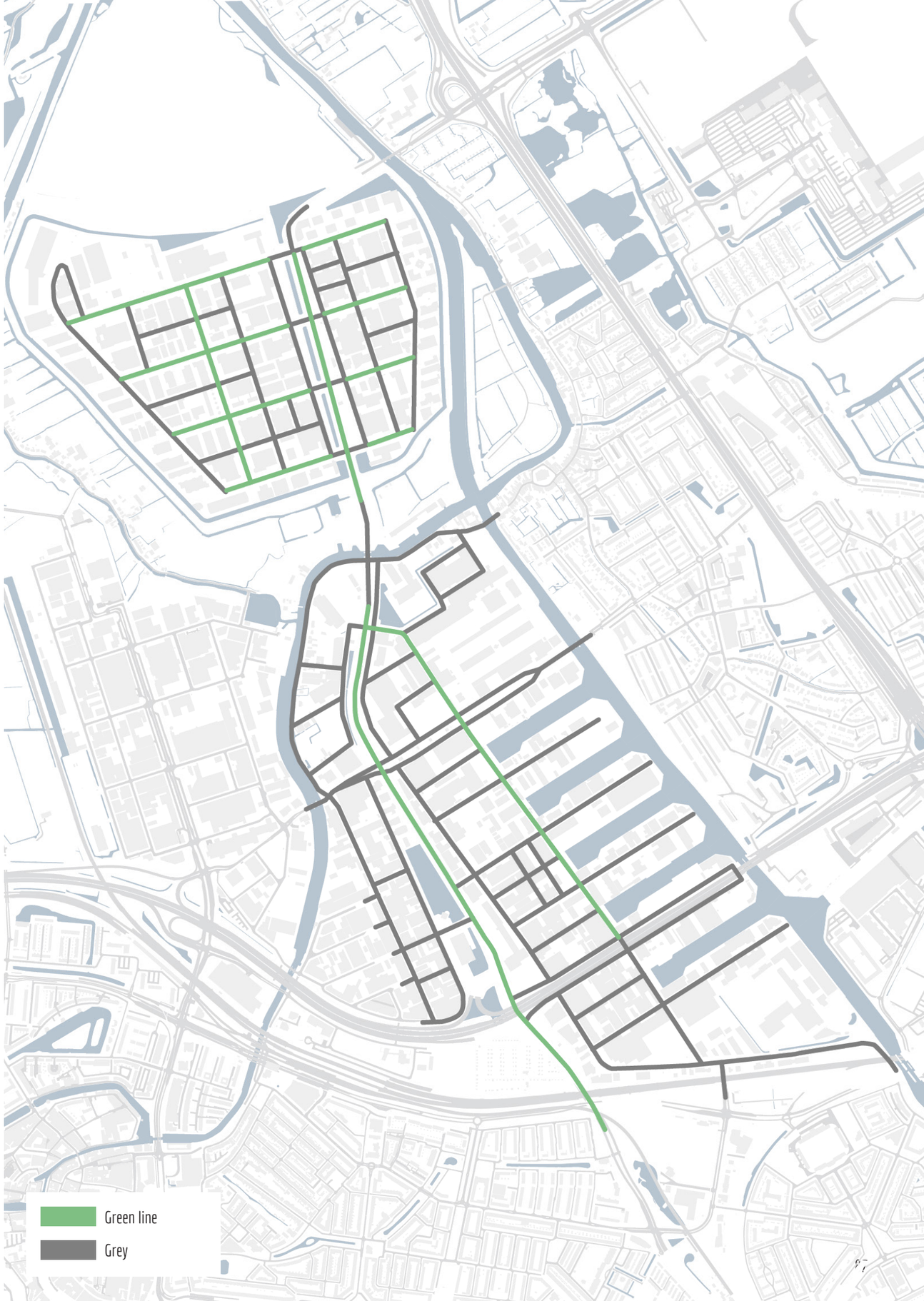
Sidewalk
Parking



Sidewalk



Only road



PUBLIC AND PRIVATE

Part of the grey structure is the private properties of the businesses. On these properties, there are all the businesses with flat roofs and paved areas and almost no green on their properties. The map to the right shows all the plots in the Spaanse Polder and where the trees and the green can be found. There are only a few trees that can be found on private properties. To be able to bring biodiversity back into the location the business owners could play a big role in bringing biodiversity back.

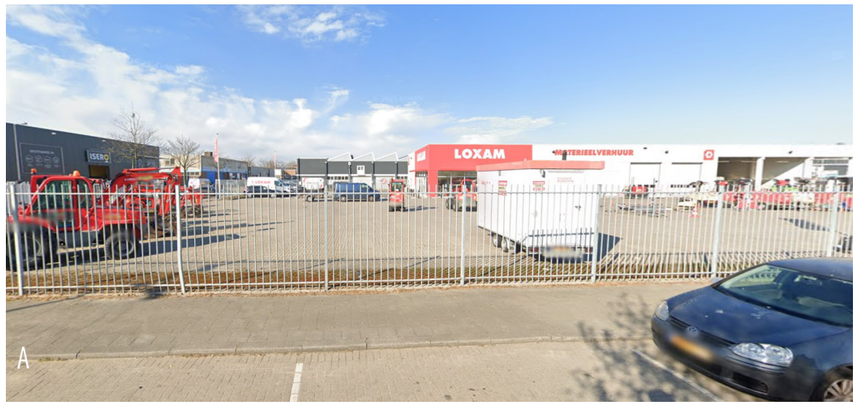
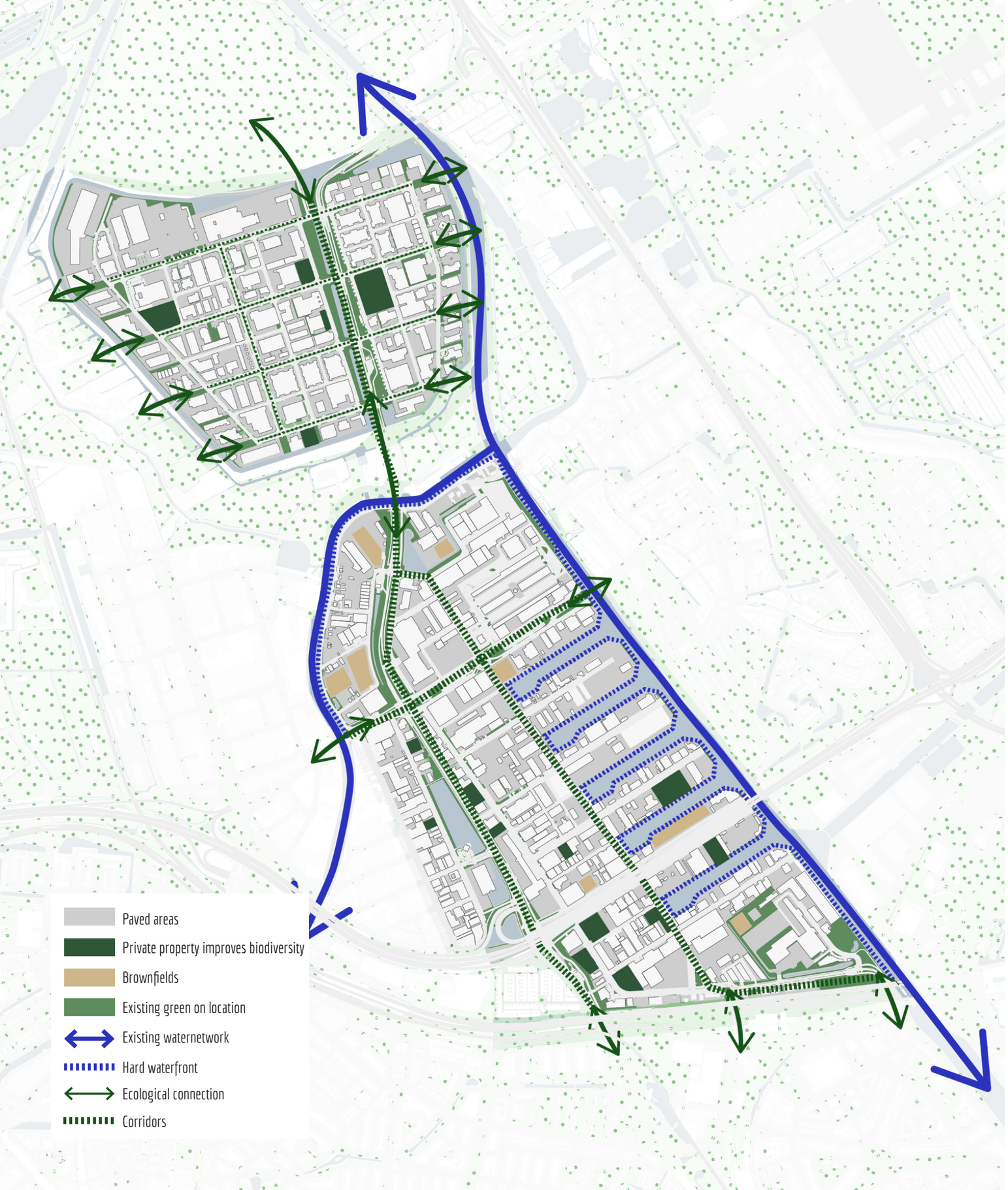


Figure 44 Private properties (Google maps, n.d.)



4.9 CONCLUSION

The analysis has given multiple typologies of the site for the blue, green, and grey structures. All these typologies have their own characteristics which form a threat or can be an opportunity to enhance biodiversity and human well-being. These typologies will be used later to find design tools to improve biodiversity and human well-being in these typologies which have been found in the analysis.

To answer the sub-question “What are the opportunities to enhance biodiversity and human well-being in a business site?” an opportunities map has been made. The opportunities map shows the opportunities for the blue, green, and grey structures and also for the private properties. An important element of wanting to enhance biodiversity is connecting ecological networks. For every structure an explanation will be given to what the opportunities are.

BLUE
Through the location the Schie goes which has enormous ecological possibilities. Now, most of the waterbodies have a hard waterfront which could be changed into a more nature-friendly waterfront. So can the waterbody be connected to the land which enhances biodiversity.

GREEN
The first opportunity is the water network but by creating nature-friendly waterfronts the water can be connected to the land. The opportunity for the green on the site is first to connect the green on the outside of the location into the location. By connecting the location site to the surrounding green corridors can be made which will go through the location to connect nature towards the city and the neighbourhoods. These corridors can be made through the infrastructure which is already there with often green lines in the middle with trees. Next to the corridors, there are some patches in the location of grass fields and brownfields which can be used to enhance biodiversity.

GREY
Now the opportunities for the two main ecological structures have been shown there are also opportunities for the grey structure. Because the amount of grey on the location is very high especially on the private properties of the businesses there are some opportunities for the businesses to help the green or blue structures and to improve biodiversity and human well-being.

In conclusion, to enhance biodiversity and human well-being there is a lot of opportunities especially when the private business owners will add to it. Creating the ecological networks with the use of the patch-corridor-matrix should be the main focus. And connecting these networks to the existing green on the outside of the location.

CHAPTER 5

DESIGNING FOR BUSINESS SITES

In this chapter sub-question 4 “What are design tools to enhance biodiversity and human well-being?” will be answered. If you want to design on a business site you need to know who are the users of this site. Four personas are introduced and what they find important for the location. Next, the different needs of animals are shown and three different animals will be chosen to show their specific needs.

The design tools are introduced and their relation to the blue, green, and grey structures. The functioning of the tools and the effect the tools have on their surroundings will be explained. Some of the tools will only improve biodiversity or human well-being but most of the tools have an effect on both biodiversity and human well-being.

Figure 45 Meadowia. (n.d.)

5.1 USERS

Knowing who the users are of the business site will help to understand what their needs are. This helps with creating new design tools and with implementing the design tools in the right location. First, four personas of people will be shown and secondly what animals need and three animals will be chosen and explained what they need.

PEOPLE
There are many different people who use a business site, especially a site like the Spaanse Polder which has at least 1400 businesses (Spaanse Polder, 2020). For this thesis four different users have been identified, these are; employer (the business owner), the employee, the truck driver, and the passer-by which is someone who is only going through the site.

Employer

Samantha is the business owner of a truck parts supplier of a company in the Spaanse Polder. She is 45 years old and has worked in the Spaanse Polder for over 20 years. She takes the car to work every day because she does not like the biking path towards her company even though she loves to cycle. She finds it very important that her employees are healthy and happy she always encourages her employees to go outside for lunch and take in some fresh air. Next to this she also wants to make profit and because her business supplies parts for trucks they need to be able to be transported easily. This is why she finds it very important that her business is well accessible by the large trucks.

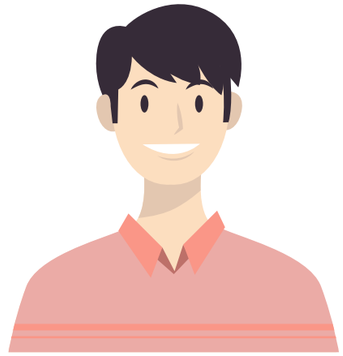
Passing through

Nick is a cyclist who often cycles through the Spaanse Polder. For him, it is important that the streets are safe to cycle through because there are a lot of trucks driving on the location. But he also enjoys his surroundings when he is cycling and especially some variety. This variety can be from different tree species to having different heights of bushes and some flowers planted. When Nick is cycling through the Spaanse Polder this is often the halfway point for him, so going for a small break in the area where you can get a coffee and apple pie would make him a regular guest to the site.

Employee

Vera is an employee at Doornbos Materieel which rents out equipment like forklift trucks and mini cranes. She has just started working here and she is still figuring out how to get to her work and where she can go to for lunch. This is why she finds it very important to create social connections with her colleagues. They now sometimes go for a walk through the business site but because it is not the most pleasant place to walk around, they often stay inside. Vera would really like to have a small park or some place to walk around which does not scream business site. She is a real social butterfly and likes to meet new people from other companies so having a place where more employees would go to where she can meet these people would really add to her wishes.

Truck driver



Joe is a trucker who often has to load and unload in the Spaanse Polder. When he has driven for a long time and he comes to the Spaanse Polder he would like to go to a simple restaurant to get some food and something to drink. He does not care about a green environment and wants to just have easy access with his truck to the location.

Figure 46 Personas (freepic.com)

ANIMALS

Not only are the people users of the location there are also animals. And with enhancing biodiversity on the location this also means more plants and animals will be attracted. But what does an animal need for its habitat? There are four components that are needed for an animal for its habitat these are; food, shelter (nest), access to freshwater, and space (National Geographic Society, 2012b; National Geographic Society, 2018). Of course, every animal has different habitat needs this will be shown on the next page with three different animals.

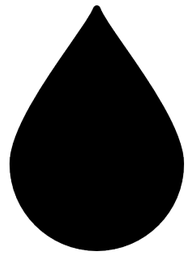
Shelter

There are many different shelters for animals, a shelter helps animals to protect themselves from the weather or from predators. But it is not only to hide in for the weather and predators it is also a place where they can raise their family or where they can sleep (National Geographic Society, 2012b). A shelter can be natural for instance a tree and preferably a evergreen tree which keeps its leaves or needles so the animal will stay hidden. But it can also be a shelter placed by humans for instance the Swallow nesting boxes or bat boxes.

Food

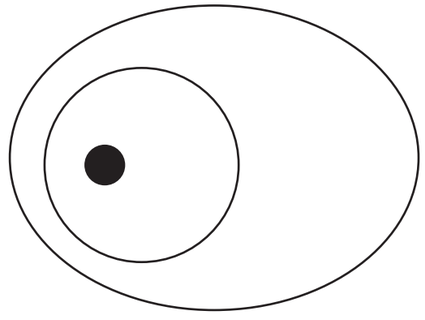
Every animal needs to eat to survive. Having the right food sources in a habitat will attract certain species. If the source will go away the animals will probably also disappear. There are a lot of trees or bushes which grow berries or attract insects that other species eat. There are some animals which we as humans help with their food source for instance birds, in the winter we put out seeds for them.

Fresh water



Having water is essential not only for animals but for all life on earth. With the Schie going through the location site there will always be water. But having access to the water is also important therefore natural waterfronts are ideal places where animals can get in and out of the water really easily.

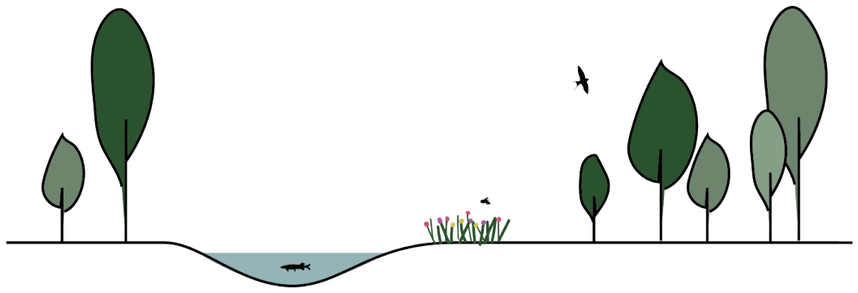
Space



Every species has its own need for space, there are animals which only need a habitat of a few meters like small insects. But there are also species that need a larger habitat mostly these species are also larger.

CHOSEN SPECIES

To have an idea of how different animals move through the location three animals will be chosen to see what they need for food, shelter, and space. A species from every habitat type which can be found on the location will be chosen, these are water, trees, and in the lower vegetation. A fish, a pollinator, and a bird will be chosen.



Swallow

Shelter
They build their nest under protruding eaves on the North or East side of the building (van Holten, n.d.). As other shelter spaces use swallows trees to hide in. Within a radius of 100-200 meters, there has to be clay, mud, or loam so they can build their nests (van Holten, n.d.)..

Food and water
For the food source, there is a need for insects around their nests with a radius of 100-200 meters (van Holten, n.d.).

Space
The swallows are only in the Netherlands in the summer in the winter they go to Afrika (van Holten, n.d.). But in the summer in the Netherlands, they have a smaller radius from 100-200 meters (van Holten, n.d.).

Solitary Bee

Shelter
The nesting space of the bees are often just in the ground but having small holes in a tree trunk can also provide for nesting places. There is only 15% of the bees that live in a bee hotel (Koel, 2003).

Food and water
The food source has to be pollinator flowers but which species specific is difficult to say because there are many different solitary bees and a lot of different flower species.

Space
Distance between the nesting place and the food source is between the 150m-600m (Gathmann & Tscharntke, 2002).

Northern Pike

Shelter
The spawing are of a Pike is in sallow waters of less than 50cm where there is a lot of planting availabel to hide in (Sportvisserij Nederland, 2006).

Food and water
To hunt the Pike likes to hide itself in a shallow waters between the reed or other plants in the water (Sportvisserij Nederland, 2006). The Pike is a predator and eats other fish but also frogs, mice, and baby ducks (Sportvisserij Nederland, 2006).

Space
The Pike is an animal that is true to one place but for the migration, the Pike can swim distances from just a few kilometers to tens of kilomoters but the exact distance a Pike swims is not know (Sportvisserij Nederland, 2006).

5.2 DESIGN TOOLS

In total there are 20 design tools that have been derived from the typologies of the analysis and from the users of the business site. They are divided into the three sections from the analysis; blue, green, and grey. The design tools in every section help with enhancing biodiversity and can also help with improving human well-being.

To really understand every design tool a more detailed explanation is given in the appendix where all these design tools are shown and what they add to biodiversity and human well-being. To give a small indication of how much a certain design tool adds to biodiversity or human well-being a "scoring" is used. In chapter 2, three principles have been selected for biodiversity and three principles have been selected for human well-being. These will help with giving a score to the design tools. For biodiversity these principles are; variety and numbers of species, habitat diversity, connecting. And for human well-being, the used principles are; health, security, and social relations. The functioning of the tools and the relations between the tools will be explained later.

An example of a tool and how it is shown in the appendix is shown on the right. For every tool, there is the larger goal of improving biodiversity and human well-being but the tool has also its own goals. Often do these goals influence the improvement of biodiversity and human well-being.

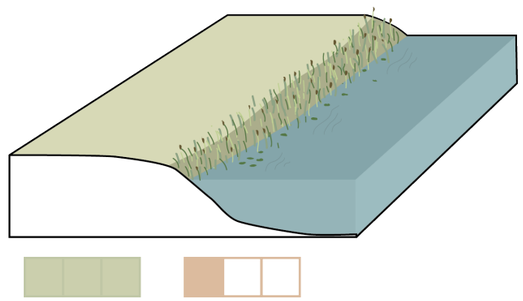
BIODIVERSITY

- Non of the principles are used
- One of the principles is used
- Two of the principles is used
- All principles are used

HUMAN WELL-BEING

- Non of the principles are used
- One of the principles is used
- Two of the principles is used
- All principles are used

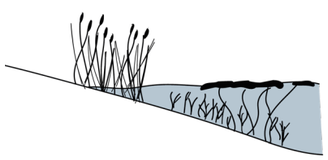
NATURAL WATERFRONT



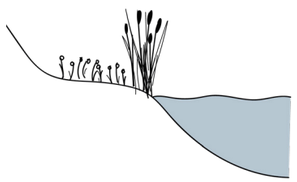
GOALS
- Noise control
- Climate control
- Entrance exit for animals
- Richness of planting
- Spawning area

A natural waterfront has a large biodiversity because there are different plants which can grow here (Gemeente amsterdam, 2018). Not only do these natural waterfronts have a richt biodiversity but they also have a functional effect. These are recreational, noise control, and climate control (Peking, 2013). Because of the gently sloping edges it is also a place for animals to be able to climb out of the water or go into the water (Gemeente Amsterdam, 2018). There are multiple types of natural waterfronts. These are the Plasberm, Drasberm, and the Flauwhellend talud (van Breukelen et al., 2003). These different waterfronts can be implemented in the existing situation depending on the use of the waterfront now. To get the best effect of the natural waterfront there should be at least 5 to 10 meters of natural waterfront created with many different species (van Breukelen et al., 2003).

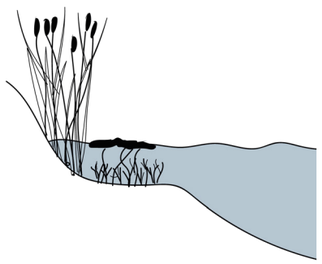
FLAUWHELLEND TALUD



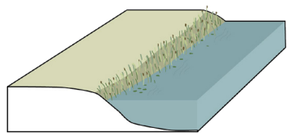
DRASBERM



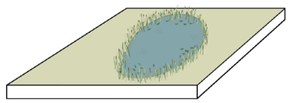
PLASBERM



BLUE

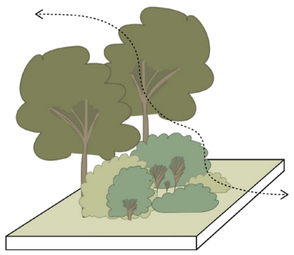


Natural waterfront

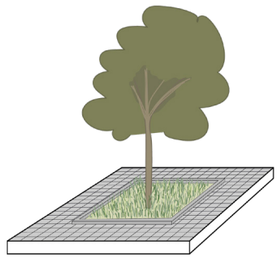


Pond

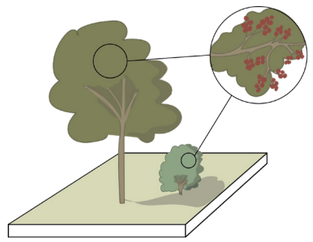
GREEN



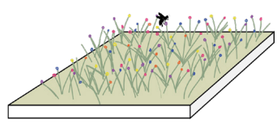
Gradients



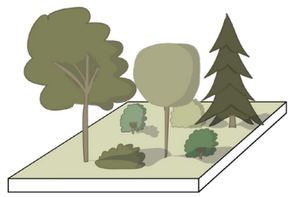
Healty tree drip



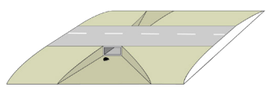
Foodsource planting



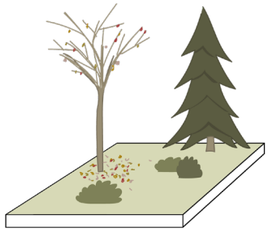
Pollinator flowers



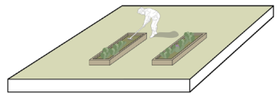
Difersity in species



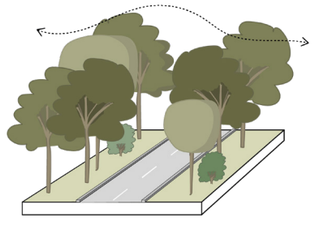
Fauna tunnel



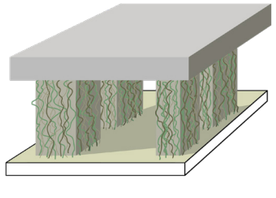
Evergreen planting



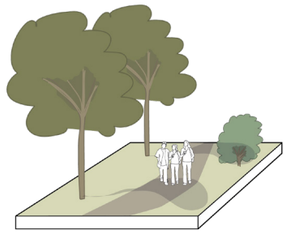
Kitchen garden



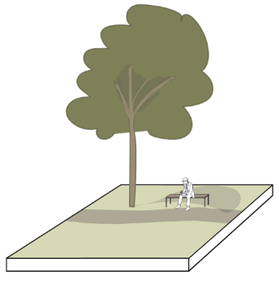
Green bridge



Green under the bridge

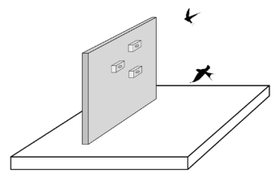


Walking path

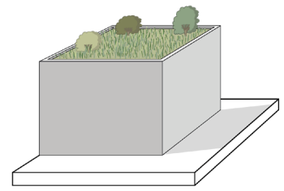


Sitting or gathering spaces

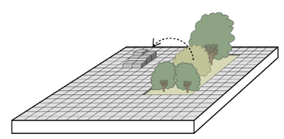
GREY



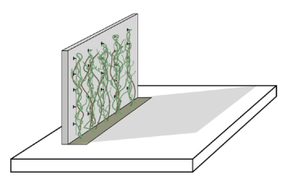
Nestplace



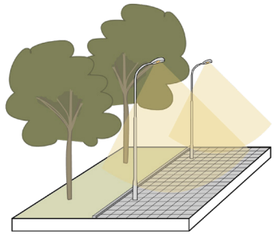
Green roof



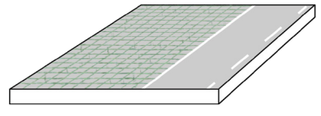
Taking out pavement



Green facade



Natural lighting



Permeable pavement

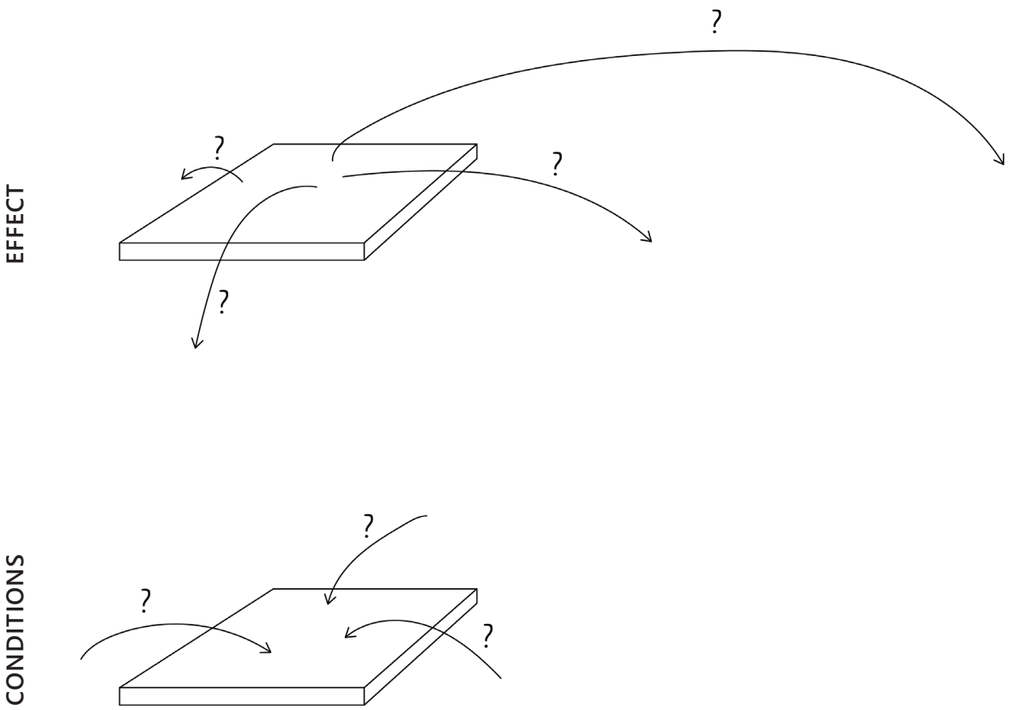
5.3 FUNCTIONING OF THE TOOLS

What is important to understand is that these tools are not only the tiles on which they are portrayed but they serve a purpose on different scale levels. Some of these tools are site-specific for instance a Natural waterfront and a Green roof for these you need a waterfront to start with and you need a building with a flat roof to implement these tools. But you also have tools like Diversity in species or Pollinator flowers, these tools can be implemented everywhere from next to the new natural waterfront to on top of a building with a green roof. This already shows the tools do not all work at the same scale or with the same conditions.

The main goal of these tools is to improve biodiversity and human well-being but all these tools also have their own sub-goals with what they improve for humans, animals, the business site, or the natural environment.

For implementing these tools on the location it is important to understand these tools. Firstly the effect a tool can have on its surroundings, every tool has its own goals and can have a different effect on a location. The effects can be on the animals living in the location or the animals which will be attracted. But the effect can also be to add to the ecological structure or be a new ecological structure. Or the tool can have an effect on another tool. Knowing which tools have what kind of effect and how these tools work together and which tools enhance each other can help with improving biodiversity and human well-being.

The second one is the conditions the tool needs to be efficient. What does the tool need to be implemented, in which climate, what location, what other tools or elements does the tool need to function at its best, or is there a need for existing ecological networks nearby? If you add a nesting place for swallows at a location where there is no food or water within a radius of 200 meters this nesting place will be useless (van Holten, n.d.).



That the tools have an effect on their surroundings and need to be in certain conditions an example has been made to how the tools can be implemented on a location. This can be seen in the figure below. There are five different tools that have been added to the location. As can be seen, is the natural waterfront all added at the now hard waterfronts, are the healthy tree driplines added at the locations where there are threes, are the pollinator flowers added on different spots throughout the location and is there a nesting place added at the buildings on facing North or East. Lastly, the diversity of species is implemented on the entire location.

In conclusion, there are two components that are important to think of while implementing the tools. These are the effect the tool has and the conditions a tool is placed in. Every tool in itself helps but adding multiple tools together could have a better effect. It could be seen as 1+1= 3, if you add two tools in the location this could improve biodiversity and human well-being better in comparison to when you add one tool in one place and one tool in another place.

5.4 CONCLUSION

In this chapter, the design tools to enhance biodiversity and human well-being have been identified. This gives an answer to the suq-question “What are design tools to enhance biodiversity and human well-being?”.

First, four different personas have been identified which explain their needs for the location at the Spaanse Polder, next to the personas which use the location there are also animals that use the location especially if the biodiversity will be enhanced. There are three animals which have been chosen one from the water, one in the sky and one close to the ground. And every need has been identified for these animals. From this together with the analysis 20 design tools have been identified which enhance biodiversity and human well-being, these tools have been divided into three sections; blue, green and grey.

These tools are all “measured” with the help of the principles which have been chosen for biodiversity and human well-being. Next to the scoring, they get for how many boxes they tick from the principles these tools also have their own goals. The tools can be found in the appendix.

For implementing the tools there are two components that need to be taken into account. These are the effect the tool has on its surroundings and the conditions is needed for the tool to function properly. For the effect a tool has on its surroundings it should be thought of the effect the tool has on the animals in the area, or the effect a tool has on other tools, and if the tool adds anything to the ecological structures. For the surroundings which are needed for a tool to function properly can be the climate, other tools, and the availability of an existing ecological structure.

Last, the implementation of the tools can be seen as 1+1=3 which means tools can enhance human well-being and biodiversity better if tools collaborate with each other and multiple tools can work together.

CHAPTER 6

DESIGN IMPLEMENTATION

The last chapter of this thesis will use research by design by implementing the tools into the location site the Spaanse Polder and give an answer to the sub-question "How can these design tools be implemented in the case study location Spaanse Polder?". This will give a better understanding of how the different tools relate to each other or what is needed to implement a tool on a certain spot. Multiple locations will be chosen to implement the tools.

First, the vision of the area will be presented. In this vision, the ecological structure, the private properties, and the recreational layer will be shown. From this vision two strategies to improve biodiversity and human well-being are introduced. Then multiple locations are chosen where these tools will be implemented to enhance biodiversity and improve human well-being.

Figure 47 Michael Fiala. (n.d.)

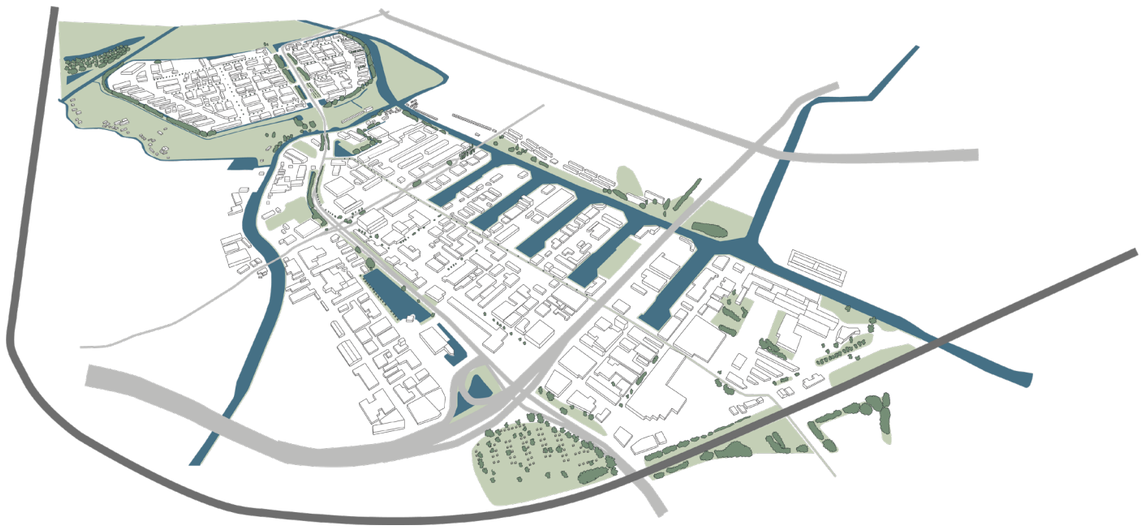
6.1 VISION

The existing nature in business parks is limited and does not help to improve biodiversity or connect to the ecological structures in the Netherlands. This is the problem field of the business parks now. Which has resulted in the vision of the business site Spaanse Polder to become a corridor for connecting ecological networks and having multiple patches on the site instead of the grey barrier it is now.

To enhance biodiversity and human well-being in a business site a vision has been made. This vision is based upon the two strategies which will be explained in the next part. The vision is built in different layers. There is the ecological layer, the private properties, and lastly, there is also the recreational routes and spots that are created by enhancing the ecological layers. These layers can be built upon each other.

As can be seen in the situation now there are some green areas around and in the location. In the North, there is a wrap around the head of the Spaanse Polder which has a lot of green. In the first layer, the ecological layer shows the corridors through the location and the patches where biodiversity will be enhanced. In the second layer, there are the private properties if they would add green roofs, green facades, permeable pavement or taking out pavement. This layer can be a key element to adding biodiversity because as can be seen the surfaces of the facades, the roofs, and the plots are enormous. The last layer is the recreational layer which goes hand in hand with the ecological layer where the patches will become recreational spots where people can go to walk around or meet new people.

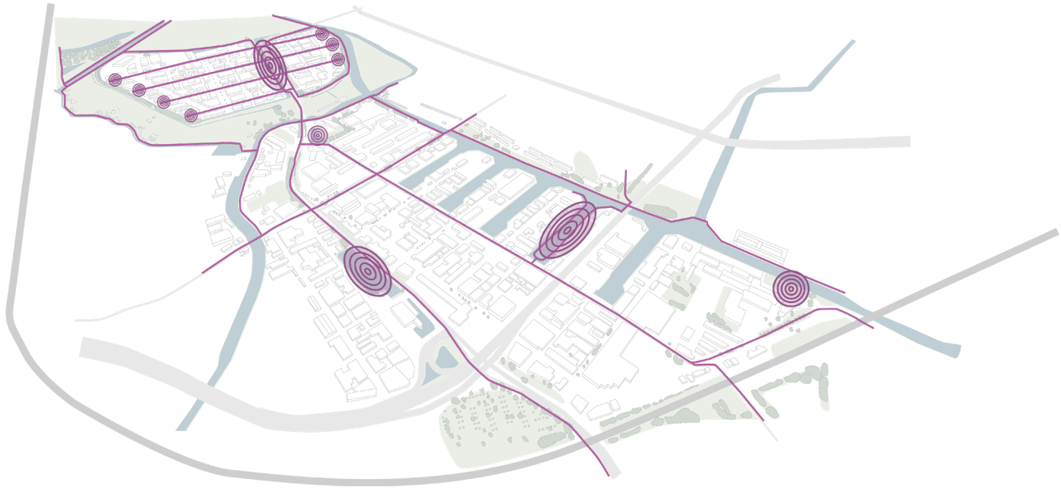
SITUATION NOW



ECOLOGICAL LAYER

PRIVATE PROPERTY LAYER

RECREATIONAL LAYER



6.2 STRATEGY

As mentioned before is the vision based upon two strategies to enhance biodiversity and human well-being on the site. The first strategy is the backbone of the ecological connections going through the location. The second strategy is a strategy for the private properties of all the businesses on the location and what they can do and what effect this can have on the main structure and how this improves biodiversity and human well-being.

BACKBONES

For having an ideal situation there are three main elements that are important for ecology. The first element is the water structure. Water is the infrastructure of the fish and small amphibians. The water is a connector not only on the smaller scale from dry to wet but also on the larger scale with fish who can migrate from the Netherlands to Germany. The second element and third element are both part of the dry connectors from which the first one are the trees which is the infrastructure for the birds and some of the insects. The last element is the grasslands, shrubs, and flowers which is the infrastructure for all the small insects and other small animals.

PATCH-CORRIDOR-MATRIX

To be able to enhance biodiversity the ecological networks need to be connected to the surrounding areas to enlarge the habitats. To the North, there is the Midden-Delfland which is partially a nature reserve. To the West there is Beatrix park to the East there is the Sidelinge park in a residential area and to the South there are broad green lines next to the roads. These ecological networks can be made through the blue structures and the green structures and of course with the addition of the patches.

BLUE NETWORK

Because most of the waterfronts are hard waterfronts this means that there are many opportunities to make these waterfronts natural waterfronts which will add to the biodiversity. With creating a natural waterfront the connection from land to water will also be improved where the animals can easily go in or out of the water.

GREEN NETWORK

The green network in the location goes from North to South and from West to East. Especially in the Northern part of the Spaanse Polder is there a clear lining structure. These green networks follow the main roads that go through the location.

PATCHES

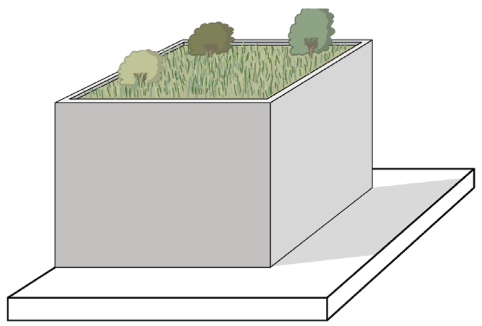
There are multiple patches in the location where biodiversity will be improved and where there is a place for people to go to. These patches are connected to the green network and sometimes also to the water network.

PRIVATE PROPERTIES

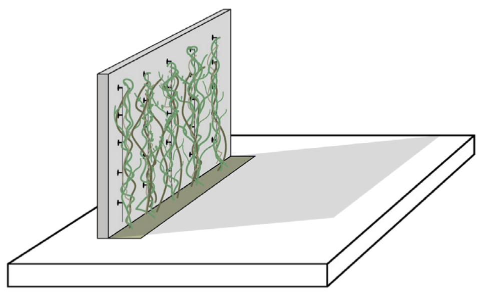
In the first strategy, the public area is used to create the main ecological connections through the location. But this does not have to be the only solution to improving biodiversity and human well-being. The businesses on the business park can also contribute to the improvement of biodiversity and human well-being. For this thesis, four tools have been chosen which the business owners can use to improve the biodiversity on their plot. These four tools are the green roof, green facade, and the permeable pavement or taking out pavement. On the right there is a map created where an option can be seen if some plots use one or multiple of the tools. For the ecological connections plots close to the newly created connections could help with improving this connection.

These tools do not only benefit biodiversity and human well-being but these tools can also benefit the business itself with maybe their image of being a green company or with climate control.

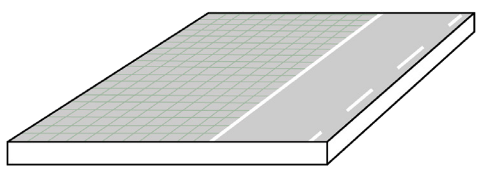
GREEN ROOF

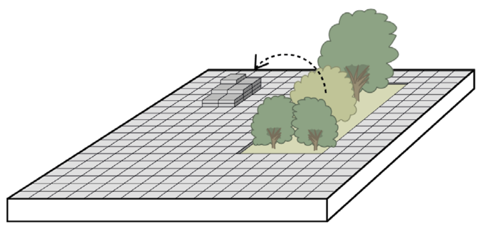


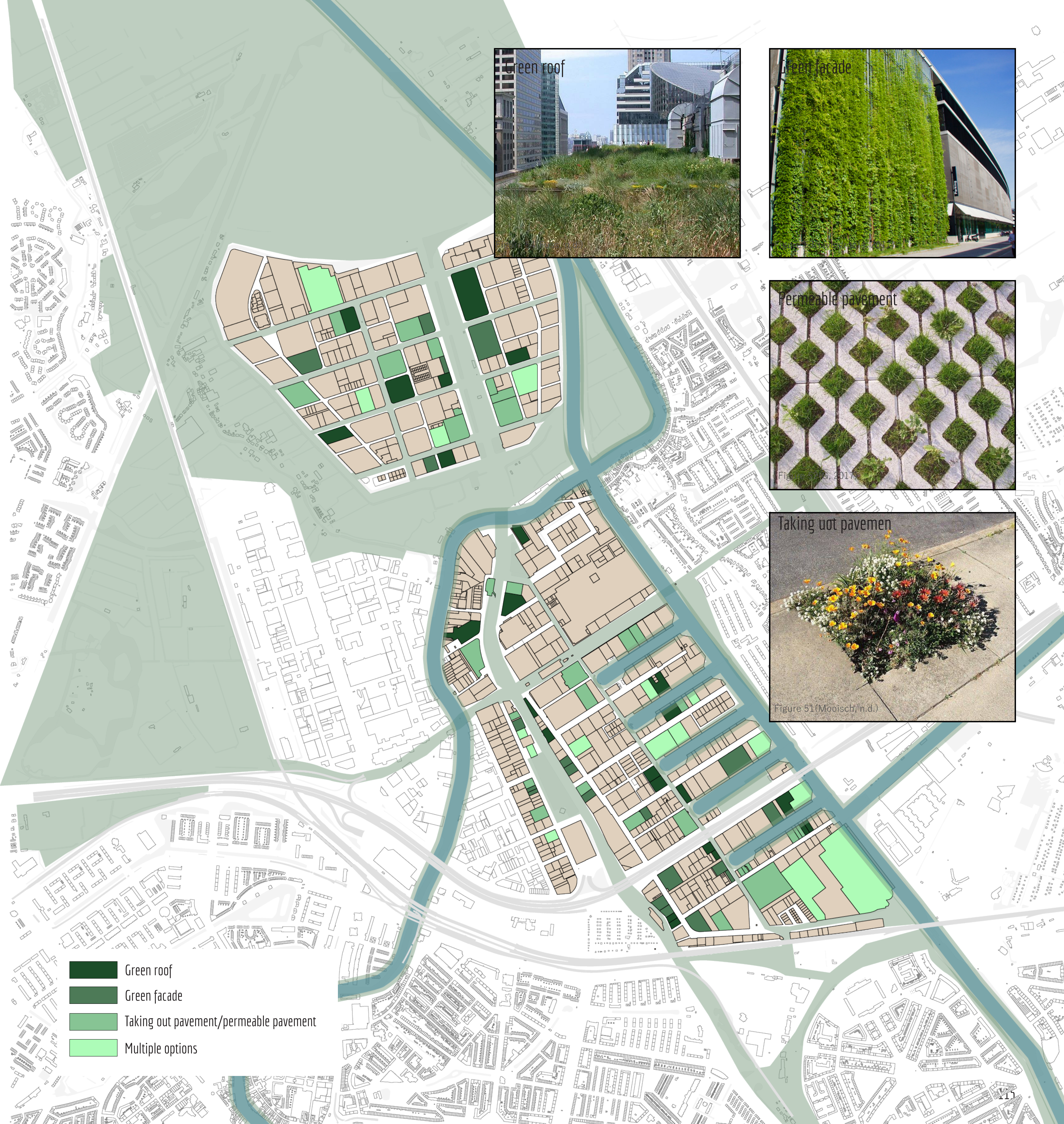
GREEN FACADE



PERMABLE PAVEMENT
TAKING OUT PAVEMENT







6.3 LOCATIONS

Now the strategy has been explained locations will be chosen to see how these tools can be implemented on these locations. To get a representative view of the possibilities of what can be done a location will be chosen located next to the water network, on the green network, three patches, and private property. Some of the locations which will be chosen are part of multiple elements. For instance the location next to the waternetwork is also a patch or where the patch is also apart of the green network.

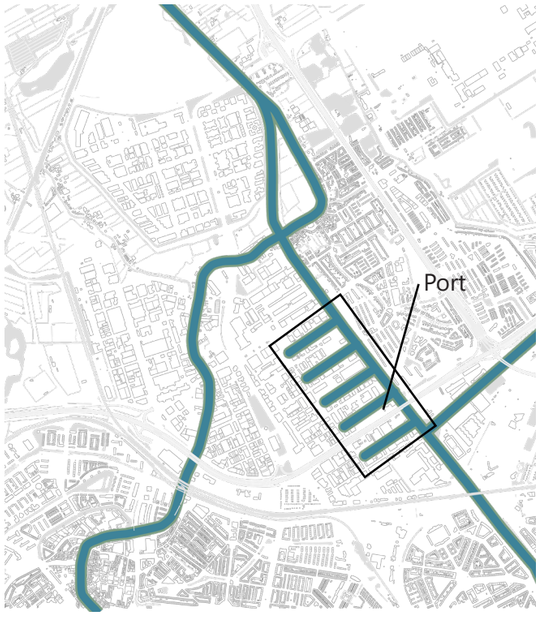
PORT
The port is the location that is part of the waternetwork. A port is not only part of the waternetwork but it is also a place for the boats to load and unload which means these port arms can be important for the businesses located next to the water.

MATLINGEPARK
The Matlingepark is a location site in the North which will be part of the green network going from North to South. But the Matling park will also be a patch for more biodiversity and a place for people to go to.

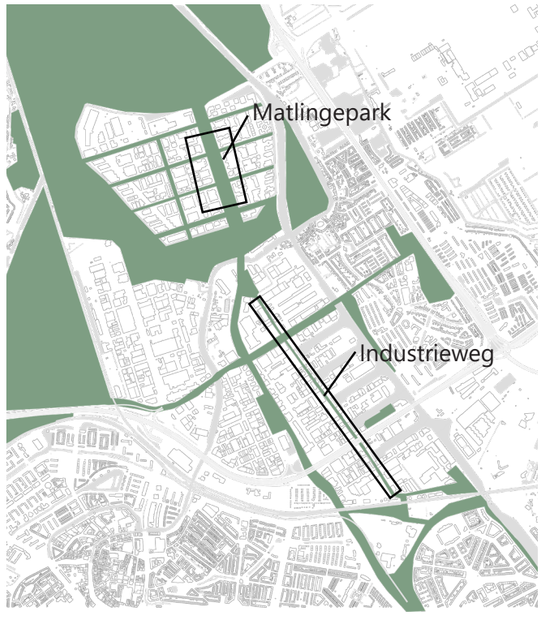
POCKET PARK
There are multiple spots where pocket parks can be implemented in the public space, they are now especially located in the North on the ends of the green corridors. One of the pocket parks will be used to design on and this will be an example for the other pocket parks.

INDUSTRIEWEG
The industrieweg is one of the roads which form an ecological connection through the area. Because the industrieweg has two different road typologies which were explained in the previous chapter this road will be used as an example.

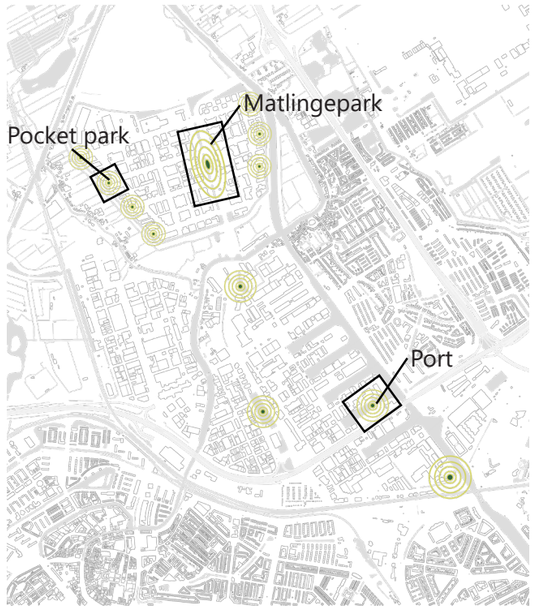
PRIVATE PROPERTY
Lastly the private property should have an example of how this could look like if businesses would add a green facade, a green roof, or have permeable pavement or take out pavement.



BLUE NETWORK



GREEN NETWORK

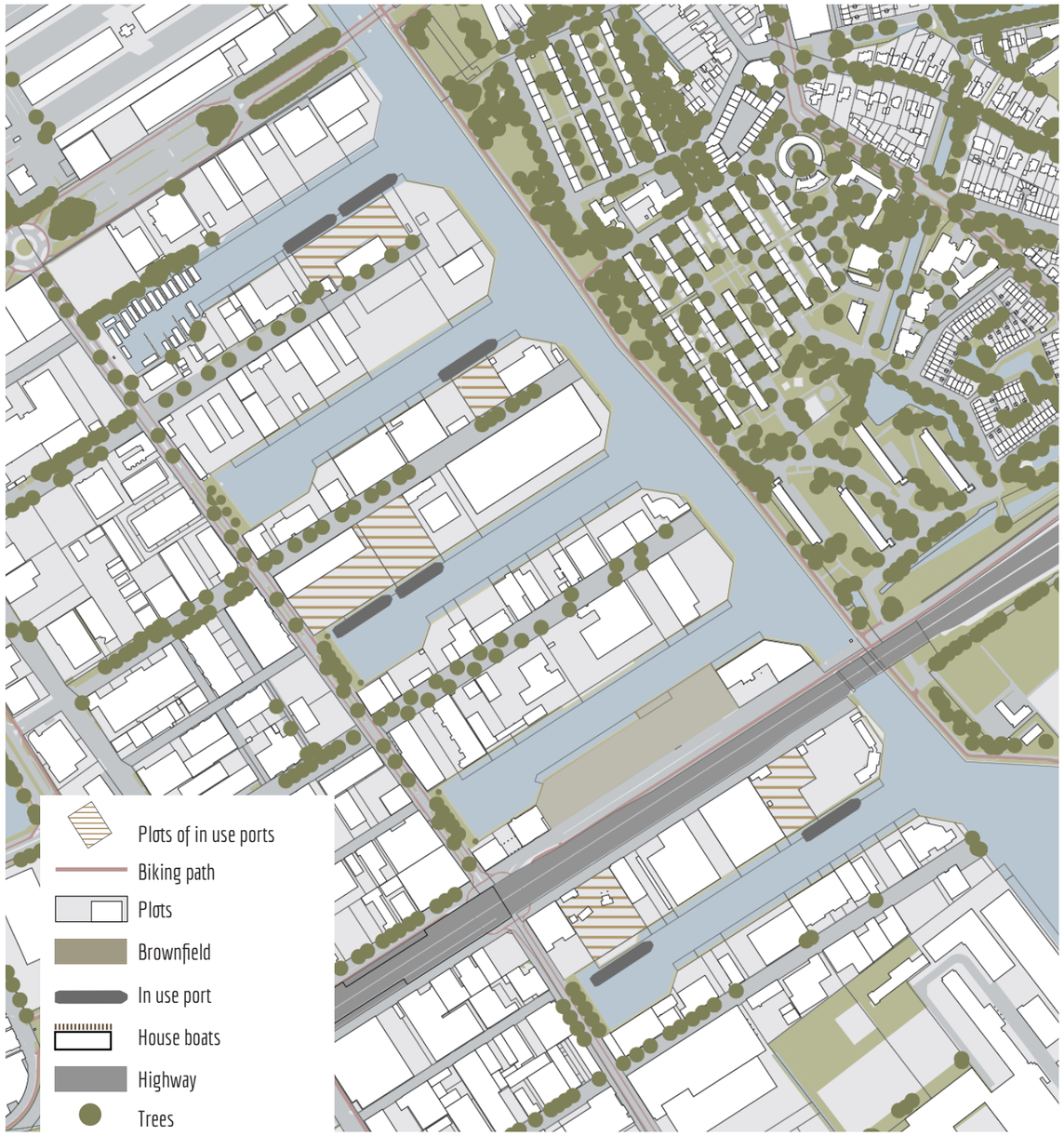


PATCHES

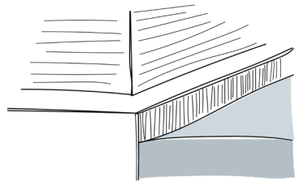
PRIVATE PROPERTY

6.4 PORT

SITUATION NOW

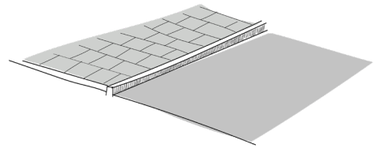


The Port is a characteristic spot in this business park. The possibility to have water bounded businesses in the area makes this business park a bit more unique than other business parks which do not have a port. Even though there are not that many businesses that still make use of the port it is still an added value for the site. The water in the port is connected to the Schie which has many ecological properties. But because the waterfronts are hard they do not add to the biodiversity. For this thesis, the arm where there are no businesses that use the water is chosen as the main location to see how this place will be redesigned and how the tools can be added. There will also be a design for businesses that still use the waterfront to make them more biodiverse.



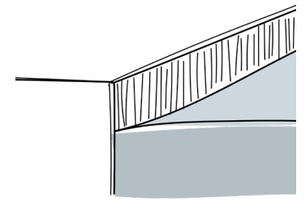
BACKSIDES

Most of the businesses around the arm are not focused on the water which means they have their backsides towards the waterfront.



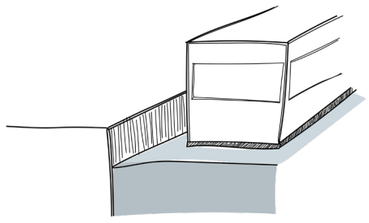
PAVED AREA

There is a lot of paved areas on the site. Because the plots of the businesses are all paved by the owners because or they use it for storage or just never took the chance to take out the pavement. If you look at the difference of paved areas between the neighbourhood to the right which has a lot more green.



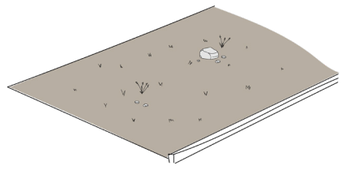
HARD WATER FRONT

The port has a hard waterfront, this means the quay goes straight down into the water. This makes it harder for small animals to get out or in the water.



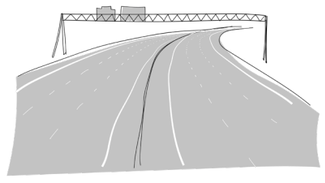
IN USE PORTS

There are still some businesses that use the water for the transport of products. Next to some in use businesses, there is also in one arm that has houseboats. There is one arm that does not have any businesses which use the waterfront.



BROWN FIELD

On the Southside of the port-arm where there are no buildings, there is a large area that is not in use and is now an open field. This offers a lot of opportunities to add biodiversity and even other functions.



HIGHWAY

In the South through the location goes the A20. The highway creates a lot of noise and pollution. The highway is raised so underneath there is parking.

NEW SITUATION

NATURAL WATERFRONT

In the new design, the hard waterfronts in the port arm have been transformed into natural water bodies. An extra pond has been added which functions as a water buffer but also creates a different habitat for multiple species because it will be a shallow pond. Next to the new natural waterfront there is a new walking path for people to enjoy the outdoors. There are multiple spots next to the walking path where there are docks with benches where people can sit down. This new natural waterfront is part of the ecological connection of the Schie but it also is a connection between water and land because one of the corridors goes past the port arm.

PARK WITH INNOVATIVE BUSINESSES

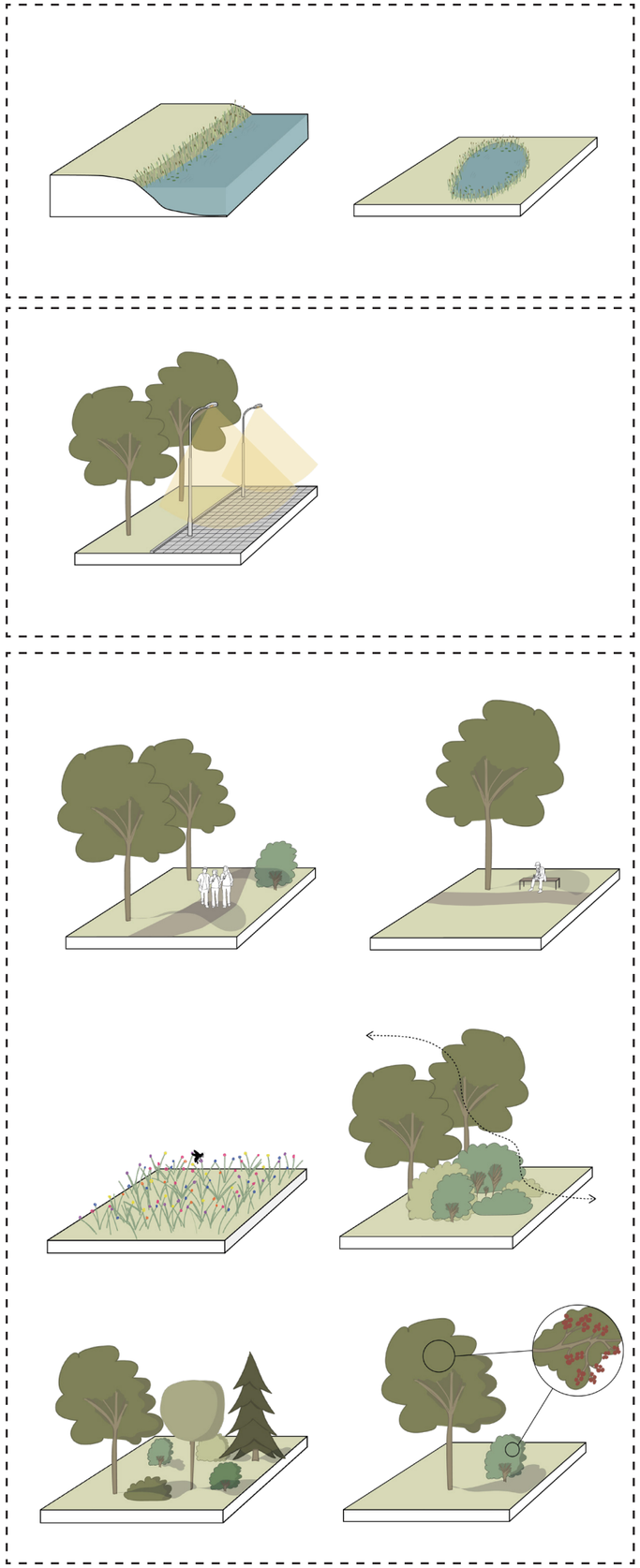
On the brownfield new innovative businesses will be settling which have biodiversity and human well-being high in their priorities. The main principle of these new businesses is that they will fit into their natural surroundings and give easy acces to the people working in the buildings. The location will also be accessible for people who do not work in the building.

IN USE WATERFRONTS

Because there are still a lot of waterfronts that are in use it is good to have a design for these waterfronts to make them ecological friendly waterfronts. It is important to keep in mind that boats still need to be able to go in and out of the arm and need to load and unload their cargo on land. To have room for the natural waterfront dukdalfs will be placed so the boats can still dock but will have a distance from the waterfront which makes room to make a natural waterfront.

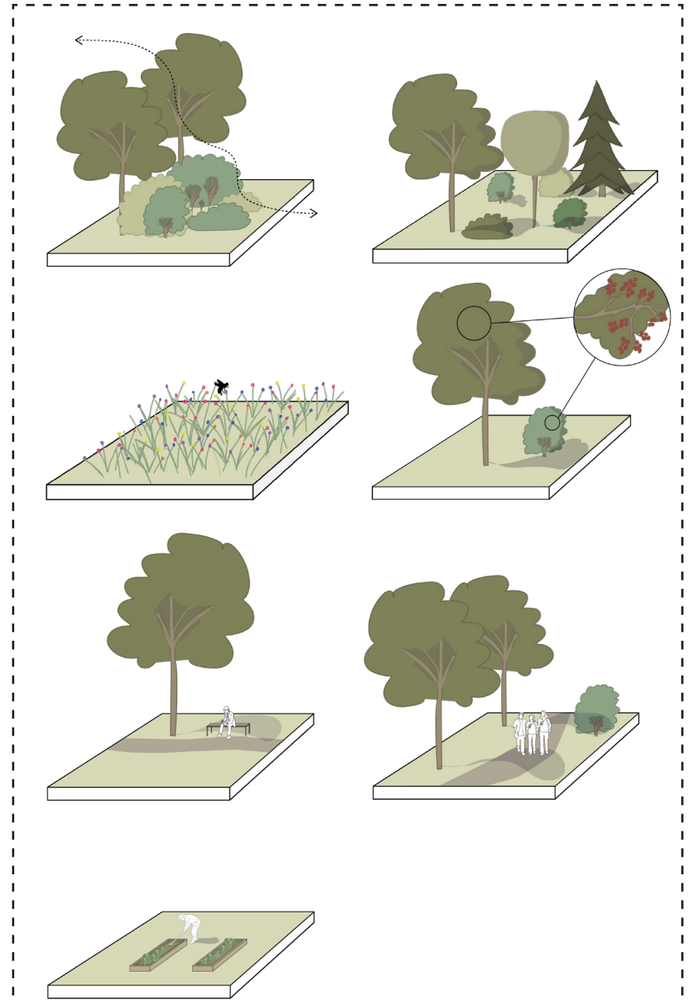
NATURAL WATERFRONT DESIGN

In the harbour arm which is not used anymore, a natural waterfront will be created with slow sloping edges where many different plants and animals can live. Next to the new natural waterfront, a long stretched pond will be created which creates a different habitat because it is shallow water and different plant species can live in this habitat. With these different plant species also different animals will be attracted. To create hiding spots multiple heights of planting is used in the area. At the moment there is almost no lighting in the area but placing normal streetlights can scare off animals so nature-friendly lighting will be used on this site. To give people a place to socialise or to rest there are docks on the side where you can sit down on benches.

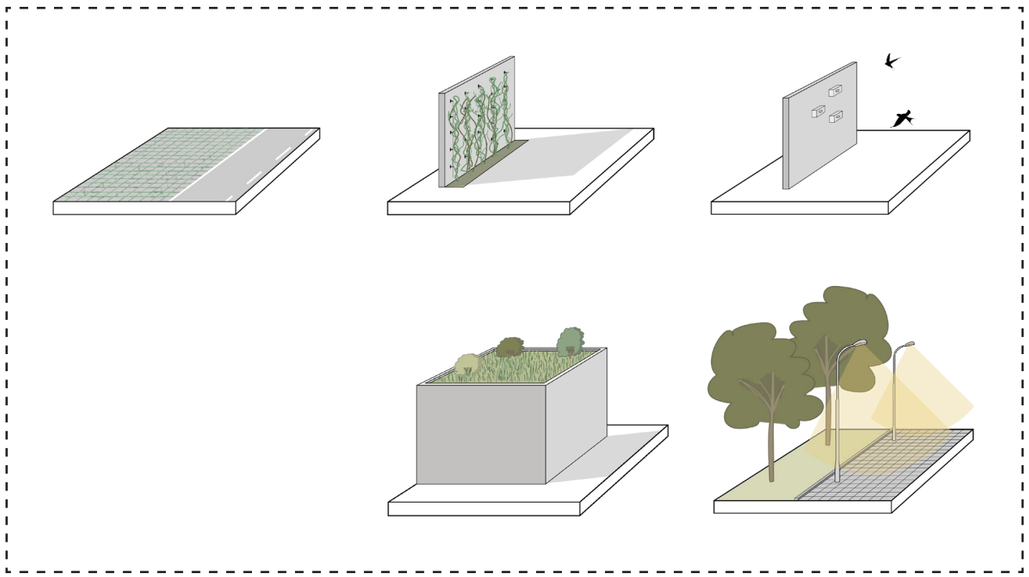


NEW BUSINESSES DESIGN

TASSH



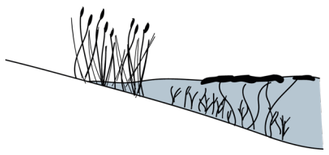
Because there is a brownfield situated next to the new natural waterfront this plot can be used to place new innovative business on the location. The businesses have to share their plot with the public because they will be publicly accessible. Because the focus is on biodiversity in the area there will be limited parking for the employees but underneath the highway, there are many parking spots that can be used. And the limited parking will motivate people to take the bike or go by public transportation because there will be good bike parking space inside the building. The roof and the facades will be green to reduce the noise pollution of the highway which is right next to it. The placing of the planting will reduce the noise pollution this will be shown later. Around the buildings, there will be nesting places for animals planting which provide food and nature-friendly lighting. To make the space also part of the business employees can start their own kitchen garden in between the buildings so they can grow their own lunch.



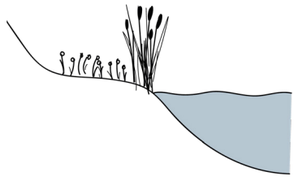
IN USE WATERFRONT DESIGN

The majority of the waterfronts of the port are still in use or at least one or two businesses situated in the arm make use of the water. In the port-arm where there are no businesses which use the waterfront the flauwhellend talud could be implemented. This type of natural waterfront can not be used for the in-use waterfronts. There are two other options to create a natural waterfront which are the drasberm and the plasberm. Because the inland vessels need to be able to dock in these arms dukdalfs could be used. Using dukdalfs further away from the edge gives the possibility to transform the hard waterfronts into natural waterfronts. The difference between this waterfront and the one in the port-arm which is not being used is the sloping of the ground. Where the in use waterfronts can be slowly sloping at first but need to go down steeper in the end because these inland vessels need to dock there in comparison to the slowly sloping ground of the flauwhellend talud.

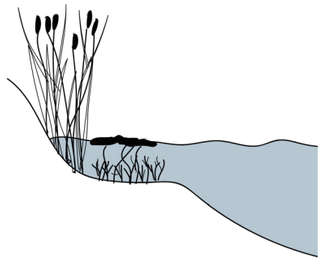
FLAUWHELLEND TALUD

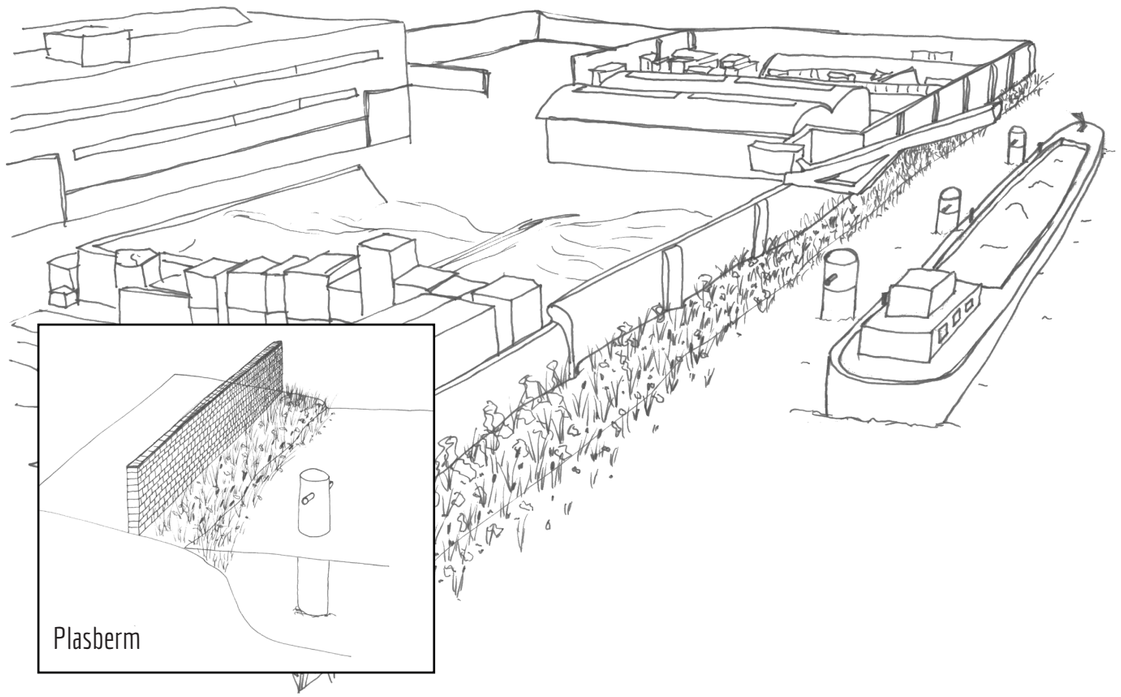


DRASBERM



PLASBERM





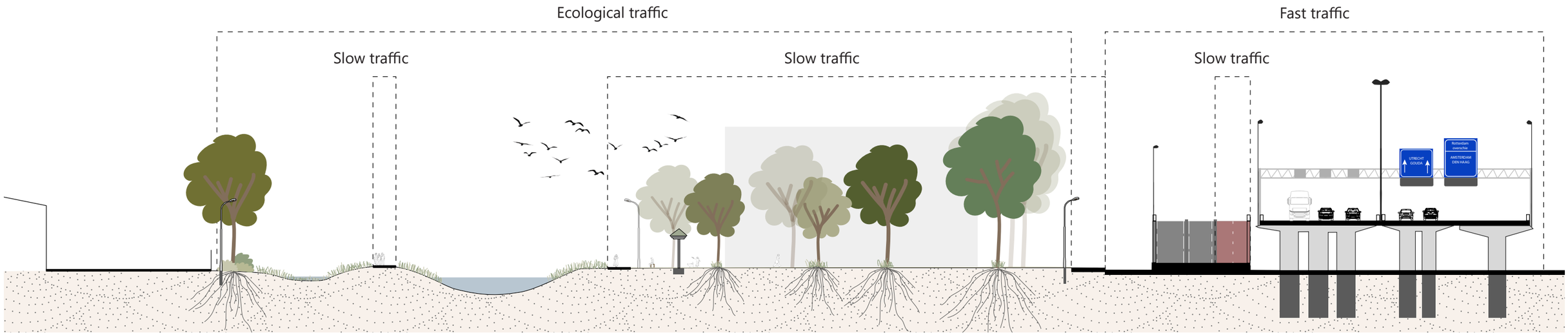
On the map, all the hard waterfronts are shown in the location. Only at the bochtafsneiding there are natural waterfronts implemented when they created it. The Schiedamse Schie which is the arm that goes to the left down is not being used by inland vessels but only by recreational boats which gives a lot of opportunities to create natural water bodies and even maybe a walking path next to the waterbody. The Delfshavensche Schie is used by the inland vessels which makes the possibility of a natural waterbody a bit more limited.

SECTION

In the section can be seen how the natural waterfront and the new innovative businesses are situated and are connected to each other. As can be seen in the section right next to the innovative businesses there is the highway which produces a lot of noise pollution. To try to reduce the noise pollution of the highway the innovative businesse will get green roofs and green facades. Next to using the buildings as buffers, the planting can also be used as a buffer, the planting used will get higher going towards the highway. The buildings will be 18m tall which means they will be taller than the highway. Between the passages between the buildings, a group of larger trees will be planted.

In the section, different traffic types can be identified. There is the slow traffic which is walking paths at the new natural waterfront and the walking in between the new businesses but also the biking path next to the highway. Then there is the ecological traffic of all the plants and animals in the newly designed plan. And lastly, there is the fast traffic at the highway next to the design.

Why these innovative companies would want to be placed here next to a busy highway can be explained if you drive on the A20 you have a perfect view of the green facade buildings which will catch the eye of everyone who will drive past. This would be a perfect advertisement for the company.



ECOLOGICAL TRAFFIC

A combination of larger trees and smaller shrubs underneath gives shelter for birds also for small mammals. Using planting not only gives shelter but also can give food like Common honeysuckle and Sweet-Brier (vogelbescherming, 2021).

Plants in a shallow water body consist of Coontail which keep the water clean. The yellow iris and yellow water-lily are plants that frogs and dragonflies use to get out of the water (Natuurmonumenten, 2021).

There are multiple plants that attract pollinators. These plants are full of nectar and need to be close to a nesting place of the insects. Every plant can attract different species so having a variety of planting will attract a variety of species.

Plants for a natural waterbody which create a hiding place for small animals can be Phragmites australis, rush or Cattail. The Cattail and the rush are plants which filter the water, if it rains and the water from the business sites spills in the river it goes past these plants which filters the water (Planten als waterzuiveraars: helofytenfilters, 2020).

Common honeysuckle

Sweet-Brier

Yellow Water-lily

Yellow iris

Coontail

Orpine

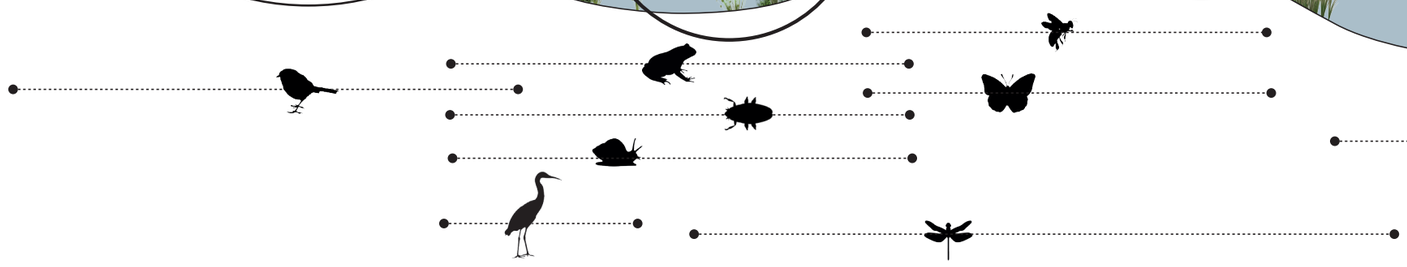
Salvia nemorosa

Ajuga reptans

rush

Phragmites australis

Cattail (Lisdodde)

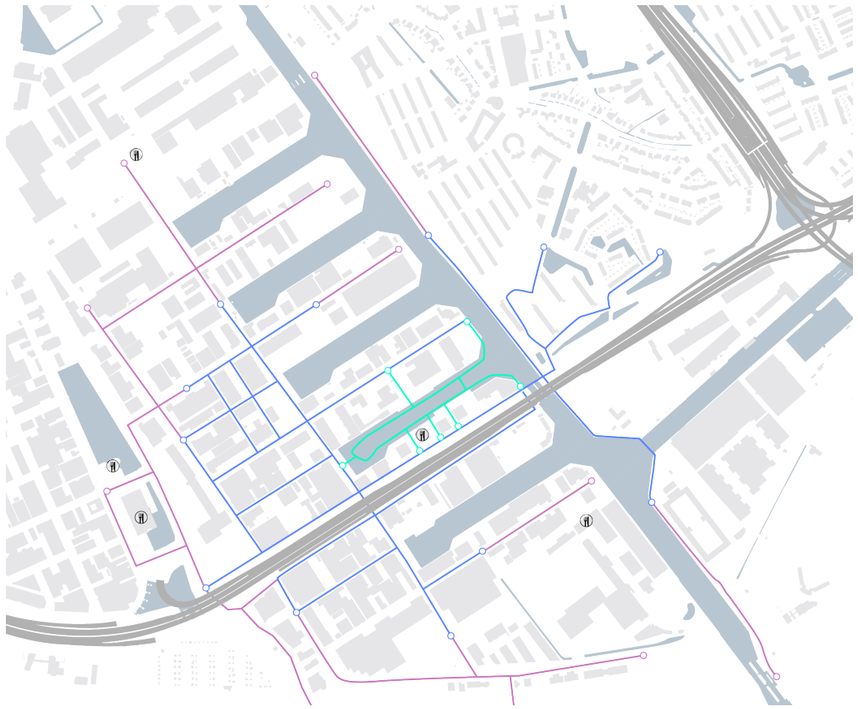


SLOW TRAFFIC

Through the creation of the natural waterfront, a new walking path is added to the site. This walking path is an ideal place to go for your lunch walk or for people who work close enough and for people who live close by in a neighbourhood who like to enjoy nature. A map has been created which shows different distances and also where there are restaurants where people can get something to eat.

There are a few places around in the area where you can get food for lunch. To the West, there is the Mc Donald's and the Schmidt zeevis in about an 11 min walk. If people want to get to the new waterfront it would be good if a restaurant could be opened in one of the new buildings on the ground floor.

Two different distances have been chosen one is 500m which is about a 6 minute walk and the other one is 900m which is about an 11 minute walk. A normal lunch break is about 30 minutes which gives enough time to go to the newly created walking path on the natural waterfront and walk back. During a site visit at lunchtime, there were quite a few people walking outside even in December.



Restaurant / snack

New walkingn path

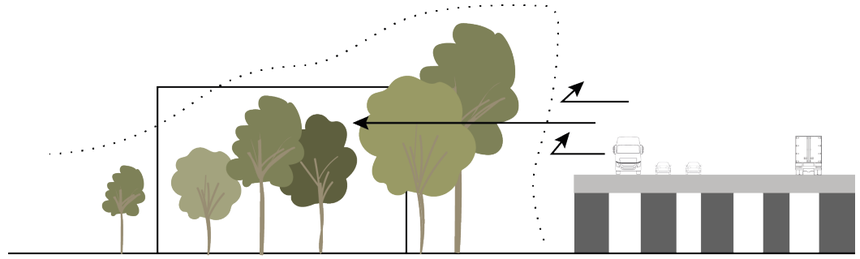
500m = 6 min walk

900m = 11 min walk

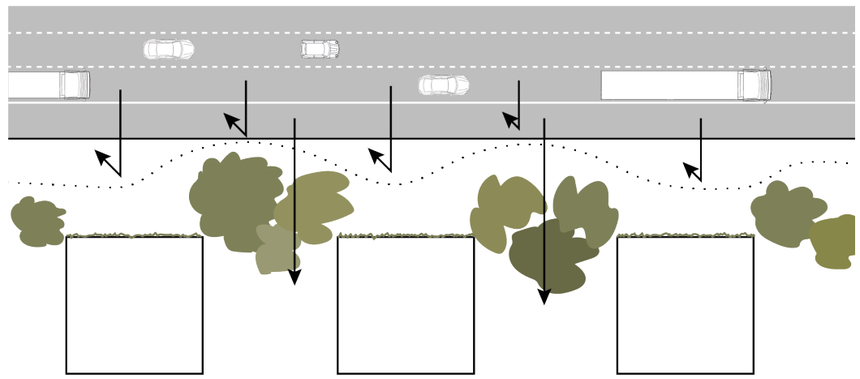
Highway

FAST TRAFFIC

As mentioned before the A20 goes through the location site. To be able to reduce the noise pollution and other pollution vegetation is used. This is done by planting trees which are bigger towards the highway and by planting trees in between the buildings. Because the buildings will be higher than the A20 is they will already hold off a lot of the noice and by using green facades they will help to reduce the pollution and even clean the air.



Side view



Top view

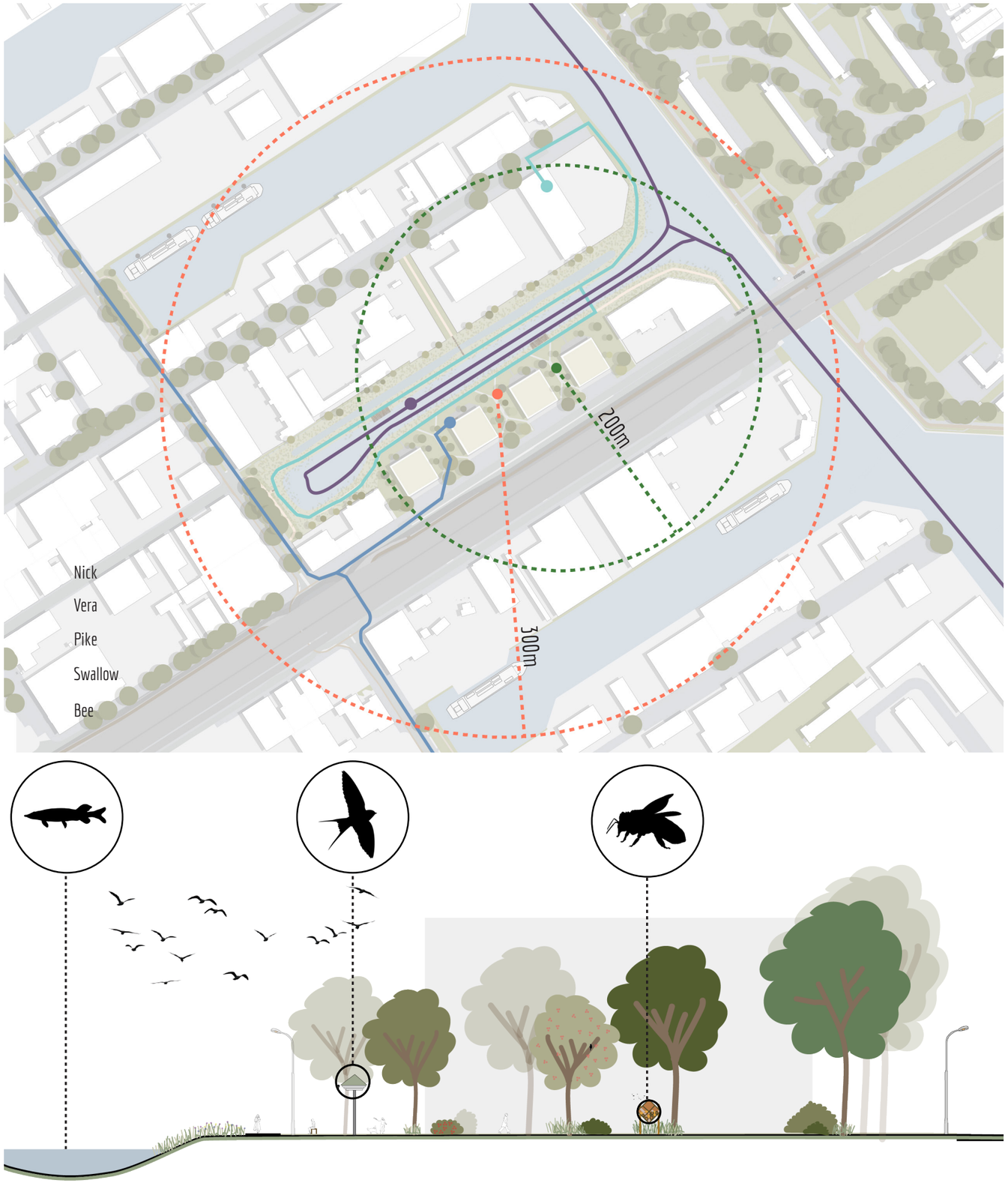
PERSONAS

In the previous chapter multiple personas have been introduced. Now these personas will be placed in the location and how they would use it. First up we have Nick and Vera, Nick is a cyclist who cycles through the location and now there is a place for him to take a break and eat apple pie and enjoy nature. Vera works in a company that is very close to the new natural waterfront. Every lunch she goes for a walk around the natural waterfront with her colleagues and sometimes meets new people at the restaurant in one of the new businesses placed.

Next there are the Swallow, Pike, and the Bee. As explained in the previous chapter these animals need to have a nesting place, access to fresh water, and they need to have a food source at a certain distance. In the section the Swallow, Pike and the bee are placed at the nesting spot for them. Around them, there is water and the food sources they need like flowers for nectar and other insects for the Swallows and Bees and the shallow water with planting where the Pike can hunt for its prey. There are also bushes and trees for shelter for the animals on land. To design for the animals it is important to keep in mind that different animals travel different distances to find their food, for instance the bee can travel between 150-600m for its food in comparison to the Swallow who wants to find insects not further than 200m from its nest (van Holten, n.d.) (Gathmann & Tscharntke, 2002). If there are nesting spaces for animals but there are no food sources for them in the distance they are willing to travel these species will not stay.

NICK

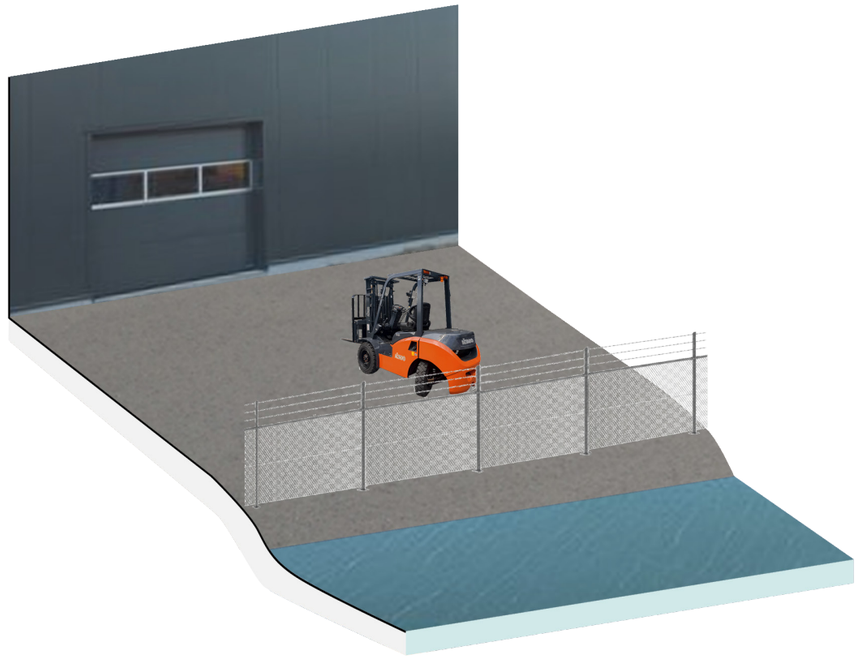
VERA



POSSIBLE STEP IN THE FUTURE

Right now all the businesses in the harbour arms are in use but it could be in the future that businesses will leave and in their place a start-up or an innovative business can settle. If these new businesses would have the same approach as the new innovative businesses and be surrounded by green which adds to biodiversity and is open for the public. The port arms could get a whole different look in the future which would look a lot more like the high tech campus of Eindhoven than the grey business park it is now.

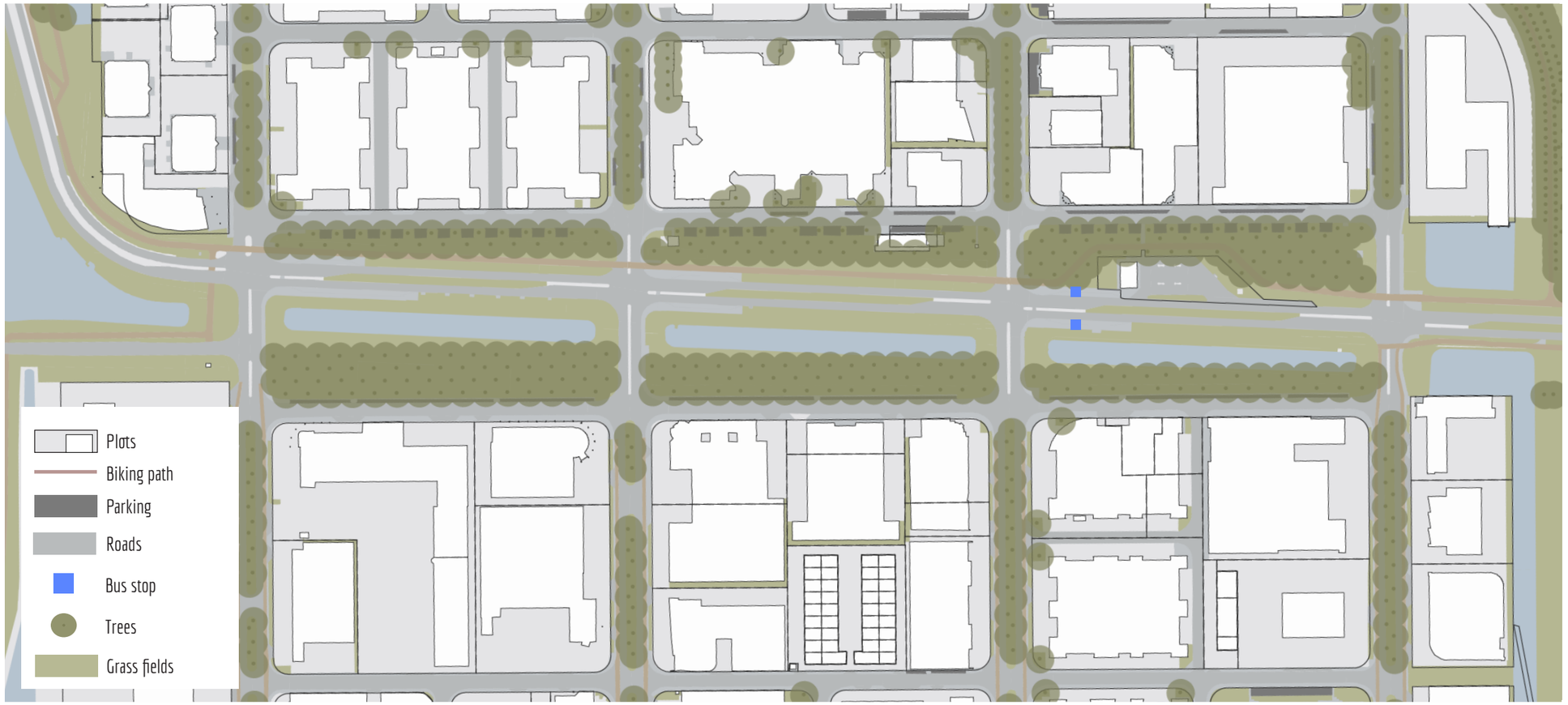
OLD SITUATION



NEW SITUATION

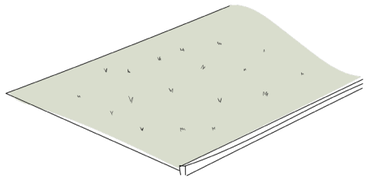
6.5 MATLINGEPARK

SITUATION NOW



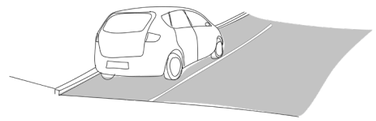
The Matlingepark is not a real park right now, at the moment it only consists of a grass field with tree lanes and some ponds. There are six separate parks at the moment where the Matlinge road goes through from North to South and two roads which go through the location from West to East. This park is part of the ecological connection going from North to South through the location. And is at the same time a patch where biodiversity will be enhanced and there will be room for people to go for a walk or sit in nature.

To the North of the location, there is a possible connection with the natural environment which will be connected through the Matlinge park into the location site. There is a barrier of roads in between but this barrier can be overcome with some of the tools.



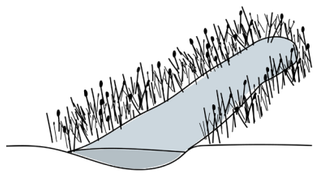
GRASS FIELD

The Matlingepark now consists of large grass fields with trees. There are no other planting on the site and it does not look inviting to go walking on the grass field between the trees.



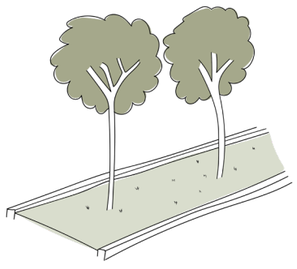
PARKING SPOTS

On the sides of the park there are parking spots situated. On the East side of the park, these parking spots have just been renewed. During the site visit, these parking spots were used intensively which means they are needed for the location.



OTHER WATER BODIES

There are three ponds situated in the location. They are connected through culverts under the road. The ponds do have a more natural waterfront which means animals can go in and out but there is not that much planting which means no food or hiding space for animals.



TREE ROWS

There are multiple rows of the same species of trees in the location. The trees are Populus x Canadensis trees and they are around 20 meters tall.

NEW SITUATION

MATLINGEPARK

In the new situation of the Matlingepark, there are a view changes firstly the crossing roads which went from West to East have been taken out which means the green can be connected and two larger parks can be made one to the East side of the Matlingeweg and one to the West of the Matlingeweg. In the park, there will be a new walking path with connections to the waterfront to sit down. Because the existing trees are very large and probably already pretty old they will be left in their place and between these trees new species will be planted to create more biodiversity.

ECOLOGICAL CONNECTION

To connect the park to the North and to the South to the existing green fauna tunnels together with a tree bridge will be used so the small animals and birds can pass through the location safely.

Old situation

- Plots
- Biking path
- Parking
- Roads
- Bus stop
- Trees
- Grass fields

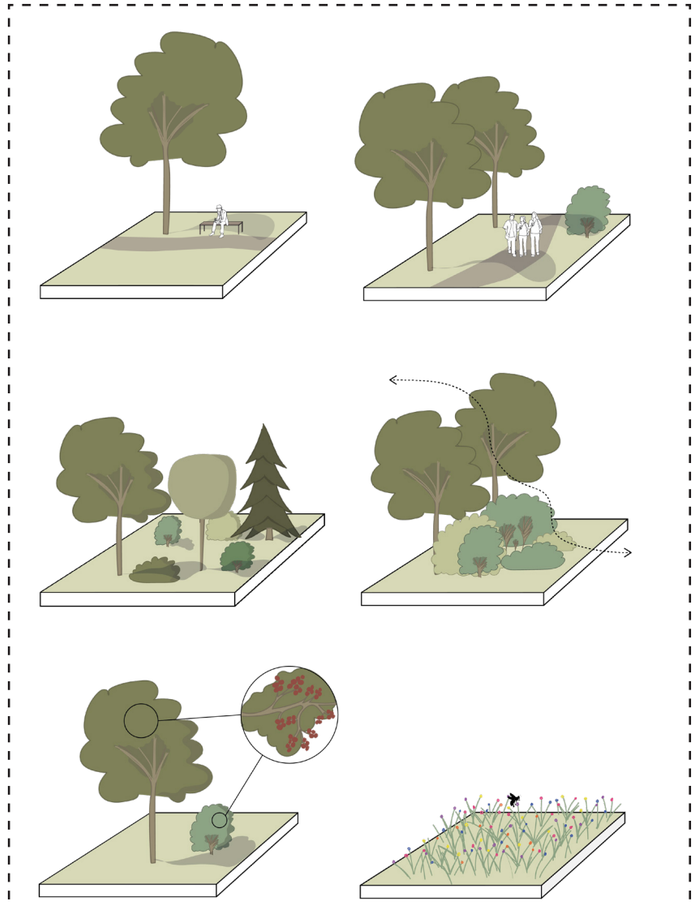
New added

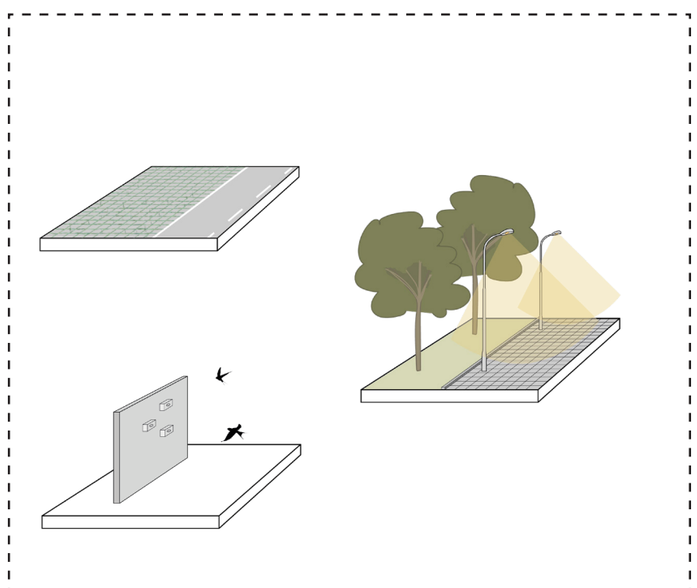
- Walking path
- New biking path
- Jetty
- New trees
- New waterplants and pollinator flowers

MATLINGEPARK DESIGN

The Matlingepark is now a park which is accessible for people to enjoy nature and to take a walk or just sit down. The park has a length of around 650m and decreases it is with from North to South from 70m to 40m. In the park, different heights of vegetation and some evergreen planting is used as a shelter for animals. There will also be nesting boxes placed in the location for the Swallow and other species. Because there is a pond which is a source of water for the animals this location could be an ideal spot for many different species. On the edges of the water, planting will be placed to filtrate the water.

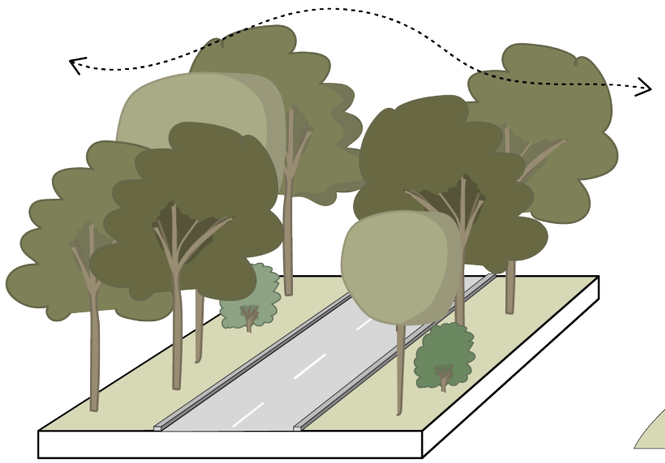
For the parking spots which are now situated next to the park will be permeable pavement used to improve the water infiltration. To light the streets natural lighting will be used to prevent animals from getting disorientated.

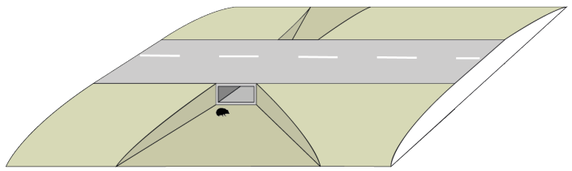




ECOLOGICAL CONNECTIONS

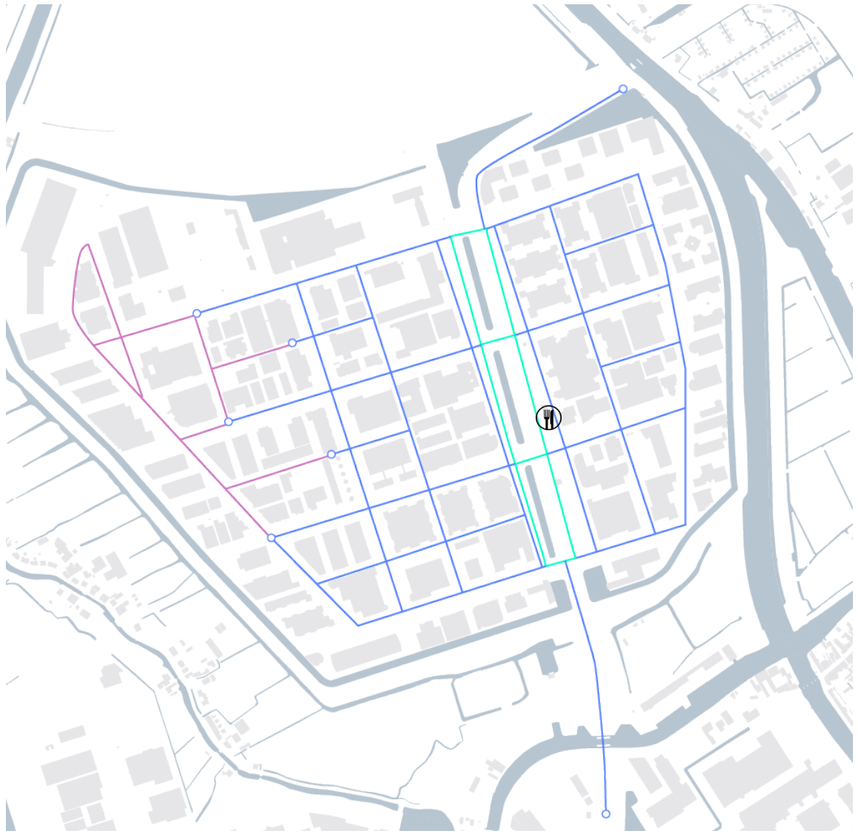
For the improvement of biodiversity ecological connections need to be made this can be done to the North and to the South of the Matlingepark. But in between the Matlingepark and the green on the outside, there is a road. There are two tools that can be used to create a connection for the animals to safely cross the road. The first tool is the fauna tunnel for the small animals which need to cross the road. The tunnel goes underneath the road so the animals do not need to cross the road. The other tool is a bridge made of trees so the birds and other animals which can fly can cross over the road safely.





WALKING DISTANCE

With the creation of this new park, a new walking path has been created where people can go to walk and just sit down. The distance from the park to the surrounding businesses is pretty close most of the businesses are in a range of 500m which is about a 6 minutes walk. Only a few businesses to the West have to walk a bit further but this means there is still a lot of time left for the people if they want to go for a lunch walk to walk around in the park.



Restaurant / snack

New walkingn path

500m = 6 min walk

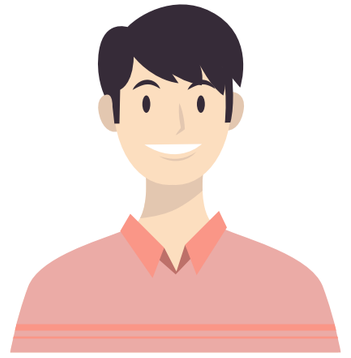
900m = 11 min walk

PERSONAS

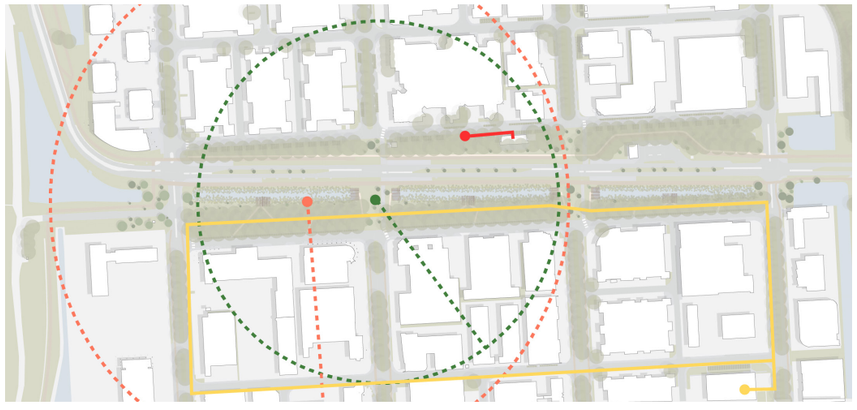
In this location the personas Samantha and Joe are shown together with the Swallow and the bee, the pike is not in this location because the water is not connected in a way the Pike can go through. Joe is a truck driver and when he comes to the Spaanse Polder he parks his truck close to the restaurant and goes in for his breakfast, lunch or dinner. Joe does not really care about the new park which is created but from the restaurant, he does enjoy looking at the newly created park. Samantha has just enough time to walk around which goes partly through the new park in her lunch break. She also encourages her employees to go outside for a walk during lunchtime or during another break.

The Bee and the Swallow both have a nesting place in the new park and from there they can get to fresh water and to enough food like insects and pollinator flowers.

SAMANTHA



JOE



Samantha

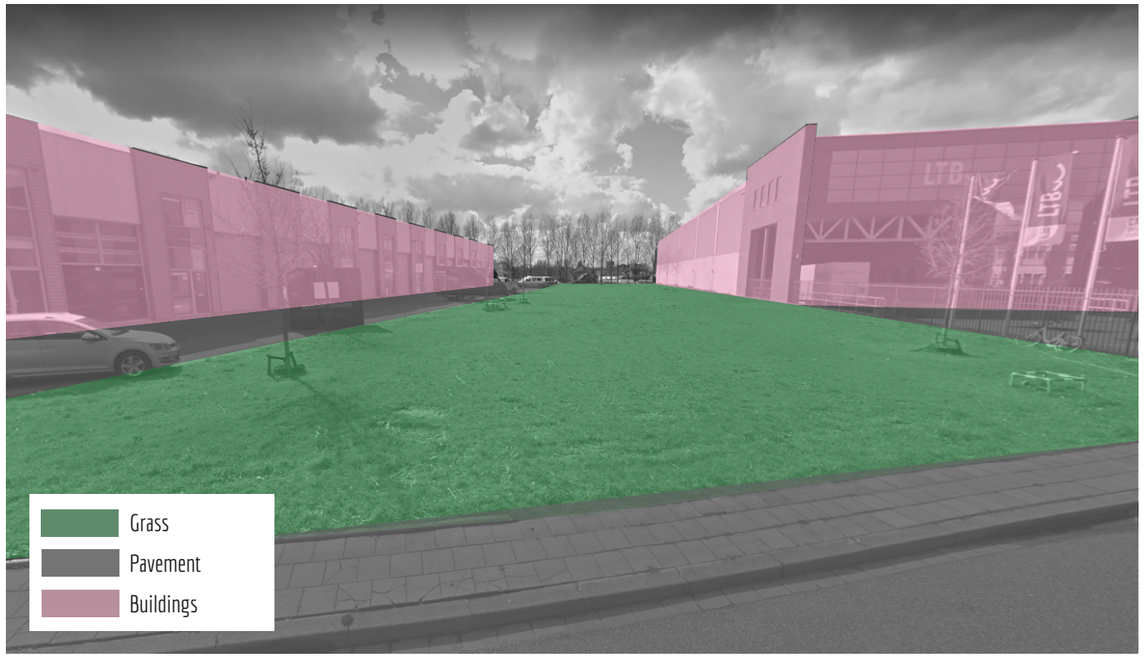
Joe

Swallow

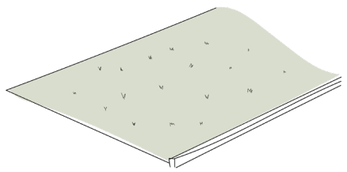
Bee

6.6 POCKET PARK

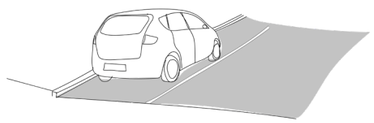
SITUATION NOW



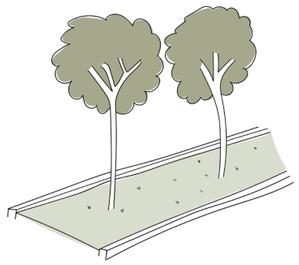
There are multiple locations on the site that could be turned into a pocket park. Now they are often just a grass field with some trees or no tree on them. Most of these pocket parks are situated in the North part of the Spaanse Polder on the ends of the roads going from West to East. Most of these pocket parks are boxed in by buildings and sometimes they are parking spaces next to them.



GRASS FIELD



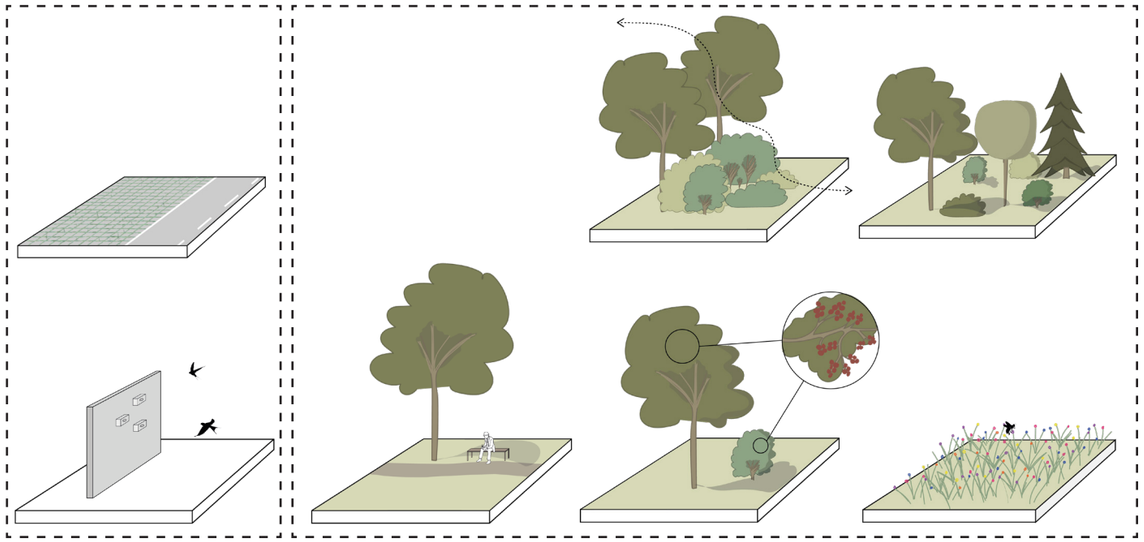
PARKING SPOTS



TREE ROWS

NEW SITUATION

For the pocket park some diversity of trees and bushes are added together with pollinator flowers to attract insects. The parking spots on the side of the pocket park should be transformed into permeable pavement parking spots to let the For the pocket park some diversity of trees and bushes are added together with pollinator flowers to attract insects. The parking spots on the side of the pocket park should be transformed into permeable pavement parking spots to let the rain infiltrate better. There will not be a walking path going through but benches can be placed so people can go there to eat their lunch or have a meeting in the fresh air. rain infiltrate better.

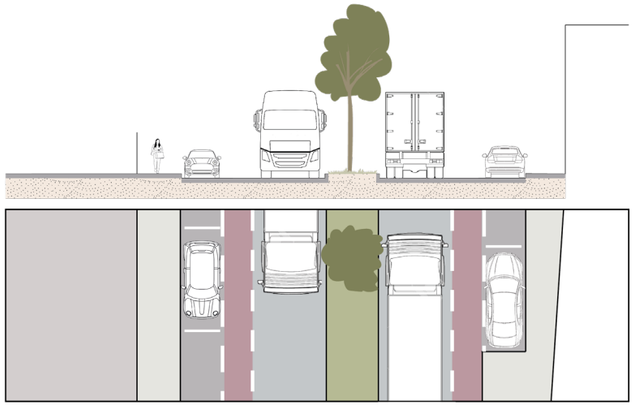


6.7 ROADS

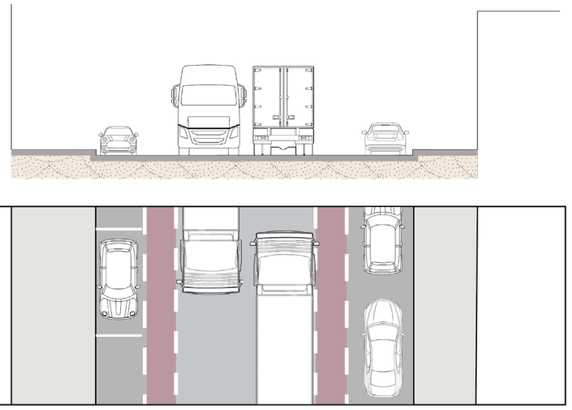
The roads are an important element of the ecological connections which go through the location. These roads are also the connectors of the different patches which will be created in the location. As explained in the analysis there are two different types of roads, one is a road with a green line in the middle and the other road type does not have any green in the middle.

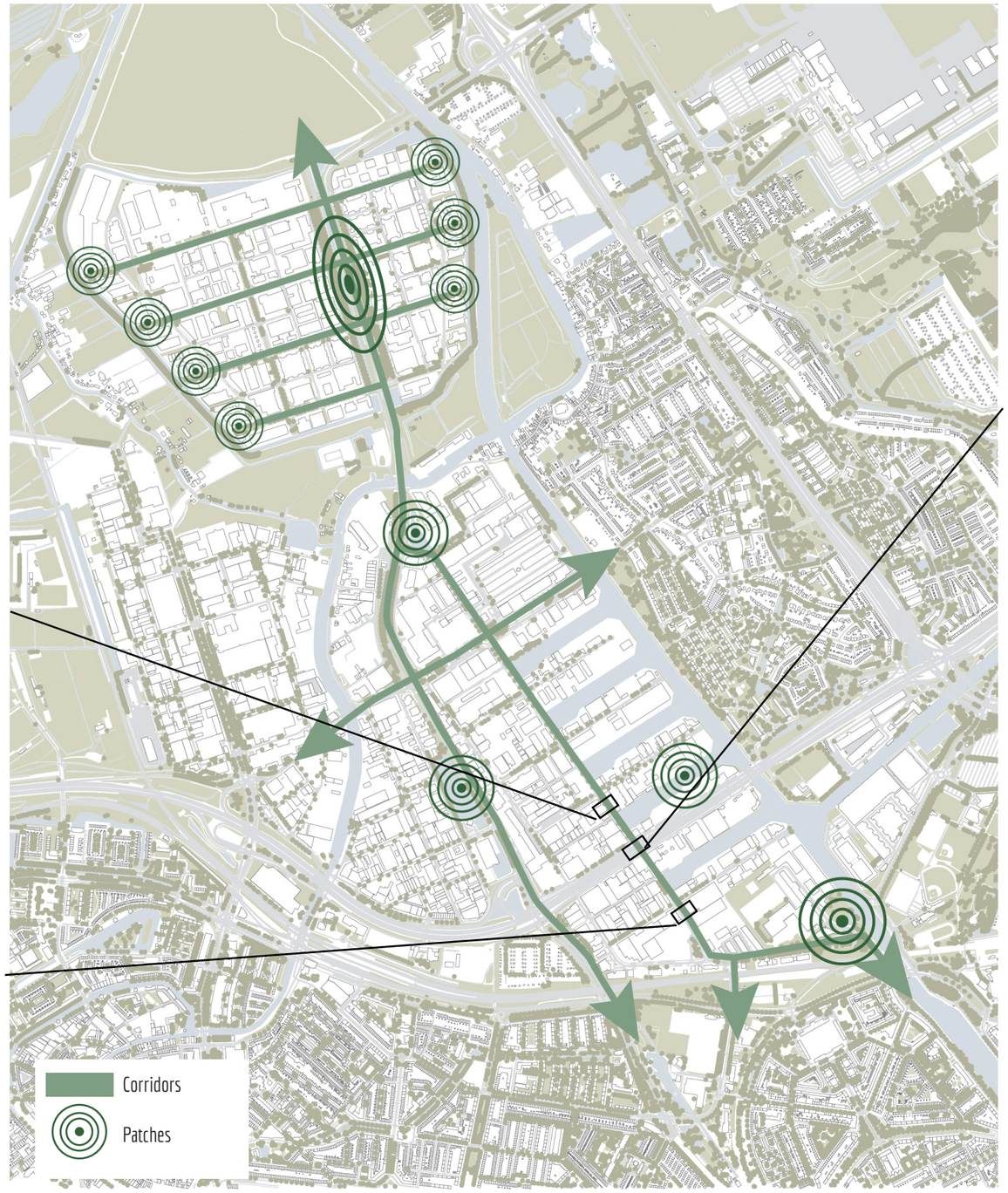
The Industrieweg is chosen to redesing because this road has both the different types. The Industrieweg also goes underneath the A20 which is now a barrier, you can pass underneath but everyting underneath the A20 is grey. If the ecolocal connection need to be made the A20 should also be taken into account.

GREEN LINE

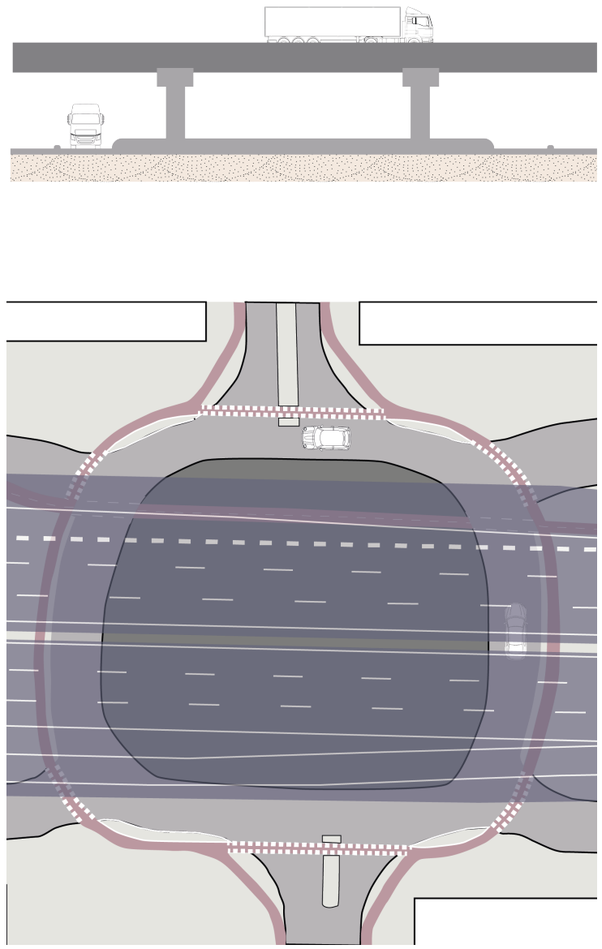


GREY

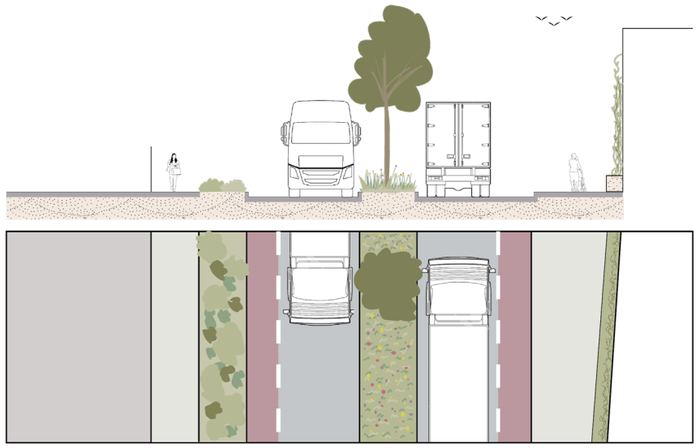




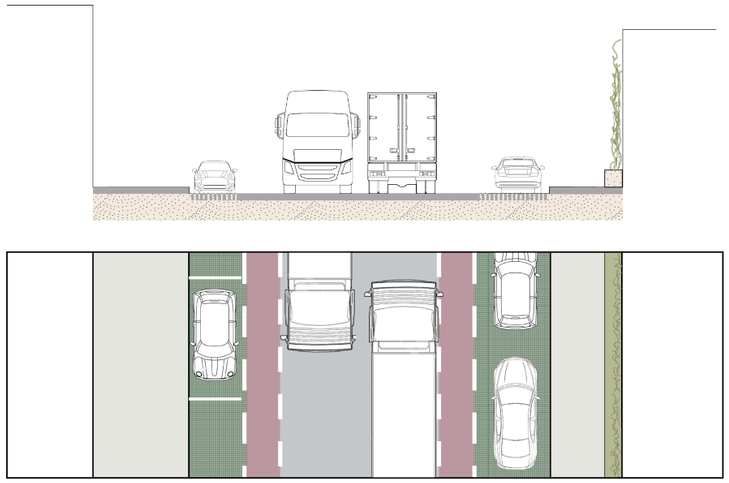
UNDER THE BRIDGE



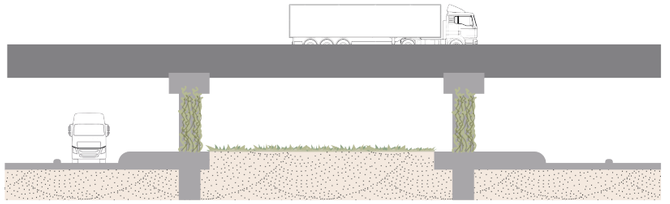
NEW SITUATION



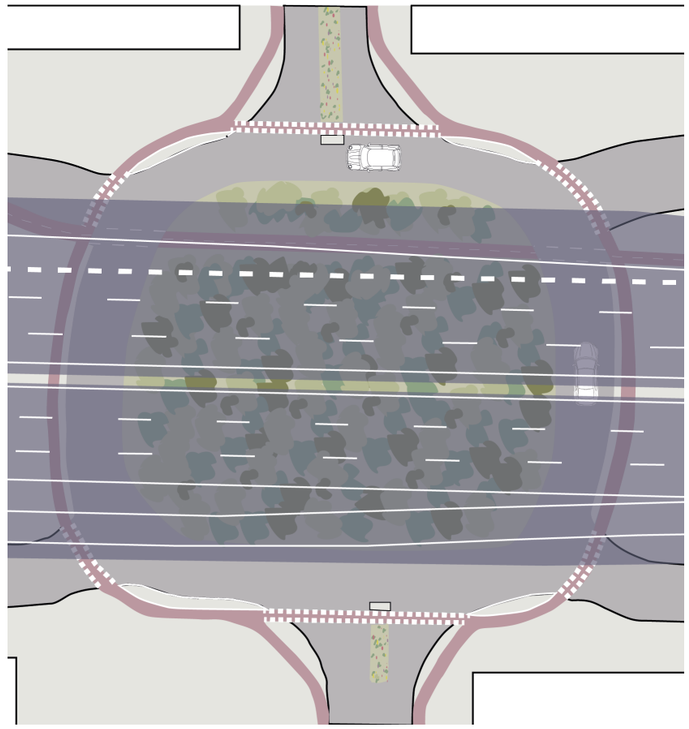
GREEN LINE
Starting with the redesign of the green line road of the Industrieweg some things have changed. Firstly the parking spots have been taken out and planting has been placed. In the middle which used to be just trees and grass there is now pollinator flowers planted. And if the private properties would want to add to the biodiversity they could add green facades to improve the ecological connection.

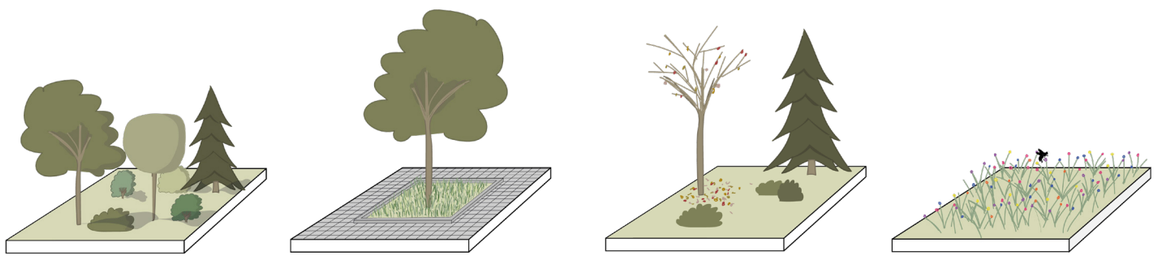


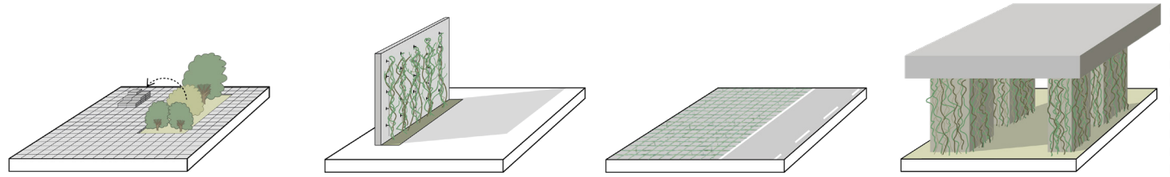
GREY
The next redesign is for the road which has no green line in the middle, for this road the parking spots have not been taken out but have been replaced by permeable pavement. This because there is still a need for parking and not all the parking spaces should be taken out. And the same goes for the previous design with the green facades.



UNDER THE BRIDGE
The last road desing is for the road under the A20. Now it is all a grey area and there is no green anywhere. There is a large roundabout which will have in the middle planting which can grow good in a more shadow environment. The pillars of the A20 will be wrapped around in green with the same planting which can handle a lot of shading.



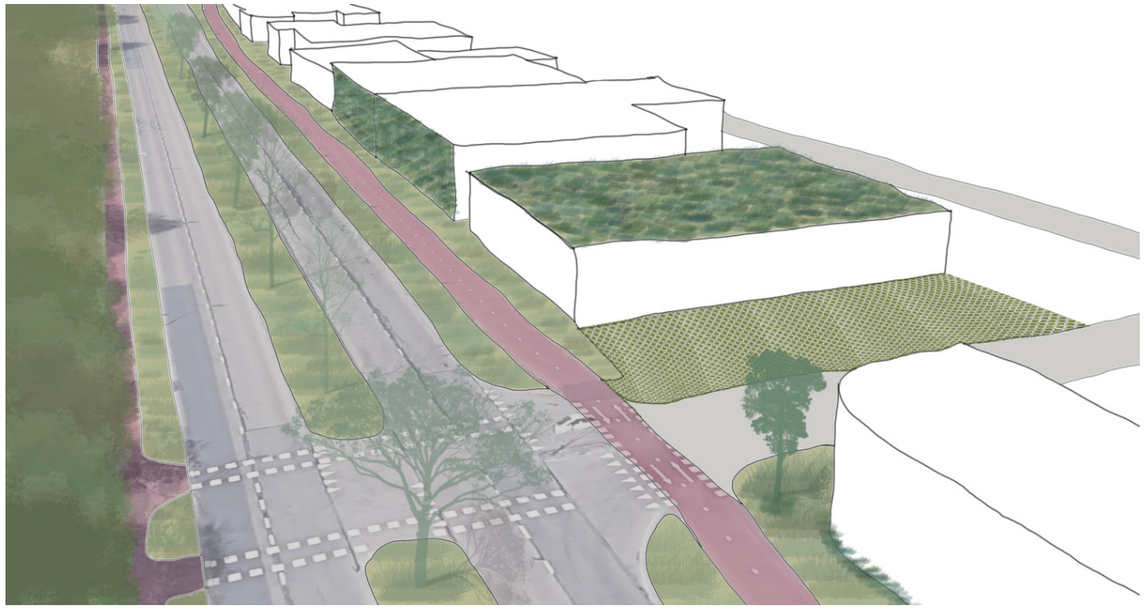




6.8 BUSINESSES

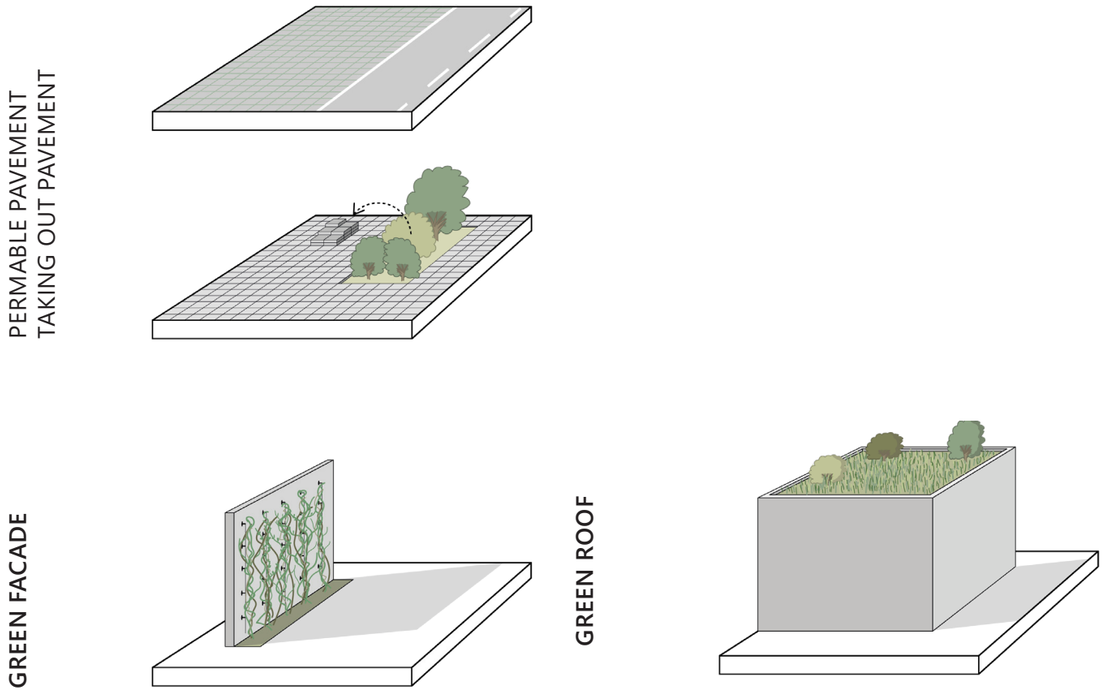
SITUATION NOW

NEW SITUATION



As part of one of the strategies are the private properties which can also play a role in enhancing biodiversity and improving human well-being. Because most of the ground on the business park is owned by private properties a lot can be done on these properties. As mentioned there are three ways a private property can add to the ecological layer, these are green roof, green facade, taking out pavement or permeable pavement.

But what is needed to persuade these business owners to get a green roof or a green facade or use permeable pavement because most businesses would not think of these changes. First of there is a need for subsidies for the businesses because most of these businesses would not want to pay for everything themselves. The municipality of Rotterdam wants to give these subsidies to homeowners, businesses and other foundations to add more green and to be able to collect more of the rainwater (Gemeente Rotterdam, n.d.). This is a good incentive for businesses to think about adding one of the tools to their property. Next to the fact some of the tools like a green roof can also have benefits like climate control it can also give the business a certain image.



6.9 CONCLUSION

In chapter 5 the 20 design tools were introduced and in this chapter, these tools were implemented on the location and has given an answer to the sub-question "How can these design tools be implemented in the case study location Spaanse Polder?".

Firstly a vision and strategy are needed to know how and where these tools should be implemented. The vision consisted out of three layers, the ecological layer, the private properties layer and the recreational layer. The vision is based upon two strategies which are the backbone and the private properties. The backbone is based on the patch-corridor-matrix principle where creating ecological connections are central. There are three main ecological networks which are the water network like the Schie, the green network which consists of two elements the trees for the sky and on the ground level of the grass, bushes, and flowers. The private property is a strategy that can help with the strategy of the backbone with its ecological connections by implementing design tools on their property like adding a green roof or a green facade.

Because there is not enough time to design the whole location multiple spots were chosen which are representative of other locations with the same characteristics. One spot is chosen from the water network, which is also a patch, two other spots are chosen which are part of the green network, and one location is chosen for the private properties. During the implementation of the tools in these locations some elements stood out.

COMBINING TOOLS

Some of the tools have to be combined with other tools to make sure they can work efficiently. For instance, placing nesting boxes in a location is the first step to attract a species but if the location of the nesting box is in an area where there is no fresh water close by or planting that can provide food the nesting box will not be used by the species. It should also be taken into account the distance between a nesting place and a food source because all animals travel different distances from their shelter to their food source.

EFFECT ON DIFFERENT SCALE LEVELS

The different tools all have different impacts on their surroundings and how far this impact goes. This impact can go from a small scale to a larger scale. For instance, the fauna tunnel which connects habitats to each other has an impact on a large scale because it connects ecological structures to each other. In comparison to a healthy tree drip where the habitat under the tree will be improved but this will have a smaller effect on the larger scale. Implementing multiple tools in the location will enhance biodiversity more than just implementing only one tool. For this can be said that 1+1=3 where adding multiple tools in a location can have a better effect than just implementing one tool in one location and one tool in another location.

THE SIZE OF THE LOCATION

Because the designing is on a business site the scales are very different in comparison to design for a residential neighborhood. The buildings on the site can be very large where an entire building can be the size of a residential building block. This means that the corridors can be very long before there is another patch where it can connect to if there are only additions in the public area. If the private properties would add to the corridors and create their own patches on their plot this distance would become smaller.

IT IS STILL A BUSINESS PARK WITH PRIVATE PROPERTIES

While implementing the design tools in the location it is important to keep in mind that the design is on a business park where people are to work. Another aspect which is important for the business parks is the connectivity of fast traffic. There are a lot of businesses in the Spaanse Polder who use their plot for storage and do not have space to transform this into a more biodiverse space. This means most of the designs need to be implemented in the public space but if businesses would be open to adding a green roof or a green facade would this certainly add to the backbone of the ecological structures.

CHAPTER 7

CONCLUSION AND REFLECTION

Figure 55 Wallpaperflare. (n.d.)

CONCLUSION

Business parks are important key locations that have the potential to become corridors for ecological networks. Right now they are often large grey areas that add to the urban heat island effect and form a barrier for the city and the green. The design tools to enhance biodiversity and to improve human well-being on a business site have been identified and implemented on the site location Spaanse Polder.

The main research question "What are design tools an urban designer can use to improve biodiversity and human well-being on a business site and how can this be implemented? Using case study location Spaanse Polder." can be answered through the help of the sub-questions of this thesis.

The design tools have been identified in chapter 5 where there are 20 design tools that have been divided into three categories. Having these design tools gave an overview of the possible solutions to improve biodiversity and human well-being. These tools are rated with the help of the selected principles for biodiversity and human well-being. These are for biodiversity numbers and variety of species, habitat diversity, and connecting habitats. For human well-being, these are health, security, and social relations. For this thesis, it is important to know how these tools can be implemented on a business site because the tools are mostly generic tools that could be implemented in every location. That is why these tools are used in the case study location Spaanse Polder.

First, an analysis of the site has been made to see what the different typologies are of the site and what the opportunities are to enhance biodiversity and improve human well-being on the site. From this, a vision could be made which is based upon two strategies the backbone, and the private properties. To be able to design in the location it is also good to know who the users are of the site. Four personas have been made of different users of the Spaanse Polder, all these personas have their needs and what they find important when they stay or visit the location. Because this thesis is about enhancing biodiversity, animals also play a big role. This is why the basic needs of animals have also been translated into design tools. There are also three species that all use a different ecological network. The Pike uses the water network, the Swallow uses the trees as a network, and lastly, the bees use the grasses, bushes, and pollinator flowers as their network.

Through research by design, the different tools have been implemented in the location and from this, there are some elements you need to take into account if you want to design on a business site. These are; combining tools, effect on different scale levels, the size of the location, and it is still a business site with private properties.

With the implementation of the design tools, the Spaanse Polder has been redesigned into an area that has ecological connections going through the location. It has created new patches which are rich in biodiversity and are places for people to go to and enjoy nature. Not only do the public areas form the ecological connections and the patches but some of the businesses also have added to the ecological connections and the patches in the location. The Spaanse Polder is no longer a grey area that forms a barrier for the city and the green but has become a corridor with its own patches which are rich in biodiversity. As a result, the heat island effect will become less and the water can infiltrate easter into the ground if there is less pavement.

By doing this research there are some questions that have arisen during the process that could be researched further. The first question is to see how these design tools could be implemented into one of the other business park types. This thesis has focused on the mixed-use business site of the Spaanse Polder but how would these design tools be implemented and how would they work in for instance a distribution park or a harbour? It could also be interesting to see how the design tools would work on the same business park type to see if there are any similarities between the outcomes of the design in the Spaanse Polder and another mixed-use business park or if they would be different. Because of the size of the location, another business site that could be smaller can have some different outcomes.

The second question is about the infrastructure this research focuses on. In this thesis, the infrastructure is used to make ecological connections. If more businesses would adapt to an innovative business design which has fewer parking spots there is a need for better public transport and a focus on the slow traffic. How would the infrastructure look like if the focus would be on better public transportation and slow traffic?

The third question is about the effect of these implementations in the long term. What would happen to the business site in 20 or 50 years? Will every business be incorporated into the ecological network and is the entire business site a place for people to go to for fun and enjoy nature?

REFLECTION

My thesis is about creating design tools that enhance biodiversity and improve human well-being on business sites using the case study site Spaanse Polder in Rotterdam.

A reflection is an important element of your research, this gives you a moment to reflect on your work and on your process. During the period of time of working on my thesis, there were moments when I doubted myself and my research subject. Did I make the right choice of researching this subject or should I have chosen a different subject? Am I researching something which is relevant? As I have spoken to many of my peers who are already graduated I know these struggles and questions during the graduation process are very common.

SOCIAL RELEVANCE

This research is not only focused on adding biodiversity which is good for the natural environment but also the effects this biodiversity has on the social aspects. A lot of cities are greenifying and seeing the benefits of this in the health of people. Especially now during the pandemic, we have seen the pressure on nature because everyone went outside to enjoy nature. Research has shown that green has a positive effect on the health of people not only physically but also mentally (Kaplan & Kaplan, 2011; van den Berg et al., 2007).

Because business parks are often situated on the border of the city between the green and the city these business parks could function as corridors for the green to go through the business park into the city. Research has also shown that if employees go for a lunch walk in the green this has a positive effect on happiness and the number of burn-outs go down (Bedrijventerreinen op de schop, 2021). Because I personally hear a lot of people around me who have a burnout or are very stressed because of work I would say this is an important step towards a healthy work environment.

SCIENTIFIC RELEVANCE

This thesis topic is a fairly new topic, there has been a lot of research about biodiversity and the use of it but in combination with business parks, there has not been a lot of research yet. Because business parks are spaces meant for business, storage, and are focused on having a good infrastructure the attention has been on this and not on the possibility of greening these sites and adding biodiversity. Most literature reviews about business parks and making these parks more environmental friendly are about how to make them more sustainable like adding solar panels and making them energy neutral. There is not a lot of literature about the natural environment in business parks or how you can enhance biodiversity on these sites. There is one researcher, Robbert Snep (2009), who has done his PhD thesis about the options and opportunities to greenifying business sites. And where he explains that bringing biodiversity in these business parks is not only healthy for nature but also for the human well-being of the people working on these sites.

Biodiversity has gotten more attention in the last years because it has become clear we as humans are very dependent on biodiversity because biodiversity provides us with ecosystem services like fresh water and medicine (Millennium Ecosystem Assessment, 2005a). And because biodiversity is declining action must be taken to reverse this decline. One of the sustainable development goals of the United Nations, goal 15, states that there is a need to halt the biodiversity loss which is happening in the world (Sustainable Development Goals, n.d.).
It has not gone unnoticed that business parks are large grey areas that could use a dash of green. In the IVN Natuur Educatie on 21 of April in 2021, it posted a piece on how it is important to greenify the business sites and to enhance biodiversity.

(Quote directeur Jelle de Jong via ANP Expert Support)

"Niet alleen de Nederlandse steden moeten groener, datzelfde geldt voor de bedrijventerreinen in ons land. We hebben meer dan 100.000 hectare aan bedrijfsterreinen in Nederland en slechts 1 procent van deze oppervlakte is 'groen' of 'blauw'. IVN Natuureducatie is daarom blij met de motie die GroenLinks Tweede Kamerlid Laura Bromet vanmiddag heeft ingediend, waarin de regering wordt verzocht een onderzoek uit te laten voeren om de kansen voor het versterken van biodiversiteit, klimaatadaptatie en gezondheid op bedrijventerreinen in kaart te brengen."

(Bedrijventerreinen op de schop, 2021)

This shows there is a need for researching the possibilities of enhancing biodiversity on business sites.

Figure 56 Sustainable development goal 15 life on land (Sustainable Development Goals, n.d.)

ADVANTAGES AND LIMITATIONS OF THE METHODOLOGY

The methods used in this thesis are research and research by design. In the first chapters of the thesis the methodology used is research-based like literature reviews and mapping of the site. Using literature to understand the subject and the connections there are gives a basic knowledge of the subject. The biggest limitation of this thesis was the lack of knowledge about business sites and biodiversity in these areas.

By mapping the location and its surroundings the different structures like water networks, green networks and infrastructure can be analysed. A limitation of this is that you can not always understand a location by just looking at maps or using google maps. This is why it is also important to go on-site visits. I have gone to the site one time where I cycled around and one thing that stood out was the massiveness of the site with its enormous buildings and big roads. The human scale was sometimes difficult to find, I could find the human scale often when there was some green around me. The site when I visited was pretty quiet but this could also be because I visited the site at the weekend.

The last part of the thesis is research by design. This is an important step for an architect or an urban designer, during this process you test your design or in my case my design tools on the location to see if the solutions work and to see how the design relates to the context (Hauberg, 2011). In this thesis design tools for enhancing biodiversity and improving human well-being on business sites that urban designers can use is part of the outcome. These tools have been implemented on the site to see how they would work on the site and its surroundings. This gives a feeling of location and how the tools can be used or how they can work or how they do not work. The biggest limitation of designing is that you do not know the outcome in a few years.

DISCUSSION OF POSSIBILITIES TO GENERALISE THE RESULTS OF THE RESEARCH

The results of the research consist of design tools to enhance biodiversity and improve human well-being on business sites. These tools have been implemented on the business site Spaanse Polder to see how they would fit in the site and how they would interact with its surroundings on the location. Because the design tools which have been used are mostly general design tools that could be implemented in every context this research could be used in a different context. For instance, the implementation of a natural waterfront in a harbour arm in the Spaanse Polder is a very large implementation if the same tool would be implemented in a small canal next to some houses this would have a different impact. There are some site-specific typologies to a business site that make the implementation of the design tools different on a business site in comparison to the implementation of these tools in a residential neighbourhood. But this will only mean the outcome will be different and not the use of the design tools.

It would be nice to see how these tools can be implemented in different business site typologies. The site I have chosen is a mixed-use site but seeing how these tools can be implemented in a port area or an industrial area can give different results. This is something that can be done in further research.

ETHICAL CONSIDERATIONS

Now if we look at adding green in residential neighbourhoods it often results in a gentrification process where the prices of the housing go up and the group of people living there now are pushed out. This thesis is not researching to add biodiversity in residential neighbourhoods but on business sites and the effect of this on the ecosystems and human well-being. The issue of gentrification with greenifying a business location will probably not be a problem or will be different. It could even have a better outcome. Because of greenifying a business site will give the businesses on this site a better image. And not only will this give a better image to the outside world but if the business site has more green this will also have an effect on the health of the employees. If the site will become known for its green appearance it will attract new companies which find sustainability and the environment important. The only downfall could be that businesses that find sustainability or the natural environment around their business not important will be pushed out of the area. But I'm not sure if I would say this would be an ethical dilemma because I think businesses should do as much as they can to fight the decline of biodiversity even if it would only be a green roof or taking out some pavement of their parking spots.
By bringing biodiversity back to the business parks these areas will become better resilient to heavy rainfalls and will not contribute to the urban heat island which will make it safer and a more enjoyable place to work. And if these business parks will become corridors for the green for outside the city into the city the neighbourhoods surrounding the business park can connect to these corridors and greenify their own neighbourhood.

Figure 57 Groen is gezond
(Groen: goed voor de gezondheid, n.d.)

Figure 58 Groen is gezond (Limpt, 2012)

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APPENDIX

URBAN HEAT ISLAND EFFECT

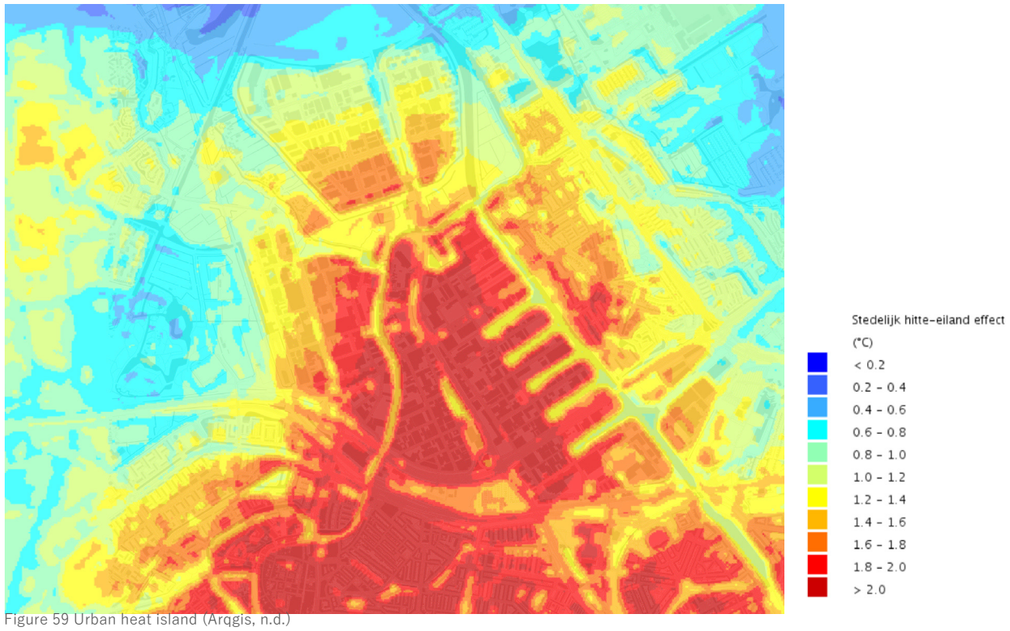


Figure 59 Urban heat island (Arqgis, n.d.)

NOISE POLLUTION

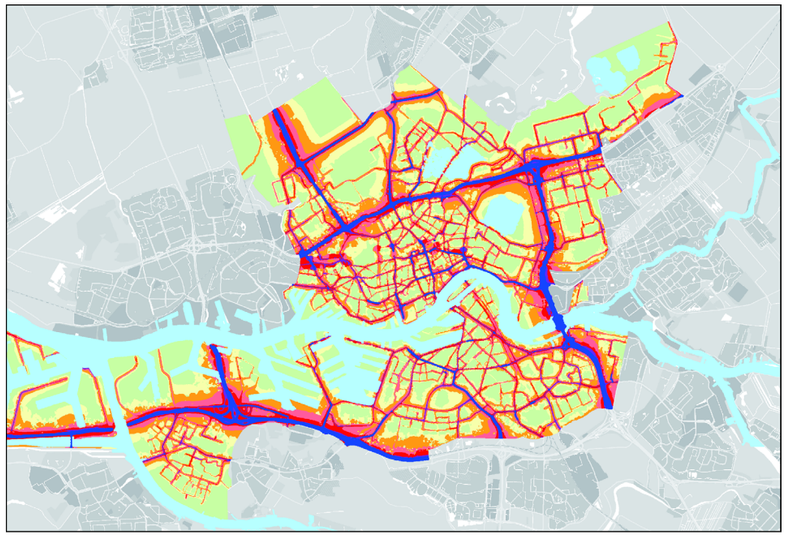
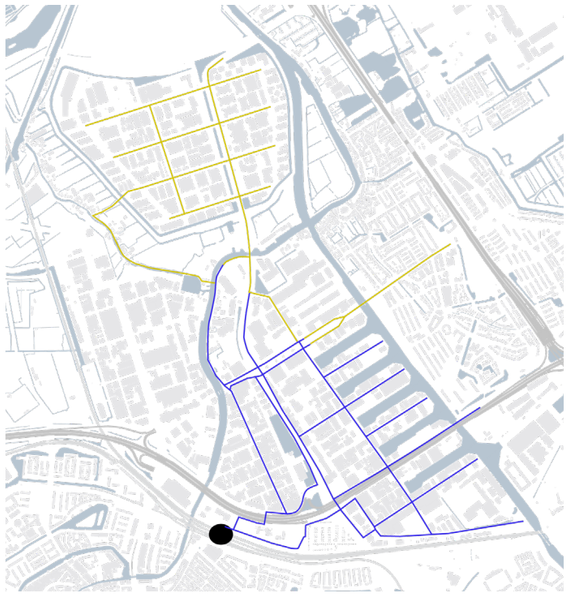


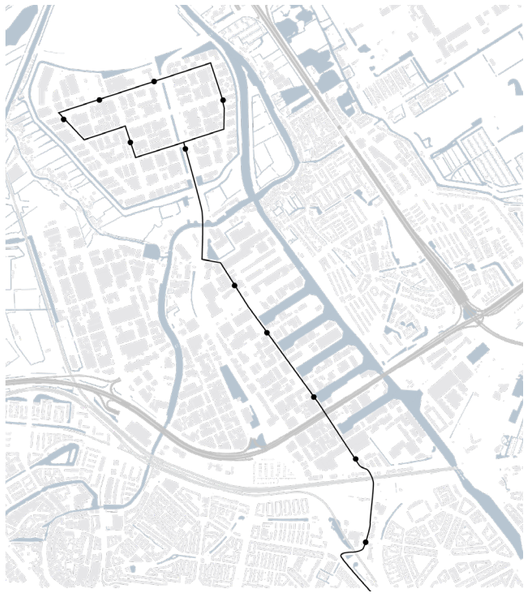
Figure 60 Traffice noice (Arqgis, n.d.)

PUBLIC TRANSPORT

Because there will only be limited parking for the employees of the new innovative businesses they need to go by public transport or they need to go by bike. In the area there are a few biking paths these can mostly be found next to the main roads. From the station Schiedam it takes about 6 to 8 minutes to get 2km into the location site. If you want to go to the furthest end of the business park it will take about 11 to 14min which is about 4km. This shows the accessibility of the site by bike from Schiedam Centrum is good.

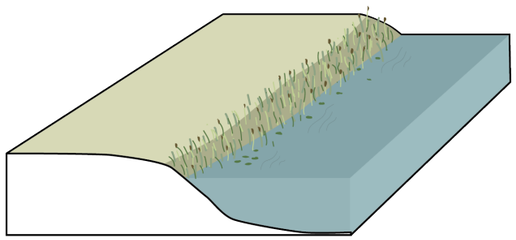
Next to the biking path there is also a bus line going through the location which is bus 42. This line begins at Marconiplein and makes a loop in the North part of the location. In this thesis the public transport will not be taken into account or changed but if more businesses in the business park want to innovate and take out parking from their terrain extra public transport connections should be made.





DESIGN TOOLS EXPLAIND

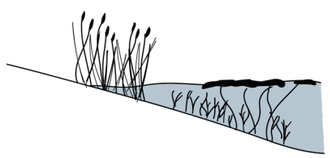
NATURAL WATERFRONT



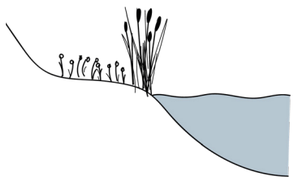
GOALS
- Noise control
- Climate control
- Entrance exit for animals
- Richness of planting
- Spawning place

A natural waterfront has a large biodiversity because there are different plants which can grow here (Gemeente amsterdam, 2018). Not only do these natural waterfronts have a richt biodiversity but they also have a functional effect. These are recreational, noise control, and climate control (Peking, 2013). Because of the gently sloping edges it is also a place for animals to be able to climb out of the water or go into the water (Gemeente Amsterdam, 2018). There are multiple types of natural waterfronts. These are the plasberm, drasberm, and the flauwhellend talud (van Breukelen et al., 2003). These different waterfronts can be implemented in the existing situation depending on the use of the waterfront now. To get the best effect of the natural waterfront there should be at least 5 to 10 meters of natural waterfront created with many different species (van Breukelen et al., 2003).

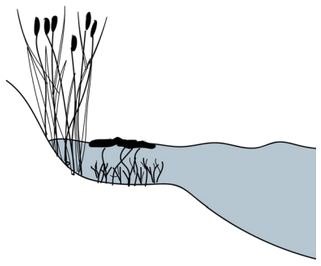
FLAUWHELLEND TALUD



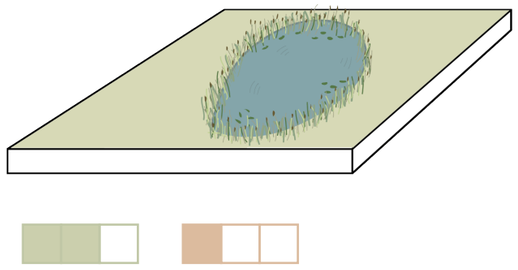
DRASBERM



PLASBERM



POND

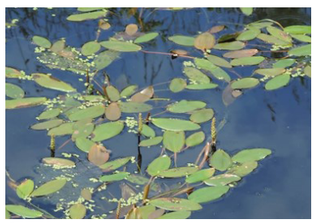


GOALS
- Water storage
- Richness of species
- Cleaning water
- Provides cooling

A pond is a waterbody with stagnant water which many species attract. A pond has a depth of at least 60cm and has gently sloping edges (Gemeente Amsterdam, 2018). Because a pond has gently sloping edges there are different depths of water in the pond which can provide for different planting species. Ponds need planting to keep it clean from algae and they provide for oxygen in the water for the different species that live in the pond. A pond can be in many different sizes from a small pond in the backyard to a large water storage pond.
Using planting near the pond which also cleans the water which goes into the pond keeps the water quality higher.

OXIGEN

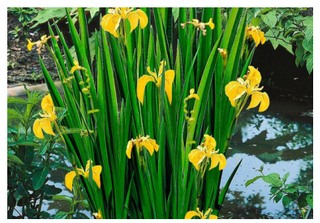
Coontail



Potamogeton

HIDING SPOT

Yellow Water-lily



Yellow iris

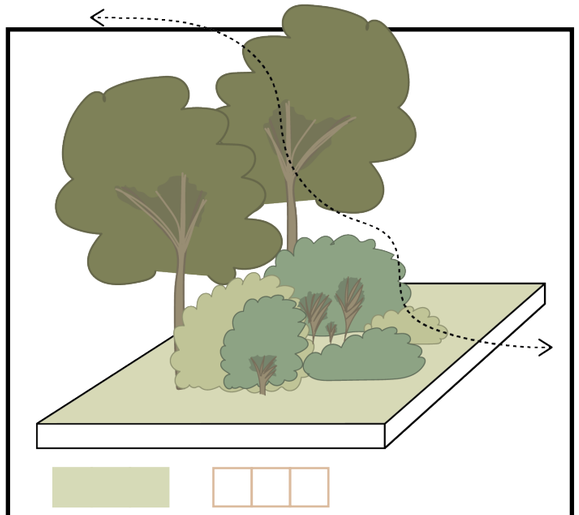
HELOFITEFILTERS

rush

Cattail (Lisdodde)

(Machiels, 2018), (Planten als waterzuiveraars: helofytenfilters, 2020), (Natuurmonumenten, 2021)

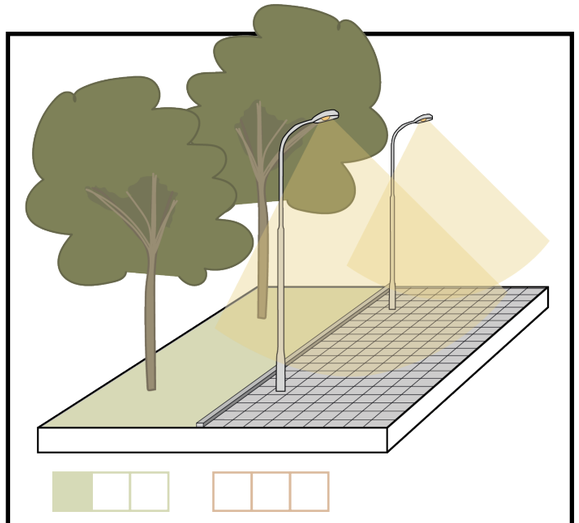
GRADIENTS



GOALS
- Provide different habitats
- Improves shading

Having different heights in planting provides multiple conditions of different kinds of species (Vink et al., 2013). In the planting multiple species can hide, nest, or find food because of the different hights animals which are ground bound can provide from this but also the species which can fly. The placing of these different hights in planting can be done in multiple spots it can often be a good space at an edge of a habitat where it goes from higher vegetation to the lower vegetation.

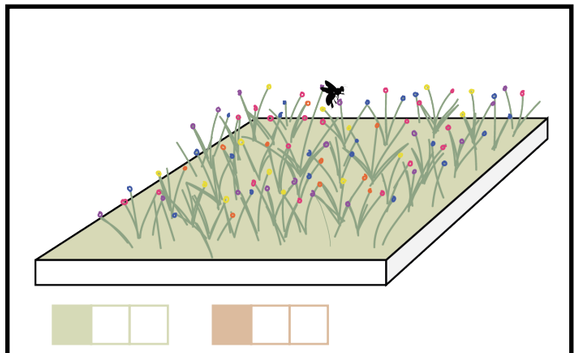
NATURAL LIGHTING



GOALS
- Reduce energy concpution
- Will not distract bats and other animals

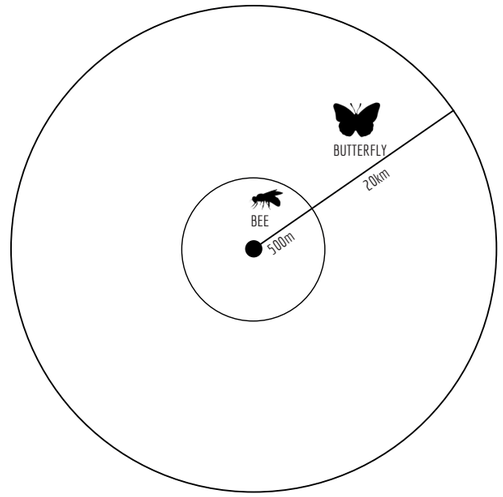
Lighting is used to light up the streeds at night to make it easier for people to navigate and it feels safer. But this light can disturb animals and plants in their daily ritmes. Especially bats get enormously distracted by lighting. It can also be that lighting does not have to be on outside of working hourse especially on a business park where people are only on the location in working hours.

POLLINATOR FLOWERS



GOALS
- Aesthetic pleasing
- Attracts insects
- Pollination of fruits

Insects like bees, butterflies, and bumblebees are an important key stone for our existence. These pollinators provide for the pollination of the plants which provide for food not only for the people but also for animals (Belang van de bij, n.d.). These Pollinator flowers can be placed in many different spots from on the edge of a natural waterfront to in the central reservation between roads. Placing these plants there is not only beneficial for biodiversity but it also has a ecstatic appearance will go up (Gemeente Amsterdam, 2018). To know how many flowers are needed one bee can visit around 5000 flowers in only one day (How Many Flowers Can a Bee Pollinate?, 2020).



POLLINATOR FLOWERS


Orpine


Ajuga reptans


Summer lilac

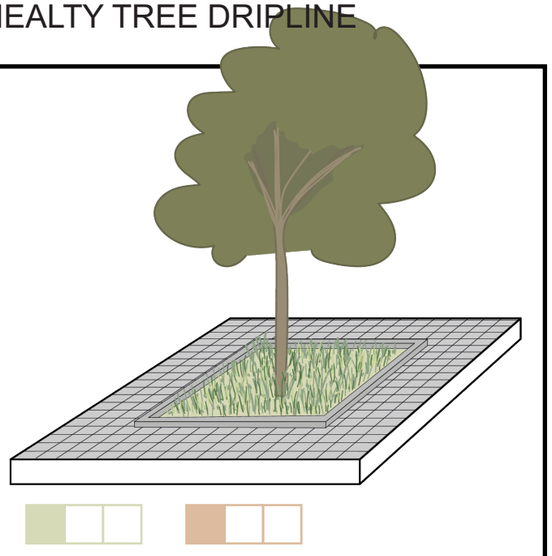

Giant hyssops


Salvia nemorosa


Lavender

(14 planten die vlinders en (andere) insecten lokken, 2020)

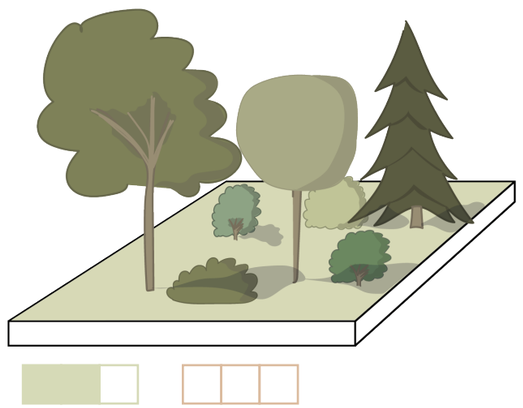
HEALTY TREE DRIPLINE



GOALS
- Better water infiltration
- Improve biodiversity
- Healthy tree

The tree dripline is the earth around a tree trunk. In cities the tree trunk of a tree is often paved but if the pavement is taken out and planting is added around the tree trunk this will improve the biodiversity of the space around a tree (Gemeente Amsterdam, 2018). But not only will the biodiversity be increased, it is also better for the tree itself because it has more space to grow and breath and there will be better water infiltration (De Boomdokter, 2021).

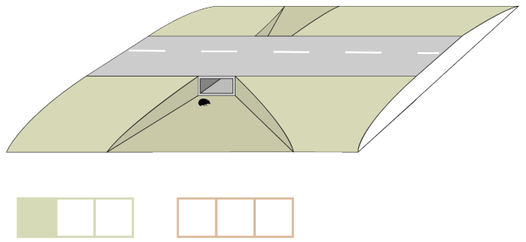
SPECIES DIVERSITY



GOALS
- Habitat diversity
- Resilience

Having a species diversity in planting improves the biodiversity and reduces the chance of decease taking out all the same species. An aspect which would be thought of is that even though there should be a species diversity the need for only using natives pieces is important. If there is a species diversity for plants this will also have an influence on the species diversity of animals because different plants attract different animals.

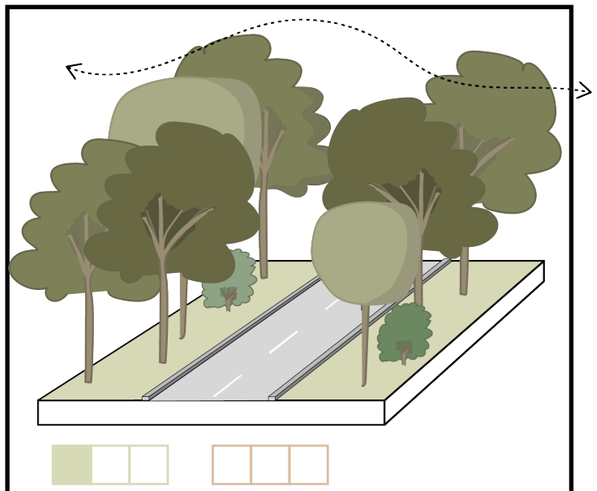
FAUNA TUNNEL



GOALS
- Connecting habitats
- Reduce deaths of small animals

To connect to the ecological networks which means to connect different habitats to each other a fauna passage could be used. This is a tunnel where small animals can go through to pass a road safely (Gemeente Amsterda, 2018). Because in a business park there is a lot of fast traffic the patches which are created should be connected but this has to be done in a safe way for the animals.

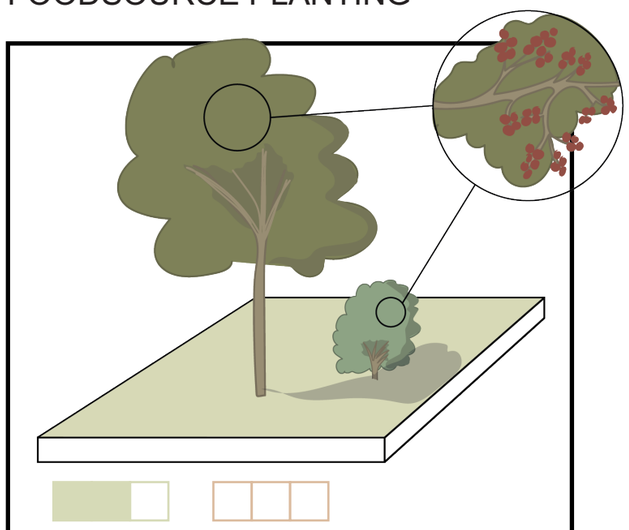
GREEN BRIDGE



GOALS
- Connecting habitats
- Safe place for birds and bats to cross roads

Another way to connect to the ecological networks is to create an green bridge without actually creating a bridge. A green bridge can be created with large trees around a road where birds and bats can cross the road without having a large open space to cross over (Vink et al., 2013).

FOODSOURCE PLANTING



GOALS
- Attract animals
- Provides for food

Creating new habitats for species there is a need for foodsource planting for the animals. You could think of an Sweet-Brier which attracts the Greenfinch, House sparrow, and te Eurasian collared dove (Vogelbescherming, 2021). Or adding the common honeysuckle which attracts the blue tit or the European Robin (Vogelbescherming, 2021).

PLANTING WIHT FRUITS OR SEEDS

Sweet-Brier

Common ivy

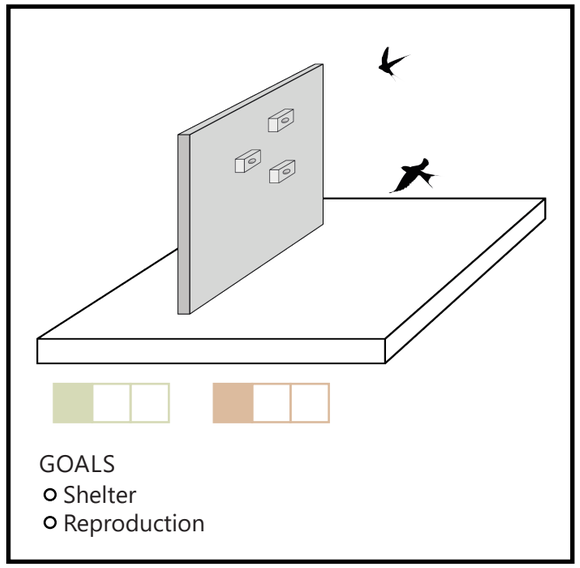
Prunus padus

Common honeysuckle

Betula pubescens

Barberry

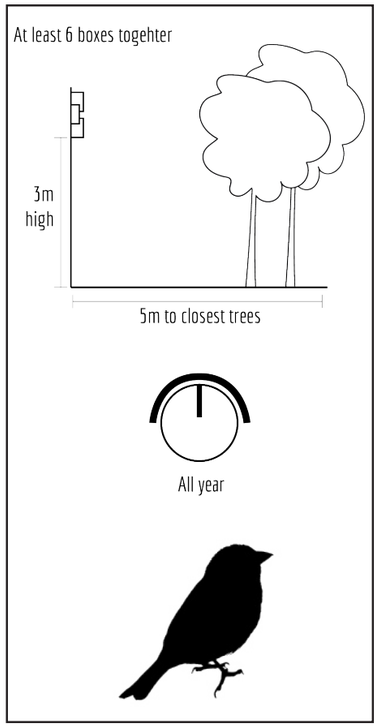
NESTING BOXES



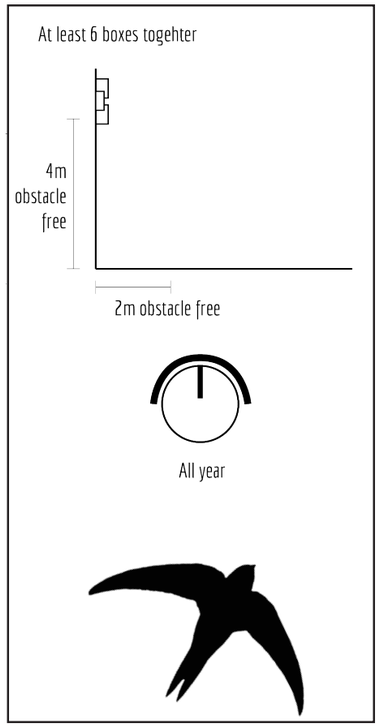
GOALS
- Shelter
- Reproduction

To increase the biodiversity nesting boxes could be used to attract different kind of species to the location. There are nesting boxes for different kinds of bird for instance the House sparrow, Common swift, Common house martin, Barn swallow, Common starling, White wagtail, Black redstart, and the Peregrine falcon (Gemeente Amsterdam, 2018). There are not only nesting boxes for birds there are also nesting boxes for different kinds of bats like Common pipistrelle, Serotine bat, and the Pond bat (Gemeente Amsterdam, 2018). Placing these nesting boxes for these animals the placement and the surroundings should be taken into account. For instance the placement of these boxes for the birds should be on the North, West, East side of a building to make sure they will not get too much sun (Gemeente Amsterdam, 2018). The height of these nesting boxes differ for different species and also the flight path can differ the same goes for bat boxes (Gemeente Amsterdam, 2018). The presence of birds can reduce stress in humans by listening to their songs and to just watching them (Mayntz, 2020).

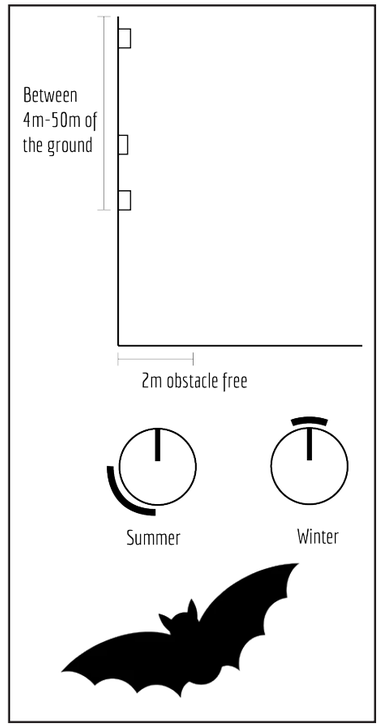
HOUSE SPARROW



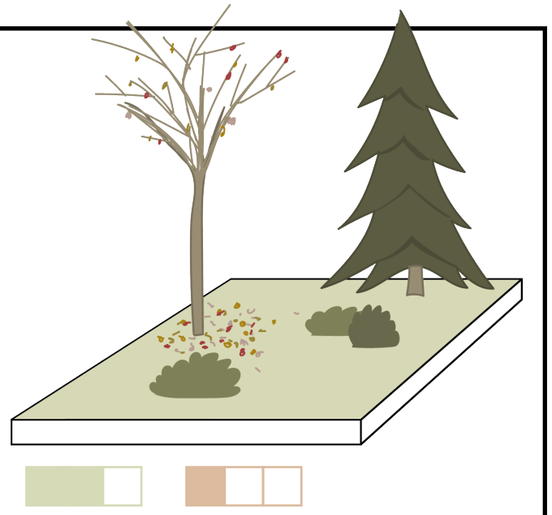
COMMON SWIFT



BAT



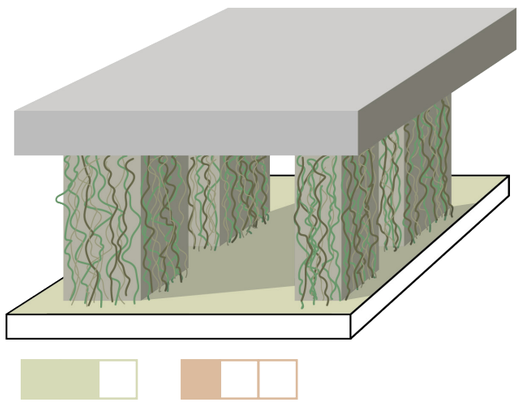
EVERGREEN PLANTING



GOALS
- Hiding spaces and nesting spaces for animals all year round
- Aestetic appearance

Evergreen planting is plants that stay green all year round. This makes these plants a perfect space for animals to nest or hide in. Evergreen planting is not only good for animals it is also something people can enjoy when it is winter there is still some green around.

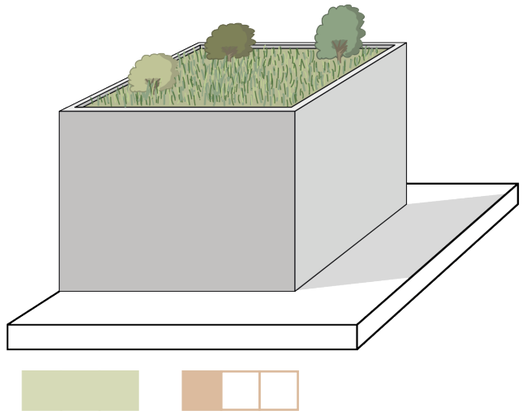
GREEN UNDER THE BRIDGE



GOALS
- Enhance biodiversity
- Reduce noice
- Connecting habitats

There are also bridges in the location where ecological connections need to be made underneath. To do this the pillars can be transformed into green facades where planting can be placed which can grow in the shade. And when there is more green underneath the bridge this could also give a safer feeling.

GREEN ROOF

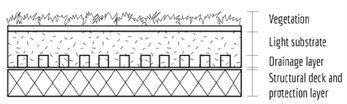


GOALS
- Adds to biodiversity
- Storm water management
- Improves air quality
- Reduces noice pollution
- Climate control

A green roof adds onto the biodiversity because many different animals are attracted by the planting on the roof like butterflies, bees, birds, and bats (Gemeente Amsterdam, 2018). But it is not only good for biodiversity but it also helps with storm water management, it improves air quality and reduces noise pollution, it also improves the membrane longevity, and it helps with climate control of the building which has a positive effect to human well-being (Oberndorfer et al., 2007)(About Green Roofs, n.d.). There are three kinds of green roof types these are the intensive roof, extensive roof, and the semi-intensive roof (Gemeente Amsterdam, 2018). Where the intensive roof has the most biodiversity and the extensive roof has the least biodiversity (Gemeente Amsterdam, 2018).

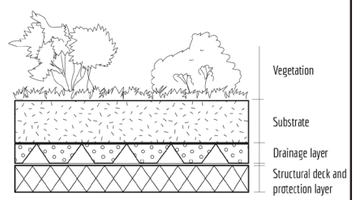
Next to the green roof there is also a brown roof or a waterproof. Where the brown roof is mostly filled with sand and stones which can be recycled rubble (Gemeente Amsterdam, 2018).

EXTENSIVE ROOF



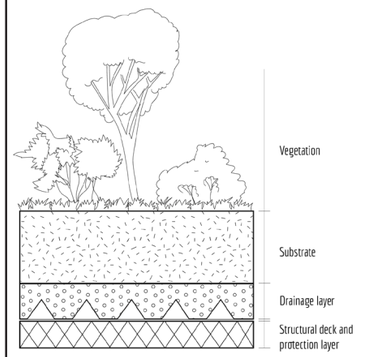
An extensive roof is consistent out of a smaller substrate layer between 4 to 7 cm (Gemeente Amsterdam, 2018). This means there are less plants which can grow on these roofs because of the limited thickness.

SEMI-INTENSIVE ROOF



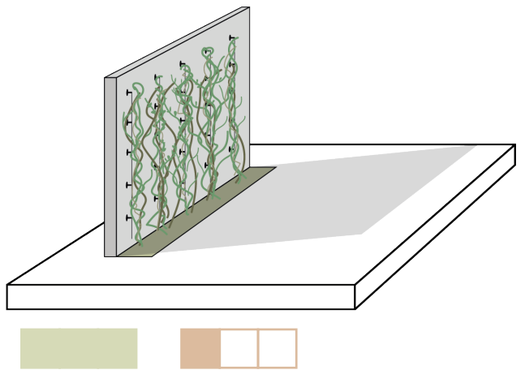
A semi-intensive roof is a combination of the intensive and extensive roof with a substrate between 20 to 40cm which varies between these thickness, because of this there is more possible for different habitats (Gemeente Amsterdam, 2018).

INTENSIVE ROOF



An intensive roof has the possibility of the most biodiversity because it has a thick substrate layer which is between the 80 and 120 cm (Gemeente Amsterdam, 2018). Because of this thick layer multiple plant species can be planted on the roof.

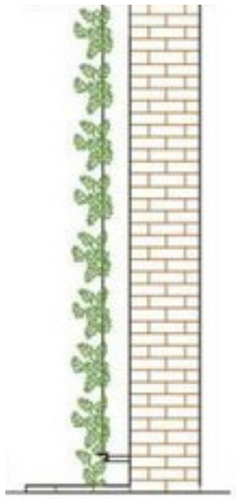
GREEN FACADE



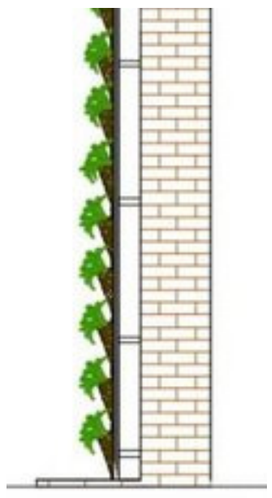
GOALS
- Hiding spaces and nesting spaces for animals all year round
- Aestetic appearance
- Improve social and psychologal well-being
- Imprives air quality

The vertical green has many of the same benefits a green roof has. It has the benefits of mitigating the effect of urban heat island, it will increase biodiversity and improve the ecological value, and it provides climate regulation which has as effect the improvement of social and psychological well-being and it improves the air quality (Hop & Hiemstra, 2013). These green facades provide shelter, food, and nesting space for insects but also for birds (Gemeente Amsterdam, 2018). If there are no trees in the surrounding area these green facades can be used as stepping stones for insects (Vink et al., 2013). Just as the green roofs there are also multiple types of green facades which can be implemented. These are the self climbing plants, climbing plants with construction, and the green facade construction.

SELF CLIMBING PLANTS

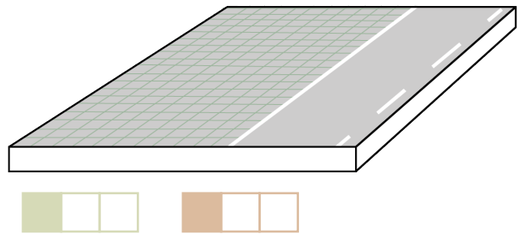


CLIMBING PLANTS WITH CONSTRUCTION



GREEN FACADE CONSTRUCTION

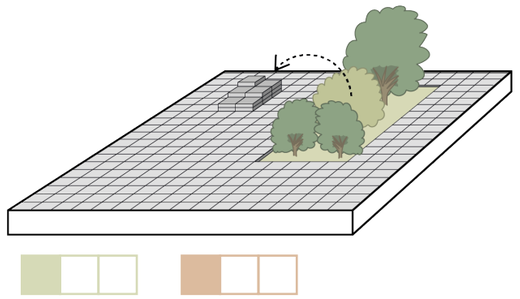
PERMEABLE PAVEMENT



GOALS
- Improve waterinfiltration
- Reduce urban heat island effect
- Less drought

A big issue is the urban heat island and the not being able for water to infiltrate into the ground quick enough. This is because a ot of the ground is paved. With using permeable pavement on spots where there is parking instead of the pavement which is used now where water can barely infiltrate in. Also because water can infiltrate easier in the ground the waterstand will be better and the chance of drought is lower. The question is if these permeable pavement would be more work to maintain but there is only need to take out the weeds every year but that is also needed with normal pavement (Waterdoorlatende verharding, n.d.).

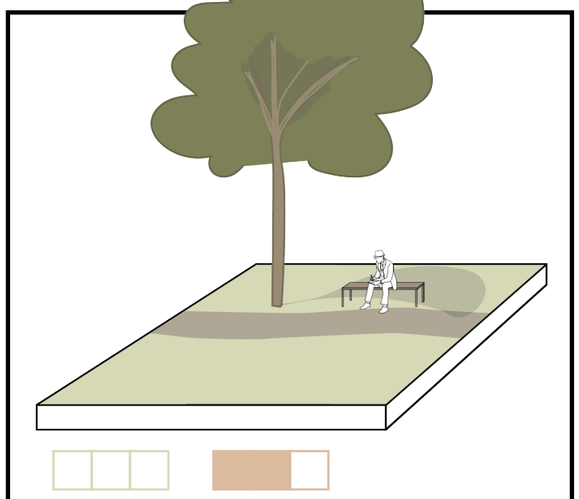
TAKING OUT PAVEMENT



GOALS
- Better waterinfiltration
- Decrease urban heat island
- Aestetic appearance

Somtimes there are spaces which are now paved but do not need to be paved. By taking out pavement green can be added. And by adding this green biodiversity can be increased using pollinator flowers to attract pollinators.

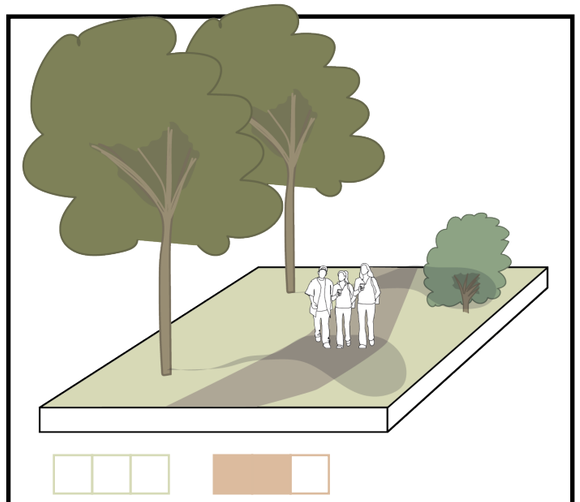
SITTING OR GATHERING SPACES



GOALS
- Good for physical health
- Stimulating of social connections

For social interaction having spaces where people can meet is very important. This can be done by placing benches near a walking path. These benches should be placed in a desirable place where there is shading and a good view.

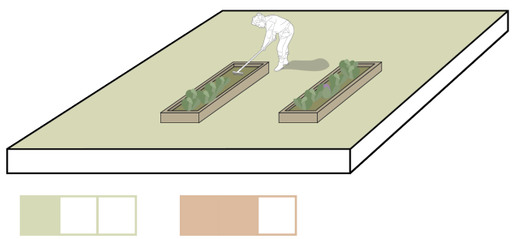
WALKING PATHS



GOALS
- Good for physical health
- Good for mental health
- Stimulating of social connections

Creating walking paths for people can stimulate people to go outside and go for a walk or a run which is good for their well-being. But these walking paths can also stimulate social relations with meeting new people or going for a walk with new people from work.

KITCHEN GARDEN



GOALS
- Place for people to learn
- Place for people to come together
- Fresh food

Kitchen gardens are places where people can grow their own crops. If someone does not have a garden at home they could have a kitchen garden at work. People can learn from each other and eat fresh food from the gardens.

What is Happening to our Biodiversity?

The role of an urban designer in restoring and protecting nature

AR3U023 Theories of
Urbanism, Delft University of Technology

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04-05-2021

Abstract – There is still a lot unknown about nature but what we do know is that because of human activity the biodiversity is declining. People are dependent on biodiversity which provides us with our ecosystem services and human well-being. The five main reasons for biodiversity loss are; habitat destruction, alien species, overexploitation, climate change, and pollution. To restore and protect biodiversity it is useful to know how much existing biodiversity there is. there are three variables to measure biodiversity with; variety, quantity and quality, and distribution. Another way to measure biodiversity is through its value where utilitarian and intrinsic can be used but the value of something can change over time. An important aspect of enhancing and restoring biodiversity is the connection of habitats and ecological networks on the smaller scale with the networks on the larger scale which stretches from the urban areas all the way to the surrounding countrysides. Urban designers play a key role in protecting and bringing back biodiversity together with ecologists and wildlife biologist, they plan large scale strategies where biodiversity is protected and restored.

Keywords – Biodiversity, biodiversity loss, ecosystem services, Urban designer, the Netherlands

1 Introduction

There are many species in the world and only a fraction has been documented. It is estimated that around 2 million species have been discovered and described but they suspect there are between 5 million to 30 million species that have not been identified yet (Millennium Ecosystem Assessment, 2005b). This means there is still a lot unknown and undiscovered about nature and its species. A definition of biodiversity is; “The variety of life on Earth at all its levels, from genes to ecosystems, and the ecological and evolutionary processes that sustain it.” (Laverty et al., 2008, pp. 2). Our Biodiversity is very complex and stretches from the smallest scale to the largest scales and is an important driver of our ecosystem and keeps it in balance. People rely more upon biodiversity than most of us know, biodiversity provides us with food, medicine, but also enriches people culturally or spiritually (Laverty et al., 2008). But our biodiversity is declining (Laverty et al., 2008). In the late 20th Century people have started to worry about biodiversity and our ecosystems and the “loss” of them and more attention is given by governments and the media (McNeely, 1992). Members of the United Nation have created the 17 sustainable development goals, where number 15 states that they want a halt on biodiversity loss together with the halt and reverse of land degradation, the protection and the restoration of terrestrial ecosystems, the promotion of sustainable use, and the combat of densification (Sustainable Development Goals, n.d.). These goals are the first steps for protecting nature and all it has to offer us.

One of the main reason for the decline of biodiversity is population growth and the rising demand for goods (Millennium Ecosystem Assessment, 2003). If we zoom in on the Netherlands the expected population growth will rise to around 18,5 million people in 2050 which is an increase of around 1 million from 2021 (Regionale bevolkings- en huishoudensprognose, 2019; Centraal Bureau voor de Statistiek, 2021). And together now with the housing shortage, there is a need to densify which will put enormous pressure on nature and its biodiversity.

This paper is an explorative study about biodiversity and the role urbanists have in restoring and protecting it. In the next part, the literature review will answer the main question and get to the aim of the paper to understand what the role of an urbanist is in restoring and protecting biodiversity.

2 Literature review

To get to the aim of this paper there are four sub-questions that will help to answer the main question; “How can we restore and bring back biodiversity which we have lost and what is the role of the urbanist in this process?” To answer this question there are four sub-questions;

1. What is biodiversity and why do people need it?
2. Why is biodiversity declining?
3. How can biodiversity be protected and restored?
4. What role does an urbanist have in bringing back biodiversity?

2.1 What is biodiversity and why do people need it?

To know how to restore and protect biodiversity first there is a need to know what biodiversity is and why people need it. As mentioned in the introduction the definition which is used in this essay of biodiversity is; “The variety of life on Earth at all its levels, from genes to ecosystems, and the ecological and evolutionary processes that sustain it.” (Laverty et al., 2008, pp. 2). From this definition, biodiversity is about all life on Earth and how this life interacts with each other and keeps each other in balance. People depend more on biodiversity in their daily lives than they know and most people do not know the impact the decline of biodiversity has on our ecosystem and what it provides for people (Laverty et al., 2008).

Biodiversity goes through many scales and to get a better understanding of the different levels of biodiversity consist of Laverty et al. (2008) shows in figure 1 the hierarchy of biodiversity which goes from genes to biomes, from a subcellular scale to a continental scale. The first level is genetic diversity which is ultimately responsible for the variation of the individuals, the populations, and the species. Genetic variation is important for the adaptability of a species to for instance climate change (Millennium Ecosystem Assessment, 2005b). The next level is the communities and ecosystems where the relationship between the different species and their environments is important. “An ecosystem is a dynamic complex of plant, animal, and microorganism communities and the non-living environment interacting as a functional unit. Humans are an integral part of ecosystems.” (Millennium Ecosystem Assessment, 2003, pp. 27). Where ecosystems come in all different sizes from the pond in the back yard to the coral reefs. The largest level of the hierarchy is the biomes like; grassland, deserts, and savanna where different communities live. In these biomes, there is a broad representation of different habitats and the different types of vegetation that span across large areas (Millennium Ecosystem Assessment, 2005b). This hierarchy of biodiversity gives a basic understanding of how biodiversity at the smallest level is connected to the largest level of biomes. And where there is a variety of life in all these different levels (Noss et al., 1994).

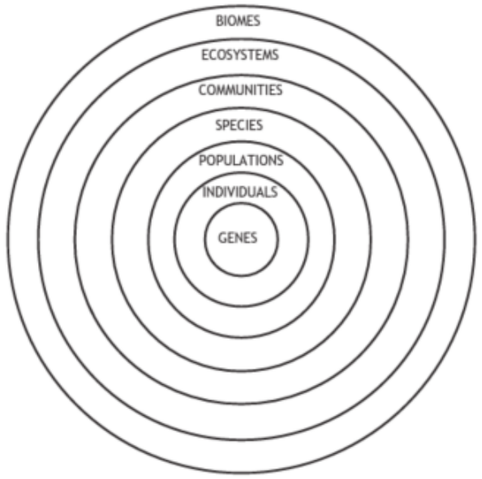

Figure 1 the biodiversity hierarchy Source (Laverty et al., 2008, pp. 2)

Biodiversity helps provide us with our ecosystem services which are important for our economy and our well-being (Summers et al., 2018). These services include fresh air, fertile soil, and recreational activities but this is only possible if these ecosystems have the rich biodiversity to deliver them (Millennium Ecosystem Assessment, 2005b). The Millennium Ecosystem Assessment identified 4 different services which the ecosystem provide for us which can be seen in figure 2 (Millennium Ecosystem Assessment, 2005a). The first service is the supporting service where we have the nutrition cycle and the soil formation, for instance, waste decomposition, soil renewal, and photosynthesis (Laverty et al., 2008). This service is mainly the support of the other services. The second service is the provision serves which provides us with food, medicine, wood and fibre, and freshwater. The third service is the regulating services like the purification of water or the climate regulation. The last service is the cultural service which includes recreation, and education. All these services have an effect on human well-being. In figure 2 the components of well-being are divided into five elements; security, the basic material for a good life, health, good social relations, and freedom of choice and action (Millennium Ecosystem Assessment, 2005a). In the figure, the potential for mediation by socioeconomic factors and the intensity of linkage between ecosystem services and human well-being is shown from low to high and weak to strong. For instance, security is most affected by the provisioning and regulating services where the provision of food and the regulation of floods and droughts affect the security of the recourses (Millennium Ecosystem Assessment, 2003). But the potential for mediation is medium and high because the possibility to purchase a substitute for the services is possible (Millennium Ecosystem Assessment, 2003). Kaplan & Kaplan (2011) explain that the natural environment plays a direct role in human well-being. Where being in nature gives us a break from our daily routines and where nature contains aesthetically pleasing stimuli which help to take the mind of these daily routines and are good for our health (van den Berg et al., 2007). Figure 2 shows that ecosystem services affect human well-being and that people need these services, and to have the services rich biodiversity is needed.

This approach of explaining why we need biodiversity or ecosystem services to provide us with human well-being is based upon the fact that we as humans are part of the ecosystem (Millennium Ecosystem Assessment, 2003). The framework which is made in figure 2 recognises the role decision-makers of different levels make which affect the ecosystem services and human well-being (Millennium Ecosystem Assessment, 2003). The different levels of decision-makers are; by individual and small groups at the local level, at the municipal, provincial, and national level, and the third one

at the international level. This can be seen as decisions like the sustainable development goals which have been made at the international level and at the local level initiatives of a neighbourhood that plant trees and flowers in their gardens or in their streets. But because of the growing population, the demand for these services is growing like food and fresh water and at the same time human actions cause these ecosystems to shrink and it is getting harder to meet these needs Millennium Ecosystem Assessment, 2003).

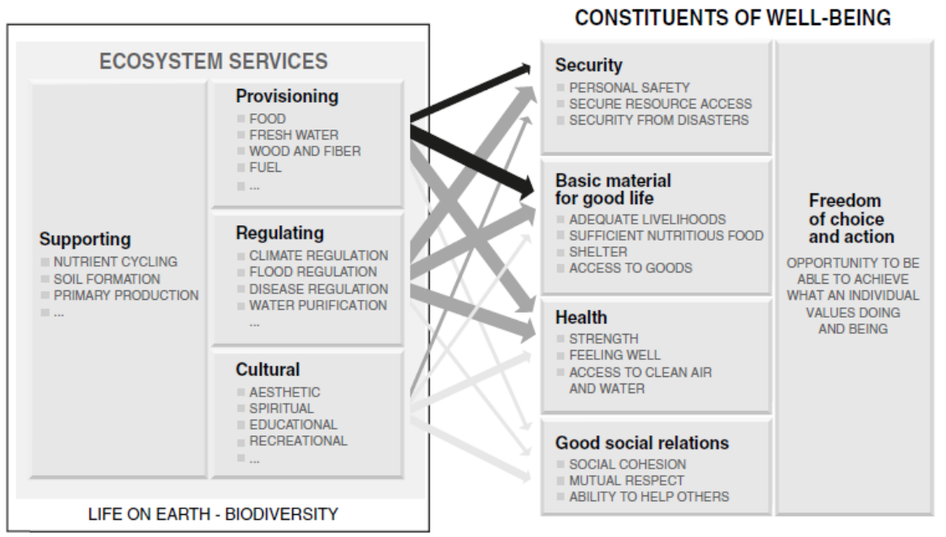

Figure 2 Linkage between the ecosystem services and the human well-being Source (Millennium Ecosystem Assessment, 2003, pp. 28)

2.2 Why are we losing our biodiversity?

Our population is growing and in 2021 people are using around 1,6 planets to provide us with the resources we need (Ecological Footprint, 2021). This means we are using more recourses of our planet than our planet can regenerate and if we would go on like we are doing now this number could go to 2,5 planets in 2050 (Mezher, 2011). To meet these needs for the people the land surface has been altered to provide us with agriculture and infrastructures which results in around 1/3 of the planet being altered by humans (Laverty et al., 2008). This agriculture has placed a lot of pressure on natural habitats and has caused spatial fragmentation. Because of the good infrastructure travelling has become more easy and invasive species are introduced by humans which threaten the local species and with this the local ecosystem (Laverty et al., 2008). And because of the industries more and more carbon dioxide is released into the earth's atmosphere which causes climate change (Laverty et al., 2008). Since 1950 humans have altered the ecosystems more extensively compared to any other period of time (Millennium Ecosystem Assessment, 2005a). The five main reasons for our biodiversity loss are; habitat destruction, invasive species, overexploitation, pollution, and climate change (Laverty et al., 2008; Millennium Ecosystem Assessment, 2005b). But the underlying factors which cause biodiversity loss are overpopulation and unsustainable consumption of the resources which help

cause the five main reasons for biodiversity loss (Laverty et al., 2008). In the next part, the five main reasons for biodiversity loss will be further explained.

Habitat destruction

Habitat loss is the loss of suitable habitat for a specific species, habitat loss makes an area not suitable for those species anymore (Lindenmayer & Fischer, 2006). A large loss of species is caused by spatial fragmentation and degradation of habitats, the main reason for this is urbanization with the construction of roads and buildings (Beatley, 2000). But also agriculture causes habitat destruction and spatial fragmentation together with deforesting, 40 percent of tropical deforestation is caused by commercial agriculture between 2000 and 2010, and another 33 percent for local agriculture (FAO & UNEP, 2020). With the population growth and the economic growth, it is likely the habitat destruction will increase instead of stabilizing (McNeely, 1992). Even though we know we need these habitats and their biodiversity we keep on destructing these areas.

A habitat has a border habitat and an interior habitat where different kinds of species live, if this habitat is split the interior habitat becomes smaller and animals that need these large interior habitats will disappear (Millennium Ecosystem Assessment, 2005b). Large habitats or habitats which are connected through a corridor are less affected by fragmentation in comparison to small habitats where only the smaller species can live which are more vulnerable (Millennium Ecosystem Assessment, 2005b).

In the Netherlands, we suffer great losses of our biodiversity, at the moment there is only 15% left of the original plants- and animal species that we had in 1900 (Birger, 2020). Some species which are on the red list in the Netherlands are; Garden dormouse, Hazel dormouse, Stoat, and Little gull (Rode lijst Nederlandse broedvogels, 2016; Rode Lijst Zoogdieren, 2020).

Invasive species

Since the European colonial period, people have been responsible for introducing invasive species to unknown environments where they have taken over the native species or made these native species extinct (Milberg & Tyrberg, 1993; McNeely, 1992). These invasive species can be competitors or predators for the native species but they can also bring diseases or they can change the habitat and alter the dynamics (Millennium Ecosystem Assessment, 2005b). This can cause a lot of problems for the ecosystems and their biodiversity.

In the Netherlands, the Crayfish which is originally from Amerika is taking over the rivers and destroying the banks of waterways and eat everything which causes biodiversity loss (NOS, 2016). But there is also an example of non-native species which are an asset to an area, the cranberries on Terschelling which are now used for cranberry farms.

Overexploitation

Overexploitation happens when recourses or species are taken or hunted in such large amounts to the point it can not reproduce the same amounts it used to do. Since 1800 the extinction rate of species has grown (Wilson & Peter, 1988). This is because humans have exploited sources like wildlife for their ivory or their fur. Some species have even exploited to the brink of extinction or have been completely extended (Millennium Ecosystem Assessment, 2005b). The loss of these species and recourses will have ecological implications but it also affects the food security of people (Millennium Ecosystem Assessment, 2005b).

Climate change

Our climate is changing where the temperature is rising, there are more extremes in the weather and the sea level is rising. Climate change not only has an effect on people but also on our populations and their species but not all species are affected the same (Millennium Ecosystem Assessment, 2005b). Species which are more vulnerable and which are sensitive for extinction have mostly specific habitat requirement, are not very mobile, and have small populations where climate change can have a negative effect (Millennium Ecosystem Assessment, 2005b). Another effect of climate change is the changing weather patterns where there are longer droughts which can cause problems for agriculture and our food production or when there is extreme rainfall which can cause floods.

Pollution

Biodiversity loss through pollution comes in many forms. McNeely (1992) has listed six of them and the consequences of these polluters. These polluters are; pesticides, acid deposition, the rise of carbon dioxide and other greenhouse gasses, the effect of CFC's on the ozone layer, heavy metals, and plastic. For instance, the use of pesticides, are often used for pest control where in England Barn owls have been reduced by 10% because of the pest control of mice (McNeely, 1992). There are many sea animals that die from plastic in the oceans because they get entangled in it or because they eat it (More and more marine animals are dying because of plastic, 2020). But species have the possibility to evolve if they have enough genetic diversity in their population (Millennium Ecosystem Assessment, 2005b). For instance, in areas where there is industrial pollution, there were moth species found which had evolved industrial melanism (Majerus & Coyne, 1998). This is only possible if there is enough genetic diversity. This means the diversity is important for our plants and animals to be able to adapt to future changes (McNeely, 1992).

2.3 How can biodiversity be protected and restored?

Knowing the main reasons why we are losing biodiversity helps with knowing how you can restore it or how you can protect the biodiversity which is still there. The five main reasons biodiversity is declining habitat destruction will be used further in this paper. But first, if you want to protect and restore biodiversity it is useful to measure the biodiversity at the site you want to restore and protect. Commonly biodiversity is measured at the level of genes, species, or at the ecosystem (Millennium Ecosystem Assessment, 2005b). There are three variables where biodiversity can be measured with (Millennium Ecosystem Assessment, 2005b);

- Variety, the variety gives the number of different types. For example the number of different bird species which live in a habitat.
- Quantity and quality, shows the amount there is of a certain species, if we talk about what people need like food, or freshwater the quality and the quantity is more important than the variety there is of a certain species.
- Distribution, the distribution shows the way species are spread. For instance, if pollinators are only located at one spot in the world they can only pollinate the plants which are there which will give a problem to other plants who also depend on these pollinators.

Secondly, biodiversity can also be categorized on its value; utilitarian and intrinsic (Laverty et al., 2008). Utilitarianism is measured by the value it has for people and intrinsic is the worth of an organism itself, where everything has a right to exist (Laverty et al., 2008). Measuring the value of something to what it is worth to people is very difficult especially because the value can change over time. This gives two ways of measuring biodiversity, the first one is through numbers and the second one is through its value. Measuring the existing biodiversity can give a starting point to knowing what is missing and what needs to be added or protected. But measuring biodiversity is not a simple task and it is difficult to measure it accurately.

An important aspect of enhancing biodiversity is the connection of habitats and ecological networks on the smaller scale with the networks on the larger scale which stretches from the urban areas all the way to the surrounding countrysides (Gill et al., 2007). Spatial fragmentation is the main cause of not having these connections with the different habitats and ecological networks. Cities play an important role in bringing back biodiversity because they often are one of the causes of spatial fragmentation (Beatley, 2000). If you look at a city there is already a rich amount of biodiversity, for instance on the roof gardens where birds can nest and where butterflies and other pollinators live (Beatley, 2000). McKinney (2008) has done research into the species richness of urban cores, suburban areas, and rural areas which can be seen in figure 3. As seen in the figure in the urban core the species richness is reduced more in comparison to the others. This is the effect of habitat loss because of urbanization, pollution, traffic, and human activities (McKinney, 2008). The amount of vertebrates and invertebrates is a lot smaller in the suburban area and in the urban core compared to the rural area. This is because in the rural area there is more space for the species and a lot less disturbance of people and traffic. But with initiatives like roof gardens, this biodiversity can be brought back into the city. The figure also shows the species richness of the plants are higher in the urban core and the suburban areas in comparison to the rural areas, this can be explained by the fact people have brought in non-native species in their gardens or their streets (McKinney, 2008). If these non-native species are kept controlled there is a smaller chance of these species taking over the native species.

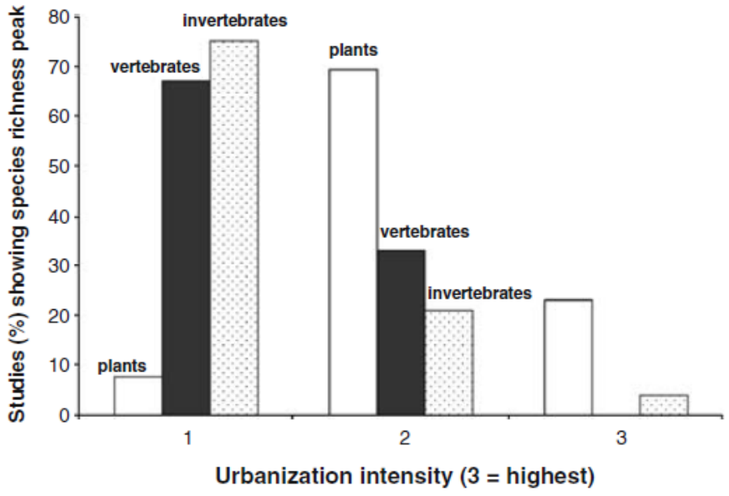

Figure 3 species richness along with the urban-rural gradient source (McKinney, 2008, pp. 166)

There is no exact way of knowing how to bring back the biodiversity in a city because every city is different. Konijnendijk van den Bosch (2021) has given a rule of thumb for successfully bringing green into the city, the 3-30-300 rule where everyone should be able to directly see 3 threes from their homes. There should be at least 30 percent of canopy cover in every neighbourhood, and that the nearest park or green space, of at least 1 hectare, should be no further than 300 meters from your home (Konijnendijk van den Bosch, 2021). This thumb of rule can be used to know where green needs to be brought in the city but if you want to enhance the biodiversity in the city Gill et al. (2007) explains that it is important to connect the different habitats to each other with green infrastructure. These green infrastructure also help with improving the well-being of people and will help with the expected climate changes (Swensen & Berg, 2020). So the most important aspects to restoring biodiversity and protecting biodiversity are by connecting the habitats and ecological structures with each other and protecting these structures against spatial fragmentation and human activity.

2.4 What role does an urbanist have in bringing back and protecting biodiversity?

As seen in the previous sub-questions the reason for biodiversity loss is primary caused by human activity. And to undo this, humans have to start initiatives to restore the damage they have done. And what role does an urbanist have in this? Beatley (2000) explains that small initiatives will not help in the long run with reversing biodiversity loss and with maintaining a healthy ecosystem. There is a need to connect green infrastructures and ecological networks to enhance biodiversity (Gill et al., 2007). This means large scale strategies and thinking is needed to bring back and protect biodiversity and the ecological structures (Beatley, 2000). Urbanists have a key role in creating and implementing these large scale strategies (Beatley, 2000). When planning a new land-use plan the role of the urbanist should also include the protection of existing corridors, transitional areas, and protecting land from future growth of a city into an ecologically rich habitat (Beatley, 2000). An urbanist can not do this alone there has to be good communication with ecologists and wildlife biologists to get the right information about a location and its habitat to preserve and to enhance biodiversity (Beatley, 2000).

The framework from figure 1 took into account the different levels of decision-makers from local to international level which affects the ecosystem system services and the human well-being (Millennium Ecosystem Assessment, 2003). Where Beatley just explained that small initiatives will not help in the long run decisions have to be made on a provincial level and on larger levels. Next to the urbanists municipalities also play a role in the preservation of habitats and their biodiversity. In the Netherlands, provinces have to make a plan of Nature Policy, which the municipalities have to build upon (Beatley, 2000). Most of nature in the Netherlands has been created by humans which makes it vulnerable to threats and has to be protected from species that are dominant or from the outside (Noss et al., 1994). Urbanists and municipalities play a key role in the protection and restoration of biodiversity.

3 Conclusion

To answer the main question; “How can we restore and bring back biodiversity which we have lost and what is the role of the urbanist in this process?”. First, the understanding of what biodiversity is and why we need it and why we are losing it will be answered. Secondly, the main question will be answered.

Biodiversity is “The variety of life on Earth at all its levels, from genes to ecosystems, and the ecological and evolutionary processes that sustain it.” (Laverty et al., 2008, pp. 2). Biodiversity is complex with many different levels which are all connected to each other. There are still a lot of species that not have been discovered which makes a lot of nature still unknown to people. Biodiversity provides us with our ecosystem and our ecosystem services. These ecosystem services are linked to our well-being and provide us with recourses like food, medicine, and water (Summers et al., 2018). Because people are dependent on the ecosystem services there is a need for biodiversity.

But our biodiversity is declining because of five main reasons; habitat destruction, invasive species, overexploitation, pollution, and climate change (Laverty et al., 2008; Millennium Ecosystem Assessment, 2005b). The underlying factors which cause biodiversity loss are overpopulation and unsustainable consumption of the resources (Laverty et al., 2008). Knowing why we are losing our biodiversity helps with understanding how we can protect and restore the biodiversity and seeing which role the urbanist can have in this process. Habitat destruction is the cause which this thesis focuses on for protecting and restoring biodiversity.

Measuring the biodiversity on a location will help to know what is missing. There are two ways explained in this essay to measure biodiversity. The first way to measure biodiversity is with numbers through; variety, quantity and quality, and distribution (Millennium Ecosystem Assessment, 2005b). To measure biodiversity through its value can be categorized as; utilitarian and intrinsic (Laverty et al., 2008). But measuring biodiversity is not a simple task and it is difficult to measure it accurately. An important aspect in bringing back biodiversity is by connecting habitats and ecological networks from a small scale to a larger scale network (Gill et al., 2007). Cities play an important role in bringing back biodiversity (Beatley, 2000). Green infrastructure should stretch from urban areas all the way to the

surrounding countryside to enhance biodiversity (Gill et al., 2007). To successfully bring green into the city Konijnendijk van den Bosch (2021) has come up with the 3-30-300 rule where 3 threes should be in sight of every house, 30 percent of canopy cover in every neighbourhood, and a park should not be further than 300 meters from your home. But to really restore and protect biodiversity habitats should be connected through corridors from the small scale to the large scale.

The role of an urbanist in protecting and bringing back biodiversity is important. The need for large scale strategies to protect and restore biodiversity and the ecological structures is where the urbanist plays a key role in (Beatley, 2000). Together with good communication with ecologists and wildlife biologists biodiversity can be restored and protected at the locations it is needed (Beatley, 2000). But not only the urbanists play a role in the protection and the restoration of biodiversity the municipality and the provinces also play a key role in protecting and restoring the biodiversity.

4 Discussion and recommendations

This paper is an explorative study that only scratches the surface of what biodiversity is and how to restore and protect it. Because biodiversity is such a complex system with many different levels which are all connected it is difficult to know exact ways of restoring it or protecting it. The knowledge that different green structures or habitats need to be connected is a beginning but how are they supposed to connect to each other and how broad do these corridors need to be and which plants and species are needed to get biodiversity back? These are questions that can be answered in further research.

Not only knowing how biodiversity is restored or protected it is also interesting how biodiversity can be measured. There are more ways of measuring biodiversity than the ones which have been explained in this paper. Every location has its own specificities and knowing which measuring tool should be used for which kind of location could be an interesting step towards a more accurate measurement of biodiversity. Knowing the amount of biodiversity is in an area can really help in figuring out what is missing.

The role an urbanist has in restoring and protecting biodiversity is relatively new. There is a need for the urbanist to gain new skills and new knowledge about biodiversity how to protect it and how to restore it (Beatley, 2000).

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