A GREEN CAMPUS

Urban ecology, nature's effects on well-being, and how to implement this into a practical design

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Implementation of ecologically beneficial green in the urban development plan for the Zernike campus Groningen

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1. Introduction & Background

"We all know how good being in nature can make us feel. We have known it for millennia. The sounds of the forest, the scent of the trees, the sunlight playing through the leaves, the fresh, clean air – these things give us a sense of comfort. They ease our stress and worry, help us to relax and to think more clearly. Being in nature can restore our mood, give us back our energy and vitality, refresh and rejuvenate us."

Forest Bathing – Dr. Qing Li

People currently live in a time in which an ongoing migration from rural areas towards cities is taking place. This dawn of the urban era affects them in multiple ways, and not all are positive. Life in the city challenges people's well-being for several reasons, but mostly because of the constant stimuli and stress-inducing situations (Refaat, 2014).

It appears that one of the best solutions to averse the negative effects city-life has on people's well-being is nature. Being, or even merely viewing, nature is beneficial for your brain performance, physically reduces stress-levels, lowers the body mass index in children, and increases mental well-being (Refaat, 2014).

Increased levels of green space in urban areas is, thus, beneficial for the residents of that area. However, the availability of green space also affects the ecosystem services provided in a beneficial way. Increased greenness can, for example, improve air quality (Bowler, Buyung-Ali, Knight, & Pullin, 2010; Nimela & MacDonnell, 2011).

Urbanization not only affects the well-being of the people living there. It also highly affects the ecological value of the area. By covering up the area with concrete and bricks, the environment changes drastically, offering new challenges for the species aiming to survive in that area (Nimela & MacDonnell, 2011).

If we want to create a truly healthy urban environment it is vital to consider the ecological aspects when designing cities and acknowledge the benefits it could provide. Developing urban areas from a more ecological point of view can, ultimately, help reducing the ecological impact urbanization has. It is said that one of the essential components of a sustainable city is incorporating ecological design (Refaat, 2014).

1.1 Nature

Nature in urbanized areas might appear different from what some readers are used to when thinking about nature. What mostly comes to mind when thinking about nature are vast landscapes with majestic mountains, or forests with endless trees and rivers running wild. However, there is no room for such forms of nature in urbanized areas. In cities where pavements and buildings cover most of the ground, nature comes in smaller forms. Consider green spaces between two lanes, or the park in a neighborhood. Within urban areas, any form of greenery is part of the urban nature.

1.2 Zernike campus

The Zernike campus is an area just outside the city of Groningen, and holds several faculties of the University of Groningen, the Hanze University of Applied Sciences, and several companies (Arends, Groenhagen, Gruijters, & Minderman, 2018). In the upcoming years, the campus will be further developed and improved. The owners of the campus' grounds, namely the municipality of Groningen and both knowledge institutions that were just mentioned, contracted the architect company West 8,

and they developed an urban development plan for the campus, that embraces the visions of the stakeholders for the campus (West 8, 2014).

This plan has also adopted a vision that aims to enhance the ecological value of the campus, by, for instance, supporting the further development of a green network. However, this has been done in a way that still allows for improvement, for instance, when looking at the flora species currently chosen. At the moment, non-native species have been chosen, rather than native species, that are vital for preserving biodiversity, amongst other things. The execution could be improved to truly support ecological development without losing grip on implementing human preferences in the design as well (Gommers, 2015; National Audubon Society, 2018).

This provides us with a challenge, namely how to incorporate the sustainability aims of the stakeholders involved with an ecologically beneficial environment at the campus that also fulfills the desires of the users of the campus.

1.3 Aim & Approach

This leads us to the main aim of this research. **How can we implement ecologically beneficial green in the urban development plan for the Zernike campus?**

The following approach has been chosen to tackle the challenge at hand. Firstly, we will look into the effects that nature has on people's well-being (*chapter 2*). How is this optimized, and what mechanisms underlie these effects? Urban areas are, in its core, developed to create a habitat for people, and it is, therefore, of value to see how we can optimize this area to increase, rather than decrease, people's mental and physical health.

Then we will focus on the urban ecological environment (*chapter 3*). What challenges does this type of environment face and what opportunities does it provide? It is important to gain an understanding of how the urban environment works.

After that, a framework will be provided that helps with creating an ecological successful design (*chapter 4*). This chapter will enlighten what values are of importance when trying to develop a design from an ecological foundation.

What follows are some examples of ways in which other organizations have improved the ecological value of an area (*chapter 5*), from small changes, to drastic ones that affect an entire organization. These examples might offer solutions to challenges the issue at hand also faces, and could, therefore, benefit from frontiers.

We will then take a closer look at the Zernike campus (*chapter 6*), what its ecological potential is, and what its current policies are. Here, we will also summarize the future of the campus, based on the urban development plan that has been set for the Zernike campus.

This all should give an initial base, from which a research can be formed that will gain insights in the desires of the campus' users (*chapter 7*). As will become clear throughout the first chapters, in order for a design to be successful, it must be desirable to the users. If this would not be the case, people will not use the area, hence, not profiting from the potential health benefits. It is, therefore, of importance to map the desires of the final users of the to-be-developed area, to make sure it would to a certain extent match those desires. For this research, we will start with analyzing two previously conducted surveys, before discussing the survey performed for this report.

When all this information has been gathered and analyzed we should have an overview of required and preferred conditions (*chapter 8*) that should be incorporated in the plan for a green zone. It is then time to find out what part of the campus' could best be redeveloped (*chapter 9*) and develop an advice that suggests alterations to the current design in order to create a more ecological design for that part of the campus (*chapter 10*).

The report will conclude with some final advice that will enlighten how the rest of the campus could be developed to make sure the overall environment of the campus will be ecologically beneficial (*chapter 11*), before ending on an overall conclusion of the project (*chapter 12*).

2. THE EFFECT OF NATURAL ENVIRONMENTS ON PEOPLE'S WELL-BEING

"Aristotle believed walks in the open air clarified the mind. Darwin, Tesla and Einstein walked in gardens and groves to help them think. Teddy Roosevelt, one of the most hyper productive presidents of the Unites States of America of all time, would escape for months to the open country. On some level, they all fought a tendency to be "tired, nerve-shaken, over-civilized people" as hiker-philosopher John Muir put it in 1901."

THE NATURE FIX, FLORENCE WILLIAMS

2.1 INTRODUCTION

Humans can be considered as urban species since around 2008. In that year, the World Health Organization published a report stating that, for the first time, more people are living in urban areas than in rural ones (World Health Organization (WHO), 2008). However, this shift in where most of us spend their lives has had surprisingly little influence on how cities are planned and built, in order for the cities to incorporate any psychological needs human beings have. We still consider nature a luxury, rather than a necessity.

Recently, interest in the beneficial effects of nature have been increasing in many different fields, such as psychology, health, conservation and economics. Nature seems to have a thusly beneficial effect on people that it not only improves their well-being, but also their creativity, cooperativeness and productivity, hence the interest in those effects from the field of economics, and from governments and organizations (Aspinall, Mavros, Coyne, & Roe, 2015; Atchley, Strayer, & Atchley, 2012; Berman, Jonides, & Kaplan, 2008).

One of the founding ideas that linked well-being to time spent in nature was the biophilia hypothesis, proposed by Edward O. Wilson, in 1993. In his book regarding this hypothesis, he states that biophilia is "the urge to affiliate with other forms of life". The central claim of the hypothesis is that humans tend to feel more at home in nature than in urban areas, because this is where we evolved and originated from. This hypothesis has been further developed to better understand our relationship with nature, and the effects of urbanization on human beings (Kellert & Wilson, 1993).

In Korea and Japan, nature has, from a spiritual background, always been an important factor in human's fulfillment and well-being. Nowadays, with their explosively rising economies, residents from both countries have been pulled into an extremely stress-inducing society, resulting in some of the highest suicide rates in the world (World Health Organization (WHO), 2017). In order to restore the psychological health of the people, forest therapy organizations have emerged, inviting people to de-stress by staying in forests for several days, allowing nature to help restore those people's well-being. These organizations have developed highly anticipated programs and are now cooperating with researchers to gain insight into how the benefits experienced by their participants comes about. This resulted in quite a few findings, supporting the hypothesis that nature has a positive claim on human well-being. We will get back to these findings throughout this chapter (J. Lee et al., 2012; Shin, 2015).

2.2 WELL-BEING

Well-being, and mainly improving well-being, is an important aspect here. However, what this concept entails, has been reason for debate, and I will therefore briefly elucidate what the concept will hold in this paper, in line with Díaz (2006). Well-being is viewed as the overarching concept that includes someone's happiness, mental health, and physical health. The level to which all three are present in the life of an individual, constitute that individual's level of well-being. It is, often, subjective, because it is based on a person's own experience of these factors, and influenced to great extent by cultural, geographical, and historical context of the society in which an individual resides. Someone's well-being

is, thus, influenced by many different factors in somebody's life, which makes it hard to come up with a policy that positively affects most people's well-being. There are, however, some basic necessities that the majority of mankind considers valuable for their well-being, such as shelter and the production of food. This combined with common, more subjective, features of 'a good life', it remains possible to build policies around improving citizen's well-being (Díaz, Fargione, Chapin, & Tilman, 2006).

2.3 Mental and physical health

2.3.1 Recovery

Research suggests that nature, whether 'real' nature or photographs of nature, has a restorative effect on the human brain (Valtchanov & Ellard, 2010). There are two main hypotheses on how this might operate. The first hypothesis is the Attention Restoration Theory (ART), proposed by the Kaplans (1995). They propose that nature has a soft-fascinating component – it makes us attentive to the scenery, without overindulging us in distracting stimuli -, that allows us to take a distance from the direct-attention most daily activities nowadays require from us. This results in people feeling less stressed, and eventually perform better at thinking tasks (Kaplan, 1995). The other hypothesis is the Stress-Reduction Theory (SRT) (Ulrich et al., 1991), which is based on the earlier mentioned biophilia hypothesis, but provides data supporting this hypothesis. Namely, this study by Ulrich et al. (1991) found that, when people are stressed, nature helps decrease the amount of stress experienced and restores their physiological activity levels, that were altered due to the induced stress (Ulrich, Simons, Robert F. Losito, Fiorito, Miles, & Zelson, 1991).

There have been debates concerning the effects of short-term nature visits, since most studies propose effects only after participants have been in nature for at least three days. But Ulrich et al. (1991) showed that nature can also have an immediate effect on reducing stress levels. A Japanese study by Qing Li (2010), concerned again with the forest therapy, also took a closer look at the effects of short-term visits, and found that the positive effects were slightly less, but still present, when people had been in the forest for just one hour. The effect also lasted shorter, but again, did last for some time after the hour spent in the forest (Qing Li, 2010; Ulrich et al., 1991). Kaplans Attention Restoration Theory (1995) was also tested for possible beneficial effects after short-term nature visits. They found that the brains of the participants who looked at photographs of nature were immediately more recovered, then the brains of those who looked at photographs of urban areas.

2.3.2 Happiness

Many people enjoy a trip to any natural environment during their vacation or any day off. Most people experience joy when being outside, and even more so when in nature. A recent, major study within the United Kingdom analyzed people's happiness among 20,000 participants at different moments in time, and analyzed this according to factors such as location or people whom the participant was with (MacKerron & Mourato, 2013). They showed that where people are, had the biggest effect on their happiness, with their happiness significantly increased when the participants were outdoors in green or natural habitat, then when they were in urban environments.

2.3.3 Other beneficial effects of nature

Many different studies have been conducted on the beneficial effects of nature on human's well-being, and even though it is not always clear how the effect relates to nature (or maybe to other factors), some of the found effects are worth mentioning. It has been shown that natural environments can also increase several human abilities, necessary for functioning well in our society, both socially and career wise. So far, beneficial effects have been demonstrated with regard to memory, planning skills, stimulating creativity, ability to focus, and several social skills, such as compassion and cooperativeness (Atchley et al., 2012; Keniger, Gaston, Irvine, & Fuller, 2013; Kim et al., 2010).

2.4 UNDERLYING MECHANISMS

Most of the research done to the effects of nature, focused mainly on the visual aspects of it. Natural environments then showed beneficial effects, but the question remained as to why nature has these effects. Promising results were provided by the research done in the forest therapy sessions in Japan and Korea, where they had shifted their focus from visual aspects to smell aspects (Q. Li et al., 2009). They found that phytoncides (volatile organic compounds emitted by plants and trees) are extremely likely to be the cause of increases in several health factors. The phytoncides released by *Chamaecyparis obtuse* (Hinoki cypress) reduce stress by lowering the levels of cortisol by 53% and can lower blood pressure by 5-7%. Both pine trees and cypress trees release phytoncides that stimulate people to relax.

These results sound as if though smell might be the underlying mechanism that lets us inhale all the benefits offered by nature. However, most aromatherapies that claim to have comparable effects aren't studied in large, clinical trials. A review study on the literature regarding this topic stated that in the current studies it is difficult to determine whether to prescribe the positive results to the aromatherapy, or to a placebo effect (Y.-L. Lee, Wu, Tsang, Leung, & Cheung, 2011).

2.5 ARE THE BENEFITS DUE TO NATURE?

In general, it is still somewhat of a mystery whether we should prescribe the mentioned benefits to nature, and if so, to what aspects of nature, or if it should be prescribed to something entirely different, such as a sense of community by meeting other (new) people when in nature, or the physical activity that is often a result of (or maybe even a motivation for) visits to nature.

2.5.1 COMMUNITY

It has been suggested by several studies that nature helps people to calm and become kinder to one another as well. A Dutch study by Maas et al (2009), for example, connected greener living areas to people experiencing less loneliness, and becoming more generous. However, this effect didn't solely seem to emerge from merely being in natural environments and taking in nature. Kuo et al (1998) propose that it is a rise in community sense that make people kinder towards each other. People are highly sociable creatures, and being outside allows them to connect and interact with others, more than inside the buildings most of them spend most of their time (Kuo, Sullivan, Coley, & Brunson, 1998; Maas, van Dillen, Verheij, & Groenewegen, 2009).

2.5.2 WALKING

Even though effects of nature also tend to arise when people are only viewing green sceneries through windows, or just via images shown to them in, if one wants to get into nature, this is almost all of the time accompanied by going for a walk. It is then questionable whether the beneficial effects are due to the natural environment, or due to the fact that people are exercising while being in nature. However, walking has proved to stimulate, for instance, healthy ageing, and must therefore not be neglected. A study suggests that a mere forty minutes of walking per day can already help protecting the brain from cognitive decline. Other studies also demonstrate that walking has a stimulating effect on creativity and that it improves memory. One review study concluded by stating that 'a growing number of studies support the idea that physical exercise a lifestyle factor is that might lead to increased physical and mental health throughout life (Hillman, Erickson, & Kramer, 2008).

2.6 CONCLUSION

Researches, governments and individuals have come to value the beneficial effects nature most probably has on our well-being more and more. Despite the mechanisms that underlie the beneficial effects of nature being not yet fully unraveled, it is clear that nature holds positive effects on human health. Therefore, it seems inevitable that more green should be implemented in urban areas. We now

have the possibilities to take a closer look at how we can alter our direct surroundings in such a way that it can help prevent physical and mental issues. Adjusting the areas we spend most of our time in will benefit humans in achieving proper 'health' as defined by the World Health Organization: "A complete state of physical, mental and social well-being, and not merely the absence of disease or infirmity" (World Health Organization (WHO), 1948).

3. THE URBAN ECOLOGICAL ENVIRONMENT

3.1 INTRODUCTION

Since the majority of the human population nowadays reside in urban regions, the urban landscape has become one of the most familiar environments to most people. Cities filled with concrete and brick cover more and more of the earth's surface to supply the demand for ever increasing cities. This, however, is not without effects on the natural environments it replaces (Nimela & MacDonnell, 2011).

Urbanization replaces many natural environments by paved surfaces and buildings. This introduces new surface materials, such as concrete and asphalt, that influence the soil's functions and introduce new nutrients and pollutants. Some areas are designed to reintroduce nature into the urbanized environment, via public parks, private gardens, and patches of green throughout the city. These 'natural' green spaces are, however, highly managed and often planted without proper consideration of ecological consequences such as effects on biodiversity and the potential to offer ecosystem services (Nimela & MacDonnell, 2011).

Green spaces in urban areas have often been created without proper consideration of their ecological value. For instance, the architect that designed New York's Central Park wanted to create an aesthetically appealing get-away possibility for residents to escape their urban life. It was not created to develop ecological value (Refaat, 2014).

Covering the soil with asphalt, buildings built densely together, and highly managed green spaces affect the natural aspects of the area. Urban regions, thus, create a new ecological environment, namely the urban ecological environment. The ecosystem in this environment is in several ways different from ecosystems in natural areas. Some examples of these differences are that urban ecosystems are often more island-like and are more often invaded by alien species. It, therefore, seems fit to consider this new environment and the urban ecosystem and discuss the influences of urbanization on ecosystem services, and some of the challenges urban areas are faced with (Niemelä, 1999; Nimela & MacDonnell, 2011).

3.2 ECOSYSTEM SERVICES

The urbanization of our planet affects how we understand, connect with, and use natural resources. Natural systems can provide resources, such as certain services or products for the human population. According to Hein et al. (2006), ecosystems services can be categorized in either of three main groups: production services, regulation services and cultural services. What follows, is an explanation of each of these separate categories (Hein, van Koppen, de Groot, & van Ierland, 2006; Nimela & MacDonnell, 2011).

3.2.1 PRODUCTION SERVICES

Production services entail the services and products provided by nature. Food production from farm fields surrounding the urban area, as well as community gardens in which food is cultivated is the main result of these production services, and still relevant for the urban regions, even though they only provide a small share of the food consumed by a city, because they remain a vital factor for the food security of some urban areas. Another significant service provided is the development and maintenance of diversity, by providing habitat for present flora and fauna. The pollination function is also a vital service worth mentioning. Many crops would vanish if their pollinators, such as the honey bee, would cease to exist. The latter is a common current issue, due to, for example, decreasing the pollinator's habitat, while also increasing the demand for agricultural crops. It is, therefore, relevant to maintain these habitats to ensure, at least, the preservation of biodiversity. However, this is often

not the case in the planning of urban landscapes, resulting in decreased biodiversity in urban areas (Barthel & Isendahl, 2013; R. S. De Groot, Wilson, & Boumans, 2002; Ernstson et al., 2010; FAO, 2018; Hein et al., 2006).

3.2.2 Regulation services

Nature regulates many processes in an environment, and certain regulations are especially important in urban regions. Due to human influence, the world experiences a grave increase of CO2 emission. Nature, however, might help modulate this process by regulating CO2 emission, for example, trees can store carbon dioxide. Due to the paved surfaces covering most urban regions, excess water becomes hard to control. This creates the need for water storage in those regions, which is another regulation service nature can provide. Other urban regulation services include, but are not limited to, air filtering, microclimate regulation, and erosion control. Implementing nature in urban areas can also help decrease the urban heat island effect, which we will discuss later. Nature not only regulates these processes, but also plays a fundamental role in stabilizing them (Bolund & Hunhammar, 1999; Davis, Shokouhian, Sharma, & Minami, 2001; R. S. De Groot et al., 2002; Hein et al., 2006; Jobbágy & Jackson, 2000).

An important benefit gained from these regulation services, is that they often influence the health of the human population for the better. Urban areas are frequently littered with dust particles from exhaust gases, which have a negative effect on people's health, and green spaces can filter these particles by taking up those polluting gases from the air, creating cleaner air. Other physical, but also psychological health benefits of nature will be discussed in the next chapter (R. S. De Groot et al., 2002).

3.2.3 Cultural services

The final main category to capture the different ecosystem services are the cultural services provided by green space. Nature is embedded in most people's idea of leisure, recreation, and culture. Many enjoy walking through nature, viewing natural landscapes and highly value nature's esthetics. These esthetics also provide creative inspiration for artists from all different types. Natural environments and nature are deeply rooted in human culture. People often rather choose to reside in areas that have some green spaces, allowing them to use these green spaces for leisure and relaxation, which motivates municipals and designers to add those kind of areas in the development of new spaces (R. S. De Groot et al., 2002; Hein et al., 2006).

3.3 Challenges & Issues

In urban regions, most surfaces are modified by humans and cover up past vegetated areas. These changes influence how cities deal with issues such as temperature, air pollution, wind, and other variables that can be headed under the regulation services nature provides. But these are not the only contend cities must deal with. These covered up areas create new ecological challenges as well. Urbanization presents novel challenges regarding both the ecosystem services and the ecosystems (Nimela & MacDonnell, 2011).

3.3.1 Heat-island effect

One of the most prominent issues urban areas are faced with is the heat-island effect, a phenomenon first found by Luke Howard (1818). The heat-island effect entails that, due to the physical properties of construction materials used in cities, they have an increased average temperature, compared to their rural surroundings. Due to this effect, many cities experience a decreased air quality, because it increases the development of pollutants.

The heat-island effect negatively affects people's well-being. During periods of extreme heat people get overheated, especially in the cities where the temperature rises even more. Urban residents get

heat-related illnesses and heat-waves result in quite some deaths annually. Some studies claim that the heat-island effect contributes to the magnitude and duration of those extremely hot periods (Changnon, Kunkel, & Reinke, 1996; Nimela & MacDonnell, 2011).

3.3.2 Regulation services challenges

The density of cities' covering material, as well as the properties of those materials offer challenges for the regulation services nature often provides. The concretization negatively affects hydrology properties of areas, by, for example, increasing the storm water runoff. Water used to be able to get absorbed by the soil or vegetation, but the concretization does not allow for this absorption, leaving the water troubled with where to go. The amount of traffic and industrial sites found in urban areas transform urban areas in significant sources of emissions, which negatively impacts the air quality as well as people's well-being (Nimela & MacDonnell, 2011).

3.3.3 Ecological challenges

Most urban landscapes are extremely patched, meaning they are designed in, often, isolated pieces with distinct borders between them. Look at, for example, a suburban neighborhood with homes and gardens all strictly separated from one another by fences, roads, or ditches. They form something similar to a patchwork. Urban green spaces are also often subdued to intense human management, generating sites with lower ecological value. The combination of most green spaces being patched and highly managed results in these areas having a lower ecological value, because of a decreased biodiversity. A possible solution to decreasing the amount of patching taking place, is create an urban ecological structure, which connects the, otherwise isolated, parts with each other (Fernández-Juricic, 2000; Hess & King, 2002; Jim, 2004).

Local biodiversity is highly effected, in either of the following ways. Plant patches' diversity is dependent on both the size of a habitat and the distance to other habitats. However, since both variables are significantly decreased in urban areas, local biodiversity is negatively impacted, with less species found in urban areas than in wildland counterparts (Nimela & MacDonnell, 2011).

However, sometimes species numbers might be eminent, even in urban areas. But even though the amount of species present is high, the functional diversity is still ablated, as depicted in **figure 1**, because of the highly-weakened ecosystem links. The weak ecosystem links increase the isolation of populations, resulting in species that are too closely related to be able to maintain species diversity and richness (Jongman, 1995; Nimela & MacDonnell, 2011).

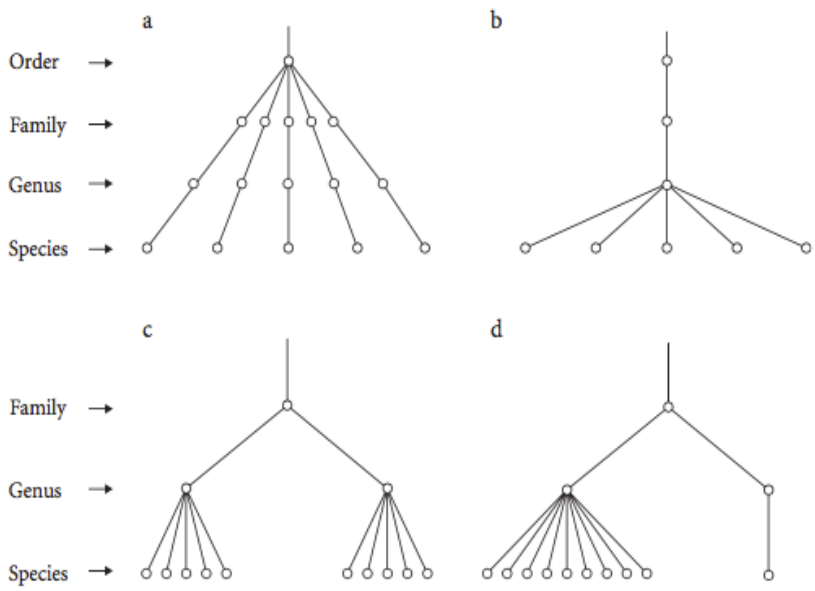


FIGURE 1: THE TAXONOMIC DISTINCTNESS OF A SPECIE IS BASED ON THE AVERAGE DISTANCE BETWEEN THE DIFFERENT SPECIES, ACCORDING TO THESE DIAGRAMS. YOU CAN ORDER THE ABOVE DIAGRAMS IN ORDER OF PREFERABILITY, WITH A BEING THE MOST PREFERABLE SITUATION AND D THE LEAST, BECAUSE THE SPECIES IN D, EVEN THOUGH THERE ARE 10, ARE TOO CLOSELY RELATED TO EACH OTHER. IF THE SPECIES ARE LESS CLOSELY RELATED, CHANCES OF THE DIFFERENT SPECIES FULFILLING DIFFERENT FUNCTIONS INCREASES. THIS RESONATES THROUGH THE FOOD WEB, CREATING A MORE DIVERSE OVERALL SITUATION. SITUATION A MIGHT JUST HAVE 5 DIFFERENT SPECIES, BUT IT HAS A HIGHER FUNCTIONAL DIVERSITY, SINCE THE SPECIES ARE LESS CLOSELY RELATED TO EACH OTHER (NIMELA & MACDONNELL, 2011).

3.4 Design over Function

Many of these imposed challenges and issues are linked to the fact that most urban planning, even, if not especially, when it concerns urban green space, prefers design over function. In the designs, developers are conscious about the aesthetic value the design must include to satisfy human perception of 'nature', which relies more on the visual, rather than on the functional values. An example are the drawings of to-be-developed urban areas, as shown in **image 1**, where the architect often displays multiple trees, and plenty of green, to make the design look more appealing (Nimela & MacDonnell, 2011).

IMAGE 1: SEVERAL IMAGES THAT PROVIDE AN IMPRESSION OF A TO-BE-DEVELOPED-AREA. THESE IMPRESSIONS OFTEN DISPLAY A LOT OF AESTHETICALLY APPEALING GREEN (AHH, 2016; BALTHAZAR, 2018; DAGBLAD 070, 2018; STAATSBERGEN, 2016).

However, urban areas do have some great potential for being more ecologically considerate and may provide, when properly considered in the initial planning phase, high levels of biodiversity and functions due to the fulfillment of possible ecosystem services. It is, then, vital to understand and incorporate the ecological and social interactions that influences and determines these patterns of biodiversity found in urban settings and the different ecosystem services that those areas can provide. This way the urban areas become more beneficial for both nature and people (Nimela & MacDonnell, 2011).

3.5 Conclusion

As we've seen in chapter 2, nature can be highly beneficial for people's mental and physical well-being in various ways. Especially in urban areas, where nature often loses ground, there are multiple reasons why more focus could and should be placed on adding, rather than deleting, more green zones. Not only will increasing the ecological value of urban areas add to the wellbeing of the citizens residing there (and more than half of the earth's population resides in urban areas nowadays), it will also help cities with certain urban challenges, such as the urban heat island effect. What we have now seen is the importance of green in cities, and why we should not only take the design and human preferences into consideration, but also the potential functions an area could provide.

4. FRAMEWORK FOR THE DESIGN

"Today, we find ourselves reevaluating conventional ideas about nature, shifting away from a model that opposes nature and culture toward one that conceives of humans as part of an integrated ecological whole."

Refaat, 2014

4.1 INTRODUCTION

Now that we took a closer look at certain mechanisms that underlie urban ecology and the different effects nature has on the well-being of people, we need to consider how these mechanisms and theories can be incorporated into an actual design. We will examine how green spaces can be thusly engineered so they fulfill ecological benefits and how we might optimize those green spaces to develop the most beneficial health effects.

4.2 ECOLOGICAL DESIGN

Ecological design entails "any form of design that minimizes environmentally destructive impacts by integrating itself with living processes" (van der Ryn & Cowan, 1996). In order to develop a design that respects ecological values, such as biodiversity and nutrient and water cycles, it is important to develop a (partly) ecological design that intrinsically bears these concepts and their implementation in mind. This is vital for designs that have the intention to demonstrate ecological values and to effectively adapt and integrate the design with ecological structures and processes and all the preconditions involved in an ecosystem's health (van der Ryn & Cowan, 1996).

4.2.1 GREEN INFRASTRUCTURE PLANNING

One strategy used to incorporate 'green' into urban planning is green infrastructure planning, a strategy often proposed by ecologists and conservationists and currently influential in the planning process of cities in many countries all over the world. It is a convenient approach to develop ecologically beneficial green networks within compact cities that often allow for little space (Benedict & McMahon, 2000; Pauleit & Duhme, 2000).

Connectivity of otherwise separate patches of green zones is very valuable for increasing the ecological value of an area. When areas are properly connected, species can migrate more easily between different habitats. It, thus, maintains the natural migration of a lot of species, but also allows for migration to new habitats when their current habitat becomes less livable. Connectivity, therefore, results in a well-maintained biodiversity (D'Eon, Glenn, Parfitt, & Fortin, 2002; Kindlmann & Burel, 2008; Taylor, Fahrig, Henein, & Merriam, 1993).

Green infrastructure planning tries to decrease the negative effects of urbanization on biodiversity. A green infrastructure might be best described as "an interconnected network of green and blue space that conserves natural ecosystem values and functions and provides associated benefits to the human population" (Benedict & McMahon, 2000). This approach is based on the main idea that natural areas cannot fully function when they are isolated parts, rather than a connected whole. Connecting different green spaces with each other positively influences the extent to which organisms migrate between the different spaces. A connection can be made between different green spaces via, for instance, hedges, verges, parkways, riparian trails, waterways, and canals. Connectivity between green spaces is, thus, key for this infrastructure to work and be able to optimize biodiversity (Benedict & McMahon, 2000).

4.3 DESIGN FOR HUMAN PREFERENCES

As mentioned before, most green spaces are designed in accordance with people's preferences and aesthetic values. It is, therefore, vital for the planning of new green spaces or redesigning existing areas that these values are considered. According to Gobster and Westphal (2004), success is more probable if cleanliness, naturalness, aesthetics, and safety of the new design is considered and guaranteed. If newly designed areas do not appeal to the community in which it is built, it will most probably not become a successful green space. For example, a park can be densely vegetated as to promote species richness, but such a park might develop possible safety risks or concerns for its users, who can feel unsafe using the park because of its density which created dark corners and low visibility. Such concerns can be minimized, though, by careful planning (Gobster & Westphal, 2004; Jorgensen, Hitchmough, & Calvert, 2002).

Even though these considerations have often led to designs that do not protect, for instance, biodiversity, this is not a necessary consequence as we have seen when examining how green infrastructure planning works. If a design is based on ecological considerations and the mentioned human preferences, it is likely that the developed green space will be an ecological success as well as a success within the urban area and among its users (Benedict & McMahon, 2000; Gobster & Westphal, 2004).

A green space network is of grave importance for increasing the ecological values of green spaces, but in urban areas, with little space to spare, it is equally important for the design that it has considered the previously mentioned aspects, as well as the area's accessibility, availability, and usage. There are concerns of loss of aesthetic appeal when applying ecological landscaping in a design. However, research supports the opposite effect, implying that applying ecological landscaping in a design could promote the aesthetical appeal of it. As landscape architecture professor Kenneth Lane put it: "an ecological approach in landscape architectural design need not negate visual design principles" (Lane, 1991).

4.3.1 ACCESSIBILITY

Accessibility entails how far or near certain green spaces are for the intended community. This can be for instance the residents living close-by a green space, but one might also consider those spending most of their time near a certain green space due to, for instance, people's jobs. When assessing the accessibility, it is most useful to use entrances to the green space as access point, and examine the true walking distance, rather than a linear distance (WHO, 2016).

There seems to be a consensus that a green space should be at most 300 meters (true walking distance) away from its users, because this equals a five-to-ten-minute walk, which motivates possible users to actually use the green space. This standard is also set as the European Common Indicator of local and public open areas, as well as the Natural England standard (Giles-Corti et al., 2005; WHO, 2016).

4.3.2 AVAILABILITY

The availability of green space in a specific area or neighborhood entails how much green space is present in the neighborhood, so a neighborhood's 'greenness', without looking at whether this is public or private green space (e.g. gardens), or the distance to green space for residents or workers in the area. It is valuable to assess the availability of greenspace, because an increased availability of green space in a neighborhood is beneficial for the well-being of the residents of that area (Giles-Corti et al., 2005; WHO, 2016).

There is not yet a consensus on what the optimum amount of available green space in an area is. However, an increased availability will provide more residents with a certain amount of green in their direct environment. Having visible green from, for instance, windows already provides beneficial

results, such as lowered aggression levels and mental fatigue. If residents are offered less possibilities to take in green surroundings, it negatively affects their ability to cope with major life issues. On the other hand, too much green, or green that is not properly managed and overgrown, has proved to negatively impact the lives of the residents as well, due to an increased anxiety, because of the fear for more crime (Kuo, Bacaicoa, & Sullivan, 1998; Kuo & Sullivan, 2001).

4.3.3 Usage

For studying the usage of a specific green space, one might examine how the users actually use the green space, or how future users intend to use it, to possibly evaluate this against the intention of the (facilities of the) green space. The usage of a green space is linked to its characteristics, which shall be discussed later (WHO, 2016).

4.4 Green space characteristics

When assessing a green space, there are several characteristics that can be considered, namely type (e.g. woodland or grass or the presence or absence of water)(Wheeler et al., 2015), size and quality (environmental qualities such as, for instance, biodiversity, but also absence of litter, naturalness and safety) of the green space (Annerstedt et al., 2012; Giles-Corti et al., 2005; Nordh, Hartig, Hagerhall, & Fry, 2009), and the green space's function (e.g. having a children's play area) (Lachowycz, Jones, Page, Wheeler, & Cooper, 2012). Different examples of the mentioned characteristics benefit different health effects. Most studies, however, agree on there being positive relations between the quality of the green space and self-reported health, whether this is mental or physical health (Annerstedt et al., 2012; Wheeler et al., 2015; White et al., 2010).

It seems a prerequisite that greenspaces fulfill certain characteristics in order for them to positively affect people's well-being. The presence of blue space (e.g. rivers, streams or ponds) is, for instance, beneficial for people's mental well-being. There are some conditions for the design of blue space to optimize its ecological value as well, such as ponds or constructed waterways should have a gentle slope and contain both shallow and deeper areas (Völker & Kistemann, 2011; White et al., 2010).

If the green space has recreational purposes as well, whether it is in the form of a sports area or mere paths people can use, it will encourage people living or working close-by to use the green space for exercise, which helps combatting obesity and other physical health issues (Giles-Corti et al., 2005; Lachowycz et al., 2012).

Regarding the optimal minimum size of the green space, consensus has not yet been reached. One study suggested that a green space needs to be at least 2 ha for it to be able to support physical activity. Yet, the European Urban Atlas states that, in order for it to even be an urban green space, the area should cover at least 0.5 ha. As we have seen in the previous chapter, the mere presence of green space can already positively influence people's well-being. This might mean that the size does not have to matter for the green space to positively influence people's well-being, but the level to which it affects the well-being increases with its size (Coombes, Jones, & Hillsdon, 2010; WHO, 2016).

4.5 Ecological engineering

Despite a current shift from 'planning for development' to 'planning for sustainable development', ecological consequences are still often ignored in the planning process. Considerations with regard to ecosystems or biodiversity are often an afterthought, which makes it hard to adjust the plan to any new insights. This leads to more and more fragmentation of different natural areas within an urban environment, developing the earlier mentioned patches. Hence, resulting in areas with lower ecological values. This also often results in the loss of certain ecosystem services that, otherwise, could have been provided, such as improving air and water quality (van der Ryn & Cowan, 1996).

Ian McHarg provides us with a model of retrogression and evolution, which is shown in figure 1, that can be applied to study, for instance, neighborhood plans and landscape designs to see how well they incorporated ecological goals. Retrogression breaks the design down into simple and often independent elements, which leads to loss of diversity which allows for a system to develop what McHarg calls 'ill health'. If such plans are, on the other hand, developed in accordance with evolution, and thus become more complex plans, they allow for the development of, among other things, diversity and the plan will entail a healthier design (McHarg, 1967).

retrogression		*evolution*	
ill-health	simplicity	health	complexity
	uniformity		diversity
	independence		interdependence (symbiosis)
	instability		stability (steady state)
	low number of species		high number of species
	high entropy		low entropy

FIGURE 2: A LIST OF ECOLOGICAL FEATURES BELONGING TO EITHER REGRESSION, AND THUS ILL HEALTH SYSTEMS, OR EVOLUTION, WHICH RESULTS IN HEALTHY SYSTEMS (MCHARG, 1967).

It is crucial for urban ecological progress that ecological engineering is added to the planning process. When ecological relevant issues are considered earlier in the process, integrating green infrastructures in this process becomes much easier and can be developed more effectively (McHarg, 1967).

4.6 FRAMEWORK FOR ECOLOGY AND DESIGN

A framework that incorporates ecological values and potential in the designing process has been proposed by Carl Steinitz. He offers six questions that can be answered multiple times throughout the development of the design or the examination of current areas, to assess, process, construct, and evaluate it in accordance with ecological landscape planning.

i. How should the state of the landscape be described?
ii. How does the landscape operate (the landscape's functions)?
iii. Is the current landscape functioning well?
iv. How might the landscape be altered
v. What predictable differences might the changes cause?
vi. Should the landscape be changed?

These questions can guide the planners involved through the process while bearing the ecological part of the design in mind. It must be noted, though, that this framework requires the participation of ecologists in the planning process from the start, in order to help with answering the questions (Steinitz, 2002).

4.7 CONCLUSION

Developing urban plans involves designing spaces while bearing engineering aspects, aesthetic preferences, and architecture in mind. But a very important factor has too often been left out of the equation, and that is the environmental and ecological value areas have or might develop (Lynch & Hack, 1984).

If we want to develop an ecological design, incorporating a green infrastructure that creates networks of green spaces is a functional and beneficial way to reach that goal. This network and the areas itself can be optimized by creating not only green space, but also blue space.

If the developed area wants to be of success within the community, it also needs to integrate the more classical aspects of site planning, namely the communities' preferences. A recreational purpose is therefore preferred, and the area needs to be clean, aesthetically appealing and a safe environment for its users. If the area is developed within a maximum of 300 meters true walking distance from the potential users' base (e.g. home or job location), it will maximize the health benefits generated by green spaces since people are most likely to use it.

Now we have collected some features that can be used to develop and assess a design. These features will be used to develop a list of requirements that the newly designed park should fulfill (see chapter 8, **table 2**). Some of these features support an ecological line of thought during the process, others are necessary to develop an ecological design and a couple can be featured if the design allows for it. In any way, it is important that the consideration of the ecological part of the design does not become an afterthought but gets incorporated throughout the process of designing. We now also hold the tools to evaluate designs during the process of creating it and after the actual development of the plans. This will help the incorporation of ecological engineering throughout the process, to make sure it will not become an afterthought.

5. EXAMPLES OF DEVELOPED (URBAN) ECOLOGICAL GREEN SPACE

5.1 INTRODUCTION

It can be considered valuable to take a closer look at other projects that have already tried to integrate (urban) ecological greenspace and see how they did so. This might be helpful in order to not re-invent the wheel, and it can also be educational, since similar projects might provide useful information on, for instance, vegetational use or management, which can in turn be used for this project as well. We will discuss several projects, some of them implemented in the city of Groningen, others somewhere else in the Netherlands or Belgium.

The examples have been chosen in the following way. They should cover a broad area of ecological work done in areas that are relatable to the Zernike campus. A closer look will, for example, be taken into how a different university incorporates ecological design, but also how a neighborhood close to the campus has been set up in order to increase ecological value. The examples have been ranked by size, hence, we will start with the biggest scale project and work our way down to the smallest scale projects at the end. Eventually, this should provide a helpful overview of examples that could be used to assess and improve different parts of the current project.

The main consensus that can be drawn from these examples is that ecological design should not be an afterthought, but rather be implemented at the beginning of the design-process. This helps to come up with more sustainable plans, that have factors such as increasing biodiversity as a goal, rather than as a coincidental outcome. These projects show that there can be a delicate and desirable balance between profit for humans and profit for nature, as well as economical gain and ecological gain. Most projects also show that an interplay between aesthetically appealing designs and ecologically beneficial design is easily achieved.

Especially the bigger projects, such as the university of Gent's transformation to a sustainable university can provide helpful information on how the Zernike campus might tackle this as well. The example provides a foundation that easily transitions to the values of the campus' developers. But smaller projects offer more direct solutions that have the potential to be implemented in future plans of the Zernike campus.

We will discuss the following projects (in order in which they appear):

I. Sustainable development of the university of Gent
II. Tiny forest Zaandam
III. Local improvement of verges (two case studies)
IV. Drielanden: An ecological neighborhood
V. DUO rooftop garden
VI. Hedgehog tunnels and bridges Utrecht

5.2 SUSTAINABLE DEVELOPMENT OF THE UNIVERSITY OF GENT

The university of Gent proposed a transition plan that discusses the way in which the university should transform in order to not only guard its current sustainability policy, but also to stimulate further progress with regard to its sustainability vision (Universiteit Gent, 2014).

The transition plan is divided into several overarching core concepts, such as energy, mobility, water management, and ecological green management. This resulted in twelve fundamental points (see **appendix 14.2**) that lay at the start of any development of the university. Also, for each of the overarching core concepts, a plan was set up to discuss how progress will be made, starting in 2012, leading up all the way to 2030, as well as a policy for future green management (see **appendix 14.2**).

For this project, we are interested in ecological design, hence, we will, from now on, only focus on the ecological green management value of the University of Gent, rather than on the complete transition plan (Universiteit Gent, 2014).

IMAGE 2: THE UNIVERSITY OF GENT (UGENT, 2017).

When discussing the core concept of ecological green management, emphasis was placed on how ecological thinking can benefit sustainable development. Plans need not merely be concerned with the preservation and development of more natural areas, but also implement 'green-management', to deal with natural areas in a more sustainable and ecological way. Sustainability, in the transition plan for the university of Gent, is the complete package, in which all different aspects that are involved with sustainable development are considered. By not just thinking economically, but also ecologically, plans become more future-proof (Universiteit Gent, 2014).

To concretize the necessary next steps for the ecological green management part, fourteen principles were derived that the university now uses to guide new plans and developments. The final goal of the university is to have all areas of its campuses managed ecologically and sustainable by 2025 (Universiteit Gent, 2014).

5.3 TINY FOREST ZAANDAM

The first European 'Tiny Forest' was developed in Zaandam, in the Netherlands, by the Institute for Education on Nature and Sustainability (IVN). By now, however, multiple tiny forests have manifested throughout the Netherlands, as depicted in **figure 3**. A tiny forest is about 200 square meters (which is about the size of a tennis field) of dense forest, located in an urban area. Up to 40 native tree species have been used to create this forest (Ottburg et al., 2018). The official tiny forests (that have a trademark) all display three characteristics:

1. For the construction of the forest, nearby school and residents are involved;
2. In or next to the forest is a classroom, that can be used for educational purposes regarding the forest;
3. Pupils take care of the forest. Schools take turns in taking care of the forest for one month.

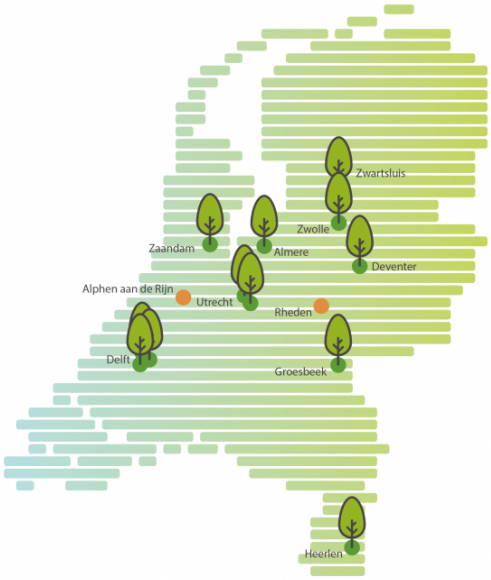


FIGURE 3: LOCATIONS OF TINY FORESTS THROUGHOUT THE NETHERLANDS (IVN NATUUREDUCATIE, 2018B).

IMAGE 3: IMPRESSION OF THE TO-BE-BUILD TINY FOREST IN DELFT (SCHOEMAKER PLANTAGE, 2018).

Once such a forest is planted, it has several positive influences on the area. Firstly, it improves the biodiversity, by attracting more animals such as birds, bees, butterflies, and more (IVN Natuureducatie, 2018b; Ottburg et al., 2018). A tiny forest also helps to improve the climate resiliency of the area, for several reasons. It helps the storage and run-off of water, filters dust

particles in the air, and is able to cool the area, which is especially helpful in urban areas that face the urban heat island effect (IVN Natuureducatie, 2018b).

All this not only positively affects the health of people living in the area of the tiny forest. It also positively affects people's connectivity with their neighborhood, and neighbors, due to its inclusive and inviting set-up, from the start on. Because residents and pupils are involved in the forest's management, people get more connected with nature and each other (De Groene Stad, 2018; Ottburg et al., 2018).

The organization behind the tiny forests plans to develop another 12 forests throughout the Netherlands, including one in Groningen, in the upcoming year (see **figure 4**). This is another step in their goal to have 100 tiny forests in the Netherlands by 2021 (IVN Natuureducatie, 2018a).

FIGURE 4: LOCATIONS OF THE TWELVE NEW TINY FORESTS THROUGHOUT THE NETHERLANDS, TO BE DEVELOPED IN THE UPCOMING YEAR (IVN NATUUREDUCATIE, 2018A).

5.4 LOCAL IMPROVEMENT OF VERGES

We will now discuss two projects that are involved in improving verges; the implementation of ecological verge management in the Noordoostpolder, and the development of flowery verges in the Leiden and Wouden region. Verges have the potential to be suitable places for plants and animals to find both food and shelter. Optimizing these areas can, thus, have great effects on the ecological value of that area (De Stentor, 2006).

5.4.1 ECOLOGICAL VERGE MANAGAMENT - NOORDOOSTPOLDER

The municipality of the Noordoostpolder implemented ecological verge management to allow for certain flower-species to come back to the area and grow in those verges again. The municipality's botanical management helped the dune valley vegetation recover. They managed to retrieve several rare species that used to grow in that area, such as *Carex serotina* and *Euphrasia stricta*, by decreasing the nutritional value of the soil, to its poorer, but original state. This was necessary, because the soil was too rich in nutrients, allowing thistles and nettles to take control, and leaving no room for the original natural vegetation. One of the ways in which management keeps the nutritional value at bay, and thus optimal for the desired natural species, is by removing clippings after mowing (De Groene Stad, 2012; De Stentor, 2006).

IMAGE 4: AN ORCHID (*DACTHYLORHIZA)*

This development also improved the safety of the roads they embrace. First of all, the water run-off increased, allowing the water to disappear from the road much quicker. Also, the soil of the verges is much firmer. If a car were to slip and slide into the verges, they won't continue slipping once they reached the verges, decreasing the chances of heavy crashes (De Groene Stad, 2012).
There is also another positive side effect that resulted from this improved management. Now that the verges have become more flowery, they have also become more colorful, which is aesthetically appealing to people using the area (De Stentor, 2006).

All in all, this successful ecological management allowed for other positive results, such as increased safety and beauty. But the main result remains the significant increase in ecological value of the verges.

5.4.2 Flowery verges – Leiden and Wouden region

For this project, eight municipalities from the regions Leiden and Wouden collaborated to develop a network of flowery verges throughout that region by either ecological management (as in the previous example) or by planting a suitable mix of seeds. Their main goal was to create a network of around 40 kilometers, that would connect verges alongside recreational routes with each other (De Groene Stad, 2014).

This newly created network would be ecologically managed, and a different mowing and sowing policy was developed. This resulted in verges that were cut less neatly than they used to be, to create a 'wilder' and more natural environment. If an area needed mowing, sheep would be allowed to graze the area, rather than using mowing machines. Also, several different flowers and plants were planted to increase the biodiversity of the verges (De Groene Stad, 2014; Gemeente Leiderdorp, 2018).

The municipalities deliberately chose to develop verges alongside recreational routes, since more flowery verges add to the beauty of the area through which those recreational routes run and can thus be used for decoration purposes as well (De Groene Stad, 2014).

This project also allows for citizen participation. Volunteers monitor the verges, and record whether, for instance, new species are attracted to these areas. Residents are also given the opportunity to adopt a verge, which increases the resident's awareness of this project and natural value, as well as gives them a chance to be involved in local projects, which adds to a sense of community and inclusiveness (Gemeente Leiderdorp, 2018).

IMAGE 5: FLOWERY VERGES ALONGSIDE A RECREATIONAL ROUTE (GEMEENTE LEIDERDORP, 2018)

5.5 Drielanden: an ecological neighborhood

Drielanden is a neighborhood built during the 1990's, consisting out of three streets, in the northeast of the city of Groningen. The initiative was the result of a collaboration between the municipality of Groningen and the 'Vereniging Ecologisch Wonen' (Association for Ecological living), and, thus, it was deliberately designed as an ecological neighborhood. The association required that the environmental impact would be considered throughout the process. The neighborhood had to include plenty of greenness and needed to become as sustainable as possible with regard to energy, raw materials, and water. Within Groningen, Drielanden is now one of the neighborhoods with the highest ecological value and biodiversity (Buurma, 2015).

Drielanden was built using sustainable material, and the location and placement of the homes was carefully chosen to receive the most amount of sunlight (and thus warmth), in order to decrease energy usage. The neighborhood also uses constructed wetland to purify its waste water, and these wetlands also add to the ecological value of the area, because it can be used (by natural communities to live here). In one of the streets, Waterland, many native species have been chosen to be planted here once more, such as chestnuts and walnuts (Buurma, 2015).

IMAGE 6: LEFT TWO PICTURES: IMAGES OF THE DRIELANDEN NEIGHBORHOOD AND ITS SURROUNDINGS. RIGHT PICTURE: AERIAL IMAGE OF THE NEIGHBORHOOD 'DRIELANDEN' (DRIELANDEN GRONINGEN, 2017).

5.6 DUO ROOFTOP GARDEN

Groningen holds several rooftop gardens, and, for this example, we will elaborate on the DUO-rooftop garden. A rooftop garden is a garden on a rooftop. This could be the rooftop of a building, but also of the building's adjacent (underground) parking garage. These gardens often hold a decorative function, but also hold other functions, such as food production (often called rooftop farming), hydrological benefits, temperature control, and can hold several ecological benefits.

The DUO-rooftop garden is an example of a design in which aesthetical and ecological values have been valued equally. The garden is about 11.000 square meters and built on the underground parking garage, that belongs to the companies residing in the building (DUO, and the local office of the Dutch tax company).

The garden holds around 50.000 plants of 200 different species, and 40.000 flower bulbs have been planted, creating a high natural value. Even though around 80-90% of the flower-species are cultural ones, they attract many native insects. Some tree species that can be found are Betula pendula, Castanea sativa, Prunus avium, Quercus cerris, Quercus petraea and Ulmus 'dodoens'. The borders of the garden were intentionally given a more natural character, to connect the garden with the adjacent forest (the 'Sterrebos') (Ebben, 2018).

IMAGE 7: PICTURE OF THE DUO-ROOFTOP GARDEN (EBBEN, 2018).

In the design, they wanted to create an optimal environment for trees and vegetation to grow. This is why the soil partly consists of lava. The designers also chose to use a variety of multi-trunk trees (such as Amelanchier lamarckii, Carpinus betulus, Crataegus x persimilis 'Splendens' and Malus 'ev ereste'), that provide the garden with year-round aesthetical value, by blossoming during spring and summer, providing autumnal colors during autumn, and displaying a natural and aesthetically appealing silhouette during winter (Ebben, 2018; Reef-infra, 2018).

Parts of the garden are managed by regular plant-management, but there are also areas within the garden that are management by nature-management. This interplay in management allows for an

aesthetically appealing garden for the visitors, as well as a natural garden with an ecological focus (Ebben, 2018).

5.7 HEDGEHOG TUNNELS AND BRIDGES

Many municipalities throughout the Netherlands try to implement hedgehog tunnels and bridges (see **image 8**), in order to create green connections that can be used by small animals, such as the hedgehog, toads, frogs, and mice to increase their habitat. It should allow the animals safe passing from one side of the water or road to the other. The tunnels and bridges for small animals are easily implemented in urban areas, when this is considered at the early stages of the development of those areas. Implementing them after the urban area has already been developed is still very doable but can also become very costly. One of those municipalities that has implemented these solutions is the municipality of Utrecht. (Den Haag, 2017; Groningen Nieuws, 2018; Municipality of Utrecht, 2004).

This project is part of a bigger 'green web project', that combines initiatives that all try to optimize public green spaces to increase their ecological value. This is done to stimulate more nature in urban areas, which increases the livability of those areas (Municipality of Utrecht, 2004).

IMAGE 8: THREE EXAMPLES OF HEDGEHOG TUNNELS AND BRIDGES (DEN HAAG, 2017).

6. THE ZERNIKE CAMPUS

6.1 INTRODUCTION

The Zernike campus is the outer town location for the University of Groningen and the Hanze University of Applied Sciences, and holds several companies as well (Arends et al., 2018). It was developed during the 1960's, and is now home to 35.000 students, 150 entrepreneurs, and provides 4000 jobs. It's a science park where science, education, and innovative entrepreneurs are connected (Zuidema, Trell, Bodewes, & Panmanm, 2017).

The campus is located at the north west side of the city of Groningen and holds great economical value for the city. Hence, it is important to continue development and improvement of the campus (Gommers, 2015). This has been the reason to connect the stakeholders of the campus with the architect company West 8. West 8 developed a master plan that embraces the urban development vision held for the campus (West 8, 2014).

FIGURE 5: PROPERTY MAP OF THE ZERNIKE CAMPUS
= MUNICIPALITY OF GRONINGEN (LOCATION OF THE COMPANIES)
= UNIVERSITY OF GRONINGEN
= HANZE UNIVERSITY OF APPLIED SCIENCES
(WEST 8, 2014)

The campus is currently very divided and allows for little connectivity between the different institutions and companies that are located on the campus. As you can see in **figure 5**, there is a division between the knowledge institutions mainly on the south part of the grounds, and the companies on the north part. Even within the institutions, there is a lot of patching. Faculties from the University of Groningen all have their own building, making matters such as communication and collaboration within a faculty easier, on the one hand, because everything is located in one place. On the other hand, however, this stalls collaboration between faculties (West 8, 2014).

6.2 A GREEN CAMPUS?

The campus also holds great ecological potential, as it is located between two nature reserves that are part of the city's ecological structure. On the north side of the campus, the city's ecological structure (green area in **figure 6**) is connected to an area that belongs to the national ecological main structure, as displayed in yellow in **figure 6.** As the campus is enclosed by the city's ecological structure, it has the potential to become, and to some extent already is, a vital part of the city's nature (Gommers, 2015).

FIGURE 6: THE ZERNIKE CAMPUS IS SURROUNDED BY THE CITY'S ECOLOGICAL STRUCTURE (GREEN), AND ON THE NORTH SIDE, IT'S CONNECTED TO THE NATIONAL ECOLOGICAL MAIN STRUCTURE (LIGHT YELLOW WITH STRIPES) (GOMMERS, 2015).

The campus already has a network of green and blue spaces, allowing for half of the campus being covered by natural biotopes (the other half being covered by buildings and pavements). These green and blue spaces provide some of the earlier mentioned functions, such as decreasing water run-off, subduing heat during the summer, and fixating dust from the atmosphere. These networks also offer residence to different animal species (Gemeente Groningen, 2014; Gommers, 2015).

FIGURE 7: ON THE LEFT: NEW AND EXISTING WATER STRUCTURES ON THE CAMPUS. ON THE RIGHT: NEW AND EXISTING TREES ON THE CAMPUS (GEMEENTE GRONINGEN, 2014).

6.2.1 BIODIVERSITY ON CAMPUS

A previous report that looked into the current ecological value of the campus found that it has a high ecological potential, however, this potential is not yet exploited as much as desired. By examining the list of desired species (set up by the municipality of Groningen) and observing which of those species have been spotted on the campus, it was concluded that the area scores well on certain species, such as amphibians, butterflies, dragonflies, and birds (a complete list of encountered species can be found in the paper by Gommers (2015)). However, it was also found that the score for others, such as bats, mammals, and vegetation, was much lower. This could be increased significantly by careful planning of the campus' construction and proper ecological maintenance (Gommers, 2015).

6.3 CURRENT POLICIES RELATED TO ECOLOGICAL DEVELOPMENT

There is a desire from multiple involved stakeholders of the Zernike campus to develop a more sustainable campus. It, therefore, seems reasonable to assume that a healthier ecological environment should be a shared value. However, this is something that is still in its infancy for some of the stakeholders involved.

The municipality of Groningen strives for nature preservation, development, and maintenance, and tries to implement this by placing the city's ecological structure (see **figure 6**) at the core. The municipality aims to strengthen certain green zones throughout the city, in order to increase the ecological connectivity.

The University of Groningen has the ambition of developing a more sustainable university. However, viewing the ecological aspects of this ambition is not yet as fully considered as it is by, for instance, the municipality of Groningen. Several projects and organisations within the university have rather recently been set-up (such as the Zernike Ecology Project and the Green Office), in order to stimulate this. This ought to increase awareness on the importance of nature and ecological value and aim to implement solutions to increase those values.

6.4 THE FUTURE OF THE CAMPUS

The urban development plan for the campus as developed by West 8 covers all visions for the campus as provided by the clients (Hanze university of applied sciences, university of Groningen, and the municipality of Groningen). This plan offers an outline regarding the direction in which the campus'

development will go the upcoming five to ten years. The main purpose of the new design is to improve the spatial quality and create a more connected campus. It can be noted that the design does not seem to have been developed from an ecological foundation, or even to have considered ecological aspects Despite the report of West 8 stating they aim to increase the green and blue infrastructure, other decisions of the design, such as the species chosen for vegetation, suggest that the amount of ecological aspects still allows for a lot of improvements. Currently, the plan seems to be an example of a design where human preferences and values have been the main line of thought, rather than placing similar value to the ecological side of the plan (Gemeente Groningen, 2014; Gommers, 2015).

One of the aspects the plan tries to incorporate, as just mentioned, is developing a more unified campus, rather than the current separation of the different institutions and companies. One of the design's aspects that was created to inspire this, is the transformation of the Zernikelaan, which should become one main lifeline that connects, both literally and figuratively. Other parts are improving the campus' infrastructure, redeveloping the parking areas (that now lead to a literal separation of north and south), making the campus overall more attractive, replacing buildings designated for new companies to mix them more with the knowledge institutions, and improving the entrances to the campus. All these alterations allow for improved ecology as well (Gemeente Groningen, 2014).

Figure 8 is the new urban development plan. In it, they've positioned the new Feringa building that will replace the Nijenborgh building, and the plans for the improved and redeveloped Zernikelaan have also already been incorporated. Many more additional changes to the campus are displayed in this design. However, the current report will only address those changes that might be valuable to this report's purpose of implementing more ecological green and increasing the ecological value of the campus, since this, according to Gommers (2015) is still an underdeveloped aspect of West8's new urban development plan.

IMAGE 9: AERIAL PICTURE OF THE CAMPUS IN 2014 (WEST 8, 2014)

FIGURE 8: THE URBAN DEVELOPMENT PLAN FOR THE ZERNIKE CAMPUS (WEST 8, 2014)

7. Interests of the Stakeholders

7.1 Introduction

Every day, thousands of students and employees make use of the campus. They are ultimately the users of whatever new buildings, infrastructure, or other changes that will be developed at the Zernike campus in the upcoming years. Hence, it is vital that those plans suit the interests and desires users have for their environment (Arends et al., 2018).

Too often designs are merely created by the architects and the client, without proper implementation of the desires the users might have. And yet, the users often value different aspects of a design than those designing it do, that view it from their expert-angle. To be able to offer an inclusive design, it seems necessary to look into the wishes of the users as well. This will help increase the livability of the newly designed area for them, which will in its turn increase their productivity as well. A study from 2015 on the opinion of students about the livability of the campus revealed that, on average, students score the campus a 6,46 (out of 10). This means that the campus received a 'passing' grade, but it also shows that there is still plenty of room for improvement (Bonnes, Uzzell, Carrus, & Kelay, 2007; J. de Groot, Kwak, & Oosterveld, 2015; Laurence, Fried, & Slowik, 2013).

7.1.1 The campus' users

We now discussed how students score the campus, but they are not the only stakeholder involved that has a high interest in the campus' developments. A previous research looked into the different stakeholders involved, and what their influence and interest with regard to developments on campus are (**figure 9**). Students, employees, and researchers are a group of stakeholders that have great interest in developments, because it directly affects their (daily) environment. However, their influence is very small, and many feel that their interests aren't considered enough throughout the planning and designing process (Arends et al., 2018; J. de Groot et al., 2015).

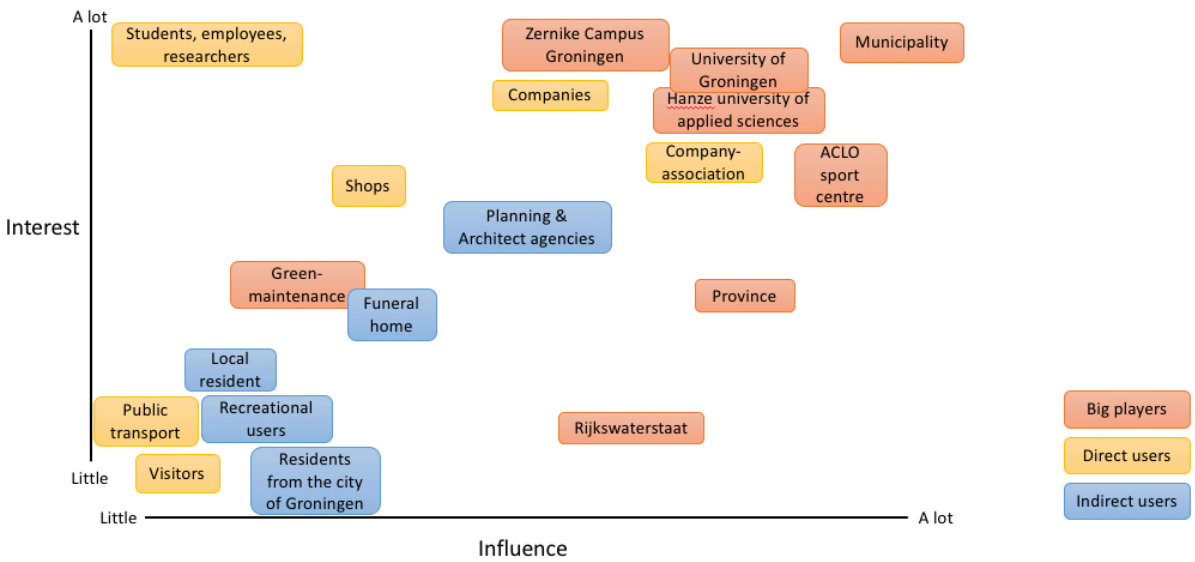


FIGURE 9: A STAKEHOLDER ANALYSIS PROVIDES US WITH INSIGHT INTO THE MAIN USERS (BOTH DIRECT AND INDIRECT) OF THE CAMPUS. THEY ARE PLACED ACCORDING TO THE AMOUNT OF INTEREST (Y-AXIS) AND INFLUENCE (X-AXIS) THEY HAVE. THE COLORS REPRESENT THE TYPE OF STAKEHOLDER THEY ARE: ORANGE = BIG PLAYERS, YELLOW = DIRECT USERS, BLUE = INDIRECT USERS (ARENDS ET AL., 2018, OWN TRANSLATION).

7.1.2 THE SURVEYS

Throughout the last several years, multiple surveys have been developed to unravel the desires and interests of the campus' various users. This report will, therefore, first briefly discuss two previous studies before covering the new study performed for this report. The latter was a collaboration with another current project trying to improve the campus' livability: The Active Ageing Campus.

The active ageing campus project is led by the Institute for Sport Sciences (which is part of the Hanze university of applied sciences) and aims to incorporate new aspects to the current plans to motivate movement and exercise and stimulate overall health of the campus' users. The end goal is to transform the Zernike campus into an active ageing campus (Institute for Sport Sciences, 2017).

The surveys will help us gain insight into the desires of the campus' users that have a high interest, but, so far, a low influence, as was shown in the stakeholder analysis (**figure 9**). The surveys tried to represent as many different people within the different (or their own specific) stakeholder groups. However, this is often difficult to realize. Especially for both universities, there are strict rules regarding the privacy of its students and employees, impeding the possibility to distribute surveys over large groups of students and employees at once. All surveys are therefore dependent on the network of the distributers and remote possibilities to distribute surveys throughout the different faculties.

7.2 PREVIOUS SURVEYS ON LIVABILITY AND DESIRES OF A FOCUS GROUP

Two of the previous studies performed, namely one by De Groot et al (2015) on livability and Arends et al (2018) on desires of a focus group, analyzed the interests of the users of the campus, and will now be summarized and discussed.

In the study of De Groot et al (2015) (bachelor students spatial sciences), it was examined how students (of both the Hanze university, as well as of the University of Groningen) scored their campus, and what specific areas or aspects would then need improvement. Their population were, therefore, Dutch students from both the Hanze and the RUG, that use the Zernike campus Groningen.

This survey found that it appears that students seem to not feel invited to use the Zernike's public space for meeting others or to relax. Why they don't is hard to say for sure, but the answers the students provided to the open questions provide some valuable insights. They missed the following facilities the most:

- Seating (32%)
- Eat and drink facilities (16%)
- Green (12%)

Improving seating possibilities is, thus, an important issue for the users of the campus to upgrade the campus' livability. According to the respondents, improving the seating is seen as an aspect that will also improve the learning environment of the campus, and is, therefore, important to consider.

Another desire that multiple students addressed, is that they would like to see a central place in the form of a park or square where they might relax or meet other people. It is notable that the campus developed multiple of these public spaces throughout the campus, however, they are, apparently, not designed in such a way that students acknowledge them as central places. Some students mention the Noorderplantsoen (a park area in the north of the city of Groningen) as an example of a central place and express their desire to see something similar at the Zernike complex. This would create a less 'grey and grizzled site', and help the campus come across as livelier.

'Green' became the 3rd biggest theme that students were missing at the campus. Students mainly seemed to want more green on campus, because they associate greenness with relaxation, or as a

calm place to study. They would like to see more trees and mention that green could provide a useful and aesthetically pleasing separation between paths and roads, and places to sit and either relax or study.

There seems to be an overlap between the reasons why students want more green and more seating, and the two opt for a combined solution.

A second study by Arends et al (2018) (university-wide bachelor students) focused on the ideas a focus group had on the campus as it is now, and what direction they felt development should head into.

The focus group consisted out of nine students and employees that either work or study at different faculties of both the RUG and the Hanze. Their input has the possibility to represent the south part of the campus that holds the buildings those faculties reside in. Despite the sample group being relatively small, the insights gained through this research might still be valuable to see how the results from the previous discussed survey stand a few years later.

The focus group discussed some aspects they felt was currently something positive about the campus, such as the open set-up of the campus, that there is lots of green, and that all necessary facilities were present. However, these positive notes were, then, related to places of improvement. So, even though there is an open set-up, there is little to no interaction between buildings (faculties) and facilities. Also, despite there being lots of green, there is little to no place to sit outside, relax, and enjoy this greenery.

Overall, the focus group wants to see more interaction between the different faculties. More interaction could be inspired by the development of meeting places. These places would then need to provide certain needs, such as enough seating, and more eating and drinking facilities, such as cafes, supermarkets, or restaurants. Another idea proposed to inspire interaction was the development of 'green islands', throughout the campus.

Also, the focus group felt that the central Zernikelaan currently literally divides (especially the south part of) the campus into two. The plan as it is presented in the urban development plan should provide an enhanced central promenade. By improving the set-up of this central road through the campus, interaction might also be encouraged. It offers the potential to become a lifeline that connects, rather than a wall that divides.

Both these studies offered the start to the survey performed for this report, because they already provided valuable insights into what aspects the campus is currently lacking, according to its users. Some of these aspects relate closely to the aim of this report and can be optimized by the development of a green zone.

7.3 A GREEN CAMPUS & THE ACTIVE AGEING SURVEY

Now, we will analyze the survey performed for this report, that has been executed in cooperation with Hanze Sport's team on the active ageing campus. In this survey we ought to examine the interests of the campus' users with regard to stimulating an active and healthy lifestyle, and how they feel about the implementation of more green, parks, and walking paths.

The survey looked at the interests of the campus' users, which in this case include the students and employees from both knowledge institutions, the employees from the companies located at the Zernike, and the residents that reside in neighborhoods adjacent to the campus. These stakeholders were chosen because of either their extensive use of the campus (which holds for the students and

employees, and companies), or their interest in becoming a more extensive user of the campus (which holds for the local residents).

7.3.1 METHODS

For the survey, the aim was to gain insights into two main questions, namely whether the users' preferences fit the requirements for ecological design as was found in the literature, and what other preferences should be taken into considerations. The questions then developed for the survey had to contribute to either of these two overarching aims. Respondents were, for instance, asked to select images that correspond the most to what they find attractive, and could choose between images of 'plain' fields, as well as ecologically richer fields. For an overview of the questions, see **appendix 14.1**.

The same issue that face de Groot et al.'s survey arose for the distribution of the questionnaires in this one. It is difficult to create a randomized yet big enough sample group because of the strict privacy rules from both universities. However, for the Active Ageing Campus project, a network was set up of different stakeholders, who all have been asked to fill in the questionnaire, and an attempt was made to find a-selective respondents as well. Eventually 179 respondents filled in at least part of the questionnaire.

After analyzing all the responses, a heat map has been generated that combined the data of 'most used green spaces', 'most attractive green spaces', and 'newly proposed green spaces'. The results of this are then displayed in the heat map to show what places are most suitable for green spaces according to the respondents.

7.3.2 RESULTS

The majority of the respondents were between 19-35 years old (**figure 10, left**) and the majority was male (**figure 10, right**). As shown in **figure 11,** most respondents are currently working (mainly at the University of Groningen) or studying at the campus. This figure also shows that the number of residents that filled in the survey compared to the other stakeholders is still relatively small, and the same holds for people employed by the Hanze university of applied sciences. It appears that a lot of people working at one of the companies located at the Zernike filled in the survey. However, it should be taken into consideration that the possible multiple-choice answers might have been somewhat misleading, leading some people who work for the Hanze or the Rug to select 'my workplace is located on the Zernike campus'.

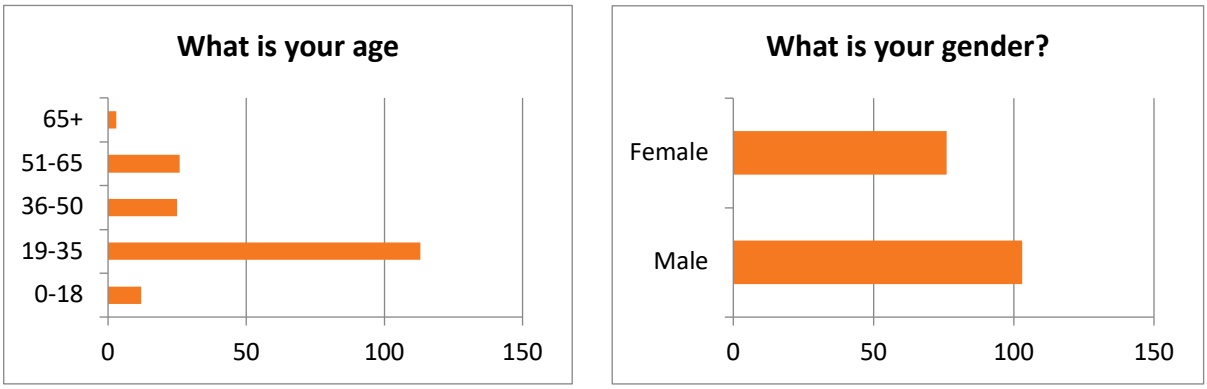


FIGURE 10: ON THE LEFT: AN OVERVIEW OF THE DIFFERENT AGE-GROUPS OF THE RESPONDENTS. ON THE RIGHT: AN OVERVIEW OF THE GENDER OF THE RESPONDENTS (N=179)

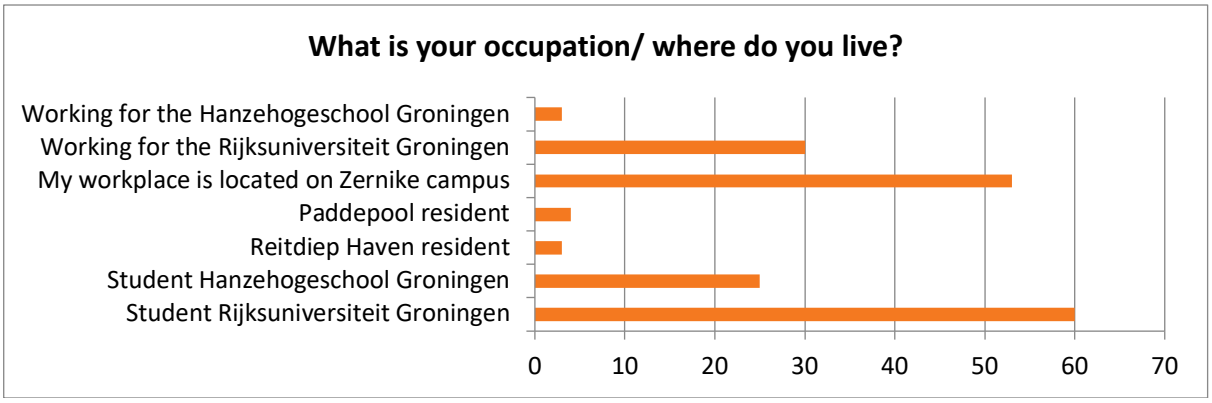


FIGURE 11: AN OVERVIEW OF THE OCCUPATION OF THE RESPONDENTS (N=178)

It appears that just over half of the respondents (51.6%, as shown in **figure 12**) prefer a flowery field over a field of plain grass. Also, as shown in **figure 13,** a majority of 77.7% opt for a field with 'rich' grass (that is filled with flowers, but in a less managed way than the flowery field from the previous figure). All in all, as shown in **figure 14**, respondents would like to see vegetation like plants and trees in a new park, rather than just grass.

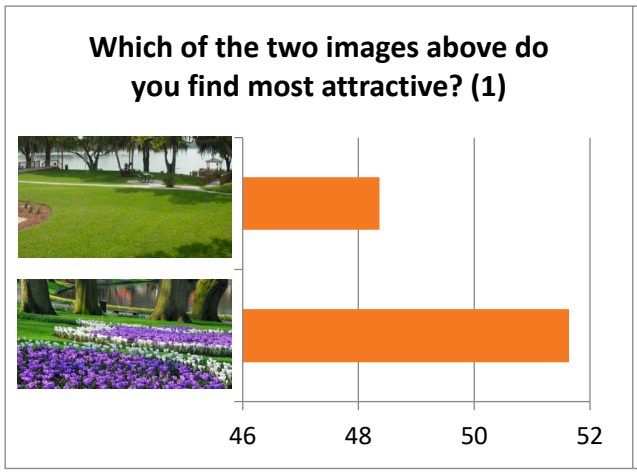


FIGURE 13: A PREFERENCE QUESTION, IN WHICH THE RESPONDENTS HAD TO INDICATE WHICH IMAGE OF THE TWO THEY PREFERRED (N = 122)

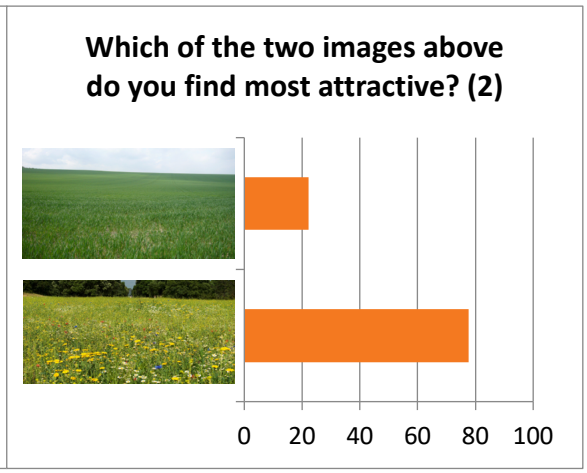


FIGURE 12: A PREFERENCE QUESTION, IN WHICH THE RESPONDENTS HAD TO INDICATE WHICH IMAGE OF THE TWO THEY PREFERRED (N=121).

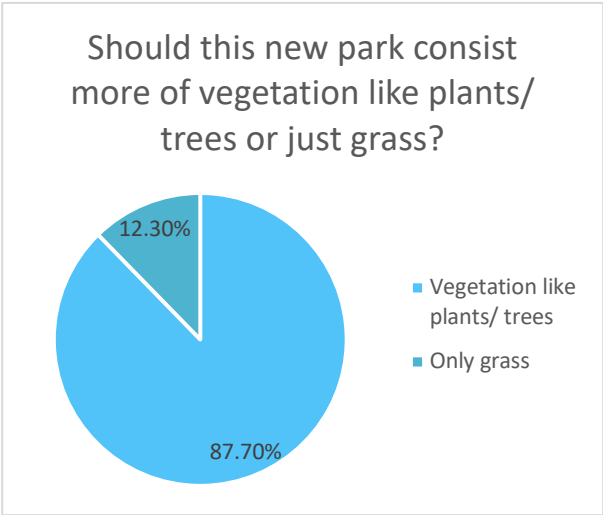
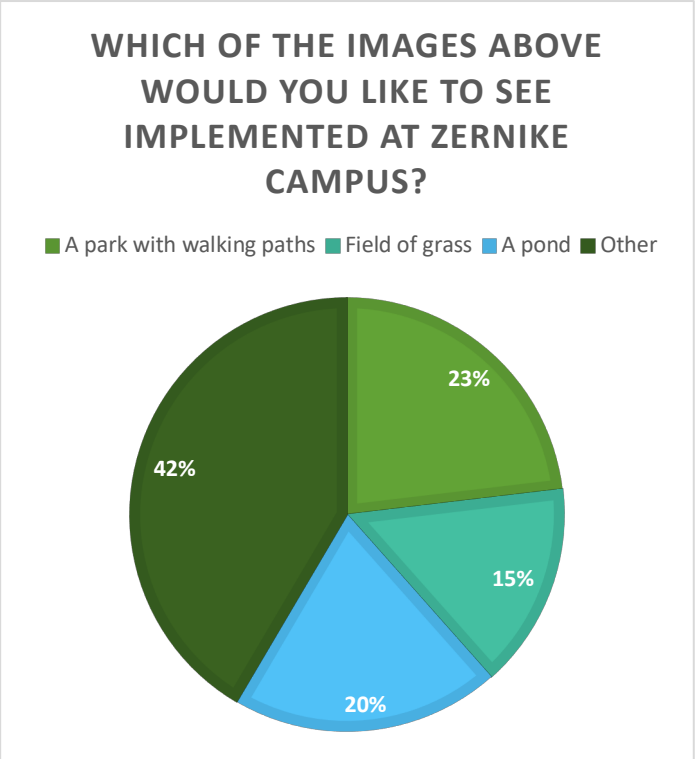


FIGURE 14: A PREFERENCE QUESTION, IN WHICH THE RESPONDENTS HAD TO INDICATE WHAT TYPE OF GRASSLAND THEY WOULD PREFER (N = 65)

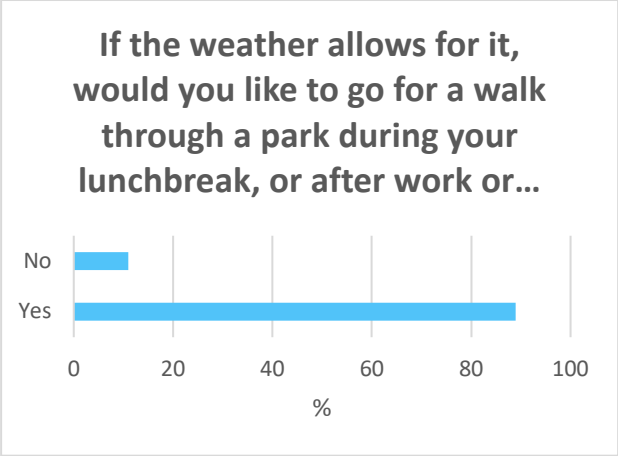
The survey tried to gain insights into what kind of facility people currently miss at the campus as well. They could, therefore, select one or multiple of the images shown in image 10, namely a park with walking paths, a field of grass, and a pond. These images correspond with a greener campus, and, thus, the implementation of additional green and blue space as discussed in chapter 3**.** There were also images shown that displayed improvements for an active campus, such as the implementation of gym equipment and running tracks. As **figure 15** shows, the majority of the responses (58%) preferred one of the green and blue space options, over the other active ageing options, and out of that group, most votes went to the development of a park with walking paths.

IMAGE 10: THE IMAGES THAT CORRESPOND WITH THE QUESTION 'WHICH OF THE IMAGES ABOVE WOULD YOU LIKE TO SEE IMPLEMENTED AT THE ZERNIKE CAMPUS?'. FROM LEFT TO RIGHT: A PARK WITH WALKING PATHS, A FIELD OF GRASS, AND A POND.



This survey also ought to shine light on whether the campus' users were open to engaging in walking more, during, for instance, their lunch break, and if so, what type of environment and requirements they prefer. A large majority, namely 89%, would like to fog or a walk through a park during lunchbreak, or after work or class if the weather allows for it (see **figure 16, left**). Also, if the respondents were to go for a walk, 92.9% would prefer to walk through a green zone (see **figure 16, right**).

FIGURE 15: THE IMAGES DISPLAYED IN IMAGE 10 **WERE CHOSEN 149 TIMES IN TOTAL AS SOMETHING THE RESPONDENTS WOULD LIKE TO SEE IMPLEMENTED AT THE ZERNIKE CAMPUS. THE OPTIONS PLACED IN THE CATEGORY 'OTHER' RELATED TO ACTIVE AGEING CAMPUS FACILITIES, SUCH AS ORGANIZATION OF GROUP ACTIVITIES IN PUBLIC OUTDOOR SPACES, AND THE IMPLEMENTATION OF SPORTS EQUIPMENT. RESPONDENTS HAD THE OPTION TO SELECT MULTIPLE IMAGES (N=255).**



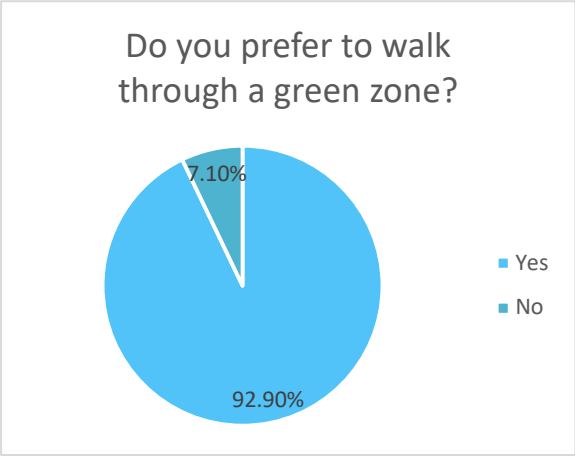


FIGURE 16: LEFT FIGURE: THIS QUESTION AIMS TO GIVE INSIGHTS INTO WHETHER RESPONDENTS ARE WILLING TO GO FOR A WALK IN THEIR SPARE TIME (N = 118).
RIGHT FIGURE: A PREFERENCE QUESTION TO SEE WHETHER RESPONDENTS WOULD LIKE TO WALK THROUGH A GREEN ZONE (N = 70).

As the literature search in chapter 4 mentioned, a green zone should not be further than 300 meters away from people, in order to utilize the park the most. The survey performed for this report wanted to find out if this number also holds for the users of the Zernike campus. It was found that, if the Zernike campus would develop an attractive park, almost half of the respondents were willing to walk up to 250 meters to reach the park (see **figure 17**).

Also, according to **figure 18**, a majority of 60.9% would like to see the walking path go through a green zone, rather than just viewing the green zone from a short distance. This seems to indicate that the campus' users don't only want the development of a walking path, because they would like to walk after, for instance, work, but that this walking path would probably be utilized most when combined with the development of a green zone through which the path runs.

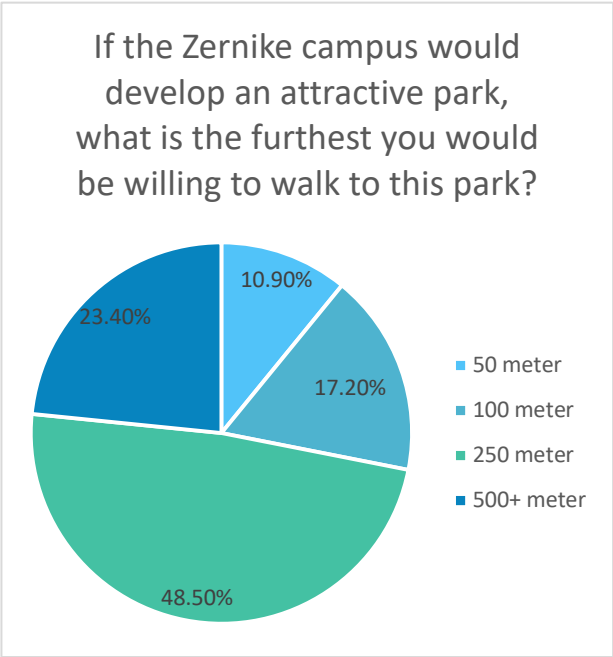


FIGURE 18: THIS QUESTION SHOULD PROVIDE INSIGHT IN HOW FAR RESPONDENTS ARE WILLING TO WALK TO A GREEN ZONE (N = 64).

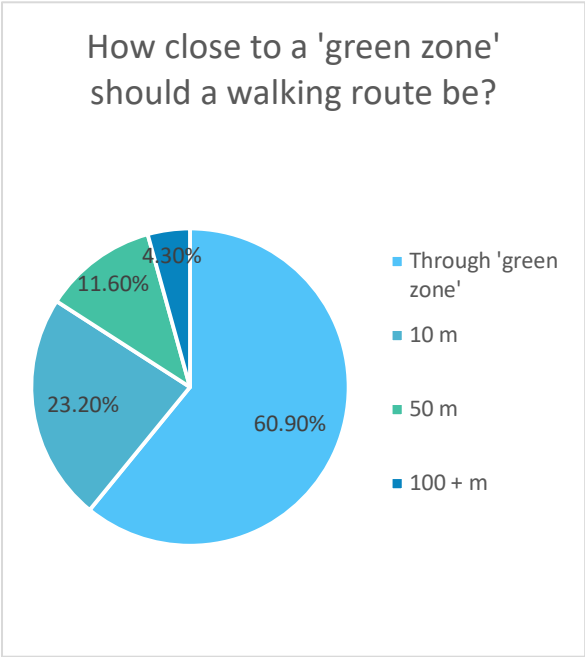


FIGURE 17: THIS QUESTIONS AIMS TO PROVIDE INSIGHTS INTO WHETHER THE RESPONDENTS WANT TO VIEW THE GREEN ZONE FROM A DISTANCE OR WALK THROUGH IT (N = 69).

The survey then focused on requirements the park ought to have implemented in order to be most attractive for users. First of all, having the opportunity to sit was something that seemed to be of value, because they, amongst other things, provide an opportunity to relax, and, when combined with table options, could be a place to meet other people as well. This was a desire that became clear in the previous surveys discussed earlier, hence, the current survey looked into this desire as well. As **figure 19** shows, almost half of the respondents would like to see 3 benches per 100m2.

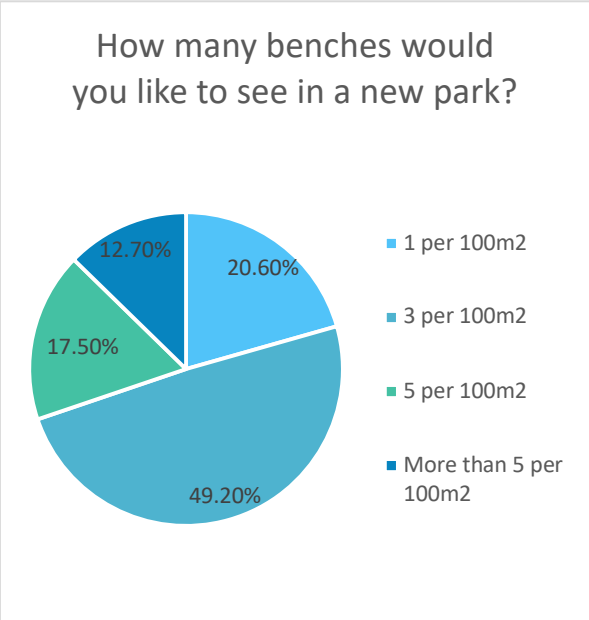


FIGURE 20: THIS QUESTION AIMS TO FIND OUT WHAT THE SEATING PREFERENCE OF THE RESPONDENTS IS (N = 63).

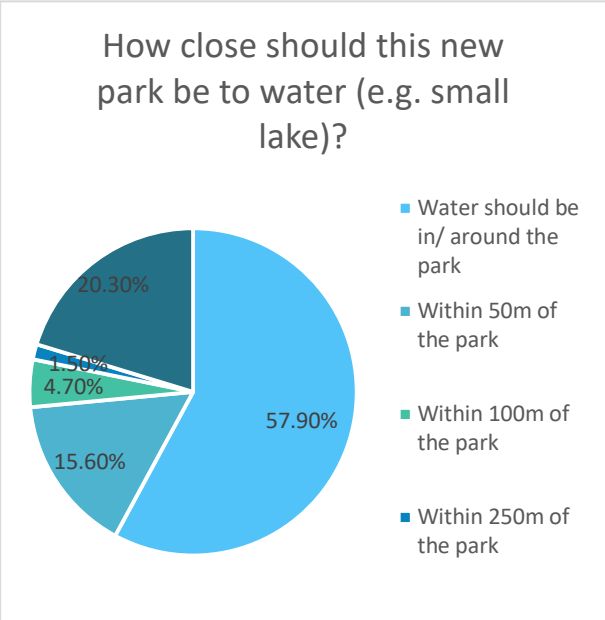


FIGURE 19: THIS QUESTION PROVIDES INSIGHTS IN THE VALUE OF WATER ADDED TO A PARK (N = 64).

So far, most questions reviewed the desire for more green areas, but, as chapter 3 also mentioned, the presence of blue space can be of importance as well when optimizing an area for both ecological and human health. As shown in **figure 20**, 57.9% of the respondents value the presence of water in or around the park. However, 20.3% of the respondents consider the presence of water in a park to not be important.

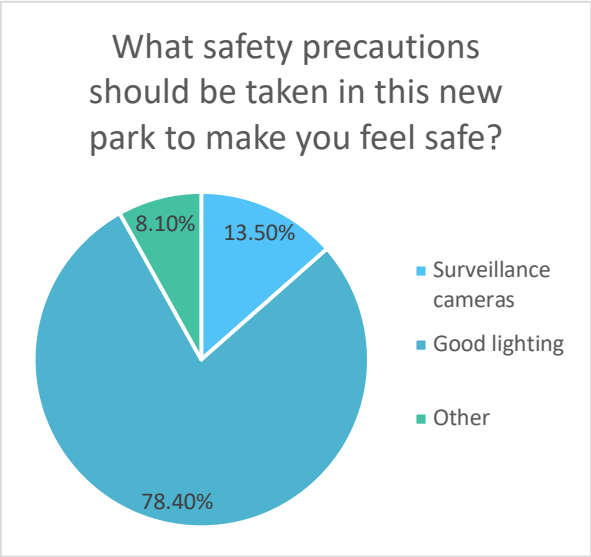


FIGURE 21: THIS QUESTION GIVES INSIGHTS INTO WHAT SAFETY PRECAUTIONS THE RESPONDENTS PREFER. MULTIPLE ANSWERS

Lastly, as discussed in 4, it is of importance to develop a park that allows the users to feel safe. We therefore asked the respondents what safety precautions should be taken in this new park in order for them to feel safe when using the park. A large majority (78.4%) requested good lighting, as shown **in figure 21**.

Finally, a heat map has been generated that combines the results of 'most used green spaces', 'most attractive green spaces', and 'newly proposed green spaces'. This heat map is shown **in figure 22**. The colored areas represent areas on the campus that have been most often mentioned as a green space that is often used or most attractive, and where new green spaces could be developed. Yellow means it is a popular area, but the more orange or even red the area gets, the more popular it was among the respondents. Three main areas can be deducted from this map, namely area A, B, and C, and out of these 3, area C is the most popular choice.

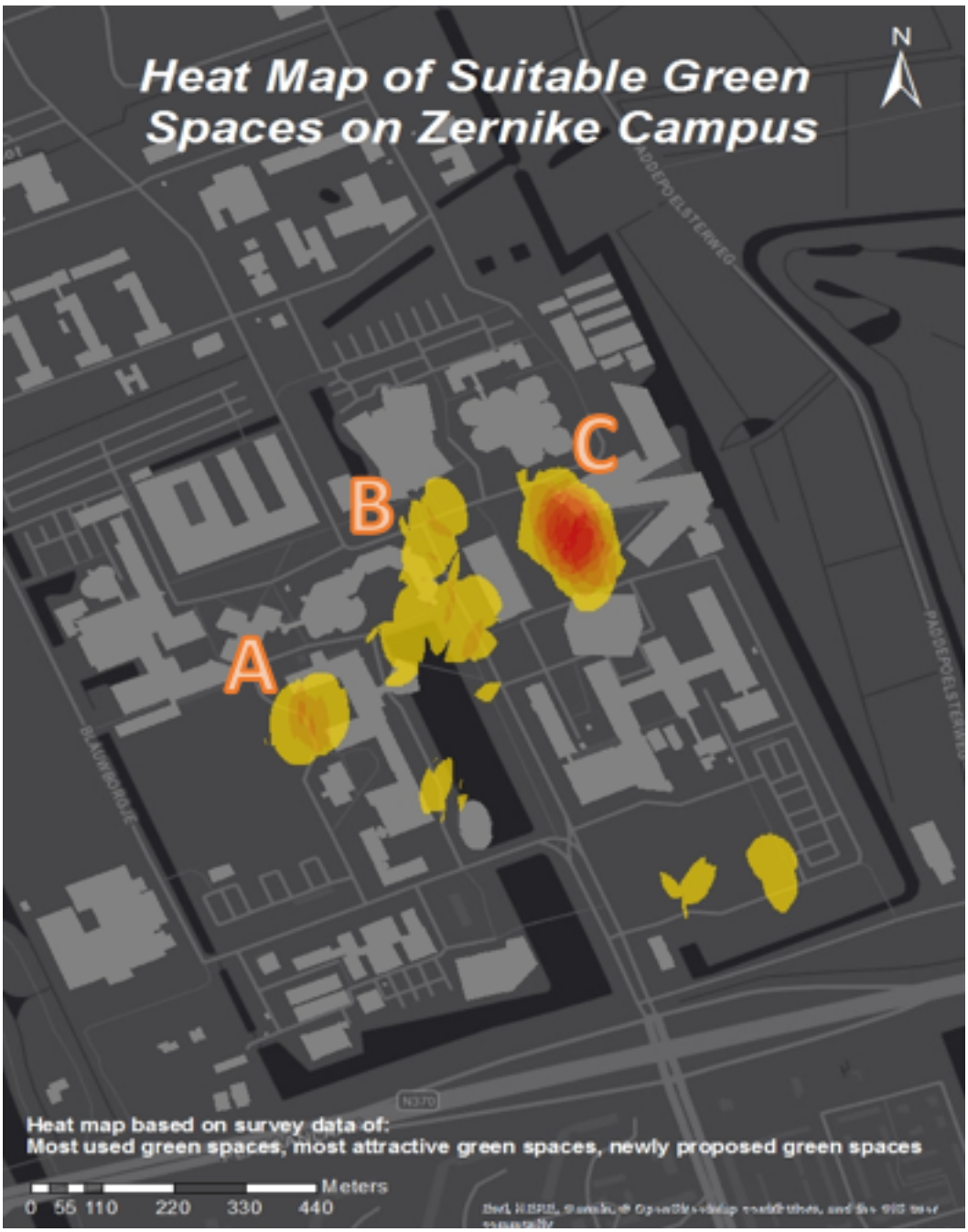


FIGURE 22: THIS HEAT MAP IS BASED ON THE DATA FROM THE SURVEY. IMPLEMENTED IS WHICH GREEN SPACES ARE USED THE MOST, WHICH GREEN SPACE DO PEOPLE FIND THE MOST ATTRACTIVE, AND WHICH NEW AREAS DO THEY PROPOSE AS POSSIBLE PLACES TO DEVELOP GREEN SPACE. A, B, AND C CORRESPOND WITH THE THREE MOST SUITABLE GREEN SPACE AREAS ON THE CAMPUS.

7.3.3 Discussion of the results

Several conclusions can be drawn from the results from the survey performed for this report. What follows is a discussion of the most important results.

7.3.3.1 Desire for green space

First of all, almost all the respondents (almost 90%) expressed a big desire to go for a walk during their lunchbreak or after work or classes, which might, in its turn, explain that 23% of the respondents would also like to see the development of a park with walking paths happening.

If such a park were to be developed, the majority of the respondents would want it to be less than 250 meters away from where they work or study, and almost half of the respondents would be willing to walk up to 250m to get to that park. This is comparable to the results from the study by Gilles-Corti et al. (2005**)** that found that a green space should not be further away than 300 meters in order to be utilized the most by citizens surrounding that area.

Most respondents seemed to appreciate greenery that they can enjoy on the campus. Over 90% of the respondents admitted preferring walking through a green zone, rather than not (**figure 16, right**). Even when the option was provided that they could walk near a green zone, over 60% still preferred to be able to walk through it, rather than alongside it. Also, almost 90% (**figure 14**) preferred to have plants or trees in a green space, rather than only grass, and images that displayed flowery field were deemed more attractive than those with only grass, as well.

All in all, this survey showed that there is a desire among the campus' users to see more green spaces implemented at the Zernike campus. It also shows that the type of greenery (namely a richer environment with flowers, plants, and trees) is preferred over highly managed fields of plain grass. This demonstrates that the campus' users are open to options for green spaces that are also ecologically more valuable, and that there might not be a mismatch between the wishes of the users and the development of an ecological design.

7.3.3.2 Blue space

When asked what facilities they would like to see implemented in a new park, 'ponds' were desired by 20% of the respondents (**figure 15**). Also, when asked how close the water should be to the park, almost 60% said they would like to see the water in or around the park, which was the biggest group. However, the second biggest group are those that do not feel it's important to add water to or around the park (20%).

The example of a blue space provided by the question ('a small lake'), might have misled some respondents, believing that the blue space would be a significant part of the part. If the example would have been left out, or changed into, for instance, 'a small pond', respondents might have felt that adding blue space to a park would be of importance. On the other hand, the group could also have remained about 1/5th of the total respondents, because having blue space simply is of less importance to the users.

7.3.3.3 Seating

There is a big interest in being provided enough places to sit down, as demonstrated in **figure 20**. A majority of the respondents would like to see 3 benches per 100m2, which seems like quite a lot. This number, however, might be chosen the most, because it can be difficult to perceive how much 100m2 actually is. Some respondents, therefore, might have overestimated this number. However, if we look at the number of users the Zernike campus has, the amount might not be overestimated. Especially during lunch breaks, there is often not enough seating for everyone, especially outside. From this point of view, 3 benches per 100m2 might be a realistic desire. These seating options could be added at

specific areas where many people might sit down during their lunchbreak, hence, clustered together, rather than spread out over the entire campus.

7.3.3.4 Safety

Parks that don't feel safe are less likely to be used, hence security options that develop the greatest sense of safety among the users are an important aspect to look into. The majority of the respondents feels safe if the park has good lighting.

7.3.3.5 Analysis heatmap

The heat map in **figure 22** showed the three most popular current and potential future green spaces at the campus. Location A (see **image 11, left image**) might have been chosen as one of the favorite locations for many respondents, since it is already a rather green area, with some areas to sit down as well. The same holds for area C (see **figure 11, right image**), which is currently set-up as a field of grass between several universities with stones in the shape of an Amphitheatre that allow for a place to sit down. Area B (see **figure 11, center image**) might be somewhat less green but has been found to be a favorite spot to sit down, possibly because of the seating opportunities (at the north end of the pond), that see a lot of sun as well (West 8, 2014). It is also in the center of the south park of the campus (see **figure 23**), and thus at a good distance to all buildings that belong to either the Hanze university or the university of Groningen.

IMAGE 11: AERIAL PICTURES OF (FROM LEFT TO RIGHT) LOCATION A, B, AND C AS DISPLAYED IN THE HEATMAP (FIGURE [X]) (GOOGLE MAPS, 2018).

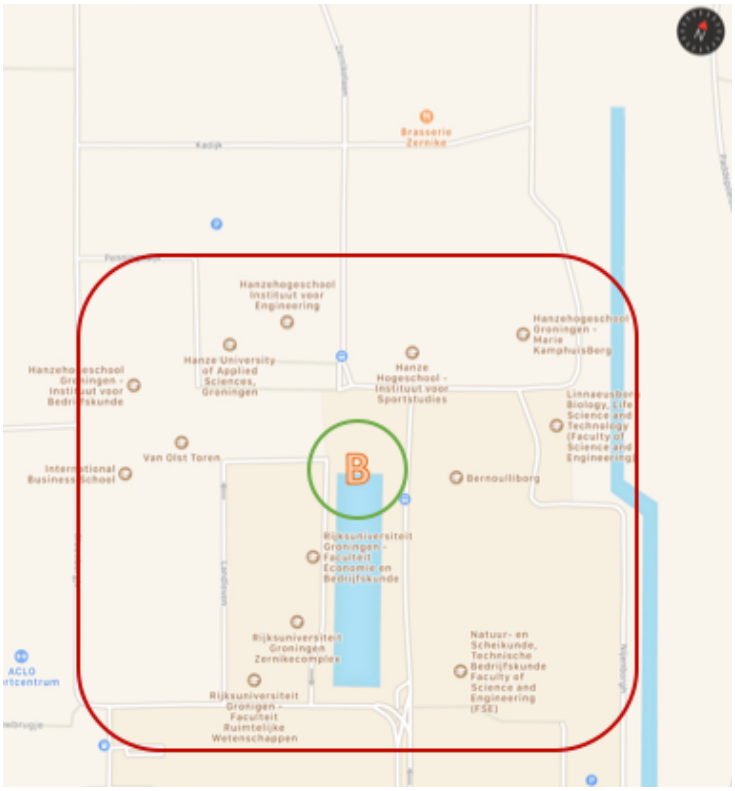


FIGURE 23: THE RED SQUARE DEFINES THE AREA IN WHICH ALMOST ALL OF THE 'SOUTH'-BUILDINGS THAT BELONG TO THE HANZE UNIVERSITY AND UNIVERSITY OF GRONINGEN ARE SITUATED. THE GREEN CIRCLE REPRESENTS AREA B FROM THE HEATMAP (FIGURE 22). THE MAP SHOWS THAT AREA B LAYS AT THE CENTER OF THE DIFFERENT BUILDINGS FROM BOTH KNOWLEDGE INSTITUTIONS.

7.4 ANALYSIS OF ALL THREE SURVEYS

We have now looked at two previous studies (namely the 'livability of the campus' and the 'dialogue with a focus group') as well as performed a new survey for this report ('A green campus and active ageing campus'). What follows is an overview of the main themes valuable for the current question at hand, namely 'amount of green space', 'amount of blue space', 'seating', and 'interaction'. A summary of this overview is displayed in **table 1**.

The focus group stated that there is plenty of green space, which is currently a positive aspect of the campus. However, according to both the previous study on 'livability of the campus', as well as the current study, there is not enough green space, and it is one of the bigger themes according to the respondents, who expressed a great interest in more green space, preferably with walking paths running through them.

There is less consensus on the possible development of blue space on the campus. The previous study on the livability of the campus, a large majority of 80% felt that there is currently enough blue space present. Also, in the current study performed for this report, 1/5th of the respondents opted that adding blue space in a park is not of importance to them. However, when asked what the respondents would like to see implemented in the park (see **figure 15**), the second largest group (20%) chose a pond. It seems that there is not a strong preference for adding additional water, but it also appears that if additional blue spaces were to be added, this would also not be viewed as a negative development.

Increased number of seating possibilities is a strong desire according to all three studies. Having enough seating is something that is currently lacking, and an aspect that the majority of all respondents wants to see improved. If outside seating options were to be improved, it could encourage the users to go outside more often for, for instance, their lunch break.

Improved seating might also improve the interaction taking place at the campus, which was also one of the re-occurring themes throughout the two previous studies. According to the focus group, there is currently a lack of interaction between different faculties, and the respondents of the first study on the livability of the campus, mentioned that a central meeting place is currently missing. More interaction would happen if the campus would be more unified, rather than split up per faculty, knowledge institution, or in a distinctive north and south side where companies are cut off from the knowledge institutions.

	Previous study: Livability of the campus	**Previous study: Dialogue with focus group**	**Current study: A green campus (and active ageing campus)**
Amount of green space	39% don't think there is enough. Also, it was the 3rd biggest theme regarding what the students miss most.	There is lots of green space (which is a positive aspect of the campus at the moment).	Respondents expressed a great interest in walking near green space and prefer vegetation over only grass.
Amount of blue space	80% feels there is enough blue space at the campus.	-	20% would like to see ponds in a new park.
Seating	Seating on the campus was missed the most by students (32%)	There is little to no seating, which is an issue for the focus group.	Respondents want to see a lot of seating in a newly developed park.
Interaction	Students express interest in a central meeting place.	The main issue of the focus group was the lack of interaction between different faculties.	-

TABLE 1: AN OVERVIEW OF THE RESULTS FROM THE TWO PREVIOUS SURVEYS BY DE GROOT ET AL (2015) AND ARENDS ET AL (2018), AS WELL AS THE SURVEY PERFORMED FOR THIS REPORT.

8. Conditions for the Ecological Park

8.1 Introduction

After exploring frameworks that can be used to develop an ecological and functional design and analyzing the wishes of the users that would end up using the park that will be designed, we can now take a closer look at the specific requirements that will form the base for creating an ecological and successful urban green-area.

We will first take a closer look at the conditions that the design needs to meet. When the required conditions are known, a location can be chosen that provides the right conditions to have the potential to be developed into an (ecological) park. After this information is outlined, a design can be developed that fits these requirements. At the end of this chapter, the design that has been developed will be discussed to explain which aspects are incorporated, and, perhaps, which are not and why.

8.2 Required conditions

Throughout the report so far, we have considered relevant literature as well as analyzed two previous surveys and performed a new survey for the purpose of this report. This has provided valuable insights into possible requirements the design for a new park should fulfill in order to not only have a higher ecological value, but also to take into consideration the desires of the possible users of the park.

Now, these insights that have been gathered throughout the report will be combined to provide us with an overview, which can be found in **table 2**. The conditions that are mentioned have been divided into three groups that cover their ultimate purpose (developing a successful area, increasing ecological value, and human preferences) and are conditions that are either required or preferred when developing an ecological and successful design, and should enlighten how to create certain conditions. The three groups entail the three vital aspects that should be kept in mind throughout the design process.

Ultimate purpose	**Condition**	**Why**
Developing a successful area	Make the design a success in its community	Have a recreational purpose for the area (Giles-Corti et al., 2005).
Increasing ecological value	Ecological aspects not an afterthought	A good approach is thought to be as followed: First, set-up the different biotopes and look at how to set-up the design in general so it optimizes the plan's ecological value. Then, adjust the plan accordingly so it also suits human preferences, and certain design (Nimela & MacDonnell, 2011; Van Nierop, 2018).
	Develop a green infrastructure	Creating a network of green spaces encourages their ecological value, as well as the community because it will allow for overall more green. Connecting green spaces with each other also improves the ecological value of an area, because areas are less closed off from each other, and, thus, allow for more migration (Benedict & McMahon, 2000).
	Combination of green and blue space	By not merely implementing green, but also blue space, both the ecological value and the positive impact on people's wellbeing increase (van der Ryn & Cowan, 1996; Van Nierop, 2018).

	Using native species for vegetation	Using native species, rather than non-native species is of importance to attract more insects, which will, in turn, attract animals that feed on those insects. Native species also stimulate biodiversity, they contribute to ecological resilience, and are already adapted to the local conditions (Gill & O'Neal, 2013; Meijer et al., 2015).
	Implement various biotopes:	Different biotopes attract different species (Van Nierop, 2018; Völker & Kistemann, 2011). What follows in this table will be some examples of beneficial biotopes.
	▪ Add small ponds	Small ponds that are up to 70 centimeters deep offer a place for amphibians, as well as a place where animals such as hedgehogs can drink. By developing a pond that gradually deepens to the maximum depth (thus creating shallow areas along its banks), birds have the opportunity to take a bath or drink from the pond as well (Van Nierop, 2018; Vogelbescherming Nederland, 2018b).
	▪ Create shelter places	Bushes can ideally be used to create shelter places where, for instance butterflies and other insects, can shelter from both heat and cold. This is important, because they are cold-blooded animals. In general, vegetation should preferably at least at some spots be dense to create shelter opportunities (Vlinderstichting Nederland, 2018).
	▪ Allow for an herbal garden in the park	Herbs, especially rosemary, lavender, catnip, marjoram, thyme, or fennel, attract butterflies and bees, because they provide a lot of nectar and are singular flowers so insects can easily reach their nectar. (Vlinderstichting Nederland, 2018)
	Implement a lawn	Lawns offer birds, such as the song thrush and the blackbird, a place to find food, because they can pull worms out of the grass (Vogelbescherming Nederland, 2018b).
	Different structures	Develop different structures with gradual transitions, by using low plants, bushes, and trees (Gommers, 2015; Vogelbescherming Nederland, 2018b).
Human preferences	Max. 5-10 minutes walking distance	The green zone should not be more than 5-10 minutes walking distance from the place where the user works or studies. This was concluded from both the survey performed for this report, as well as by the literature search. This distance optimizes the health benefits of green zones for people, and, if a green zone would be further away, less people would feel inclined to visit the park during, for instance, a lunch break. (Giles-Corti et al., 2005; WHO, 2016).
	Natural look/ Aesthetically appealing	The area should be appealing for people to use; hence it should have an aesthetic value. People also tend to appreciate a more natural look over an intensely managed look (Gobster & Westphal, 2004).
	Safety	The users of the area should have a sense of safety, so too dense vegetation does not stimulate this and should be avoided (at least in the areas people will most likely use). Lighting is also a good option to add to the sense of

	security (Gobster & Westphal, 2004). By using smart lighting (that only lights up when someone enters the park) and a specific color of light, the park will be more favorable towards animals. Allowing a park to be fully dark at night will be more attractive for, for instance, bats. Smart lighting that lights up when someone enters the park, but otherwise remains dark, can provide darkness for the animals, but safety for the people. If the lights are on, they should radiate a favorable color for animals, so they will be least disturbed by the going on of the lights. The most favorable color is amber-light (Irwin, 2018; Van Nierop, 2018).
Clean	The area should not be contaminated with trash (Gobster & Westphal, 2004).
'Cuddliness factor'	The species a park will attract need to be (at least partly) preferable by people, so attracting, for instance, too many wasps or vipers might increase the biodiversity of the park, but it won't be a place where people want to go. The animals that the park will attract need a certain 'cuddliness factor' (Gobster & Westphal, 2004; Van Nierop, 2018).

TABLE 2: AN OVERVIEW OF THE DIFFERENT CONDITIONS THAT ARE REQUIRED OR PREFERRED WHEN DEVELOPING AN ECOLOGICAL DESIGN.

9. THE OPTIMAL LOCATION

9.1 INTRODUCTION

One of the main ideas found in literature, is that the ecological aspects of a design should not be an afterthought, only implemented once the rest of the design is already completed. If we want to grant equal value to both human and ecological preferences, we should keep both in mind from the start (McHarg, 1967).

As mentioned previously, the Zernike campus will change significantly in the upcoming years, due to the development of new buildings and the restructuring of the campus' infrastructure. A desire for 'upgrading' the campus' 1960's design has been a shared desire and has been what inspired the new urban development plan that will guide the campus' evolution the next 5-10 years (West 8, 2014).

On the one hand, this is a challenge, because the plan that will be developed here, will need to be sustainable despite all the upcoming changes. On the other hand, this grants us with the opportunity to implement ecological values at an early stage in the development process if we 'ecologize' an existing plan of which it is known that it will be implemented at the Zernike campus.

9.2 POTENTIAL LOCATIONS

A map was developed that depicts potential locations, which is shown in **figure 24**. The areas highlighted on that map have been chosen according to either one of the following reasons. First of all, the three current favorite spots of the campus' have been appointed in red (area 1, 2, and 3). They are favorite spots at the moment and might have the potential to be even further developed. The yellow areas (area A, B, C, and D) are areas that will be changed significantly according to the urban development plan for the campus.

It can already be seen that there appears to be a focus on the south side of the campus. This is mainly the case, because these potential locations have been chosen partially in accordance with results provided by the surveys. However, these surveys often don't represent the users of the north side of the campus, because they are not within the network of the survey-makers. By incorporating location D, the Zernikelaan, it has been tried to provide a possible location that could connect the north and south side of the campus in a better way.

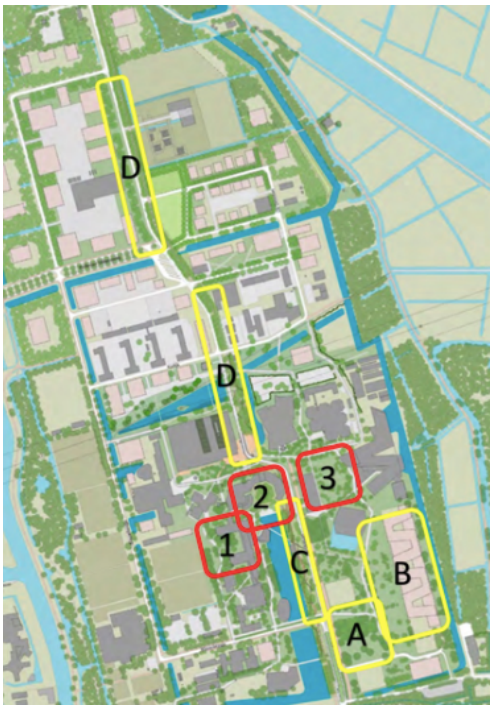


FIGURE 24: THE 6 POSSIBLE LOCATIONS

Summaries of possible locations as shown in **figure 24**.

A. This is currently a small wet woodland area on the campus. The new urban development plan wants to thin out this area to make it more open, and eventually create a connection towards the yet-to-be-developed Feringa-building. However, it might be valuable to assess the current ecological value of this area first, before deciding on its re-design (West 8, 2014).
B. The new Feringa-building will be located here. However, the realization of the new building has been postponed multiple times, and it is unsure

whether the current design still needs adjustments before it can be developed. Hence, implementing new ideas in the current design might not be sustainable (West 8, 2014).

C. A new green zone will be developed alongside the improved Zernikelaan. This park is adjacent to the pond and will be thusly adjusted that the pond will become a livelier area itself (West 8, 2014).
D. The Zernikelaan runs through the entire campus area and will be transformed significantly. It will be thusly developed that the road will be surrounded by a lot of greenery, and it will lie adjacent to several newly developed green zones (West 8, 2014).

1. This area appears to be a favorite place for people to currently spend some time outside. It is rather closed off, but for the faculties residing in the buildings adjacent to this area, it is apparently already a proper green zone.
2. This is a rather central place for the southern part of the campus, and the benches in this area that look out over the pond have been found to be popular places for students to sit down when the sun shines. This location is also closest to the (entrance of the) local supermarket.
3. The area marked by number three lies between two buildings that mainly hold the faculty of science and engineering, and the Energy Academy, which holds both Hanze university and University of Groningen faculties. The area is now a lawn with low stone benched designated as seating areas, which are shaped in the form of an Amphitheatre. This is another location filled with students once the sun is out. The area is also designated to be used for certain activities or events, such as the performance of a play or summer barbeques organized by study associations.

What will follow is an analysis that assesses which of these locations is most suitable for the development of an ecological park. As it will turn out, location C will be the favorable location for the design, due to its location, proximity to the geographical center of the south side of the campus, the feasibility of redesigning this area, and because it has the most buildings (hence, faculties) in its proximity.

9.3 Assessment of potential locations

First of all, both D-areas designate parts of the new Zernikelaan. This should become a connecting road throughout the entire campus, with lots of greenery to, partly, shield of the buses and other vehicles driving by via the Zernikelaan, as well as mute the noise. The plans for this location (the Zernikelaan as a whole) are already very concrete, which makes it a location with great potential to be redeveloped and create an ecological design. However, the area is small in width, and the green alongside the road that could be looked into and perhaps re-designed, remains green next to a crowded road. For the development of a green zone that attracts animals, it is preferred to have an area that has a less high-intensity usage. Because this road will be adjacent to several new green zones, and is itself a small green zone, it might still be valuable for the development of a green network.

For now, that leaves us with locations situated at the south side of the campus, where mainly the Hanze university and the university of Groningen reside. Despite that it was not preferable to focus on either side of the campus, it becomes clear that for this project, an area located in the south side will be the most suitable location. However, when analyzing the final result, a closer look must be taken into how these ecological improvements can be implemented throughout the rest of the campus, for not only the benefit of the campus' ecological value, but also its connectedness and becoming one whole campus.

This leaves us with 6 possible locations, which we now assess based on their range. It was found that the campus' users prefer to walk no more than 250 meters to get to a green zone. We will therefore take a closer look at which buildings are within this 250m range of either the entrance to the green

zone (if it is a big, spread-out area) or the center of the green zone (if it is a small area), as well as how the locations are situated (**see figure 25**).

1. This area is very closed off from the rest of the campus. If you don't have to be there specifically, you might never know of its existence, because it lies behind several buildings that belong to one faculty. Despite that the road that goas through the area isn't a dead-end, it's also not a main road, and its mainly used by students that are destined for the adjacent building. Also, the 250-meter radius shows it excludes almost half of the buildings in this area of the campus. According to the urban development plan, the area also won't be re-developed extensively, which makes this area less favorable as a location for implementing an ecological design.
2. Area 2 is very central. According to the 250-meter radius, only the new Feringa-building and the facility management buildings are out of range. It's a quite open area and lies closely to the main route through the campus (the Zernikelaan). It's also near to the local supermarket.
3. Quite some buildings are excluded from the 250-meter range of this area. Also, it's located too much in between buildings belonging to the same faculty, which might make it harder to find this location, if you don't naturally pass the area. Another downside for this location is that it already has a specific set-up (the Amphitheatre outline), and this won't change according to the current urban development plan.

A. This is currently a small woodland area on the campus. The new urban development plan wants to thin out this area to make it more open, and eventually create a connection towards the yet-to-be-developed Feringa building. On the one hand, this is an ideal location to incorporate an ecological design, rather than merely thinning out the area to open it up. However, there also isn't a clear and concretized plan, yet, and might not be developed until more certainty regarding the Feringa-building is realized. The 250-meter range also shows that this area is too far for the majority of the buildings.

B. Before the Feringa-building lies a lawn that has not yet been further filled in. This area will be re-arranged drastically with the new building and the removal of the Nijenborgh-building. However, these plans are not yet fully concretized, as was mentioned earlier. The same problem also arises that arose for the woodland-area, namely that the radius shows that most buildings are outside the 250-meter range. The buildings that are within range mainly belong to one faculty, hence, a park in this area might exclude other faculties too much and won't be able to become a central meeting point.

C. As was mentioned before, green zones will be developed alongside the renewed Zernikelaan as displayed in the urban development plan of West 8, and one of those green zones is a new park between the Zernikelaan and the pond. Because of the length of the park, its range from both the south and the north entrance cover almost all buildings (or at least the entrance of that building), which makes this a possible location to develop a central meeting point. It also lies next to the main route through the campus, which makes the area more visible for the campus' users, which might result in more people making use of this area once it is redeveloped.

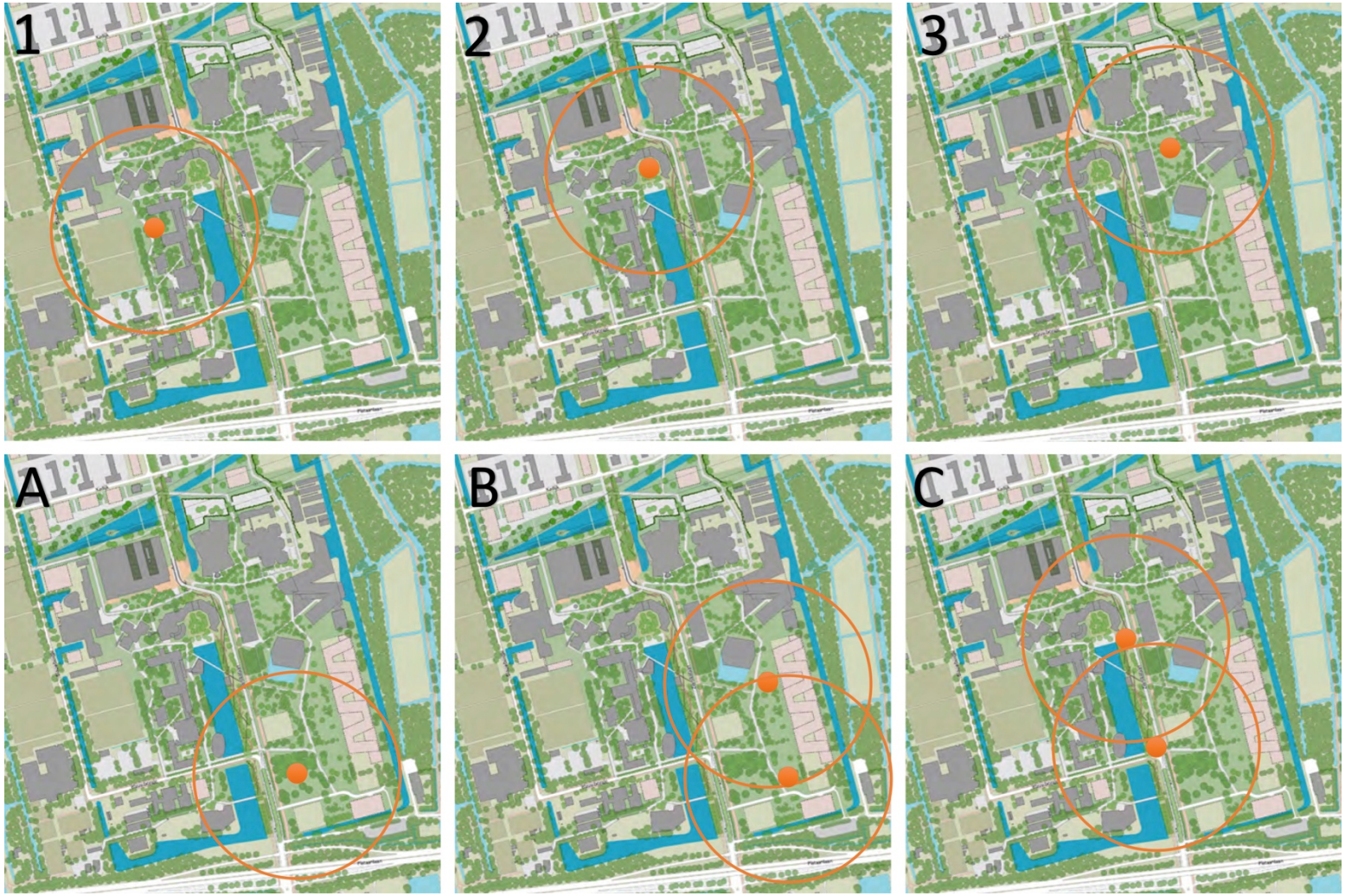


Figure 25: The dots represent the center of the area as presented in **figure 24**. The circle surrounding the dot shows the radius of 250 meters from the center. These maps now show which buildings are within the desired 250-meter radius from the possible (and most likely) entrance to the park. Because area 1, 2, 3, and A are rather small areas, their centers were chosen to use for determining the range. Both area B and C cover larger areas, hence they have two entrance-areas (and two radiuses, to display the 250-meter range for both entrances).

9.3.1 A CENTRAL PLACE

A strong desire for a central place to, for instance, meet people has been expressed throughout all surveys. An obvious place might be at the center of the area you want to connect with each other. Hence, **figure 26** was developed, that displays the edges of the south part of the campus and appointed the true center of that area. Once again, the south part of the campus is used to look for the center, rather than the campus as a whole, because the possible locations have already been reduced to those situated at the south side.

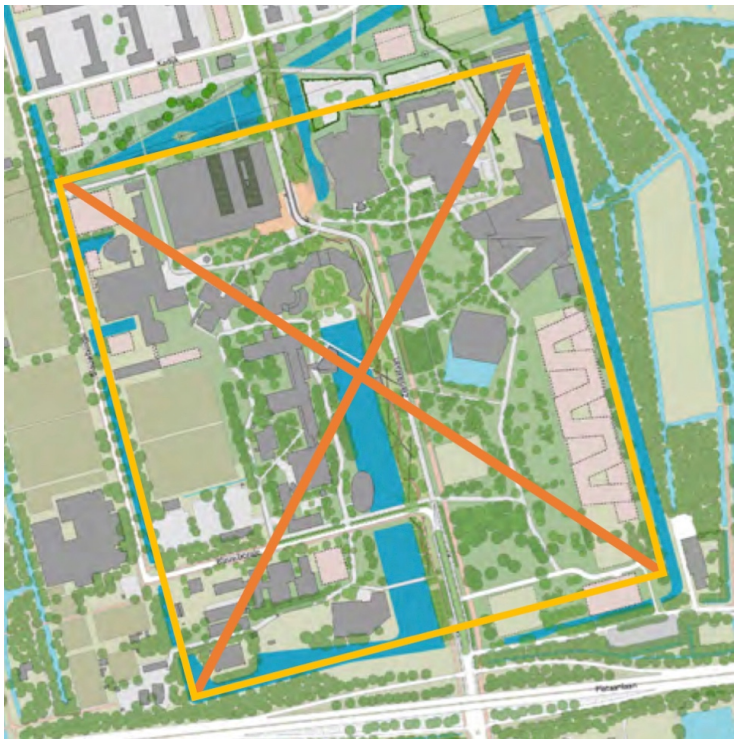


FIGURE 26: THE YELLOW SQUARE MARKS THE AREA OF THE SOUTH SIDE OF THE CAMPUS. WHERE BOTH ORANGE LINES MEET MARKS THE CENTER OF THAT AREA. AS CAN BEEN SEEN IN THIS PICTURE, THE TRUE CENTER LIES IN THE POND, BUT IS CLOSE TO THE AREA WHERE THE NEW GREEN ZONE WILL BE DEVELOPED. IT, THEREFORE, HAS THE POTENTIAL TO BECOME A CENTRAL MEETING POINT FOR THE SURROUNDING FACULTIES.

Both area 2 and C are very near this center and might offer the best potential to be used as a central place. Area 1 is, in linear distance, also rather close to this central point, however, it is separated from it by a building, making the true distance (it takes to get to the center) much longer. The fact that it is very closed off, and not so much a 'passing-through' area, makes it a less ideal location to be used as a central meeting point.

9.3.2 FEASIBILITY OF REDESIGNING A LOCATION

The campus will receive a rather invasive make-over in the upcoming 5-10 years. Many of the campus' areas will change drastically. Others perhaps not so much, but all of the campus' ground are and will be affected by the urban development plan. This offers a challenge for the feasibility of this current project. If the plan is to be successful, it should not be located at an area that will not exist in several years, because it has been designated to the build of a new building, or because it has been given a new impulse with regard to the infrastructure.

On the other hand, the design might have the biggest chance of implementation if it affects an area that will be altered anyways in the upcoming years. This was, the ecological aspects of the design will be integrated from an early phase on, and, as was mentioned before, this is important for the development of ecological designs.

To make sure the plan that will be designed is feasible and sustainable, it will thus be a design based on development-plans that have already been concretized and have the status to most likely be implemented at the campus. We have already looked at several requirements the location should fulfill and can now narrow this down to the locations that fulfill this new requirement, namely being an area that has concretized plans that will be executed in the upcoming years. This leaves us with two areas, namely area 2 and C.

9.4 THE OPTIMAL LOCATION

For now, the most concretized plan is that for the Zernikelaan and its adjacent green zones, which include both area 2 and C. Both have more green implemented in their design, and both are close to the central point of the south part of the campus. However, due to its length, area C covers a broader range of buildings which entrance is within the 250m radius of both entrances to this green zone. Area 2, on the other hand, is already a favorite location to use for the campus' users, hence, it is likely that they will remain using the area, even if it is adapted. Whereas users need a new incentive to change their current favorite location and make use of area C. **Table 3** provides an overview of the just mentioned aspects for both area 2 and C.

	Area 2	**Area C**
Proximity to central point	+- 50 meter	+- 10 meters
Favorite place	Yes	No
# of buildings within 250m range	10	12

TABLE 3: THE MAIN FACTORS INHERENT TO CHOOSING THE OPTIMAL LOCATION, AND HOW THEY APPLY FOR BOTH AREA 2 AND C.

Overall, the best option seems to be area C, which has to overcome mainly one obstacle, being that it is not a spot people currently associate as a green zone they like to be at. However, this is easier overcome than proximity to the central point or increasing the number of buildings within the 250m range. These latter two issues that make area 2 less favorable are issues inherent to the design and the location and impossible to overcome.

The park will need to fulfill two main functions, namely obeying the desires of the campus' users, as well as optimizing the ecological value of the area. Area C is a lot bigger in surface, making it a better environment to adjust in such a way that it still obeys human preferences, but leaves enough room to make the design also truly ecological.

9.4.1 A GREEN NETWORK

Furthermore, this area is at an ideal location to be a central point for the further development of a green network at the campus, connecting this inner heart with the outer ecological structure. To develop a green infrastructure, lifelines of green should run through the area to connect green zones with each other. By adding a green center to the already existing network, the value of the network might be increased. And, if a connection is made between the surrounding ecological structures and an inner green zone, the campus might integrate better with its surroundings, allowing for an overall ecologically improved area.

Hence, the design will focus on area C, the area designated to be a new park on the campus. An already existing idea of developing a green zone at that specific location can be further developed to make the park an ecological park as well. It's a central area and might, thus, be inviting to all the users located at the south park of the campus. This area has the potential, both in community sense and ecological sense to become a beating heart of this part of the campus.

FIGURE 27: THE LOCATION OF THE NEW PARK (ORANGE AREA) WITHIN THE CAMPUS' CURRENT NETWORK OF EXISTING OR TO-BE-PLANTED TREES.

10. ADVICE FOR THE ECOLOGICAL PARK

10.1 INTRODUCTION

Now that we have come to a conclusion regarding the location and the required conditions for the plan based on the literature and surveys, a design can be made to incorporate those conditions on the chosen location. **Figure 28** shows an outline of improvements on the current design. The lay-out of the original design can be largely maintained with regard to the walking paths. We will first take a closer look at the outline, and into the choices that have been made and why, and which species have been chosen for vegetation.

10.2 IMPROVEMENTS ON THE CURRENT DESIGN

The main idea is to form a vegetation structure, so, create levels that, together, form a gradual 'slope' downwards in height. These different levels should offer various habitats for multiple species. Alongside the road, there will be several trees, that reduce noise coming from passing vehicles, as well as provide shade, and shelter. The next level will be bushes and shrubs, that partly help reduce the noise in some places, but they are also valuable food, shelter, and nesting sources for insects, butterflies, and birds. After that there will be grasslands in the park, of two different kinds. Alongside several of the walking paths and some other areas, natural meadows will be developed, that attract insects and butterflies, as well as increase the aesthetical value for people using the park. The park will also contain some short grasslands (lawns) that offer food (e.g. earthworms) for particular birds and could be used by the campus' users as an area to lie down during warmer days.

The park will also contain two ponds, on either side of the park. These ponds will be 70 centimeters deep and have a gradual slope towards its maximum depth. The ponds provide a drink facility for animals, as well as a place for amphibians and other water living creatures to reside. Alongside as well as inside the ponds, suitable plants will be planted (which species we will use will be discussed later on), which might also provide shelter, food, and nesting opportunities, and which shield off part of the pond from the walking paths. This decreases the amount of disturbance from people using the walking paths for the animals residing in or using the pond (Swistock, 2013).

Even though the area will be planted in the beginning, eventually it should evolve by itself into a natural zone and attract new species. With a right base that has been developed from an ecological foundation, this park should eventually become a dynamic area that, for the most, can self-sustain and keep evolving without too much interference (Refaat, 2014).

An important aspect to help the park evolve into a natural zone is by proper ecological management. In order for the park to maintain its developed ecological value, a certain ecological maintenance is required. How such a park should be maintained differs per part. For instance, certain parts of the park should be allowed to maintain themselves, without too much intervention from people. These areas should, for instance, only be mown once a year, to allow for seed development and spreading. Lawns on the other side could be mown more often, for instance once or twice a month, to allow for food availability. However, ecological maintenance requires a shift from the current traditional mindset, to a new, ecological mindset. This is also why it makes such a change so difficult. In order to create a successful ecological maintenance program, it is of importance that the parties involved in the maintenance of the campus' grounds are aware of how to ecologically maintain specific areas. A policy should, therefore, be developed to instruct the involved parties (Gemeente Tilburg, 2014; Habitus, 2018)

FIGURE 28: AN IMPRESSION OF THE IMPROVEMENTS THAT HAVE TO BE MADE TO THE DESIGN OF THE PARK, IN ORDER TO DEVELOP IT INTO A PARK WITH ADDED ECOLOGICAL VALUE.

The campus' grounds that are owned by the University of Groningen and the Hanze university of applied sciences are maintained by a shared maintenance management. Currently, ecological considerations are not part of the maintenance policies. This means, on the one hand, that there is room for improvement and the development of new policies that can be implement. On the other hand, it also means that the maintenance management needs to undergo quite some changes from how they are currently managing the campus' green zones, and how, for instance, the park should be maintained.

10.3 Species selection

In order for the design to result in an attractive area, we must look further into the types of vegetation that will be planted or sown. For the flowery areas in the design, a mix of different native species can be used, and **table 4** shows some examples of native species, that display a varied mix in color, height, and flowering period. They are preferred species for several butterflies and insects. Some of the species bloom at night and will therefore also attract moths. A colorful palette was chosen, to also develop an aesthetically appealing image for the people using the park. The species vary in height and must therefore be placed in such a way that they create a gradual decrease in height towards the walking paths, placing the lowest flowers nearest to the paths, and the higher plants closer to the bushes. There are options to purchase carefully selected mixes of seeds, via, for instance, 'De Cruydthoeck'. A mix of seeds can be chosen that suits the soil of the park, and other possible requirements (Cruydthoeck, 2018; Vlinderstichting Nederland, 2018; Vogelbescherming Nederland, 2018b).

Latin name	Image
Prunella vulgaris	
Leucanthemum vulgare	
Oenothera biennis	

Origanum vulgare	
Malva moschata	
Silene latifolia subsp. alba	
Papaver rhoeas	
Hieracium pilosella	
Lotus corniculatus	
Crocus tommasinianus	
Sedum acre	

TABLE 4: EXAMPLES OF SELECTIVE NATIVE WILD FLOWERS, VARYING IN COLOUR, HEIGHT, AND FLOWERING PERIOD.

10.3.1 Herb garden

An area in the design has been designated as the new outside area where Frankville (a local community that wants to develop a sustainable campus) can create a kitchen garden. This has already been done once by the community, but due to the campus' redevelopments, they had to move their garden inwards. However, an outside location is preferred, and herbs can benefit an ecological design a lot. Butterflies and bees are attracted to, for instance, rosemary, lavender, catnip, marjory, thyme, or fennel, because they offer plenty of nectar (Frankville, 2012; Vlinderstichting Nederland, 2018).

10.3.2 Shrubs and trees

The urban development plan already states which types of bushes and trees will be planted in the new park. However, most of these species are non-native, and should, therefore, be replaced by native species. **Table 5** shows possibilities of native species that could be planted. Berry or nectar providing bushes need to be implemented as well, because they provide food for animals, birds and insects. They also have a high aesthetical value. Adding shrubs or trees that also provide berries during the winter, such as the native holly (*Llex aquifolium*), need to be implemented as well, to provide birds with food even in that specific season (Vlinderstichting Nederland, 2018; West 8, 2014).

Bushes & trees
Prunus padus
Tilia cordata
Prunus avium
Quercus robur
Tilia platyphyllos
Ribes rubrum
Euonymus europaeus
Llex aquifolium

TABLE 5: EXAMPLE OF NATIVE SHRUB AND TREE SPECIES THAT COULD BE IMPLEMENTED IN THE DESIGN (GENENBANK BOMEN EN STRUIKEN, 2018; VOGELBESCHERMING NEDERLAND, 2018A).

10.3.3 Other facilities in the park

A strong desire for enough seating has been expressed throughout all the surveys. However, the areas in which people will sit down, meet, and relax, might be disturbing for fauna. Therefore, it was chosen to create two designated seating areas which will cluster users together. This not only benefits the quietude for the fauna, but also increases the users' sense of community.

Another issue that had to be considered is how to make people feel safe when they are in the park. First of all, it was decided to not create too many dense areas. At some spots, trees and bushes have been clustered together more, but mainly at areas where this isn't too close to the walking paths. The areas designated for human use remain as open as possible to increase a sense of safety. Also, lighting will be necessary throughout the park. For the location of the lighting, the currently existing plan was maintained. The lampposts have been placed at the same spot as in the original design. However, the lights will have to be 'smart', meaning they will only light up when someone enters the park. Otherwise, certain animals will be disturbed too much at night, and won't settle in this new area. Also, the light of the lampposts should be amber-colored. Again, to make sure that when the lights go on, their light doesn't affect the animals too much.

One main issue remains, and that is the bustling Zernikelaan, on which many (big) vehicles pass every hour. Even if the area has become a beneficial area for animals to reside, they might still not be able to get into this new area. Hence, a solution must be considered to help animals cross the Zernikelaan

and, thus, increase their habitat. A good option for this would be the implementation of a 'hedgehog tunnel'. Despite its name, these tunnels also help other species, such as toads, frogs and mice. And, as we've seen when discussing an example of the implementation of hedgehog tunnels and bridges, they offer a good means to increasing the animals' habitat.

As mentioned before, other projects concerning the redevelopment of the campus are also currently taking place, such as the active ageing campus. For the active ageing campus, a plan has been developed to implement activity-promoting facilities to certain areas at the campus, and one of the proposals focusses on the same area as the one redesigned in this report. The main idea from the active ageing campus is to implement work out gear throughout the new park, as shown in **image 12**. However, if we want to create an area that is not too disturbing for the animals residing there, it is suggested to change the location for the work out gear to another area at the campus. Hence, it has also not been included in the current design.

IMAGE 12: AN IMPRESSION ON HOW WORK OUT GEAR COULD BE IMPLEMENTED IN THE NEW PARK AREA AT THE ZERNIKE CAMPUS.

A desire expressed via the surveys is the increase in food and drink facilities. However, these types of facilities have not been included in the current design, for the same reason as why the work out gear has been left out. The focus of this park should be a place to relax and meet for people, but also that it is an inviting area for animals to reside. If we want to create this delicate balance between nature and people, we cannot facilitate all the users' desires, in order to take the needs of the animals in consideration enough. The local supermarket is also relatively close to the park area, and there is still the possibility to implement other food and drink facilitates in the redevelopment of other areas, such as the one closer to the Kapteynborg. Hence, the need for more of these facilities can still be fulfilled elsewhere and does not necessarily need to be located at this park.

11. FURTHER ADVICE

11.1 INTRODUCTION

This report so far offers a design for a park on the Zernike campus, based on an ecological foundation that could be implemented between the pond and the Zernikelaan. However, as was discussed in chapter 4, connectivity and overall more ecological thoughts throughout the designing process is important. What follows is, therefore, an advice on how to tackle the rest of the campus in order to improve the campus' overall ecological value and optimize the environment for the well-being of the campus' users.

11.2 ECOLOGICAL DESIGN

Despite the current design provided by West8 having mentioned the desire to implement ecological value, its execution seems to suggest otherwise. This was seen in, for instance, the species chosen for the bushes and trees, where currently non-native species have been chosen. What the current report has tried to achieve is altering the design as provided by West8 to improve the ecological value created by it.

This, however, has only been done for a specific small area at the campus, namely the creation of an eco-park. Key for the rest of the design as developed by West8 is altering it in order to create a design that truly values the ecology of the environment and tries to optimize this to improve the campus overall. This way, necessary adjustments can be made in time, which will, eventually, make 'ecologizing' the campus' grounds less expensive, and easier to do.

What is vital, is to consider ecological maintenance as well. If there is no change in the current maintenance, a lot of aspects, such as planting a mix of seeds of native flowers, will be in vein, because mowing it away will destroy the ecological value it created. A plan must, therefore, be developed that aims to create a policy for ecological maintenance of the green areas at the campus. This will allow for increased ecological value.

Eventually, the University could opt to consider a green management policy, like the one adopted by the University of Gent. By following the future views as described by the University of Gent (see appendix 14.2), new projects can all gain in ecological value added.

11.3 CONNECTIVITY

One of the ideas that has been implemented in the current West8-design is creating an improved green network on the campus. This is in line with the aims of the municipality of Groningen and could help strengthen the city's ecological network.

However, as discussed in chapter 4, there is room for improvement when considering how to create improved connections. Connectivity is not merely about planting additional trees and bushes, for instance, but the type of species chosen should be carefully considered as well. When doing so for all the areas that are going to be altered in the upcoming years, the value of the connections made can increase significantly.

All in all, this report provides an initial adjustment of the current urban development plan for the campus as offered by West8 to optimize the ecological value the campus' ground could exert. And despite this being a proper start, it is, now, key to implement certain of the proposed adjustments to the other areas on the campus that will be re-developed in the upcoming years as well. It is only then that the campus can be transformed into a truly ecologically valuable site.

12. CONCLUSIONS

It has long been claimed that nature might play a significant role in human well-being. And yet, this apparent vital idea seems to be undervalued when designing the area in which more than half of the world's human population resides. Allowing for a greener habitat for people is beneficial in multiple ways. Not in the least for people's well-being, but also for the ecosystem services provided by greenery. Designs of green spaces in an urban environment should aim to incorporate biodiversity, habitat protection, and sustainable development, since these are not mere social but environmental needs.

When (re)designing urban areas, one of the core values should be to create ecological value. The world, and, in a smaller sense, any urban area, should be seen as an integrated whole. This does, however, suggests a changed role for the designers. The designers are now required to develop a natural area in a way that will allow for it to further evolve and which stimulates the natural processes.

What this study aimed to achieve, is increasing the ecological value of the Zernike campus' grounds in such a way that it also matches the users' needs and desires. By researching how to optimize the current urban development plan in an ecological fashion, and advice for a new design for an eco-park at the campus has been created.

This outline has been developed from an ecological foundation, combined with insights into the needs of the users in order to create a successful design. The advice could be viewed as complementary to the current urban development plan. It kept the basis and values of the original design for the designated area, whilst improving the ecological aspects of the design in order to achieve an increased ecological value.

The alterations that have been made, and the research this report provides to support its claims about the kind of alterations, could and should be further implemented into the other green areas of the campus. It could offer a model to use when assessing the other green areas. Especially with regard to the species chosen, valuable changes could be made, by changing the current non-native species into native species.

As has been mentioned throughout this study, adding to the natural environment of an urbanized area proves to be valuable for both nature and man, and should, thus, not be left out of any urban development plan. Implementing ecology in similar developments offers potential solutions for the ever-increasing problems with the environment. It adds to sustainability and natural preservation, which are both currently under a lot of pressure, globally.

What this report, thus, ultimately tries to show, is the importance of adding ecological value to the core aspects to consider when designing green spaces in urban areas. When striving for a sustainable future that acknowledges our world as a closed system, implementing what is best for our nature is key. We cannot look at a future solely based on human preferences and needs. And when one takes a closer look, you will even find that what humans prefer and what nature needs is not even that far apart.

"Green is the prime colour of the world, and that from which its loveliness arises."

PEDRO CALDERÓN DE LA BARCA

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14. APPENDICES

14.1 APPENDIX 1: SURVEY QUESTIONS

Maptionnaire survey – ecological questions

Introduction
The following questions all relate to the amount of nature on the Zernike campus at this moment and your possible wishes on the development of nature on the campus.

Questions

1. If the weather allows for it, would you like to go for a walk through a park during your lunchbreak, or after work or class?
    a. Yes
    b. No

2. If the Zernike campus would develop an attractive park (with e.g. walking paths, benches and lots of green such as grass, flowers and/or trees), what is the furthest you would be willing to walk to this park?
    a. 50 meters
    b. 100 meters
    c. 250 meters
    d. 500 meters

3. What part of the Zernike campus do you currently find most attractive?
    a. Select an area on maptionnaire

4. Which of the green spaces in the pictures do you find most attractive?
    a.  OR 

5. Which of the green spaces in the pictures do you find most attractive?
    a.  OR 

6. Which of the following images do you currently miss the most at the Zernike, but would like to see? You can select multiple images.

a. 
   i. A pond

b. 
   i. A field of grass

c. 
   i. A park with walking paths.

7. Does the idea of more nature on campus sound appealing to you?
   a. Yes
   b. No

14.2 APPENDIX 2: GREEN MANAGEMENT POLICY AT THE UNIVERSITY OF GENT

12 STARTING POINTS

What follows are the 12 starting points of the park- and green maintenance and policy of the University of Gent (Universiteit Gent, 2014).

1) It aims at a sustainable, dynamic and diverse development of the park where people-oriented, nature-oriented, environmentally-oriented and organization-oriented facets go hand in hand in a harmonious way.
2) It supports a permanent and structured consultation with target groups.
3) It realizes sustainable parks and green areas in which the changing needs of society are met dynamically.
4) It leads to parks and green areas in which the observed social functions are dealt with in an integrated manner.
5) Park and green management systems based on zones with a pronounced main function may, however, better fulfill certain functions, but are less acceptable on large areas of parks and green areas.
6) It retains and increases species diversity where possible.
7) It realizes parks and greenery with a high structure diversity.
8) People-oriented measures are aimed at an attractive and varied park / green in which the user finds his or her liking.
9) The nature-oriented measures aim to maintain and / or increase biodiversity.
10) Due to its environmental character, park and green management complies with the general duty of care for the environment in the environmental policy plan.
11) The organization-oriented measures are aimed at realizing an optimal corporate culture based on quality.
12) The principles of harmonious park and green management are medium- and long-term goals.

FUTURE VIEW

In 2025, all areas of Ghent University will be managed sustainably and ecologically, in accordance with the above-mentioned starting points. In order to achieve this, the vision of harmonious park and green management must be followed and maximally applied to the following principles (Universiteit Gent, 2014):

- There is a great diversity in terms of planting.
- Maximum use of species that stimulate the greatest added value in terms of biodiversity.
- Maximum use of native (autochthonous) plants, not invasive exotics.
- Expert planting of trees so that they can last for a long time.
- Blue space is provided wherever possible.
- Natural processes are taken into account during construction (the right plant in the right place) and with good management, whereby space is given to plants, animals and ecosystems.
- Management is tailored to the specificity of the site (see Aelmoeseneiebos, Botanic Garden, etc.).
- The planting takes place in function of the prevention of noise nuisance, the screening of visual nuisance and to maximum fulfill ecosystem services.
- Various functions can be combined (e.g. fruit production, aesthetic aspects, ...).
- Cultural-historical elements are retained.
- Sustainable road hardening is used.
- Road pavement is used efficiently. Existing paved surfaces may be softened where they are no longer useful.

- The green environment is accessible so that as many people as possible can enjoy it (picnic tables, benches, ...).
- Students from relevant directions are involved in construction and maintenance of the green.