



# Nightscape

*An exploration of the future for the nocturnal urban  
landscape design*

## Colofon

Nightscape: An exploration of the future for the nocturnal urban landscape design

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Author | Aileen Hallie

Student number - 4965086

Delft University of Technology, The Netherlands  
Master | Architecture, Urbanism & Building Sciences  
Master Track | Landscape Architecture

First mentor | Ir. N.M.J.D. Tillie  
Second mentor | Ing. A.J.C. van der Helm

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## Abstract

Light can be a wonderful thing. It allows one to see in the dark. Since the development of lamps, the intention has been to eliminate darkness from the night, as darkness is associated with danger, demons, the unknown, and all sorts of 'scary' things that lurk in the dark. Although light is helpful, dark nights are also needed. Not only did humankind use the position of stars to navigate or measure time, but it also inspired the artistic and philosophical aspects of wonder and awe at night. This thesis project started with a personal fascination for the night sky. The research focuses on the consequences of using artificial light at night. Light not only prohibits sight of the stars but also negatively impacts both flora and fauna. Moreover, that is not the only effect of artificial light at night. The natural human experience of the night also changes due to excessive light use. Darkness is being pushed out of the nocturnal experience under the belief that light leads to safety, while research shows no significant correlation between light and actual safety. Light use at night is continuing. As recent studies show, artificial light at night is increasing by 6% a year on a global scale, causing an increase in light pollution issues. Therefore, this report argues that we are losing the night. It describes the harmful effects of light on nocturnal ecology, human health, and the nocturnal landscape experience. This subject is gaining more interest in recent years but is still underrated and not (yet) put on the agenda of governments and municipalities as much as this report argues that it should. This report aims to contribute to a raising awareness for the topic and as an example of possible explorations of how to treat the experience of the night and nocturnal ecology in design by creating dark connections, transitions in the landscape, and new spatial lighting guidelines for the urban context. The goal is not to switch off light but to examine different possibilities of using light in a night-friendly way. Ultimately, this report could be a sound principle for nocturnal urban design and how to deal with the far-reaching consequences lurking in the light.

**Keywords:** nocturnal ecology, nocturnal landscape experience, light pollution, streetlight, the night, stars, transitional lighting zone, spatial lighting guidelines, artificial light at night



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# Chapter 01

## THE LOSS OF THE NIGHT

*While light at night is welcome, can there be such thing as too much? In doing away with darkness, what beauty do we loose?*

*- Paul Bogard (2014)*

## 1.1. INTRODUCTION

*"For my part I know nothing with any certainty, but the sight of the stars makes me dream."*

- Vincent van Gogh

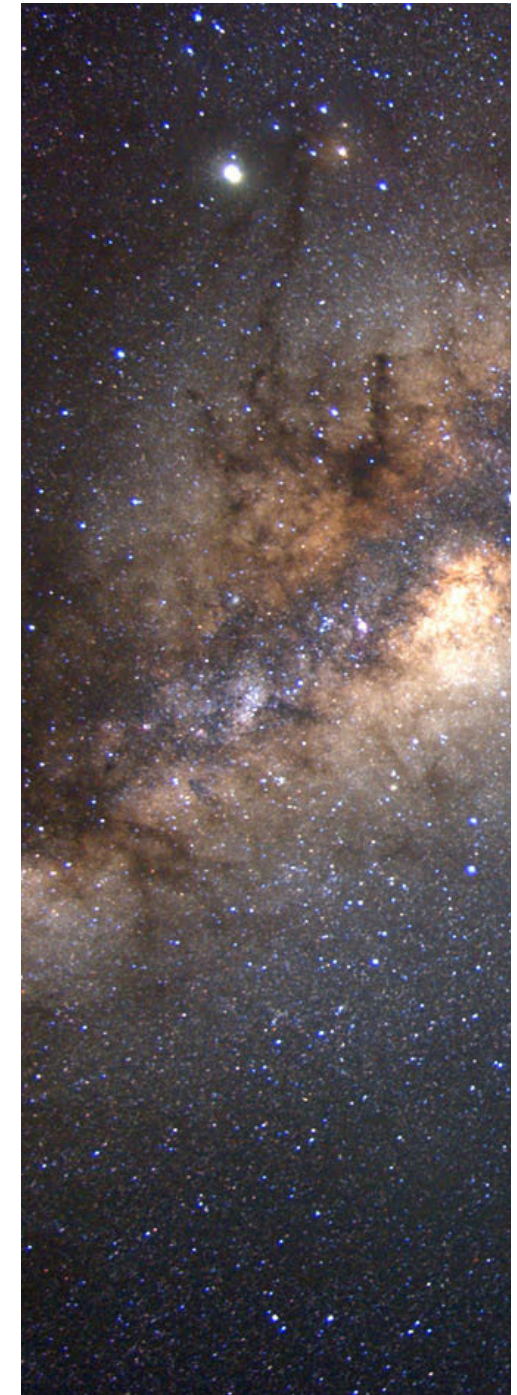
Humankind is losing the night. From the beginning of time, the nighttime and its richness were used in stories, maps, traditions, explorations, and as a big inspirational source. The earth's surface has changed a lot, but the day-night cycle always stayed relatively the same until the last hundred years (Bogard, 2021). The night gives the earth a breath and a pause, but this is slowly being taken away. One can consider day and night as polar opposites. The light and the night are in constant conflict (Stone, 2019). However, one can not exist without the other. Together, they are in balance.

As a child, I was inspired by the stars and always looked up into the dark sky. The readers of this report may have also experienced this feeling of awe and wonder. The feeling of taking a break from the day and entering the mysterious realm of the night. The moment when human senses are recalibrated and when it is harder to judge depth, distances, colours, shapes, sound, and direction. The night is a totally different world than the day (Morris, 2011). How can one location be so different

in its experience? To me, that is a fascinating question because most people know this odd feeling. At the darkest hours, imagination and fascination are the most powerful feelings. However, this experience is in danger. The excessive presence of artificial light is not only altering the human perception of darkness, but it is also affecting nocturnal ecology, human health, and plant growth. Yet the knowledge on the impact of artificial light on our ecosystems is still limited (Spoelstra et al., 2015). It is time to raise awareness to these issues through a fresh look into the opportunities for landscape architects and urban designers. As the International Dark Sky Association (2019) reframes it, dark nights should be considered a universal heritage that needs protection.

Darkness can represent many things. Most of the time, it is seen as a static opposite of daytime. However, this limits one's interpretation of the dynamic and varied ways darkness can be considered as. The understanding of darkness will remain misunderstood since most western cultures see darkness as a place where evil and negativity exist (Dunn, 2020). As stated by Dunn & Edensor (2020), this negative image of darkness was already noticeable in medieval times, when powerful supernatural forces and multiple terrors like ghosts, witches, demons,

hobgoblins, dark elves, and ghouls were lurking in the dark. These stories were further fuelled by Christian beliefs and biblical texts. After all, the devil himself operates in the dark, while God is by definition the light. It was in the Enlightenment period that the perception of darkness changed. The scientists at the time were more interested in the objective knowledge rather than superficial belief systems. In this report, many aspects of light and darkness will be addressed. It is about time the world stops misunderstanding darkness and starts embracing it.





## 1.2. ARTIFICIAL LIGHT AT NIGHT

Since the invention and development of electrical light, the goal has been to eliminate darkness from the night (Bogard, 2014). In 1870 multiple European cities installed a newly invented 'arc light' or 'Moonlight towers' in the city. The intensity was so big that the lights were placed on high lamp posts above the city ground to not blind people with the harsh direct light. This marked the first step towards an increasing problem worldwide that we are dealing with nowadays; light pollution.

The usage of artificial light at night (ALAN) is far from slowing down; it is increasing by 6% per year (Spoelstra et al., 2017). The research that resulted in The New World Atlas of Artificial Night Sky Brightness (Falchi et al., 2016) shows that more than 99% of European and U.S. populations live under a light-polluted sky, and more than 80% of all world populations live in the same conditions (Figure 1.1.). Something as mundane as the Milky Way is invisible to 1/3rd of the world's population, including 60% of European inhabitants (Figure 1.2.) and 80% of the U.S. and more than a million children born today will never experience the Milky Way, and its full extend (International Dark Sky Association, 2017). On the global map, it can be seen that

cities are the most illuminated. The Netherlands jumps out of the image with parts of Italy and England. When taking a look at The Netherlands, it is apparent that the Randstad, especially the Hague and Rotterdam areas are the brightest. Every three years, the Atlas Leefomgeving (Atlas Leefomgeving, n.d.) monitors light emissions. Trends from 2012 to 2018 show that some parts of The Netherlands have a decrease in light emissions and some parts have an increase (Figure 1.3.). This has to do with changing policies in glasshouses and light emissions.

This report explores the altered experiences of the night landscape and ecological effects due to excessive light at night with a focus on The Netherlands. In the absence of artificial light, one might expect true darkness. However, when the eyes get enough time to adjust, one will discover the natural lights of the night. The moon, natural atmospheric emission (airglow), stars, the Milky Way, and Zodiac light are natural light sources (Falchi et al., 2016). Even during a moonless night, the sky naturally emits 22 mag/arcsec<sup>2</sup> (magnitude per square arcsecond is the unit in which the surface brightness of celestial objects is measured). This means it is still not pitch dark (Falchi, 2016). This is called the 'night sky background'. Artificial light can be scattered through the

night sky and cause multiple types of light pollution such as light trespass (light falls where it was not intended), glare (excessive brightness and visual discomfort), clutter (excessive groupings of light sources), and skyglow (excessive brightening the night sky) (International Dark Sky Association, 1988).

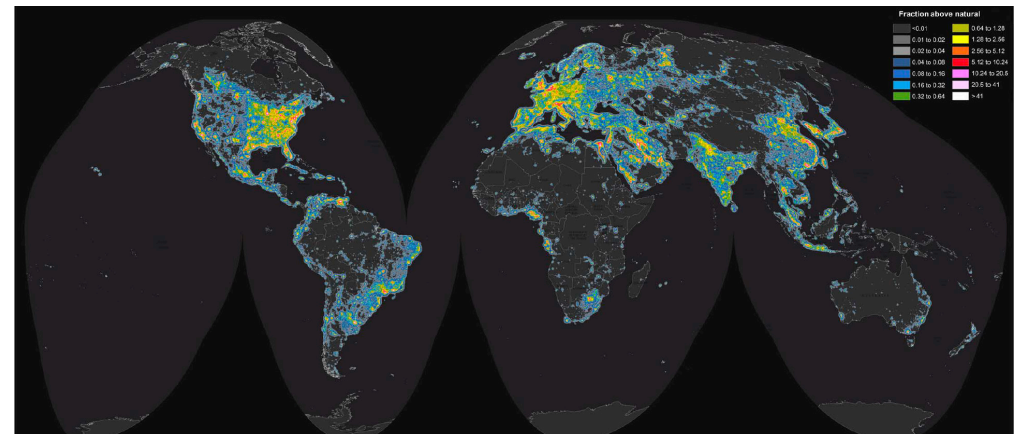


Figure 1.1. World map of artificial sky brightness (Falchi et al, 2016)



Figure 1.2. In Europe, The Netherlands is one of the most light polluted areas, next to Belgium and Northern Italy (Atlas Leefomgeving, 2022)

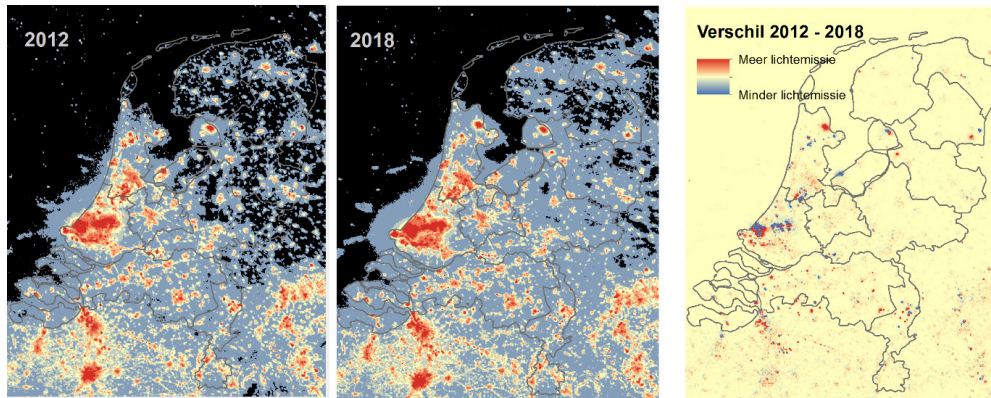


Figure 1.3. Lightemission in the Netherlands between 2012 and 2018 (Atlas Leefomgeving, 2020)

### 1.3. THE OBJECTIVE

Light pollution and the use of artificial light at night are increasing by 6% per year (Spoelstra et al., 2017). Recently, this topic has been broadly researched. However, another problem arises. New lighting implementations may be introduced to limit the upward shining direction, or interactive lighting systems are explored, there needs to be more consideration of the overall experience in the (what I call) in-between-zone of light and dark areas. It might be a strong starting point to think in terms of light and dark areas, but how about the transition between them?

This graduation project aims to find a balance between light and dark and everything in between in a spatial way. The landscape is in constant dialogue with its users during the day

and night (Figure 1.4). It is fascinating to take a closer look at the conflicting needs of human usage of artificial light and nature's need for dark nights. Most often, human interventions are altering the landscape and the way the landscape is being used. Many problems arise when adding artificial light at night; therefore, this project aims to raise awareness for the topic and explore the tender balance between the nocturnal needs of humans and nature. This report specifically focusses on bats since they play a significant role in the nocturnal landscape and are incredibly light-sensitive. They are also the only species that is 100% nocturnally active. Another high percentage of nocturnal activity is amphibians, with 93,3% (Hölker et al., 2010). Figure 1.5. shows the diurnal and, thereof nocturnally active species. However, this does not mean that other species will benefit from

a darker area as well. Therefore, the focus lies on the human experience and bats, but the overall ecological and urban fabric will benefit.

#### Problem statement

One of the problems is the bright lights shining into our eyes, causing glare or other types of light pollution (Dark Sky Association, 1998). This prevents the eyes to adjust to darker conditions and for people to be able to look past the light, into the dark. I have experienced this phenomenon multiple times at night, annoyed that I could not look past the 'wall' of light. While walking in the dark at night, and having interesting conversations with others, I realized that the urban nocturnal landscape has many hard contrasting elements. The pathways are mostly lit and form a big curtain of light which one can not look past. The amount of light creates many boundaries in the nocturnal landscape, making it difficult for people to leave the lit areas. One can wonder why it is important to enter a dark area anyways. This way of thinking already has a bias that darkness is not needed. That is a problem since this report argues that the perception and misunderstanding of darkness should change.

A new perspective can be created when looking at the topic from a different point of view. Insights into the nocturnal ecology, human

perception of a nocturnal landscape, and different attitudes towards darkness will be given in this report. When one considers darkness as a natural, collective heritage, the perception and attitude toward dark places might change (International Dark Sky Association., 1988). Since the invention of streetlights, the intention has been to eliminate darkness at night. However, as this report advocates for darkness, it is important to understand the relationship between darkness, the circadian rhythm, the individual health of organisms, the health of ecosystems on a broader scale, and the ancient relationship between humans and the night

#### Problem statement

No spatial darkness corridor and lighting strategy exists that contributes to a dark urban landscape experience that evokes awareness for the importance of darkness while improving the nocturnal ecology (with a focus on bats)

#### Research Question

How can a new spatial darkness corridor and lighting strategy contribute to a dark urban landscape experience and evoke awareness for the importance of darkness while improving the nocturnal ecology (with a focus on bats)

#### Sub-research question



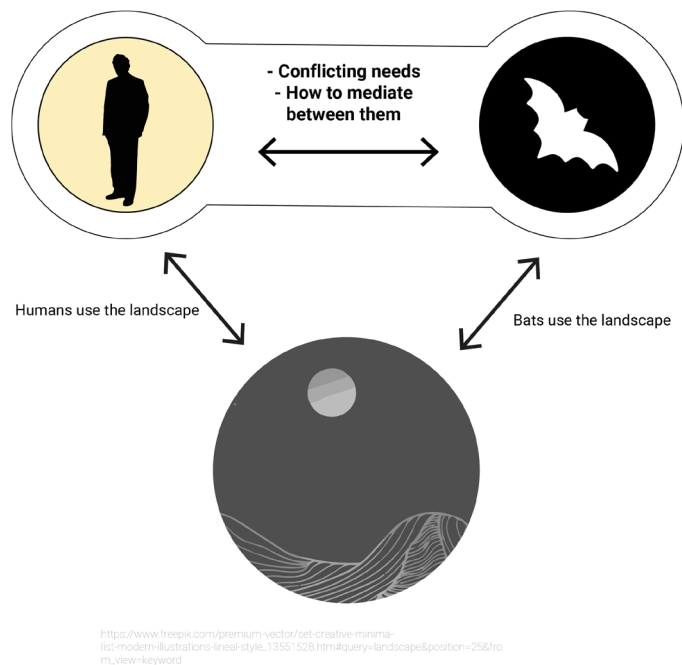


Figure 1.4. The search for the nocturnal dialogue with conflicting needs and experiences between humans and bats

#### Bats and amphibians need the protection of the night

	Estimated number of described species	Thereof nocturnal[%]
<b>Vertebrates</b>		
Mammals	5 488	63,8
primates (incl. <i>H. sapiens</i> )	432	31
bats	1100	100
birds	9 990	19,6
reptiles	8 969	16,6
amphibians	6 433	93,3
Fishes	30 700	14,1
<b>Total</b>	<b>61 580</b>	<b>28,0</b>
<b>Invertebrates</b>		
Insects	950 000	49,4
Lepidoptera	180 000	77,8
Coleoptera	500 000	60
Crustacean	40 000	50
Arachnidae	98 000	5
<b>Total</b>	<b>1 232 384</b>	<b>64,4</b>

Hölker et al. (2010)  
Trends in Ecology & Evolution

7 19.12.2021



Figure 1.5. More species are nocturnal than one might think. These are the percentages of nocturnally active species. Bats are the only ones that are 100% nocturnally active (Hölker et al, 2010).

1. What is a dark urban landscape experience?
2. How to create a lighting strategy?
3. What is a darkness corridor, and how to design it?

#### 1.4. CONCLUSION

In conclusion, the increasing presence of artificial light is causing light pollution, which has significant negative impacts on the environment, human health, and our perception of darkness. The nighttime has always been a source of inspiration and wonder, and it is essential to protect it as a universal heritage. Landscape architects and urban designers can play a critical role in finding innovative solutions to mitigate light pollution and promote the preservation of the night.

While efforts are being made to limit the upward direction of light and implement interactive lighting systems, more attention needs to be paid to the transition zone between light and dark areas. This graduation project aims to find a balance between the needs of humans and nature in the nocturnal landscape, with a particular focus on bats, which are highly sensitive to light. By exploring this topic, this project aims to raise awareness and contribute to a better understanding of the importance of protecting the night.

The issue of bright lights causing glare and other types of light pollution is a significant problem in the urban nocturnal landscape. This creates many boundaries and makes it difficult for people to leave the lit areas, preventing the eyes from adjusting to darker conditions. However, changing the perception and attitude towards darkness can create a new perspective and understanding of the relationship between darkness, the circadian rhythm, individual and ecosystem health, and the ancient relationship between humans and the night. This report advocates for darkness as a natural, collective heritage and emphasizes the importance of finding a balance between light and dark in the urban landscape.

# Chapter 02

## METHODOLOGY AND FRAMEWORK

*Humans are animals as well, and there's no reason to give ourselves any higher level in the ranking than everything else. And so when light/dark cycles mess up seasonal patterns of trees or breeding cycles of amaphibians, which I think is quite well established, there's no reason to think it's not doing the same to us.*

- Steven Lockley (2011)  
(found in Bogard (2014). p125)



## 2.1. METHODOLOGY AND GRADUATION PROCESS

A combination between Landscape Architecture and Industrial Design Engineering (IDE) was made for this graduation project. This combination was necessary since the domain of nocturnal landscape design does not exist (yet). Designing for darkness is a relatively new subject, and I felt the urge to understand more about lighting design. At the faculty of IDE, the course 'Lighting Design' (first semester 2022) was what I needed to understand the complexity of this subject more since I did not know anything about how to design with light. This course opened up a 'new world' for me of endless possibilities and a new way to look at the spatial design. From designing one single lamp to designing a complete lighting plan. My graduation process went towards a lighting plan rather than a single lamp, since a comprehensive lighting system has a bigger impact in the urban context. Light should work together on a big scale to make a lasting impact on the nocturnal experience of the urban landscape and to improve nocturnal ecology. Next to that, I wanted to know more about prototyping and followed another course at the faculty of IDE, called Interactive Technology Design (Second semester 2021). This course allowed me to explore technology

and work with led lights in groupwork. The course taught me to think about interactive design and user-oriented design. This helped me to think in terms of dynamic lighting and how streetlight could react to the users of the landscape.

This report uses two main frameworks to understand the landscape and lighting in the urban context. The first framework is the human experience of a nocturnal landscape. This is important since landscape experience plays a significant role in how the landscape is perceived. Typically, a daily setting is used in a design, however, it is odd that the nocturnal situation is often forgotten in design since it is equally as important. The nocturnal landscape may not be used that intensively, but there are great opportunities to change that. In order to re-connect the night to the human experience, new design approaches should be made to make the night more attractive for recreational purposes. The night has many qualities that one should be aware of and could be enjoyed by those who do not have the time to recreate during the day. A better nocturnal understanding and design will contribute to a better nocturnal landscape experience.

In order to research the nocturnal landscape experience, a literature

study about the importance of darkness was conducted, a questionnaire was made and sent to people who like to make night walks and interesting interviews with Marjolijn van Heemstra and Ruben Hein about the meaning of darkness. Lastly, the author of this report went outside at night and recorded personal experiences and experiences of those who joined in the night walk. It was a challenging and abstract process to explore a nocturnal landscape experience. The results can be found in chapter 3 of this report.

The second framework focuses on the importance of nocturnal ecology, with a focus on bats. Not only has the human landscape experience changed due to the increase of artificial light at night, but flora and fauna are impacted as well. This thesis research uses recent discoveries about the harmful effects of light on the behavior, reproduction, and physiology of both plants and animals (Bennie et al., 2015). Nature has developed its biorhythm based on the natural day-night cycle of the earth. Everything is in sync. However, since the upswing of artificial light at night, the biorhythm of the earth is out of balance. For this thesis project, I focussed on the effect of light on bat species. Bats are fully nocturnal and highly light-sensitive; thus, light greatly impacts them. Chapter 2 of this report explains the far fetching

negative effects of light. The design process itself was very complex, and sometimes more questions arose instead of answers were found. Since this is such a new topic, some assumptions and combinations of sometimes contradictory research had to be made. During the research phase, I got tangled in all the information, research, and new discoveries on this exciting topic. The graduation process was complex, and many steps were taken (Figure 2.1.).

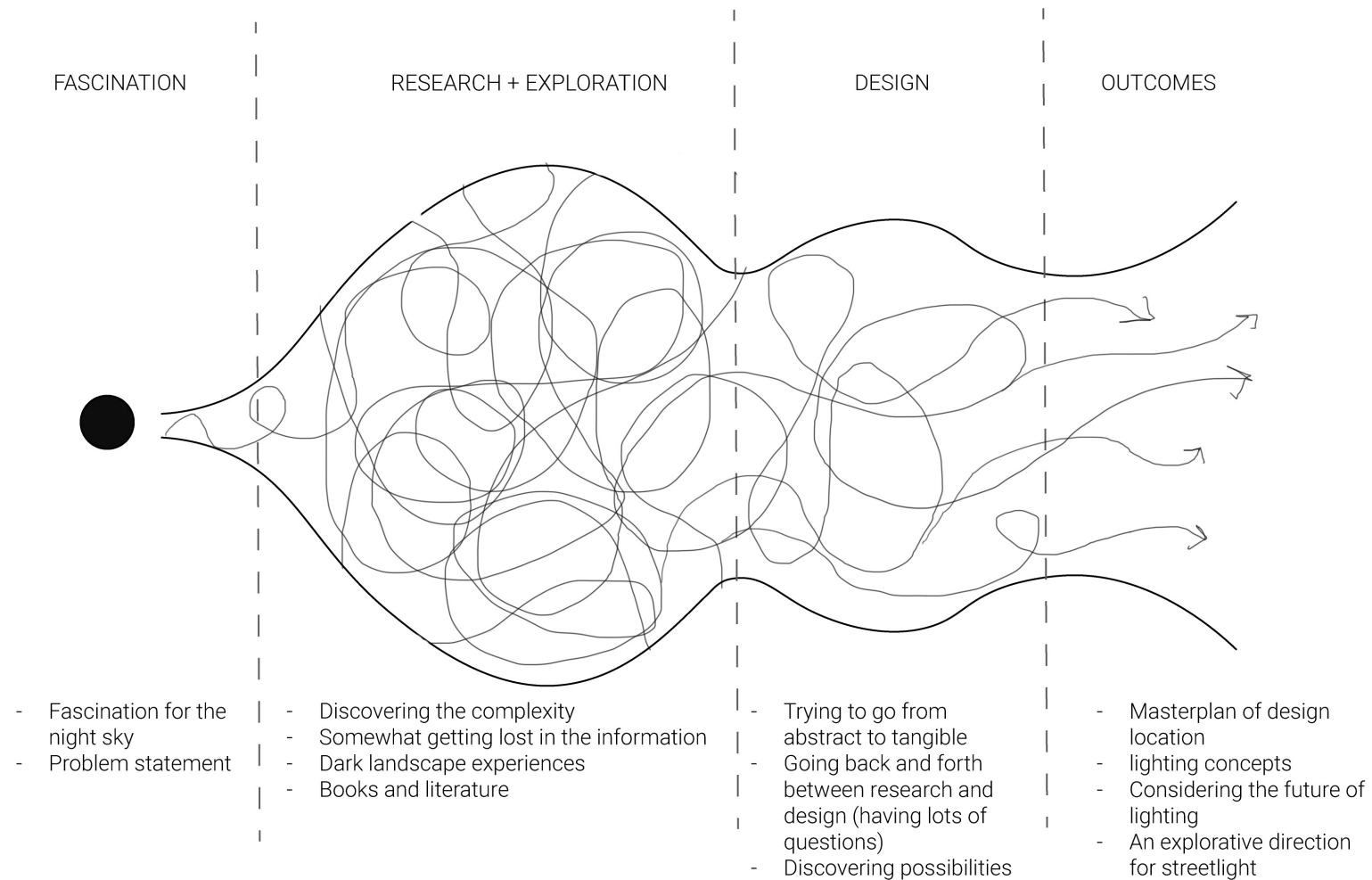


Figure 2.1. The experience of the graduation process. It started with my personal fascination, then quickly became very complex and chaotic. It slowly developed into a design and interesting outcomes. Made by author.

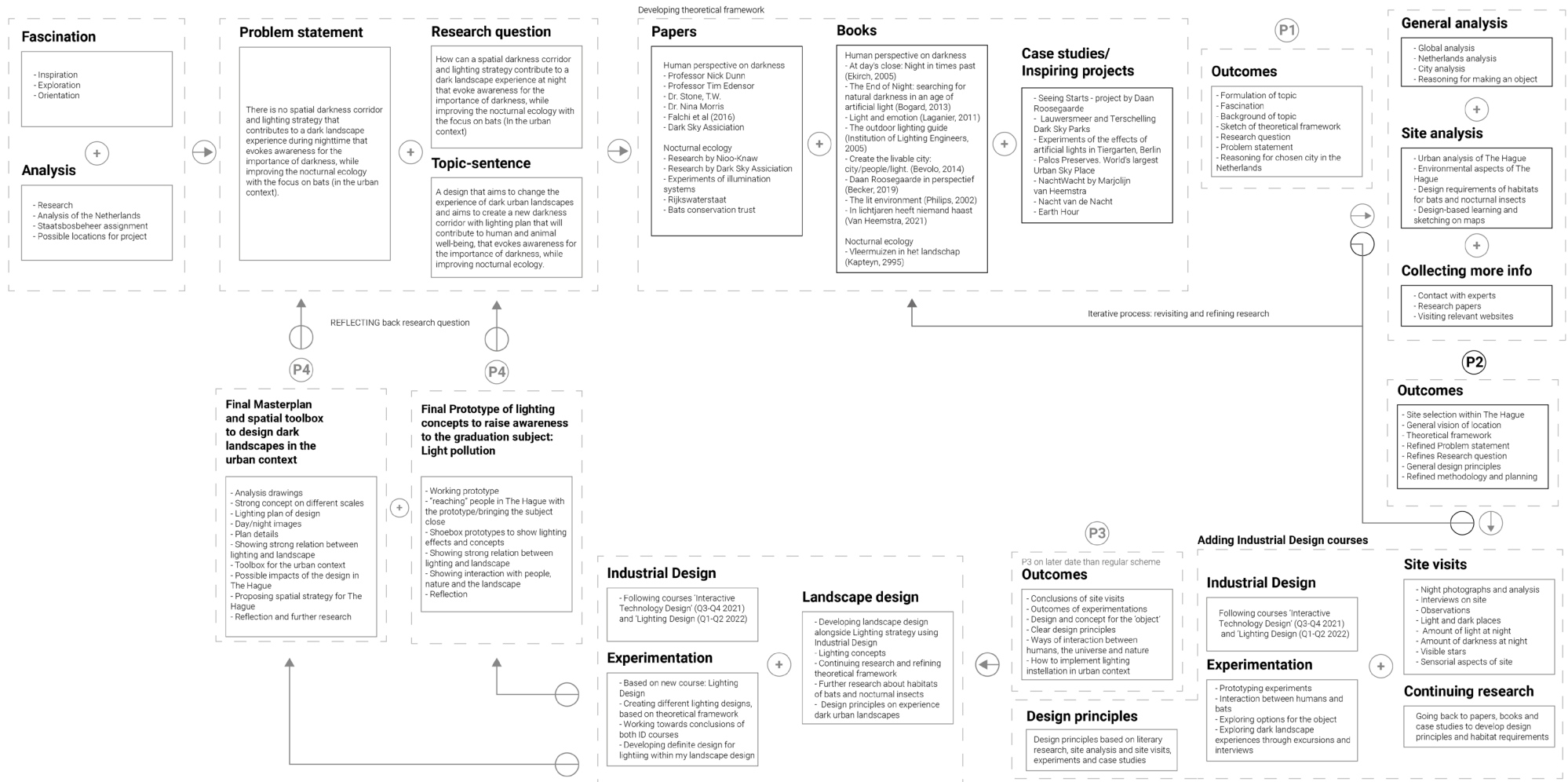


Figure 2.2. The graduation process and main goals. It was a complex and insightful process with additional courses at the Industrial Design Engineering faculty of TU Delft, The Netherlands.



## 2.2. HUMAN NEED FOR DARKNESS

### Human health issues

Humankind is losing true dark nights due to the increasing usage of artificial light at night (ALAN). Next to the issue of losing a valuable natural occurrence, it is important to understand that ALAN brings many health problems as well (Figure 2.3.). Outdoor artificial light at night has been associated with all kinds of cancer (Stanhope et al., 2021). The cause is thought to be the disturbances in hormonal cycles and rhythms in the body due to the disruption of the circadian rhythm (Figure 2.4.). The circadian rhythm is associated with regulating metabolisms, hormonal systems, and cancer resistance (Ouyang et al., 2018, found in Stanhope et al., 2021) and functions as the biological day-night rhythms of our bodies. When the natural rhythm gets out of balance, human health, animal health, and ecosystem health will suffer as a consequence.

### Light and safety

Ever since the use of light, safety has played a significant role. We use light to see and to ensure that we do not fall over a branch or walk into a stone wall at night. So light has many positive and necessary aspects. Nights without light could

be dangerous, and lack of light could have deadly consequences. In the 19th century, European cities used to 'close' the day off. Ringing bells were used to indicate nightfall and everybody would stay in their homes after the sound of the bells. There are numerous stories about unfortunate people being in accidents because they could not see without lights (Brox, 2010). In 1830 a watchman died while chasing an alarming noise. As he ran through a dark street in New York, he ran into a post and died (Bogard, 2014).

When cities used big open fires to illuminate the nighttime, it formed relatively good sight at night, but there was also a big danger due to the uncontrollable nature and wooden houses. Thus ironically, light usage in the 19th century was already required to be balanced.

Even though the link between safety and light has always been assumed,

clear evidence was never found (Dark Sky Association, 1988). Many consider light to be a means to 'show' dangerous people and to provide orientation at night. Nevertheless, there is growing awareness that light shows potential targets and blinds them so they can not see outside the bright areas (Brands et al., 2015). I noticed this phenomenon during a night walk as well. The light is meant to show the way and where to walk. The other areas of the parks or natural areas are usually not illuminated and left dark. This is a good thing since minimal light is scattered through the natural area, but this creates a harsh boundary between lit areas and dark areas (Figure 2.5.). The harsh streetlights and dark offroad areas create visual boundaries and lines in the nighttime landscape. This causes unclear areas, and one might feel scared since it becomes impossible to see what is hiding in the dark, behind the curtain of light. Further explanation of the experience of this

visual phenomenon is explained in chapter 3. The strict boundaries in the patterns of light and dark areas could even create dangerous situations since it is nearly impossible to see what is hiding in the dark. Thus, light shows boundaries, but I would argue that one can see more with less light. Without the bright lights, boundaries would fade away, and the landscape would become visible. Therefore, less light causes more sight.

A research conducted in England and Wales shows that switching off, part-night lighting, dimming light, and white light have no apparent effect on crime rates or increased crime (Steinbach et al., 2015). Another significant research made by a research and analysis unit of the Illinois Criminal Justice Information Authority in 1998 (Morrow et al., 2000) shows that the increasing number of streetlights and lighting levels in Watt had a negative effect on safety and crime.

The intention of the project was to

#### Environmental exposure

Increasing ALAN  
in outdoor space

#### Mechanism being affected

- Endocrine disruption
- Circadian dysregulation
- General stressor

#### Health outcome

- Breast cancer
- Prostate cancer
- Sleep problems
- Poor mental health
- Obesity
- Poor cardiovascular outcomes

Figure 2.3. Health effects of ALAN. Image made by author (made after Stanhope et al, 2021)

increase the feelings of safety and decrease crime in alleys surrounding residential and arterial streets by adding more lights with higher Wattage in those areas and studying the area for a year. The number of criminal incidents increased by 21% after the installation and implementation of this project to make the alleys safer. Every type of crime increased. Offences increased by 14%, property offences by 20%, and other incidents by 24%. The research suggests that the opposite of what most people expect is true about lighting and safety. More and brighter lights do not decrease crime but seem to increase them.

'So, one might feel safe underneath a streetlamp, but this might be an illusion. While light at night is welcome, can there be such a thing as too much? In doing away with darkness, what beauty do we lose?' - Stevenson (2018. Cited in Bogard, 2014, p44).

Just because some light saves us and improves our safety in some ways does not mean that more of it will lead to more safety. When there is too much light, one can not see what is behind or around the light anymore. The light will blind the eyes, one can not see anything anymore. The contrast in our vision is taken away by the light. Thus to improve visibility, contrast is needed, and lights

should be dimmed. This allows the eyes to adapt to lower levels of light. Adaptation takes time. Staying in an illuminated area is fine, but a problem occurs when the illuminated area is next to a dark area. This way, the eyes need to adapt suddenly and do not have enough time to get used to the light (Bogard, 2014).

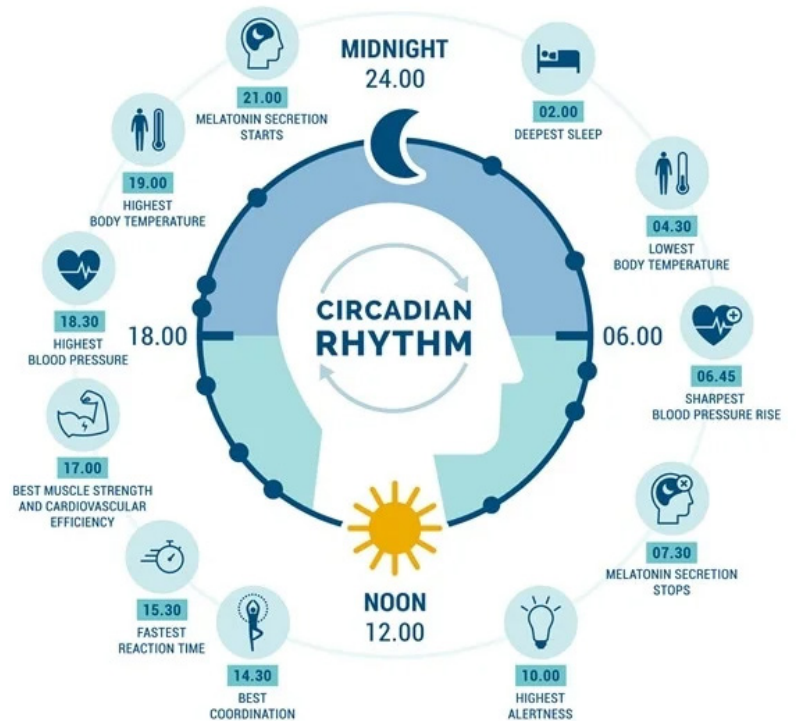


Figure 2.4. The natural circadian rhythm regulates the sleepiness and wakefulness of the human body. This natural rhythm tunes human health. When it is disturbed by ALAN, many health issues can arise. (Smith and Pharm, 2021)



Figure 2.5. The hard contrast between dark and light areas-Bosjes van Pex (30-08-2022, 10PM)

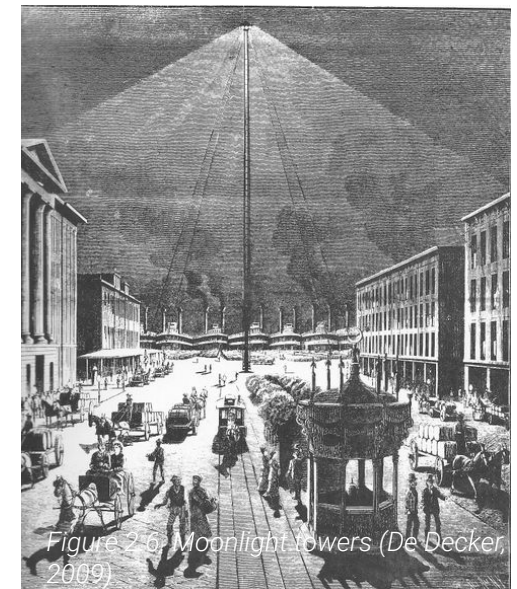
## A new perspective: history and future of streetlight

At the beginning of time, there was only the light of the sun, the moon, and the stars. At night, moonlight would shine through the trees and light up the earth with its soft, gray glow. Animals and plants are tuned to this natural breathing rhythm. It is not clear when humans discovered fire, but the remnants of an 800.000 year old human-made fire were found in Israel (Recker, 2022). After this discovery, fire developed into more sophisticated ways. It was during ancient Greece and Rome that lamps were developed. Around 400 BC, oil lamps were used to see at night and to protect houses (HeiSolar, n.d.). The introduction and use of artificial light at night was very different in different countries (Lintsen, 1993). For the Netherlands, the usage of candles and hand-carried lights was the norm. It was believed that streetlight was unnecessary since people were responsible for their own lights. There was no urge to develop streetlight. Only when European societies' political and social structures changed, the need for light at night began to rise. Artificial light was first applied to factories to illuminate big halls to work longer hours. However, soon the light began to spread out towards streets, squares, markets and homes. The trade market in the late Middle Ages was the start of the public need for artificial light and to

extend the daily activities of thriving economies. The first public effort for streetlight was made in London in 1417 to place lights outside homes to illuminate streets collectively. The governor of London ordered every citizen to place their oil lamp outside their homes to protect their front doors with light against intruders (HeiSolar, n.d.). There were some hanging systems that improved the streetlight, but it was in 1817 that a big-scale lighting system was applied. London was the first city in the world to have illuminated streets (Bogard, 2013). It must have looked spectacular. The development of light did not end there, in 1878 in Paris, the arc lights/moonlight towers were invented and implemented in multiple cities in Europe. These lights were designed to be so bright that darkness would not exist anymore (figure 2.6). However, the lights were so bright and harsh that the lights had to be placed on top of 90m high towers (De Decker, 2009). Soon, the U.S. also adopted these types of lights and implemented them in the cities (Bogard, 2013). However, they needed to be revised. The harsh lights were blinding people, and the lifespan of the installations was short. In 1879, Thomas Edison invented the carbon-thread incandescent lamp, which soon replaced the harsh arc lamps. When the sodium lamps were invented in 1930, all lights were replaced again, and most lights still

have the sodium lights installed. These lights have a natural yellow/orange glow. Only recently was a new type of light invented; the led (light-emitting-diode). Currently, it is an exciting time in terms of lighting development. Dynamic lighting, smart lighting, and the effect of light pollution are being discovered and researched. Designers should take this chance of change to develop more than just dimmable lights. The environment, design, and human experience of the nocturnal landscape should take the center of attention. Too often, colour rendering, financial gain, and feelings of safety are leading topics in the development of light. However, much more is possible. As this subject is still vastly explored, only a little information about spatial effect and implication of dark areas is known. There is more awareness about the importance of darkness, but more is needed. It is not about simply shutting off the lights, it is about how to design with it, in harmony with the landscape itself. Nocturnal landscape design and lighting design should go hand in hand. The world should re-think the definition of streetlight, and not simply as 'just always there during the night,' as many are unaware of the amount of artificial light at night. The future of streetlights can have many different shapes and explorations. Thus further research is needed to know more about the spatial effects of new ideas about lighting. It is only

recently that smart lighting has been experimented with, so designing for the future of streetlights is both complex (with lots of knowledge gaps) as well as a great opportunity to hook on to this topic. That makes the design process (Figure 2.1.) very challenging. However, this did not stop me from picking up the challenge with both hands. Figure 2.7. shows the development of streetlight and the context of this thesis project.





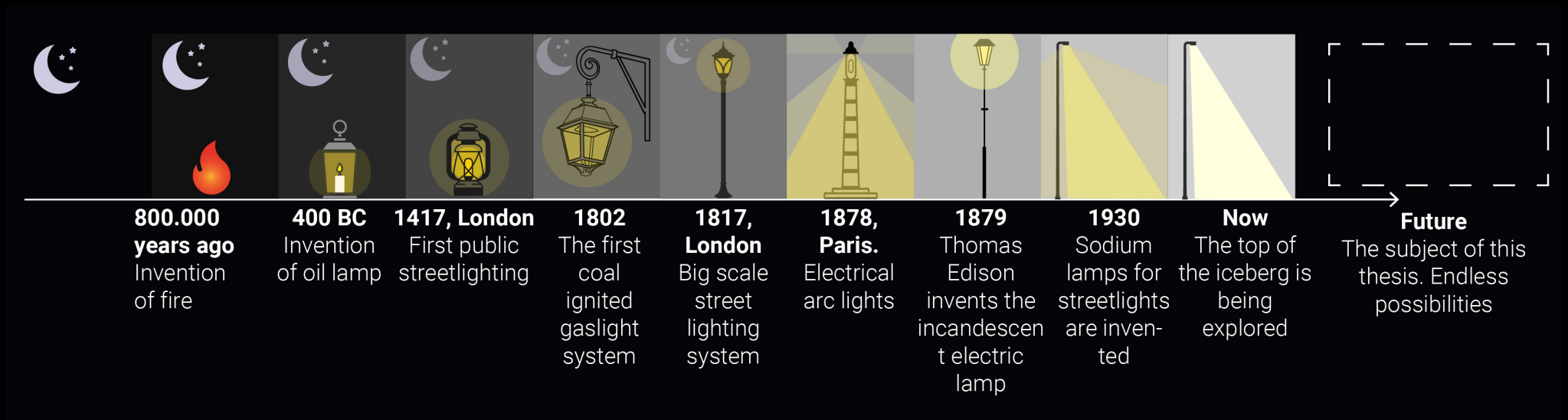


Figure 2.7. The development of streetlight and the futuristic position of this thesis project.

## 2.3.IMPACT OF LIGHT ON NOCTURNAL ECOLOGY

The exact effects of artificial light on nocturnal animals is not researched thoroughly. Moths and bats are most known for their light-responsive behaviour at night. In 2011, a research was carried out in The Netherlands called the project 'Licht op Natuur' (Light on nature) was initiated by multiple institutes and researchers (Vakblad Natuur Bos Landschap, 2017). For this research of 'Licht op Natuur', a test setup was made to measure the effects of different coloured light installations on different species. The activities of nocturnal butterflies, birds, and mammals were observed during the night. A different experimental setup was made near special crossings for amphibians. The experiment was finished in 2017 and can be found here: Het licht op natuur/Licht op het landschap project (<https://lichtopnatuur.org/nl>). From the research, only the tip of the iceberg is discovered. Artificial light influences the physiology, behaviour, and reproduction of both plants and animals (Bennie et al., 2015). Surprisingly, it turns out that animals also use the stars, constellations, and the position of the moon to orient themselves in the landscape (Foster et al., 2018). Figure 2.4. illustrates the far-stretching effects of light on all organisms. However, according to Gaston et al. (2015), the

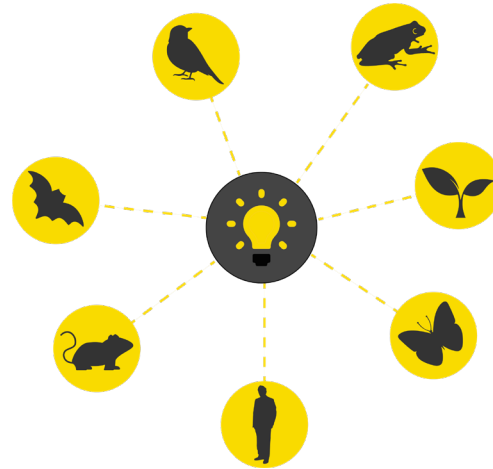


Figure 2.4. Far stretching effects of artificial light. Image made by author

impact on populations, communities and ecosystems remains poorly understood due to the small amount of research.

### Nocturnal butterflies

From the project 'Licht op Natuur', it was discovered that the behaviour of nocturnal butterflies is influenced by artificial light. The animals will fly towards the light and get 'captured' by the light. This way, they will exhaust themselves, get eaten more easily, or harm themselves by flying into an object. According to Bennie (2015), artificial light is considered as one of the big forces behind the decline of moth populations in illuminated cities. Moths are essential pollinators, and herbivores are one of the primary food resources for bats and birds. As Bennie (2015) states, the effects of light on nocturnal butterflies will lead

to a cascading effect in the top-down, bottom-up, non-trophic, and trophic interactions between species. This means that many other species and, eventually ecosystems can suffer from the harmful effects of light on nocturnal butterflies.

### Amphibians

The project 'Licht op Natuur' also showed a significant effect of light on toads at night. Like most amphibians, toads are active at night and attracted by streetlight due to the many insects that collect themselves around the light source, which makes it easy for toads to eat them. This causes toads to risk being killed by traffic. However, during migration season, toads seem to avoid light sources (Van Gunsven et al., 2015). During the experiment in 2012, 2013, and 2014, the results show that white and green light disturbs the toads the most, and red light seems to disturb them the least. Light sources near migration routes can form a big problem in migration for toads. However, Van Gunsven et al. (2015) argue that it is possible to redirect toads towards a safer route by using light during migration season. This way, light can be used in a good way.

### Birds

Light and darkness are the most important signs for birds to activate their activities. The changing day-night rhythm can change the cycle for birds

drastically. An example is the effect of white light on the coal tit. When they sleep near a white light source, the amount of stress hormone is higher than usual, and sleeping patterns are negatively influenced by white light.

### Mammals

The project 'Licht op Natuur' also investigated the effect of light on small mammals, like bats and mice. Most mouse species are active in the dark and avoid all coloured lights. Some mouse species were less affected by red light, but other species would even stop their activities altogether when any coloured light was present.

### Bats

Borges et al. (2016) describe bats as the most important nocturnal pollinators of the vertebrate species. Most of the time, nocturnal animals, such as bats, collect nectar from flowers as a reward in the night. This is beneficial to plants because windspeeds at night are typically lower (less transportation by wind), and opening up the flower at night causes less evaporation than during the day, mainly in warm climates. Thus nocturnal pollination is more common than one might think in warmer climates. Moths and bats are the most species-rich and quantitatively most important in these animal groups. Bats help the agricultural sector by eating the damaging Suzuki-fruitfly, rice moths in Spain, damaging nocturnal

butterflies for wine production in France, and lots of insects that harm maize production in the U.S. (Korsten, 2022). Next to that, bats play an essential role as bioindicators of the landscape (Jones et al., 2009). Based on bat population and behavior, one can determine the status of plant populations on which they feed and pollinate. Many environmental changes are happening globally, and bats are excellent indicators because they are very sensitive to comprehensive environmental stressors, such as rising sea levels, fragmentation of forests, metal pollution, and light pollution. Next to that, bats perform key ecosystem services such as pollination, fruit dispersal, and arthropod control (Jones et al., 2009). Because they are the top predators of the nocturnal insects, they are good indicators for insect populations and environmental changes. Day and night cycles and seasonal changes that affect natural light have been critical aspects in the development of biological and ecological processes (Gaston, Visser, Hölker, 2015). Artificial light causes two main problems. Firstly, light is being introduced in places, times and intensities where it naturally does not occur. Secondly, the light contains a spectrum that is very different from sunlight, moonlight, or starlight. The lights vary in spectrum, from narrow bandwidth, like low-pressure sodium lamps, to broad bandwidth, like high-

intensity discharge and LEDs. This causes many ecological effects, e.g., altering physiology and behaviour. This then causes alterations in resource use, reproduction, mortality, immigration and emigration at the level of populations (Bennie et al., 2015). This alters and restructures biological mechanisms on all scales. This can happen in 3 ways, which is called the cascading effect (Figure 2.6). The direct effect of ALAN can change one species which can lead to a complex and far-fetching indirect effect on other mechanisms, structures and functions. This way, all animal and plant species are connected and influence each other massively. This becomes a major problem for humankind, as humans use the ecosystem services that the landscape provides to us. Failing ecosystems on a broad scale can cause noticeable effects like lack of clean air and water (due to less vegetation that functions as natural filtering systems), food availability, natural resources and building materials and so on. In the case of bats in the Netherlands, insect plagues can take the upper hand, and food resources and financial benefits within the agricultural sector will decrease. The importance of bats in The Netherlands is described in chapter 3.3. of this report.

### Effect of light colour

Light has many properties of its

own. Different light colours can have different effects on organisms (Figure 2.5. (Factsheet Verlichting en natuur, n.d). Since it is impossible to have the most optimal light for all animals, this report focuses on the light spectrum within the orange/red light. The reason is that bats and most other animals experience the least negative effect from this light spectrum and the impact on skyglow is small. Bats are susceptible to light, but their behaviour varies with different light colours. Spoelstra et al. (2017) experimented to measure the responses of bats to different light spectra. This research concluded that white and green light should

be avoided. The light with these wavelengths had a significant effect on all bat species that were observed during the experiments. These included *Myotis*, *Plecotus* and *pipistrellus*. The responses to light have to do with the light-shyness of the bat species. Some species are very light sensitive and avoid light places at night, while other bat species use the light for hunting accumulated insects flying underneath the lamp. The latter sounds beneficial to bats, but it is actually causing a decrease in insect populations due to high mortality rates of insects caused by the exhaustion of being trapped by

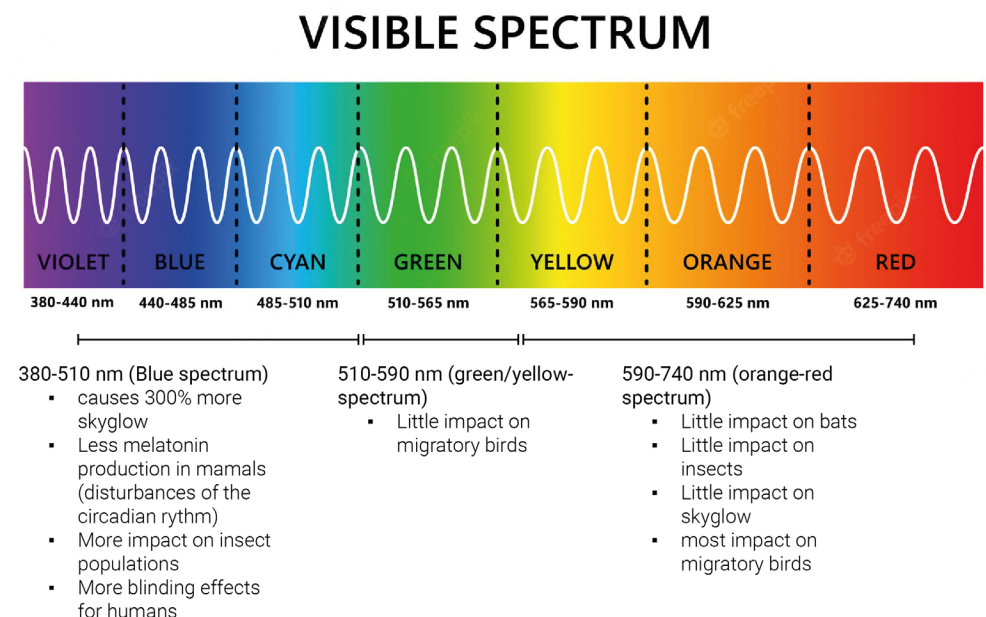


Figure 2.5. Different effects of light on different aspects. Made by author.



the light or being easily caught by predators such as bats. Thus, light pollution contributes to the decline of insect populations worldwide (Boyes et al., 2021).

## 2.4. CONCLUSION

The graduation project is a

combination of landscape architecture and industrial design engineering to design for nocturnal landscapes. The report uses two frameworks to understand the human experience of nocturnal landscapes and the importance of nocturnal ecology, specifically on bats. The author conducted research on the

negative impact of artificial light at night (ALAN) on humans and the environment. Although light is necessary for safety, excessive light can create visual boundaries, blind the eyes, and increase crime. To improve visibility, contrast is needed, and lights should be dimmed. The graduation process was complex, and the author

took courses in lighting design and interactive technology design to understand the subject and explore technology. The report includes research on the nocturnal landscape experience through a literature study, questionnaire, and interviews.

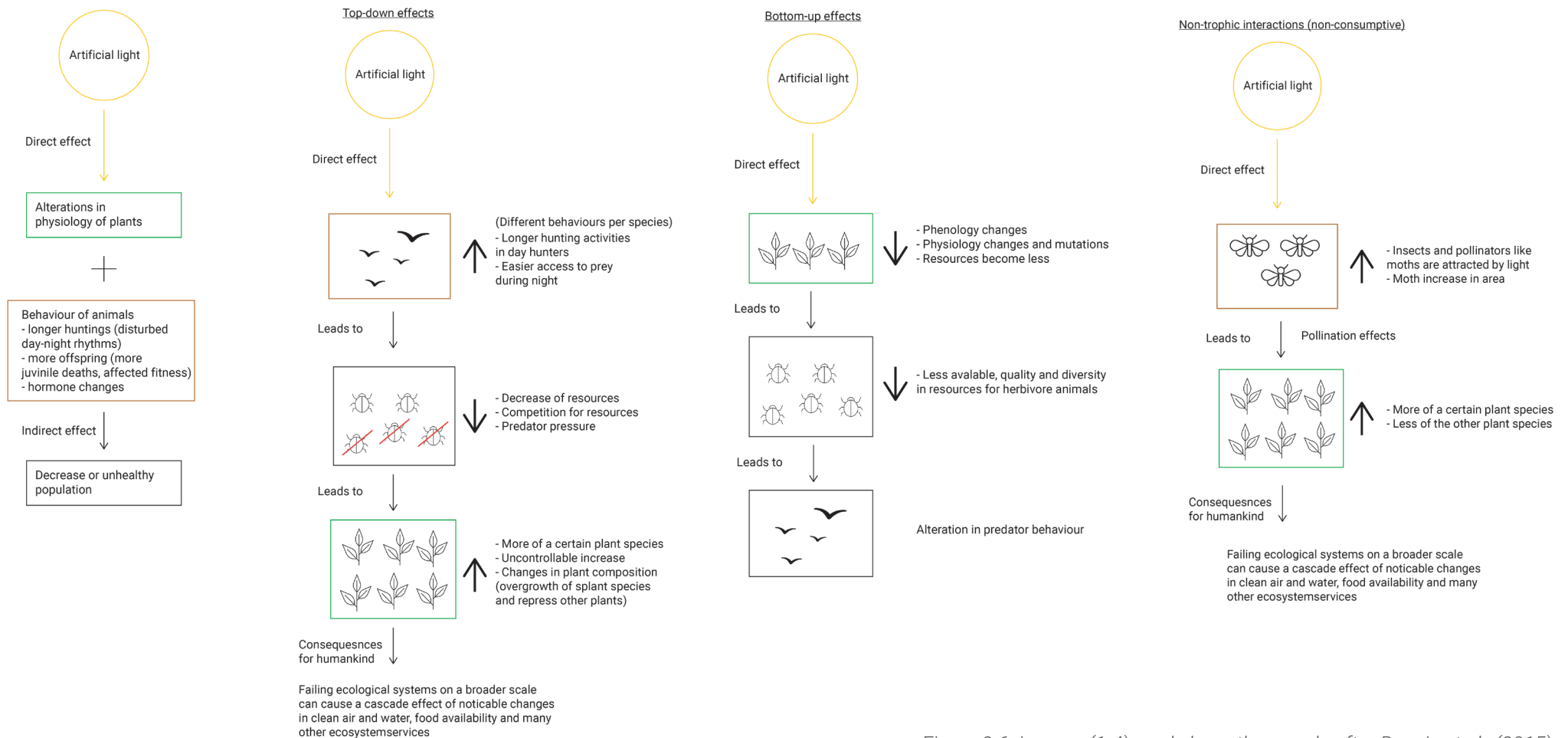


Figure 2.6. Images (1-4) made by author, made after Bennie et al., (2015)

# Chapter 03

## THE DARK URBAN LANDSCAPE EXPERIENCE

*The secrets are very simple. Blend light with the surroundings. Do not annoy the birds, the insects, the neighbors or the astronomers.*

*- Francois Jousse (2010)  
(found in Bogard (2014). p125)*

### 3.1. THE HAGUE AS A CASE STUDY

The aim of the thesis is to find spatial strategies to improve the nocturnal landscape both in terms of human experience and nocturnal ecology, focusing on bats. For this experimental and explorative design approach, the Dutch city of The Hague is chosen to search for possible spatial solutions. The Hague is one of the big cities located in the highly illuminated area called the 'Randstad' and contains many outdoor light sources, such as streetlights, houses, glasshouses (in the Westland area), and a highly illuminated city center (figure 3.1). The excessive light use in the city leads to adverse effects on plants, humans, and nocturnal ecology. The latter forms the majority of the earth's biodiversity (Van Langevelde, 2016) but is mostly overlooked during spatial design processes.

Cities can be considered complex organisms that change and contains flows that require multiple interpretations, views and representations (Martinez-Diez & Santamaria Varas, 2016). Diversity and complexity are essential for a city to be more resilient (Vink, Vollaard & De Zwarte, 2017). The landscape can be approached from many different angles. One can look at the historic layers or geological layers. Most

often, a green, blue and brown layer is studied, even though the dark layer of the city and the effect of ALAN is gaining interest in multiple scientific fields, light pollution has not yet achieved the amount of attention and awareness that other global forms of pollution have gained (Davies, 2017). Figure 3.2 illustrates the layered context of the city and the position of this thesis report.

#### Location and context

The Hague is located on the Dutch coast and was naturally built upon the dunes that were formed by natural processes. Beach, beach ridges, and dunes geologically shape the city. In between the high areas were streams of water that naturally collected the dune water. These lower areas transformed into peat areas. The Haagse Beek is one of those ancient peat areas that collected dune water and is still visible in the city today (de Ruiter, 2009).

The Haagse Beek is a stream that existed long before the middle ages. It was a water stream that collected and transported water from the dunes toward the North Sea. Around the 13th century, the Haagse Beek was adjusted by count Floris IV. He connected the stream with the Binnenhof, the location of the Dutch government, to refresh the waters surrounding the Binnenhof, The Hofvijver. However, this plan failed

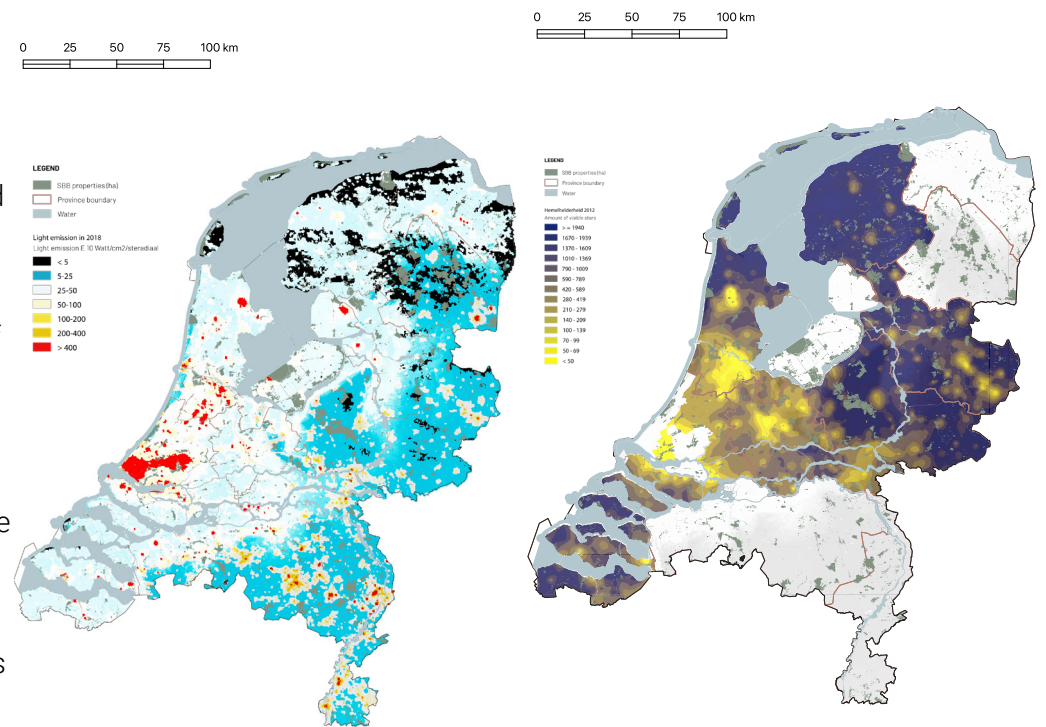


Figure 3.1. The 'Randstad' and The Hague/Westland area are bright red on the Light emission map (left) and the city is located within the yellow area on the 'Visible Stars' map, so little stars are visible (right).

and the stream became a problem in itself due to bad water quality. As the city expanded, houses and roads were built around the Haagse Beek, causing the Haagse Beek to transform from a natural structure outside the city to a natural structure in the urban context. The starting point of the Haagse Beek is near the Westduinen. It goes towards the Meer en Bos and through the Bosjes van Pex. Down the stream, it goes underneath a big canal, the 'Afvoerkanaal.' When it resurfaces, it goes through the

Stadhoudersplantsoen towards Zorgvliet and ends in the Hofvijver, an iconic lake at the Binnenhof. Due to the city expansion, green areas of the city were 'narrowed down' and fragmented. The Haagse Beek area was one of them. During the second world war, the stream was modified dramatically to serve as 'Atlantikwal.' The occupiers used this 'tank ditch' to defend against England when needed. The natural stream was only restored after the war. Nowadays, the Haagse Beek is considered one of the 'green

### Some landscape layers

#### The green layer

- Ecological
- Fragmentation
- Lack of green space

#### The blue layer

- Aquatic ecology
- Water pollution
- Floodings

#### The brown layer

- Soil ecology
- Soil pollution
- Drought

#### The dark layer

- Nocturnal ecology
- Light pollution
- Human perception

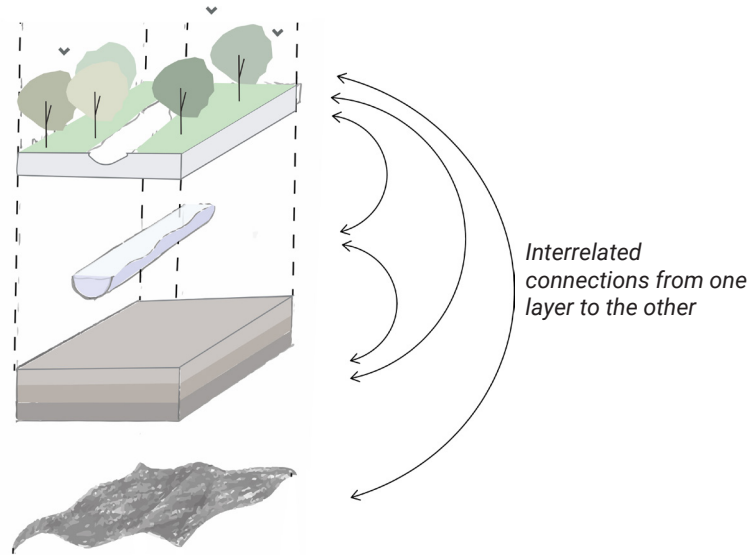


Figure 3.2. Example of some of the layers and its own set of implications for the environment, made by author

arteries' of the city. It is even part of the main green structure for the Hague.

### Darkness corridors

The development of streetlights in The Netherlands first started in The Hague. In 1570, the city implemented 33 candlelights, which a candle lighter would light up at night. In the 17th century, the lights were replaced by oil lights and around 1780, gas lighting took its entrance. In the 20th century, electric light was introduced in The Hague (Baldewsingh, 2010). Today, the city of The Hague is one of the few cities to develop a 'Visie op Licht' (Lighting vision) for the city

([https://denhaag.raadsinformatie.nl/document/6039089/1/RIS298658\\_Bijlage\\_1\\_Visie\\_op\\_Licht](https://denhaag.raadsinformatie.nl/document/6039089/1/RIS298658_Bijlage_1_Visie_op_Licht)). The Lighting Vision of The Hague aims to create four types of lighting zones in the city and its own set of implementation tools. The document describes Eco light, Road light, Living Light, and City light. These different lighting types are expressed in light 'DNA' (colour, colour display, material use, historic lighting, and flexibility for designers to implement their own ideas in lighting designs and lighting plans. Though the document gives general directions for the implementation, it is important to look at the spatial qualities and atmospheres as well.

Further ambitions for the city are to reduce energy use by 40% and slowly replace all lights with sustainable LED lights by the year 2038. This will have a positive financial effect.

The design challenges for designing for darkness are endless. One design concept on the regional scale comes from lighting Atelier LEK, located in Rotterdam, The Netherlands. They developed the idea to create Darkness Corridors in The Netherlands, and the author of this report has been in contact with the founder of Atelier LEK, Iris Dijkstra. The vision of the darkness corridors is that dark areas should be preserved and, when possible, should be spread out like an oil stain in the landscape (Figure 3.3). This way, darkness habitats can be created and connected on a regional and local scale (Figure 3.4).

As urban areas continue to grow, preserving natural landscapes becomes increasingly important. However, this is often challenging when it comes to ensuring that areas of darkness are also preserved. In most cities, natural landscape elements such as water streams, parks, and other green spaces tend to be the least illuminated areas, making them ideal candidates for developing a darkness corridor. When considering the scale of a city such as The Hague (Figure 3.5.), it becomes clear that dark areas are highly

fragmented and surrounded by light. Therefore, it is essential to approach natural landscape structures from a new perspective, one that emphasizes the value of darkness

To create a darkness corridor, possible connections can be made within this fragmented landscape. The Haagse Beek, a water stream that aligns within one of the possible darkness corridors, has the potential to become the primary carrier of the darkness corridor. Given that it is already part of the main green-blue structure of the city, adding the value of darkness to this stream creates a green-blue-dark connection (Figure 3.6.). This will not only preserve a natural landscape element but also create a new habitat for nocturnal species.

By focusing on the potential darkness connection within the Haagse Beek, the vision of Darkness Corridors can become a reality. Figure 3.7 shows the area of focus within this potential darkness connection. In essence, the idea of developing Darkness Corridors offers a new perspective on urban design, one that prioritizes the preservation of darkness as a valuable component of the natural landscape. As cities continue to expand, it is crucial to explore innovative solutions like Darkness Corridors to ensure that natural landscapes are not only preserved but also enhanced.





Figure 3.3. Darkness Corridors concept developed by Atelier LEK (<https://www.atelierlek.nl/projecten/rasa-rotterdamse-academy-voor-stadsastronauten>)

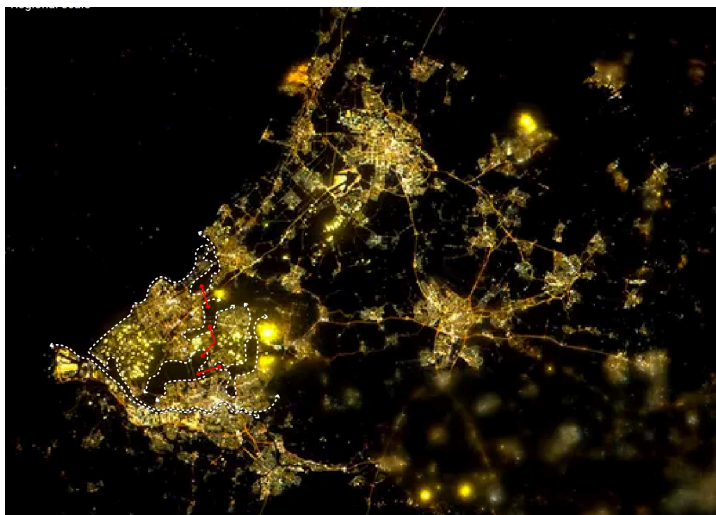


Figure 3.4. Potential darkness corridors on regional scale for The Hague. Made by author.



Figure 3.5. Potential darkness corridors on the city scale of The Hague. Made by author.



Figure 3.6. Dark places 'embrace' the city and possible connections can be made. Dark ribbons cross the urbanized landscape and form the potential to connect fragmented pieces. The Haagse Beek can become the carrier for such combined green-blue-dark connection.

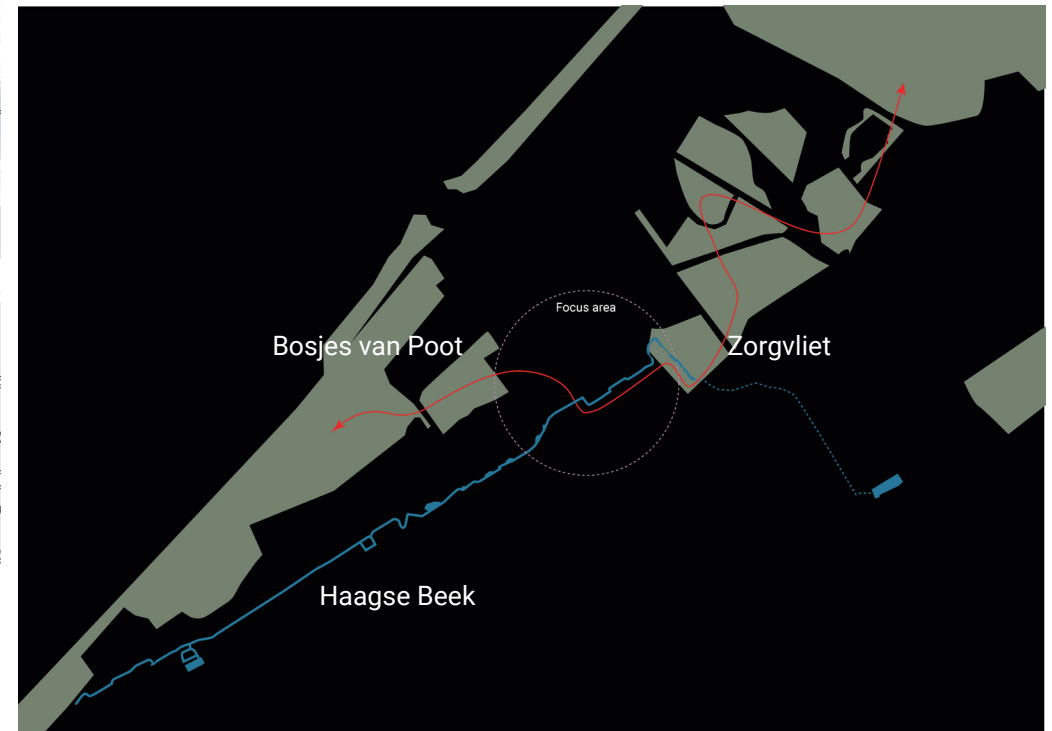


Figure 3.7. The Haagse Beek has the potential to be the main green-blue-dark connector of Bosjes van Poot and Zorgvliet. This area can become the first darkness corridor where people can experience a darkness route in the urban context.



### Site impression

The contrast between the day and night experiences of the area is striking. In the daytime, the area bustles with activity, and the streets are alive with cars and pedestrians. The natural areas and parks are teeming with people walking their dogs, picnicking, and enjoying outdoor activities. The sunlight illuminates the environment, providing a warm and inviting atmosphere. However, as the day transitions to night, the ambiance of the area undergoes a significant change. The once-bustling streets become chaotic and overwhelming, with bright lights from streetlights and cars creating a sharp contrast against the darkness. The natural areas and parks become uninviting, with less foot traffic and an eerie, almost foreboding feeling due to the lack of visibility. The sounds, blinding lights, and sudden movements create an intense and overwhelming sensory experience for those who venture out at night. To illustrate this stark difference, the author has included a series of pictures in Figure 3.8 that capture the contrasting experiences between day and night in the area.

On the other hand, there are advantages to exploring an area at night. For instance, the absence of crowds and the peace and tranquility of the environment can create a sense of solitude and relaxation for those who seek it. Natural areas and parks



Figure 3.8. An impression of the differences between day and night of the design area. Taken on different dates in september 2022.



at night offer a unique opportunity to experience the nocturnal wildlife of the area, which are rarely seen or noticed during the busy day.

## Conclusion

In conclusion, The city of The Hague is selected as a case study to explore possible spatial solutions to improve the nocturnal landscape. The Haagse Beek is a potential primary carrier of a darkness corridor in The Hague's fragmented nocturnal landscape, which could create a green-blue-dark connection. Despite the importance of nocturnal ecology, it is mostly overlooked in spatial design processes. The landscape can be approached from various perspectives, including historical, geological, and ecological. Although the dark layer of the city and the impact of Artificial Light At Night (ALAN) are gaining interest in multiple scientific fields, light pollution has not yet gained the same amount of attention and awareness as other global forms of pollution. This thesis seeks to address this gap by providing spatial guidelines to improve the nocturnal landscape, taking into account both human experience and nocturnal ecology.

The night can provide a sense of adventure and mystery as people explore the area in a different light. The change in atmosphere can be fascinating, and the contrast between the bustling daytime and the quieter nighttime can offer a unique perspective on the area. It is important to consider how the design and placement of lighting can impact the night-time experience of the area, and how it can be used to enhance or detract from the atmosphere. Proper lighting can make the area feel safer and more inviting, while poorly placed or overly bright lights can detract from the natural beauty and make the night feel overwhelming. Overall, the day and night experiences of the area offer two distinct perspectives, each with its own advantages and challenges.



### 3.2. THE HUMAN PERSPECTIVE OF DARK LANDSCAPES

*To go in the dark with a light is to know the light. To know the dark, go dark. Go without sight and find that the dark too blooms and sings and is traveled by dark feet and dark wings. - Wendell Berry (via Bogard, 2013)*

This quote by American poet Wendell Berry suggests that to truly understand and appreciate both light and dark, one must experience them separately. To know the light, one must venture into the darkness carrying a source of light. This allows them to understand the value and significance of the light in illuminating the darkness. Similarly, to truly know the darkness, one must immerse themselves in it completely, without any source of light, and experience it firsthand. This enables them to see that even in the darkness, there is beauty and life, as it is also inhabited by creatures that navigate and thrive in the absence of light. Overall, the quote emphasizes the importance of embracing and experiencing both light and darkness in order to gain a deeper understanding and appreciation of the world around us.

Although the light/dark (day/night) binary is appealing, it is problematic, as power lies not in the final win

of one over the other, but in the instability between the two. Darkness is not an absolute absence of light, and one's perception oscillates between the two. In this regard, geography has given little attention to the interplay between light and dark and their impact on people's experience and understanding of the world around them (Morris, 2011).

Light is often used to show a clear pathway for people to follow, but this creates strict boundaries that discourage exploration of the unknown. Fear of the unknown is caused by the lack of sight in the dark areas, as light is often depicted as a symbol of guidance through the world. One can only move safely and confidently in well-lit areas. Ironically, the light reduces visibility, making the experience of the surroundings less enjoyable. During personal field trips, it became apparent that the sharp boundaries of light made it less pleasant to step outside of one's comfort zone. However, when one dares to venture into a dark area, the distant lights transform from pleasant to annoying. This reveals the paradox that light actually shows less of our surroundings. Darkness, however, reveals the complete landscape, making it limitless. Therefore, the use of light shows limits, while true darkness shows limitless possibilities.

#### The dark landscape experience

It is very difficult to grasp the abstract experience of a dark landscape and make a design based on it. To get a handle on the topic of this part of the research, the author of this report made a questionnaire and held informal conversations about the night with many people as well to inspire the process. Thanks to Marjolijn van Heemstra (theater maker, author, and ambassador of Nacht van de Nacht in 2021), my questionnaire was spread amongst various people who joined her night walks in the Vliegenbos in Amsterdam. The questionnaire was focused on the sensorial experience of the nocturnal landscape. The author of this report also joined in one of the night walks and could add it to the overall sensorial experiences (Figure 3.10). On this night walk, sights became useless. Soon the other senses became stronger. Birds were singing, which was odd since bird sounds are usually associated with sunrise or during the day. Details in the dark stood out, like light colours of materials, flowers, and leaves. Oak leaves seemed almost white against the dark backdrop of the night. During the night walk, depth disappears, and the shapes of shadows and objects seem to change. It felt like another world. All lights outside the forest suddenly became intruders, like objects that did not belong in this newly discovered world. Weirdly

enough, it felt safer in the dark than in the light. One could see all the surroundings while being in the light, only the things that were also inside of the reach of the light were visible.

Based on personal experiences and the experiences of other people who enjoy walking outside at night, a 'canvas' to express the experience of the dark landscape in an artistic way was created. For this process, the technique of a life-book was used with the help and artistic experience of my mother. The process started with a mindmap and many associative words of dark landscapes. These words were categorized into groups of similar words and experiences. The conclusion was three main landscape experiences; the transforming, contrasting, and contemplative landscape (Figure 3.11). These colourful mix media booklets represent the sensations the various nightwalkers experienced in the landscape, which can be used in nocturnal landscape designs.

*Contemplation* of a dark landscape experience is about the peace, quiet and unity of soft shapes and shadows. This is rarely experienced in a city due to the busy energy of cities. *Transformation* happens when colours, shapes, and shadows seem to change in a surprising way. At night, nothing seems as it is. Not only visually, but smell plays

an important role as well. During one of the night walks, smell was a significant indicator of borders in the landscape. One could smell if a forest edge were 'transforming' into a grassland due to the change of smell. Participants of the Nacht-Wacht also experienced the smell of flowers at night, indicating flowering fields and causing a surprising experience in the dark. The *contrasting* nocturnal landscape experience is about all the contradictory elements in the landscape. An example being light and dark places. Sharp boundaries are felt at night, and light colour tones stand out against the dark background. There are two distinctions in the contrasting landscape experience. One is desirable, and one undesirable. The undesirable is already present in current streetlight situations, it occurs when rigid boundaries between light and dark happen, as described before. In a new design, this should be avoided. A desirable contrast is subtle. This is especially noticeable when plants would have a light-toned leave, bark, or flower. At night, it would appear white. Not only colours, but pathways would also stand out, due to different materials. From the questionnaire, it was discovered that people did not always notice the different pathways in a visual way, but could feel it underfoot. This can lead to unpleasant surprises and edges of pathways were not always clear. Large objects, like tree trunks, work

well to indicate edges because one can feel them and sometimes see them in the dark. The full extent of the booklets is included in the appendix of this report. When looking closer into the experience of light, four types of light pollution can be differentiated (Dark Sky Association, 1998). Glare occurs when excessive brightness causes discomfort to the eyes, skyglow is the phenomenon in which the sky is being lit at night, light trespass happens when light is falling into places where it was not intended/needed to fall, and clutter is the excessive use of groups of light sources that are bright and confusing for the eyes. During one of the night walks, these types of pollution were visible. Figure 3.12. shows that only a small portion of the streetlight is falling where it was intended to fall, which is downwards towards the path. However, much light is escaping from this designed direction, causing more problems, which is illustrated in the following two images. Figure 3.13. shows the additional effects that many lights cause together; light clutter. The materials surrounding the light sources become very important in terms of unintended reflective surfaces. This can cause extra light to be scattered around. When entering a dark area, the lights can be seen from within the area, causing glare, trespass, and other forms of light pollution (Figure 3.14). This alters

the experience of the dark area, which then becomes not as dark as it naturally would have been. The dune shapes of this particular area stop some of the light beams, but due to the height of the lamp posts, light can shine through the barks of the trees. In this case, vegetation plays a significant role in the experience of the outside lighting. A layered edge of vegetation would have prevented light from shining into the dark area. Moreover, lower lamp posts and more directed light beams would also have prevented light from leaking into the dark area.

It became clear that the entrances of the dark areas and urban parks are very important 'gateways' to the dark urban landscape experience. During the day, most natural areas are well accessible, and some places are very inviting, like the Henry Dunantpad near the Haagse Beek (Figure 3.15). However, during the night, the place (and especially the entrances of the areas) change dramatically (Figure 3.16). The place becomes uninviting and highly dark compared to the lit surroundings, where one might feel unsafe and uneasy walking down the path. Due to the contrasts of light and dark areas, the dark areas feel like black holes one would not dare to enter. The camera settings made the image appear lighter than the actual situation. In reality, the pathway was not as visible as in the image.

## Collection of dark landscape experiences



### Visibility of colours

- Light coloured plants are well visible in the dark background of the nocturnal landscape
- Contrasts is visible due to different white, gray, blue and purple tones



### Visibility of shapes

- Contours of trees were very visible and some shapes seemed to melt together
- Clear colours are absent and shapes are less sharp



### Experience of visibility of stars

- Peaceful
- quiet
- magical
- overwhelming when not used to seeing stars in daily life
- 



- The touch of leaves against the face can be a surprising and refreshing feeling
- The touch of the humid air and plants makes one feel awake and alive
- Every sense of touch is more intense



### Type of smells

- specific trees
- grasses
- damp/wet air/water
- flowers

### Experience of the smells:

Smell senses become more intense due to the lack of sight at night. The smell contributed to the orientation of changing landscapes. At the borders of forests and grassfields, smells changed, thus indicating a change of the landscape.



### Type of sounds

- leaves of trees
- the wind
- animals in bushes
- Insect sounds (zooming)
- cars
- other humans
- birds

### Experience of the sounds:

The natural sounds were experienced as mysterious and gave the feeling of a pure connection to nature. The dynamics of the surroundings were experienced in terms of sound. The sounds of birds and insects are more apparent during the night. Cars were experienced as annoying.



### Orientation and walkability

- Orientation and walkability was easy when the pathways were visible due to lighter colours of materials
- Walkability is difficult when transitions of materials are too different
- When given enough time to adjust the eyes to the dark, walkability improves due to better vision in the dark

Figure 3.10. A collection of different experiences of nightwalks, conducted from conversations, questionnaire and interviews. Made by author.



Figure 3.11. Three main nocturnal landscape experiences. Made by author.





Figure 3.12. The effects of a single streetlight at night. Made by author

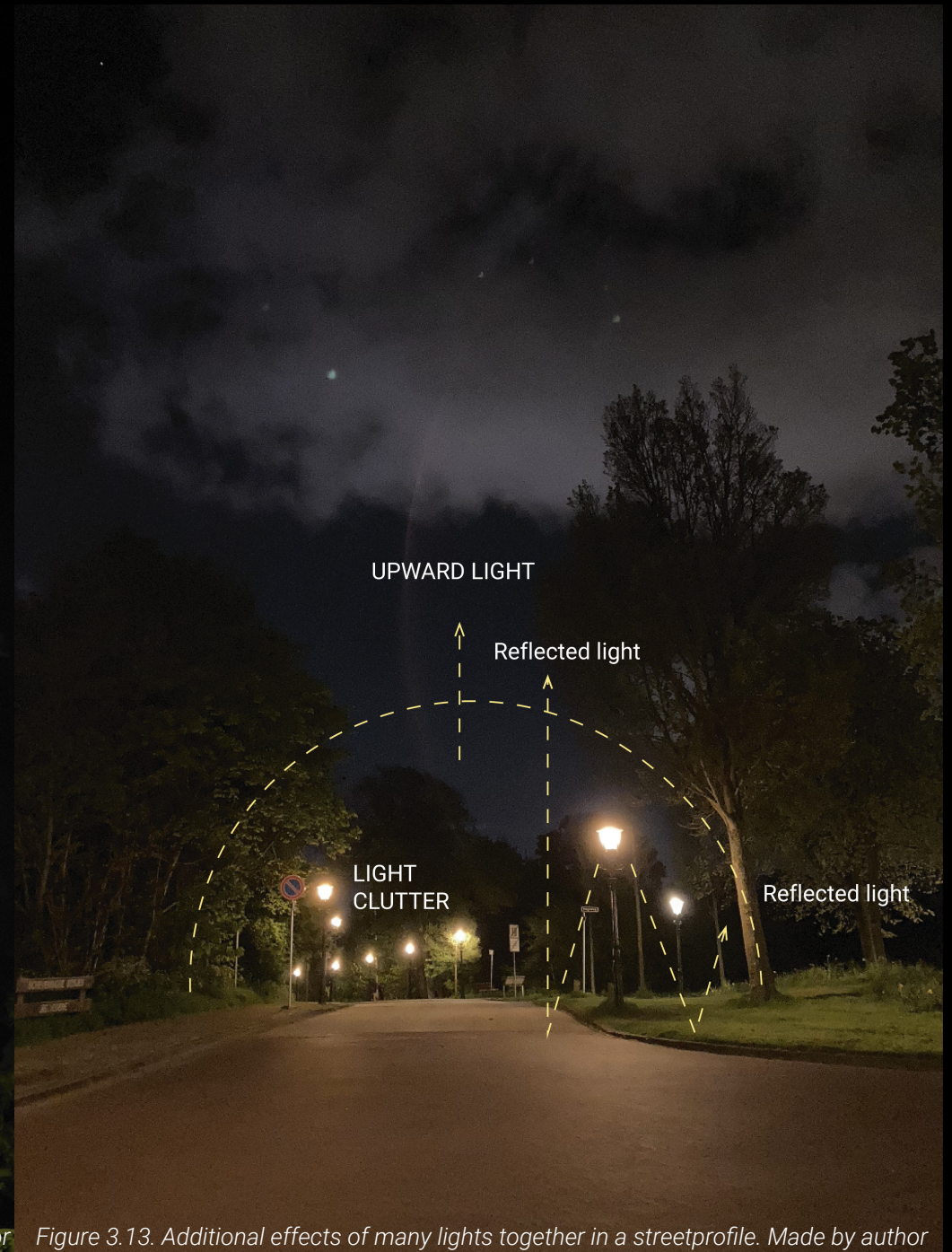


Figure 3.13. Additional effects of many lights together in a streetprofile. Made by author



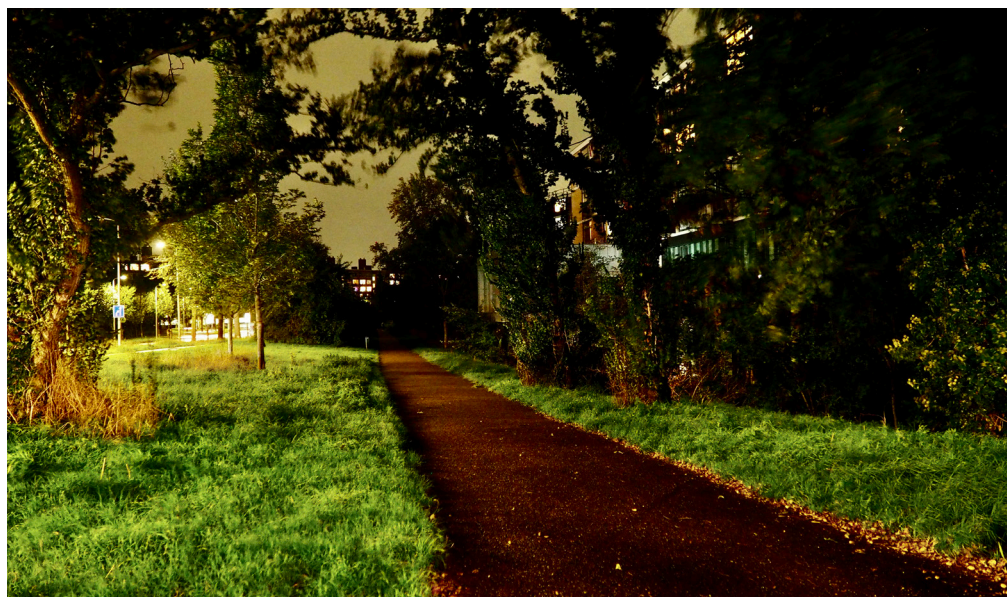


Figure 3.14. The big impact of light on the experience of a dark area. Made by [Paula](#) 83





*Figure 3.15. Henry Dunantpad during the day. This area feels very natural and accessible for people on foot. Made by author on 17 September 2022 at 3.00 PM*



*Figure 3.16. Henry Dunantpad during the night. This area transforms into a dark area with strict borer of light and dark area. (In reality, the area was darker. The camera settings made it image appear lighter). Made by author 5 October 2022 at 9.00 PM*



### 3.3. NIGHT LANDSCAPES FOR BATS

#### Fragmentation of the nocturnal landscape

As green space becomes scarce, fragmentation occurs in almost every aspect of the landscape. As cities become bigger, natural spaces become smaller. Natural habitats such as woodlands and ponds are declining and it is essential to create and protect habitats from further fragmentation. The nocturnal fragmentation of the landscape refers to the breaking up or dividing of natural habitats, specifically during the nighttime. This can occur due to human activities such as urbanization, agriculture, and resource extraction. When habitats are fragmented, it can make it more difficult for nocturnal animals to move around, find food and mates, and maintain their populations. In addition, it can also make it harder for them to adapt to changing environmental conditions.

Light pollution is an essential aspect of the fragmentation of the nocturnal landscape, which can make it difficult for people to see stars and other celestial bodies. In essence, this is a vertical fragmentation of the experience of the nocturnal landscape, causing a visual disconnection between earth and the universe. Moreover, dark areas are needed to maintain the

natural pace of day and night. This rhythm is especially important to bats. Bats have many vital functions in the nocturnal ecological system, and specifically in The Netherlands, bats are the natural pesticides for many insect plagues (Korsten, 2022), like mosquitos and insects that form a plague in the agricultural sector (Figure 3.17). In order to understand these little creatures, it is essential to know that different bat species exist. The book by Kapteyn (1995) describes that different species have different body types and hunting habits that prevent competition between bats (Figure 3.18). One should not consider the bat as one species but rather as a multitude of different creatures of the night. Each species has its own set of preferences and usage of the landscape. The flying routes, habitat, light sensitivity, residence preference, and flying distances differ per species. Figure 3.19 shows the table with these aspects per bat species. Some hunt in the open landscape, others in a closed landscape or on the water surface. Although every species has a different way of using the landscape, making a general set of design guidelines for bats in The Hague is needed to design with.

#### Regional

The dunes in the Netherlands are an essential part of the habitat for several bat species, including the greater mouse-eared bat, whiskered



Figure 3.17. A Pipistrelle eats 1000 mosquitos, moths and beetles per night. That is 210.000 insects per year (Korsten, 2022).

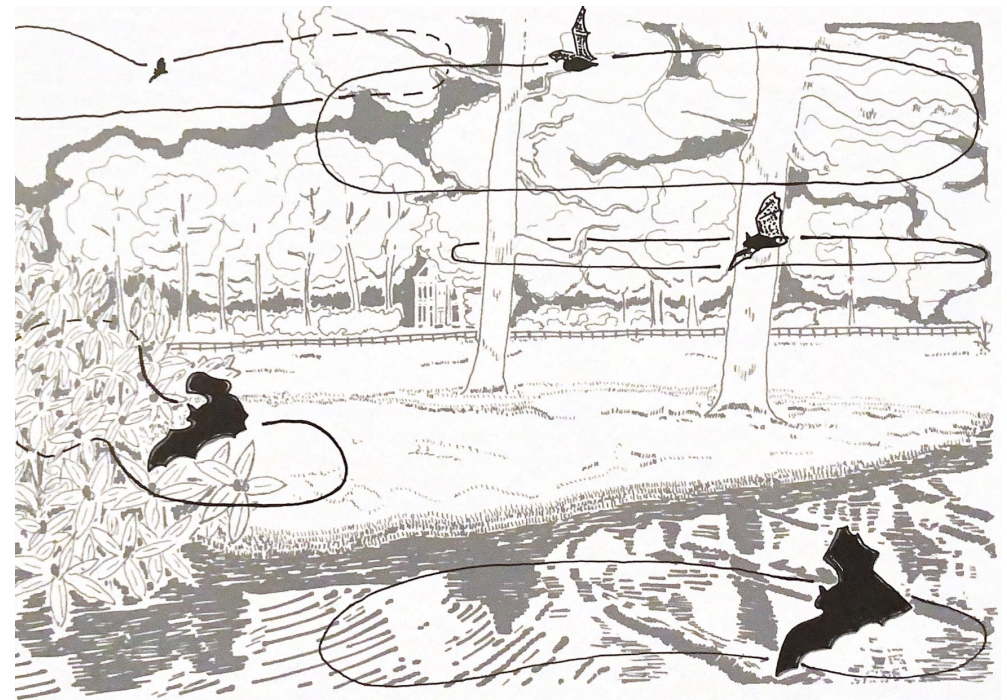


Figure 318. Different bat species have different hunting habits and bodytypes to prevent competition between species (Kapteyn, 1995).



	Status	Licht jacht	Licht route	Verblijfplaats		Afstanden	Vliegroutes		Jachtgebied
Baardvleermuis	Z					1-10 km ••			
Watervleermuis	A					1-20 km ••••			
Meervleermuis	Z					1-30 km •••••			
Franjestaart	Z					1-10 km ••			
Ingekorven vleermuis	ZZ					1-10 km ••			
Gewone dwergvleermuis	A					1-15 km •••			
Ruige dwergvleermuis	VA					1-20 km ••••			
Rosse vleermuis	VA					1-40 km •••••••			
Laatvlieger	A					1-20 km ••••			
Tweekleurige vleermuis	ZZ					1-30 km •••••			
Grootoorvleermuis	VA					0-5 km •			
Grijze grootoorvleermuis	ZZ					0-5 km •			

Figure 3.19. A schematic overview of the 12 most spotted bats in The Netherlands. A = general, VA = somewhat general. Z = rare, ZZ = very rare. The table shows light sensitivity, residence, distances, flying routes and habitats (Limpens, 2004).

bat, common pipistrelle, and parti-coloured bat. These bats spend eight months of the year underground in winter, with more than 2,000 individuals overwintering in the underground bunkers and passages in the dunes. These bunkers were originally built as defensive structures during the First and Second World Wars, but since the late 1970s, they have served as breeding and wintering sites for bats. During the summer, bats live in the inner dune edge or polders. Every year, the entire population flies back and forth between the dunes and the inland areas. The winter population in the dunes constitutes approximately 10% of the total Dutch population of bats and is a particularly high density of bats in Europe. In fact, the greatest European concentration of the greater mouse-eared bat overwinters along the Dutch coast. Due to this, the breeding and wintering sites of bats in the dunes have been designated as Natura 2000 areas with the greater mouse-eared bat as the target species for conservation. These areas include Berkheide and Meijndel, Kennemerland-Zuid. (Haarsma, 2015)

Bats migrate solitarily or in small groups, and their migratory behavior is challenging to observe except where they are compelled to follow a fixed structure, such as on the Afsluitdijk and Houtribdijk. It is suspected that most routes to the

dunes are used between mid-July and the end of October, with the return to the polders taking place between March and May. Bats primarily migrate around midnight and during calm weather conditions. The majority of the routes are presently unknown, and an unknown route cannot be protected, which can have negative consequences for winter populations. The map (figure 3.20) depicts the known regional routes along the coast, which reveal that only a few locations appear to have bats crossing the road or going underneath via a viaduct or tunnel (Haarsma, 2015).

### Bats in The Hague

In The Hague, 12 bat species can be found. This number is relatively high because there are only 21 bat species in The Netherlands (Vogelaar et al., 2017). This makes it very important to protect and design for bats in the city of The Hague, to prevent a decrease in the number of bat species. As mentioned before, some bat species are light-shy, and some are not. Specifically for The Hague, bats can be divided into two groups based on their light sensitivity.

#### 1. Light sensitive bats

- Myotis daubertonii (watervleermuis)
- Myotis dasycneme (Meervleermuis)

- Plecotus auritus (gewone grootoorvleermuis)
- Vespertilio murinus (Tweekleurige vleermuis)
- Myotis mystacinus (Baardvleermuis)
- Myotis nattereri (Franjestaart)

#### 2. Non-light sensitive bats

- Pipistrellus pipistrellus (Gewone dwergvleermuis)
- Pipistrellus nathusii (Ruge dwergvleermuis)
- Eptesicus serotinus (Laatvlieger)

### General guidelines for bats

Design guidelines for bats can be established despite the varying ways in which different bat species utilize the landscape. This is particularly relevant for The Hague, where the pipistrellus and Myotis species are prevalent. As demonstrated in Figure 3.21, there are general guidelines that can be followed to ensure the well-being of bats in urban landscapes. Additionally, this figure depicts the potential challenges that may arise and the corresponding solutions. These solutions include reducing fragmentation of areas, increasing green spaces, establishing connections through hop-overs, and creating darker areas or a shadow side for light-shy bats and other light-sensitive animals to use.

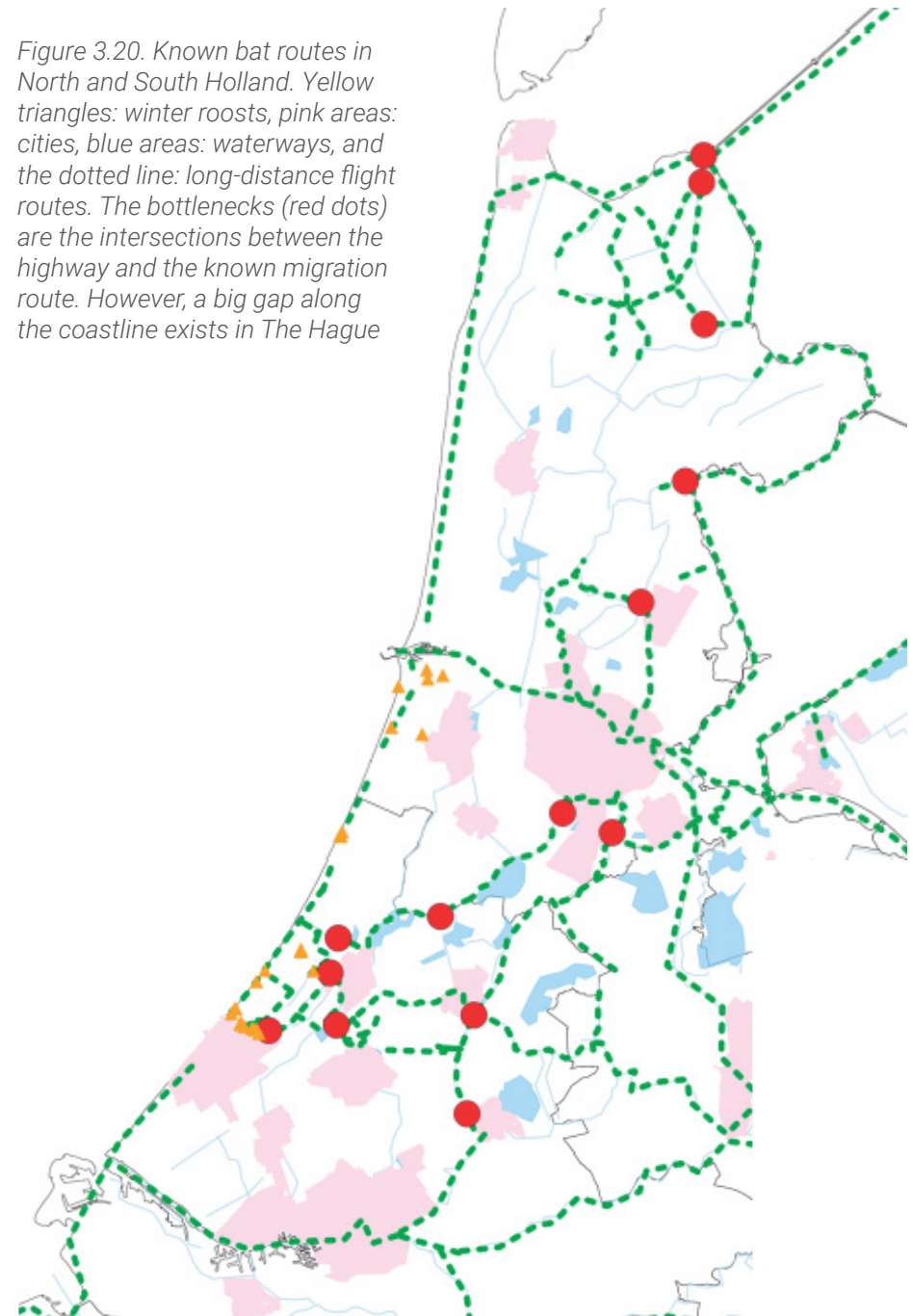


Figure 3.20. Known bat routes in North and South Holland. Yellow triangles: winter roosts, pink areas: cities, blue areas: waterways, and the dotted line: long-distance flight routes. The bottlenecks (red dots) are the intersections between the highway and the known migration route. However, a big gap along the coastline exists in The Hague



The creation of a connected network of dark spaces, open and closed landscapes, waterways, and linear structures is crucial for the survival of all bat species. This network, when established, will not only benefit bats but also other nocturnally active animals like amphibians, moths, and small mammals, ultimately making the area more accessible and livable for all. At a larger scale, this network of the Haagse Beek has the potential to connect the Westduinpark-Bosjes van Poot- Zorgvliet-Meijendel area. By adhering to these general guidelines, a diverse network of spaces can be established to enable nocturnal life to flourish.

Some key aspects are the following:

#### *Stimulate diverse insect populations*

- Enhance flowers and understorey to stimulate diversity in the insect population in open landscape areas
- Native trees attract most insects
- Create unmown areas
- Climbing plants can create green vertical space for bats and insects

#### *Water elements*

- Maintain freshwater sources
- Create or maintain various water ponds of different sizes for different habitats
- Stimulate water plants

#### *Roosting elements*

- Native old trees should remain in the landscape for roosting potential
- Use a buffer zone of trees, shrubs and understorey surrounding a (potential) roosting tree of 1,5 times the canopy
- Buildings nearby bat habitats can become good roosting places; add artificial hibernacula near potential houses

#### *Commuting elements:*

- Routing between roost and foraging areas are fundamental to all bat species
- Commuting routes make use of linear structures of the landscape, these should be added or maintained
- Tree lines and hedges have the potential to connect fragmented landscape patches for bats and other animals
- Avoid gaps greater than 10m, as bats are not able to hop over
- Add dense grasses, flowerbeds and hedges to stimulate safe places for diverse animals such as toads, spiders, and invertebrates
- Light should be avoided in these commuting elements
- Use eco passages for nocturnal animals

Figure 3.22 shows the main bat species that are active in this specific area in The Hague. Most diversity is detected in the Zorgvliet area and Westduin and Madestein areas. Additionally, the Haagse Beek can

#### Linear landscape structures

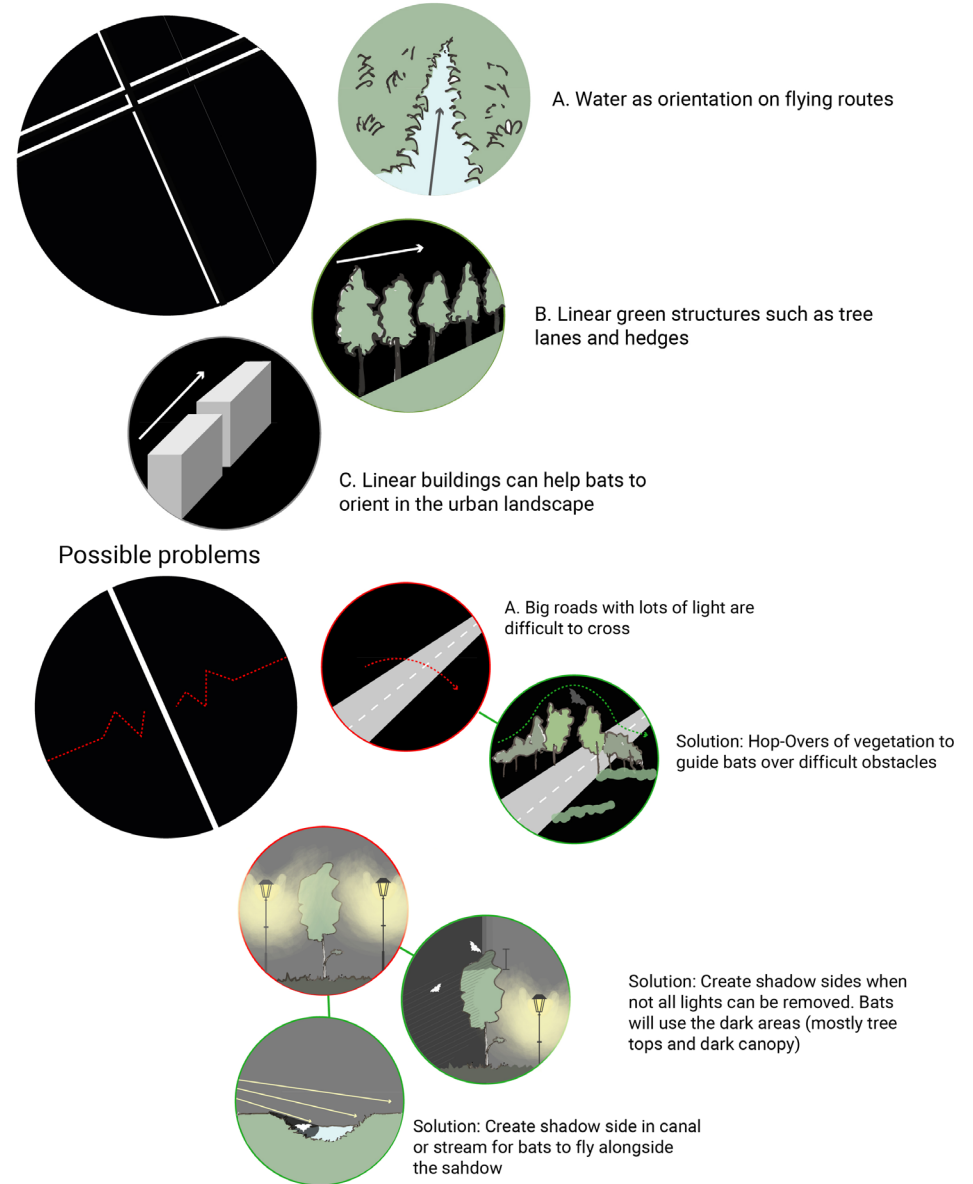


Figure 3.21. Some general guidelines of landscape structures for bats. To connect roosting areas and foraging areas, linear shapes such as tree lines, waterways, and buildings are important elements. Most bats avoid excessive light at night; thus, it is important to create shadow sides and hop-overs to cross difficult barriers in the landscape and create a continuous landscape flow for bats and other nocturnal animals to use.

be a great connector to combine the green-blue-dark structure. However, there are some difficulties existing in this structure that prevents a strong green-blue-dark connection. This is illustrated in figure 3.23. Big gaps can be seen in the nocturnal landscape, and the locations correspond with roads and housing, cutting off the natural linear structure of the Haagse Beek area. This goes hand in hand with lighting, creating obstacles within the green-blue-darkness areas. Fragmentation confuses bats, and crossing the barriers becomes difficult. The *Pipistrellus* is the most active in this area, probably because they are the most optimistic species and less light-sensitive than other species. Only the *Pipistrellus* can pass the highly lit areas and overcome the light barriers. Other species might find it more difficult, especially the very light-sensitive *Myotis daubertonii*, which could use the Haagse Beek water structure, but the map shows little activity in this area.

Another vital aspect of bats is the timeframe of activity. It is important to anticipate their most active timeframes during the night. Het Lux Lab describes four timeframes: morning, evening, late evening and night. The *Pipistrellus* and the *Myotis mystacinus* species are active very early, just after sunset (Kapteyn, 1995). The *Eptesicus serotinus* follows and when it is truly

dark, *Myotis daubertonii* and *Myotis dasycneme* will fly out. Most of their active hours is related to their light sensitivity. When the weather is cloudy, bats will fly out sooner and when sunset and sunrise change due to seasonal change, the activity of bats changes with it. It is essential to implement these timeframes in streetlight technology.

In summary, fragmentation of the nocturnal landscape refers to the negative impact of human activities on the natural environment at night, including the loss of habitats, the disruption of animal behavior and the reduction of dark skies.



Figure 3.22. Map shows bat activity in the design area of The Hague.

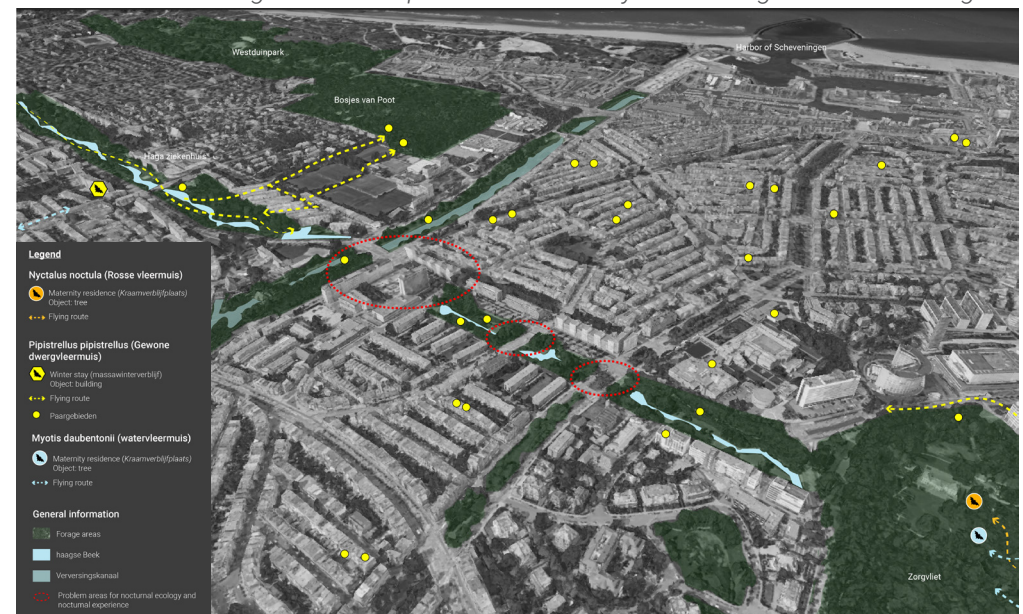


Figure 3.23. Axi image of bat activity of the design area and problem areas



### Lighting developments

As cities change and develop, Cities are constantly changing and evolving, and the need to address the impacts on biodiversity comes with that. Urban areas have the potential to play a significant role in supporting native species and enhancing local ecosystems. The 'Landscape and Urban Design for bats and biodiversity' document by the Bat Conservation Trust serves as an excellent example of how cities can integrate ecological principles into their urban planning and design processes.

However, while there is growing awareness of the negative impacts of artificial lighting on both ecosystem health and human health, new findings must be implemented in a thoughtful and suitable way.

The Netherlands is currently experimenting with bat-friendly lighting, which has the potential to reduce negative impacts on bat populations significantly. These lights have longer lifespans and require less maintenance, making them more sustainable and cost-effective than traditional streetlights (Figure 3.23). The LED lights are ambercoloured and contain monochromatic light with a wavelength of 590 nm and colour temperature of 1700K up to 2200K (Hommen, 2022).

Despite the potential benefits of

bat-friendly lighting, there is currently no clear spatial design or plan for how to integrate these lights into the urban environment. Often, these lights are simply placed next to traditional streetlights, which can create a jarring contrast in color and atmosphere (Figure 3.24). This can be particularly harsh for pedestrians and other users of the urban environment, as it disrupts the overall sensory experience of the space. In order to address this issue, it is essential to develop transitional lighting plans that help to soften the boundary between different light colors, intensities, and levels of darkness. This can help to create a more seamless transition between different lighting conditions and enhance the overall experience of the space for humans and other living beings alike.

One particularly promising example of successful transition lighting can be seen in the 'Het Lux Lab: Onderzoek Strijp-S-Eindhoven' project in Eindhoven (Zonneveldt, n.d.). This project focused on the intersection between human behavior and different lighting, and its success in integrating different light colors and intensities offers important lessons and inspiration for urban designers and planners. In particular, there is significant potential to experiment with vertical lighting design by making lamp posts smaller and testing out interactive lighting. By embracing



Figure 3.23. An example of a batlamp. Light is soft and warm and has no negative effect on bats, insects and other nocturnal animals (Hommen, 2022)

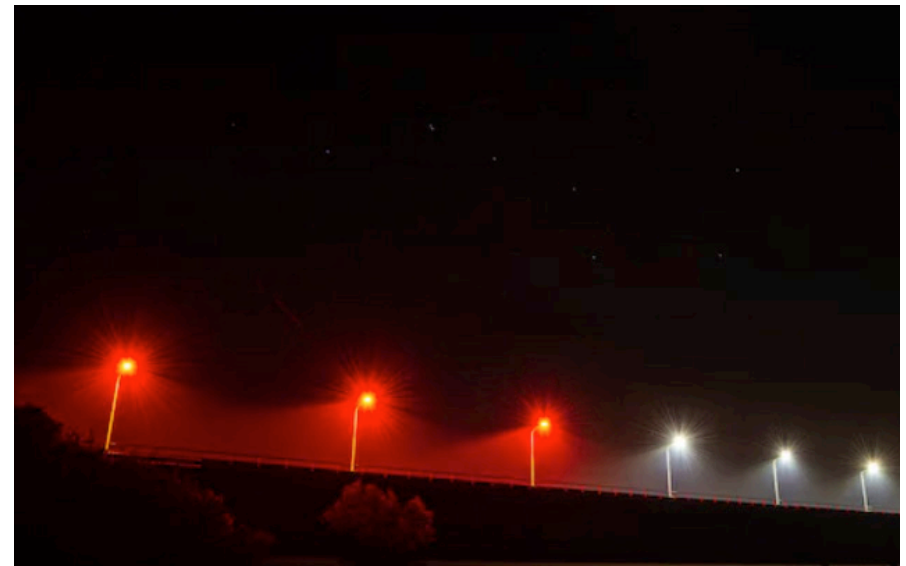


Figure 3.24. The placement of batlights cause high contrast in light colour and no transition is seen. From (<https://www.rijkswaterstaat.nl/wegen/weg-beheer/natuur-en-milieu/verbinden-natuurgebieden/vleermuisvriendelijke-verlichting>)

creative and innovative solutions to urban lighting design, cities can create more sustainable and healthy environments for both humans and other living beings (Figure 3.25)

### Plants list

The design of a nocturnal landscape should consider the importance of plant species selection to attract insects, which are the main food source for bats in the Netherlands. Thus, the choice of plant species should be carefully evaluated. A mixture of night-flowering meadows, shrubs, fallen dead wood, and groups of trees should be added to the open landscapes to create a diverse habitat that attracts many nocturnal animals, including bats. In addition to attracting nocturnal insects, the use of night-blooming species can also enhance the nocturnal activity of animals in the area.

It is crucial to include both native and foreign species in the design of the nocturnal landscape to improve the overall ecology and insect populations. The use of native species is highly recommended to attract native insects, as they have evolved to rely on these specific plants. However, foreign species can also be added to enrich the landscape with different scents and aesthetics.

A comprehensive list of both native and foreign plant species suitable for

a nocturnal landscape is provided in figure 3.26. The list includes species such as the common honeysuckle (*Lonicera periclymenum*), soapwort (*Saponaria officinalis*), privet (*Ligustrum vulgare*), and night smelling damask flower (*Hesperis matronalis*) among others.

Furthermore, it is important to note that not only night-blooming plants should be considered in the design of a nocturnal landscape. Diurnally active plants can also be added to enhance the overall ecology and attract a wider range of insects. By including a mix of plant species in the landscape, the diversity of insect populations can be improved, providing a better food source for bats and other nocturnal animals.

In summary, the selection of plant species is a critical component of designing a successful nocturnal landscape. A diverse mix of native and foreign plant species, including night-blooming and diurnally active species, should be included in the design to attract a wide range of insects and enhance the overall ecology of the area.

### 3.4. CONCLUSION

The human perception of environmental conditions during nighttime can be described as uninviting due to the sudden transition

from light to dark. This abrupt change prompts the other senses to become more alert as they compensate for the reduced visual input. Smell, touch, hearing, and taste might become more sensitive at night as a result.

A comprehensive exploration of personal experiences and questionnaire responses can reveal three primary types of nocturnal landscape experiences: contemplative, contrasting, and transformational. These experiences are distinct and unique for every individual and situation. Together, they create an immersive

nighttime experience. Designing nighttime landscape experiences requires a careful consideration of several factors, including the type and placement of lighting and lamp post height, as well as the importance of plant species to attract insects, particularly for bats in the Netherlands, which are insectivorous. A diverse mix of night-blooming meadows, shrubs and trees is recommended to create a habitat that attracts nocturnal animals. The Haagse Beek forms a potential nocturnal landscape, which could create a green-blue-dark network of the city.

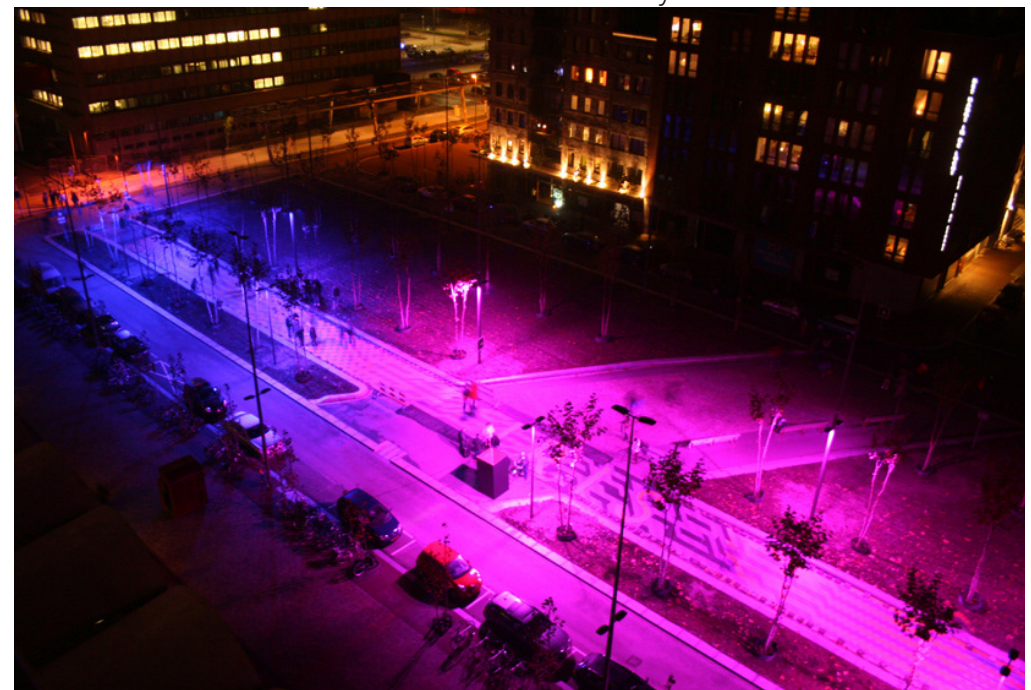











Figure 3.25. Blending lightcolour for softer transitions can be used to soften the design for The Hague between the current white lights transitioning into red light

Plant species	Blooming image	Native plant	Night blooming plant	Light	Implementation in design
<p>Lonicera Caprifoliaceae (Kamperfoelie)</p> <p>Height: 6-10m Width: 10m Type: vine</p>		Yes	Yes	Needs shadow and moist soil	This plant smells great at night and attracts many nocturnal insects. It will be used to grow underneath trees in meadow flower areas for insects and bats
<p>Mirabilis Jalapa (vieruurtje/ nachtschone)</p> <p>Height: 50cm-80 cm Width: 30-40cm Type: Bulbs and tubers</p>		No, the plant originates from Peru but can be used in The Netherlands as well	Yes, flowers open around 16u ('Het vieruurtje')	Needs sunny or half-shadow	This plant opens up around 16u and smells during the night. It is suitable in a flower meadow
<p>Oenothera (Teunisbloem)</p> <p>Height: 15cm Type: groundcover</p>		No, these plants originate from North-America, but is planted in The Netherlands as well	Yes, most species from the Oenothera genus are night blooming plants	Needs sunny place	This species can be invasive, so it is important to look at the type before planting. The plant is suitable for a dune landscape, like in The Hague. It will be used in the flower meadow as ground cover to attract nocturnal butterflies
<p>Hesperis matronalis (damastbloem)</p> <p>Height: 60-90cm Type: shrub</p>		No, this plant is originally from Southeast Europe and central asia, but it is widely used as garden plant in The Netherlands and it grows well in dune areas	Yes, this plant smells nice and butterflies use it during the day as well	Needs half shadow and moist place	This plant is suitable as bordering plan. It will be placed near the edges of the Haagse Beek area to densify the edges and add a pleasant smell at night



Plant species	Blooming image	Native plant	Night blooming plant	Light	Implementation in design
<p>Zaluzianskya capensis (Nacht Phlox)</p> <p>Height: 25cm Width: 60cm Type: ground cover plant</p>		No, it is native to Africa	Yes, it brings a nice honey-almond sweet smell to the area	Needs a sunny place and dry ground	This scent goes well with the sweet smell of the 'four o'clock' that will also be used in the design. Place them together for an emowering smell (Badgett, 2022)
<p>Saponaria officinalis (Zeepkruid)</p> <p>Height: 70cm Width: 50cm Type: low shrub</p>		Yes	This plant gives its pleasant smell during day and night	Needs a sunny place and drained soil	This plant attracts nocturnal butterflies, bees and diurnal butterflies
<p>Lilium candidum (Madonna's lily)</p> <p>Height: 1-1,5m Width: 1m Type: Bulb</p>		No, the plant originates from Balkan regions and is naturalized in most parts in Europe	Yes, the plant gives a subtle scent at night	Need half-shadow	The lily prefers still water and can be placed near The Haagse Beek. Maintenance should make sure that the plant will not become invasive
<p>Nymphaea (waterlily)</p> <p>Type: Herbaceous perennial</p>		No, the plant comes from tropical areas, but some hybrid species can survive colder climates as well.	Some species are night blooming. Most hybrid species that can handle the cold are blooming during the day, attracting diurnal insects and stimulating diurnal ecology	Lives on the water surfaces	Most night blooming species can not survive cold temperatures. It is important to remove these plants and place them in a warmer place during winter times. Most insects are not active during winter either and will not miss them

Plant species	Blooming image	Native plant	Night blooming plant	Light	Implementation in design
<p>Ligustrum vulgare (Liguster)</p> <p><i>Height: 3-5m</i> <i>Type: big shrub</i></p>		<p>Yes, this plant can grow in dune areas and attracts local insects and even nocturnal butterflies at night. It is especially a valuable plant for the ligusterpijlstaart (a big nocturnal butterfly species in NL) (Leurs, 2023)</p>	<p>No, this plant attracts bees and insects during the day</p>	<p>Needs sun and half-shadow</p>	<p>Liguster naturally occurs in dune areas and is a dense and (with mild winters) evergreen shrub. This makes it suitable to create layered edges and to block streetlight at night.</p>

# Chapter 04

## GUIDELINES TO DESIGN FOR NOCTURNAL LANDSCAPES

*In a dark time, the eye begins to see*

*- Theodore Roethke (1963)*

*(found in Bogard (2021). p11)*



## 4.1. INTRODUCTION

Artificial light has become a pervasive feature of modern life. While it has undoubtedly brought numerous benefits, including increased safety and productivity, it has also had some unintended consequences. One of these consequences is the disappearance of the night. As urban areas continue to grow, light pollution has become a significant problem, affecting nocturnal animals, human health, and the aesthetics of the night sky.

To address this problem, this thesis report aims to provide a set of guidelines for maintaining dark urban places and preserving the night for both ecological and human benefits. These guidelines have been developed by the author through extensive research on the negative effects of light on nocturnal ecology and human nocturnal experience, described in the previous chapters. They are intended to serve as a tool for those seeking to incorporate darkness into their designs, whether they are landscape architects, urban planners, or policymakers.

The guidelines are not prescriptive but rather flexible and adaptable to different contexts and situations. They are based on the premise that the night is a valuable resource that needs to be protected and that darkness is

an essential component of a healthy ecosystem and a satisfying human experience. The guidelines cover a wide range of topics, including lighting design, landscape implementations, and spatial organization. They also take into account the needs and preferences of both nocturnal animals and human users of the night.

The following chapters of this report provide examples of how these guidelines can be implemented in practice. Through a case study for The Hague, the author illustrates the potential of incorporating darkness into urban environments. The aim of the guidelines in this report is to encourage others to consider the importance of darkness in their designs and to provide them with practical guidance on how to do so. Ultimately, the goal is to create a sustainable and vibrant environment for all inhabitants, where the night is not only preserved but also celebrated

## 4.2. TRANSITIONAL ZONES

During my research, it became apparent that the nocturnal landscape consists of two distinct areas: light or dark places. There seems to be no in-between areas, which can pose a challenge when designing urban environments for both day and night experiences. Adaptation of the human eye from dark to light occurs rapidly, typically taking only a few seconds. However, adaptation from light to dark takes longer, up to 20 minutes, according to Baldewsingh (2010). As a result, designing transitional zones between brightly lit areas and darker areas is needed to ensure safety and comfort for those transitioning between the two.

Furthermore, when designing the area, it is important to take into account the various layers of lighting that may be present. This is because light can have an effect not only in the immediate vicinity but also in the surrounding areas. To mitigate this impact, it is recommended that perpendicular roads that intersect with the darkness corridor be utilized as transitional roads. This is because they can indirectly affect the overall nocturnal landscape experience within the darkness corridor.

To enhance the transformative experience of these transitional roads, they can be designed to gradually change the lighting, color, distribution

and intensity (Figure 4.1.). This will help to create a more immersive and unique experience for those who are passing through. Overall, careful consideration of the lighting design can help to create a more cohesive and enjoyable nocturnal environment where people feel 'guided' into dark areas to explore.

The type of lighting used in transitional zones can affect the overall nocturnal landscape experience. While bright and powerful lights may be necessary in areas with high traffic, softer and more subtle lighting may be appropriate for areas that require a more relaxed atmosphere. This can include warm-coloured lighting, lower lamp post heights, and a more even distribution of light. These zones play a crucial role in creating a seamless transition from brightly lit areas to dark areas. By designing transitional zones in this manner, it can create a more balanced and harmonious nocturnal landscape that caters to the needs of both day and night activities.

When designing such transitional zones, it is important to consider the hierarchy and speed limits of the different roads in the area (Figure 2.). Certain transitions in lighting may require adjustments to accommodate the maximum speed limit, ensuring safety for those traversing the area. In the streetlighting document, roads

are put in different classes, based on their speedlimits. This helps categorize different lighting levels. Calculations between these lighting levels can be performed to determine the appropriate length and distance of these transitional roads (NPR13201, 2016). Existing calculations can be used, however this is based on the transition between different lighting levels and does not take colour, distribution, lamp post height and transitions from dark to light into consideration. These are new elements that should be added to calculations and design guidelines.

$$L = 5 \cdot V / 3,6$$

Waarin:

L= lengte overgangszone

5= 5 seconden

V= ter plaatse toegestane snelheid weggebruiker (in km/h)

3,6 = omrekenfactor van [km/h] naar [m/s]

Voorbeeld: Voor een snelheid van 80 km/h betekent dit een afstand (L) van circa 111 meter.

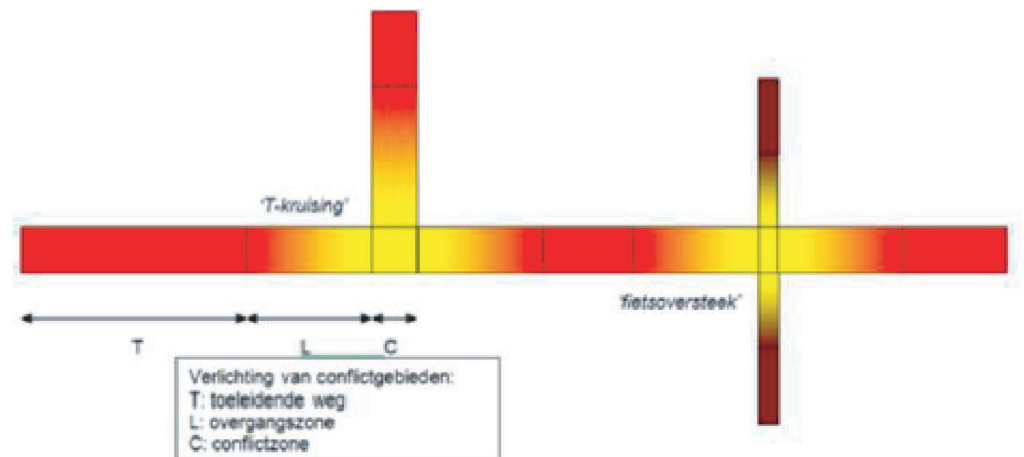


Figure 4.3. Existing calculations for transitioning between light levels. New findings should be added

Therefore, it is difficult to calculate the exact distances. Assumptions have to be made. For transitions in lighting it is important to take the maximum speed limit into mind to take safety into account.

In conclusion, transitional zones are a crucial aspect of designing urban environments that cater to both day and night activities. By considering the distribution, colour, intensity, and height of light sources, we can create a more seamless transition from brightly lit areas to darker areas, creating a more balanced and harmonious nocturnal landscape

TRANSITION ZONE

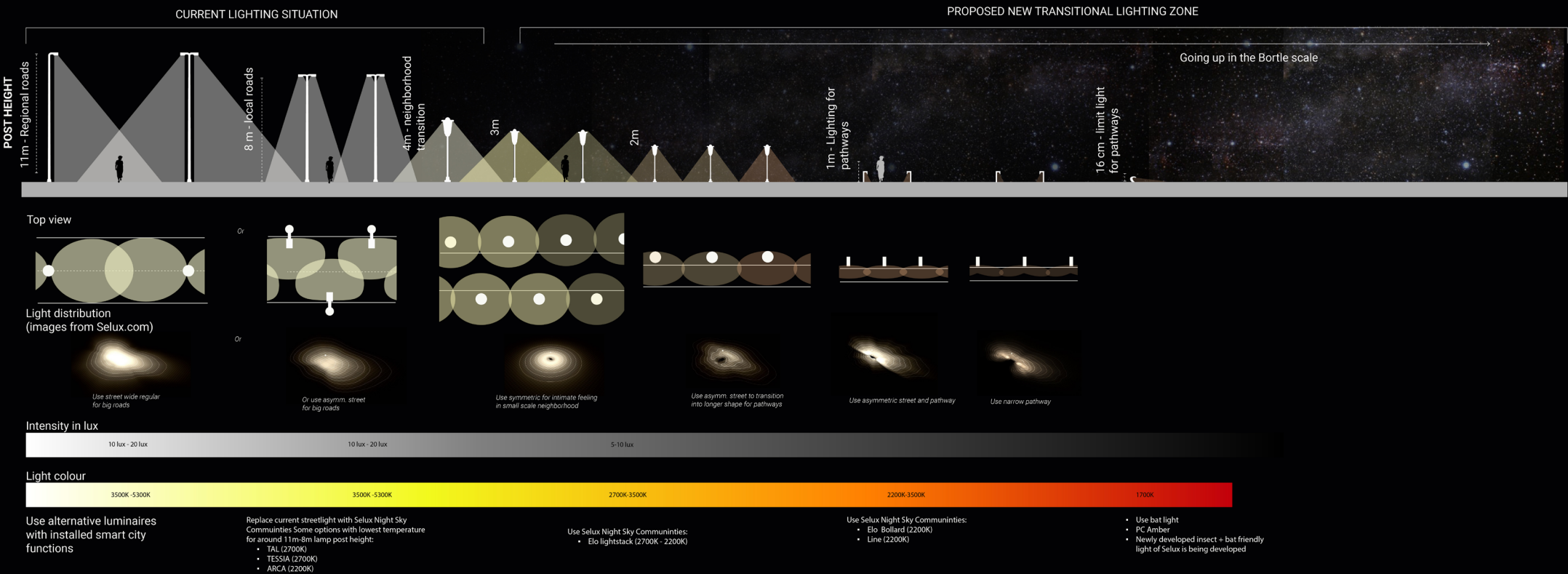
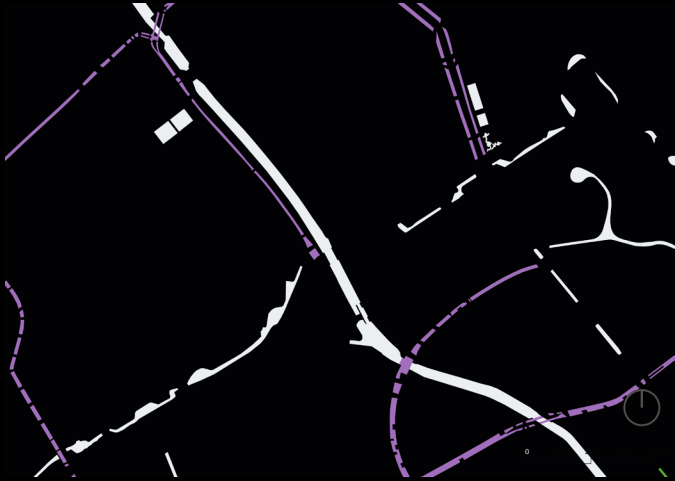


Figure 4.1. Transitional roads can be designed to gradually change the lighting, color, lightsource height, composition, distribution and intensity. When these elements work together with the landscape, an immersive and guided expereince can be provided into dark areas

## TYPES OF ROADS IN THE AREA

Local roads 50km/h



Footpaths



Regional roads 50km/h



Neighborhood roads 30km/h



Cycling roads



Total overlay



Figure 4.2. The different types of roads intersect this highly urbanised design site. Speedlimits can be used in the existing calculation



## 4.2. GUIDELINES

### Part 1: guidelines for nocturnal ecology

Part one of the guidelines for the nocturnal landscape focuses on the preservation of nocturnal ecology. The first step is to analyze the specific location and identify any nocturnal migratory routes for animals. In cases where such routes exist, nocturnal ecology should be given priority. Therefore, it is crucial to consider both the location and the activity of nocturnal animals when designing lighting for a specific area.

The second guideline pertains to the color of lighting. According to Hommen (2022), lighting is least harmful when it is soft and warm, with temperatures ranging from 1700K to 3500K, but not exceeding 3500K. Lux levels should be kept below 1 lux. However, even at this low level, it is still more than the full moonlight, which has a range of 0.05 to 0.1 lux, as noted by Christopher (2017).

The third guideline emphasizes the direction of light. Lighting should be directed towards the intended area, avoiding light pollution as much as possible.

The fourth guideline focuses on the height of lamp posts. Lower lighting is less likely to disturb bats during their flights. Bat Conservation Ireland

(2010) has conducted extensive research on these specifications. The fifth guideline is concerned with the interaction between streetlights and bat activity. Bats fly out of their roost areas at specific time frames (Kapteyn, 1995). Lights near these roost areas should correspond to the specific species and their fly time.

Guideline six suggests creating shadow sides to important linear structures such as waterways and tree lines, providing a dark side for bats to use.

The seventh guideline recommends creating hop-overs when streets form an obstacle or when a linear structure has a gap of more than 10 meters. Bats can become disoriented and lose their way without these hop-overs.

Guideline eight suggests adding night blooming flower meadows to attract nocturnal insects, which serve as the food source for many animals, including bats. This would improve the overall nocturnal ecological systems of the area and create foraging areas for many animals.

When these guidelines are implemented in an area, the entire area can become a network of residences, flying routes, and foraging areas for nocturnal animals. This will greatly improve the overall nocturnal ecology of the area.

### Part 2: guidelines for human nocturnal experience

Part two of the guidelines for the nocturnal landscape focuses on the human experience of the night. In areas with high contrasts between light and dark zones, it is essential to prioritize the creation of transition zones. For instance, when an illuminated street leads to a nocturnal route for animals, the illuminated route should gradually transition from light to dark to minimize the impact on the nocturnal ecology and difference between light and dark.

Another key guideline is the importance of different nocturnal landscape experiences, each of which is crucial in enhancing the human experience of the night. These experiences contribute to the appreciation of the sensorial aspects of night walks and can be used to create a particular atmosphere in the landscape. By making the night exciting and sensorial, these experiences can create a unique and enjoyable experience for the user.

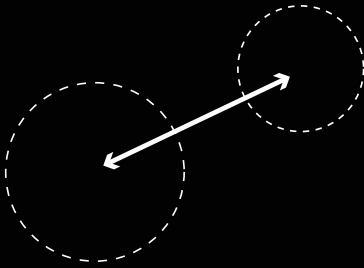
The final aspect of the guidelines relates to interactive lighting, which is currently being experimented with by multiple lighting firms. However, a potential issue with motion sensor lighting is that it creates a spotlight effect. This effect can make individuals easily visible to those hiding in the dark, potentially leading to unsafe situations. To address this, it is sug-

gested to dim the light in the motion sensor-activated zone while illuminating the surrounding lights. This way, people can see their surroundings better, leading to increased feelings of safety. The guidelines provide different scenarios of this type of interaction to illustrate potential solutions.

In conclusion, these guidelines for the human experience of the night emphasize the importance of transition zones, the different nocturnal landscape experiences, and interactive lighting. By implementing these guidelines, it is possible to create a sustainable and safe environment that promotes the appreciation of the sensorial aspects of the night.

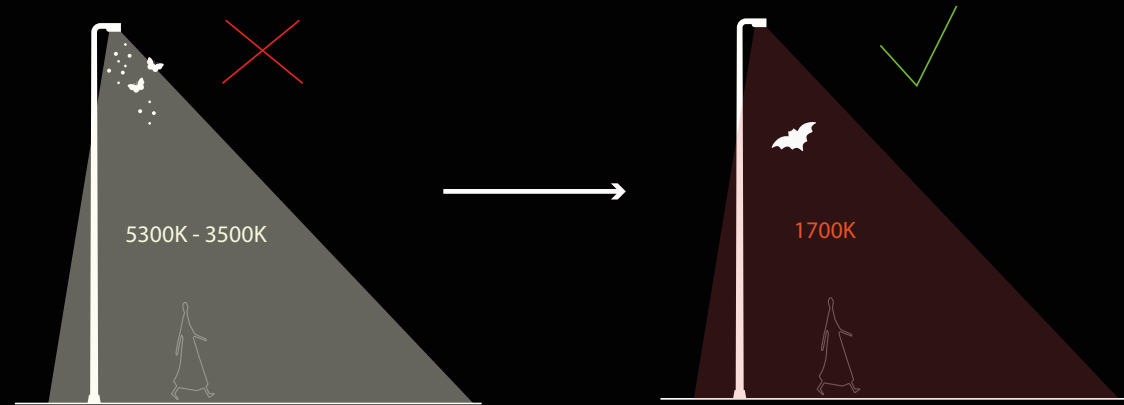
## PART 1: NOCTURNAL ECOLOGY

1



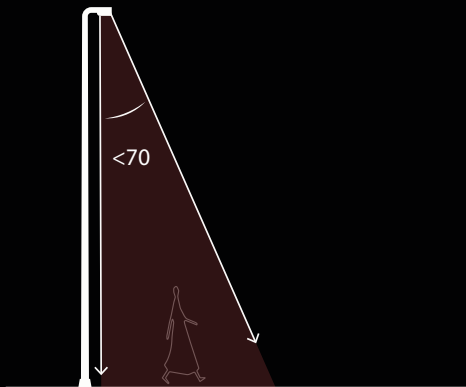
Prioritize nocturnal ecology when nocturnal animal routings or foraging areas are present in the area (**location** is important)

2



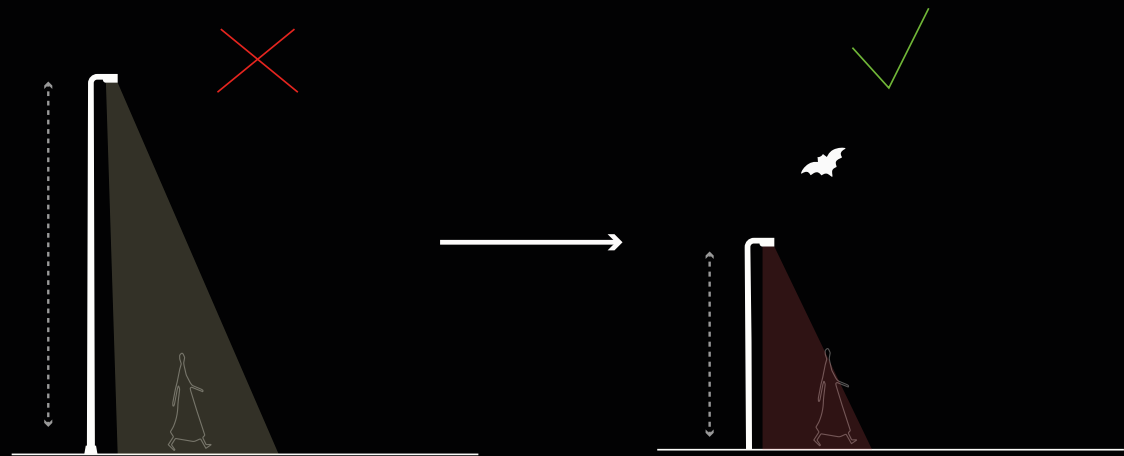
**Friendly light** for bats and insects (around 1700K, no more than 3500K) when light is necessary. Cold white light (>5300K), neutral white light (3500-5300K) and warm white light (<3500K) should be avoided, or lux value should be <1 lux (for reference: moonlight is 0,2 lux and my measurements of streetlight in The Hague was between 8 and 10 lux).

3



Light **direction** should go towards the intended direction (down and direct light). To prevent light pollution, use a light angle <70 degrees

4



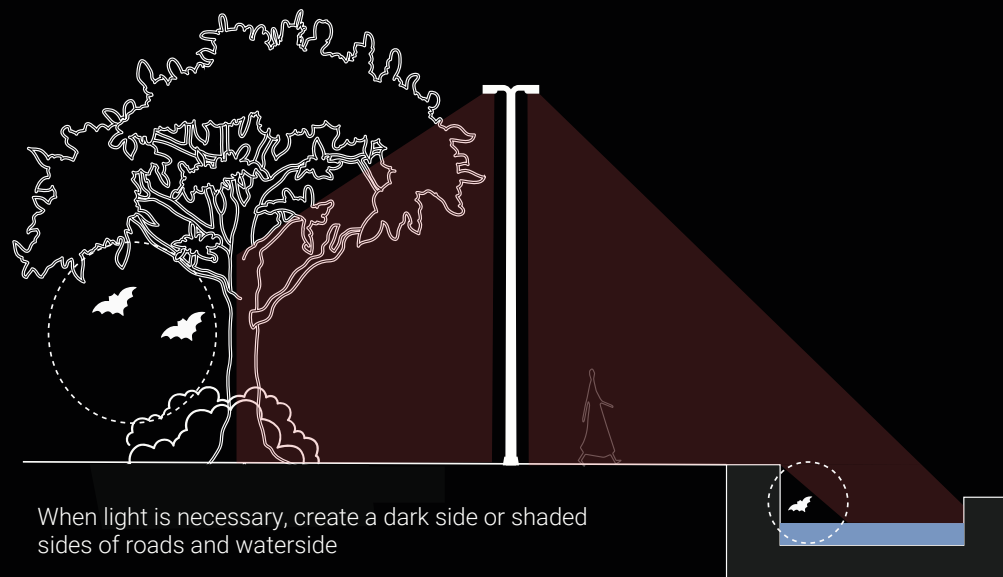
Light on lowest pole **height (<8m)** is best to avoid disturbances for flying animals like bats

5



Light nearby bat residents and alongside flying routes and foraging areas should **correspond** to the flying times of bats (nearby lights should stay off)

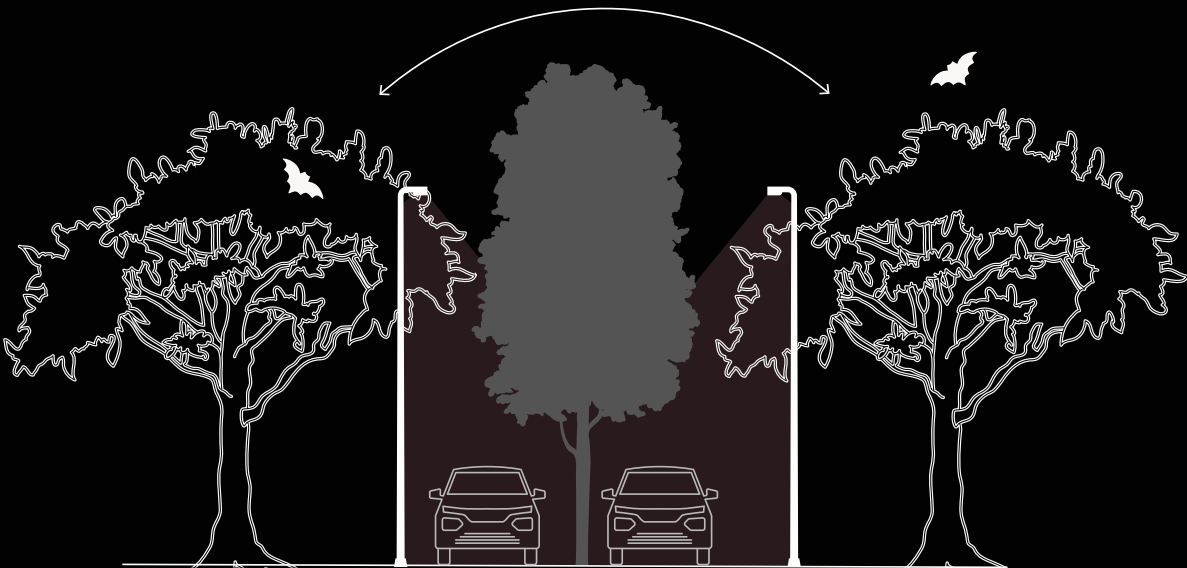
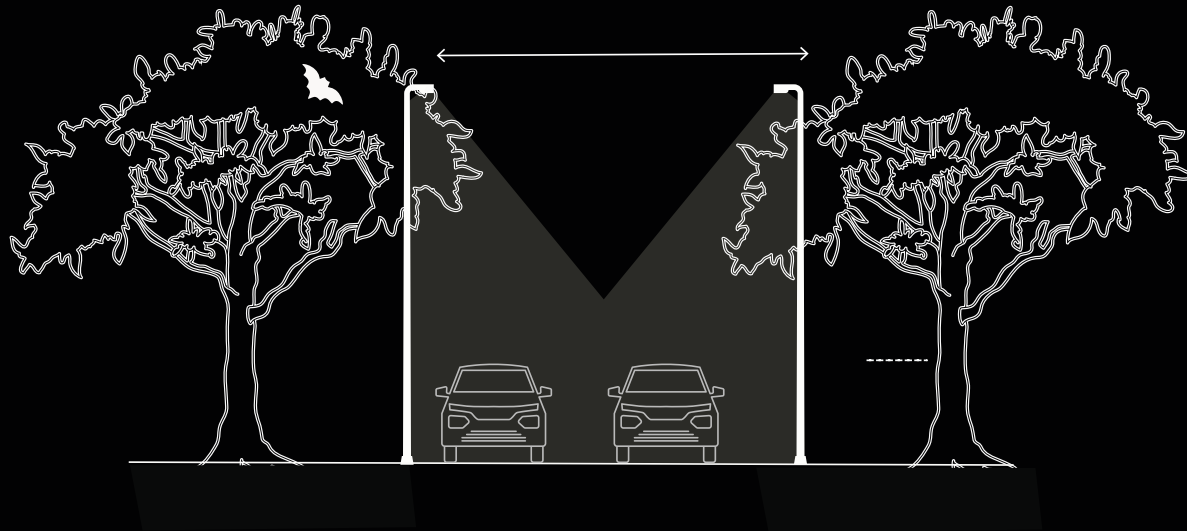
6



When light is necessary, create a dark side or shaded sides of roads and waterside



7



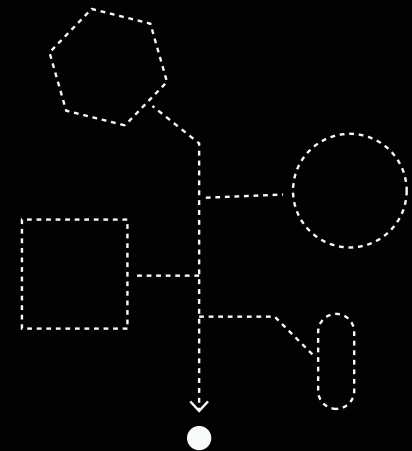
When roads cross flying routes, tree tops should reach to the other side in order for nocturnal life to cross over. When needed, add extra hop-over for bats by adding extra trees or making roads smaller. Animals can cross over via tree tops, so it is important to **reconnect** important nocturnally active areas

8



Use **vegetation** (like *Cestrum nocturnum*) that attracts insects at night, though native plants are preferred

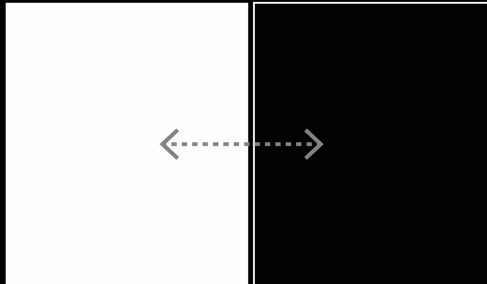
9



A **network** of residence, flying route and foraging areas should be established by a combination and consideration of the above mentioned toolbox for nocturnal ecological life, which not only bats will benefit from

## THE DARK LANDSCAPE EXPERIENCE

10



Prioritize the development of transitional zones when contrast between light and dark area is high, transition is needed

11



Lighting should emphasize on 3 main dark landscape experiences:

### Contrasting landscape experience

- Subtle switch from relative light area to dark area
- Open landscape to close landscape
- Different materials underfoot
- Light-coloured vegetation or objects against the dark backdrop
- Sudden touch by leaves or humid air

### Contemplative landscape:

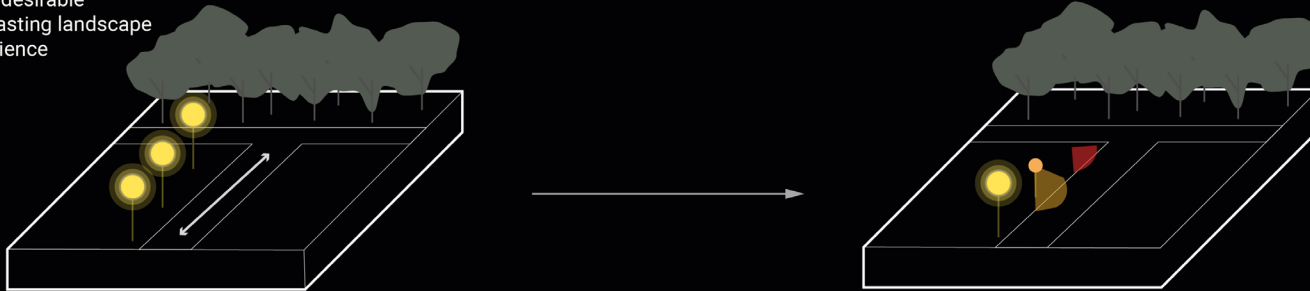
- Unity
- Darkest areas
- Peace and quiet
- Smell of flowers and natural soft sounds

### Transformative landscape:

- Change of smell indicating a change in the landscape
- Change of light colours and light intensity
- Change in lamp post height
- Sound indicates the dynamic of the environment

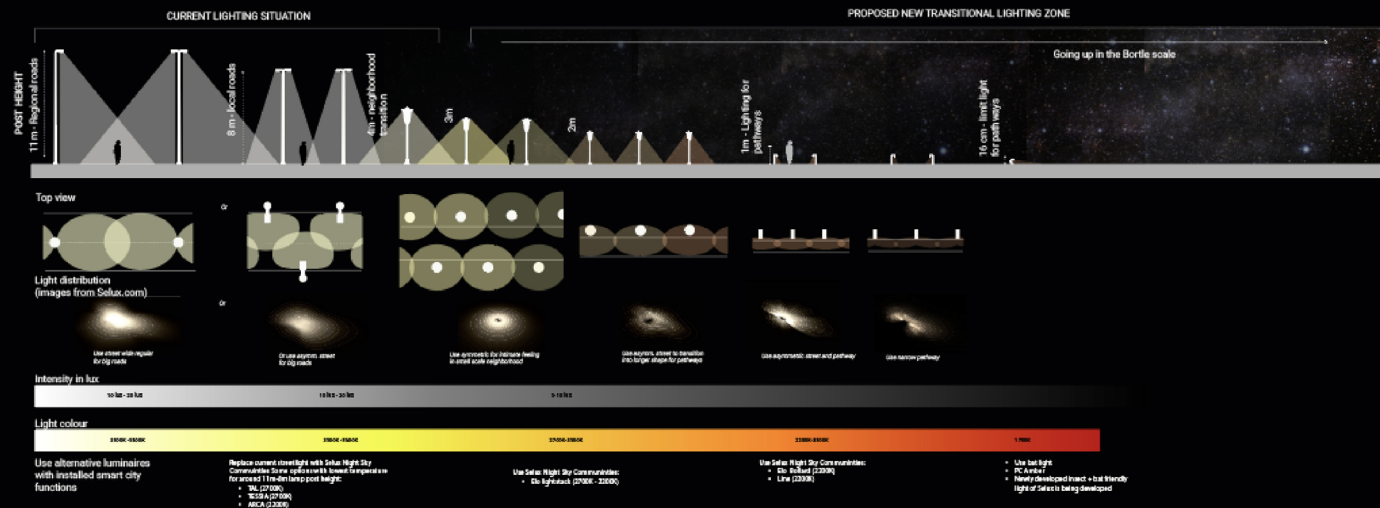
## 12 Transition zones

- (Current situation)
- An undesirable contrasting landscape experience



Lights on a **perpendicular** direction to a dark area have a major influence on the experience of the area, as light reaches inside a dark area from the outside. It should gradually transition to guide people into the dark area without a sudden contrast and should not negatively influence the experience (glare and light trespass). This can be done both in lamp post height, light intensity and colour. While lamp posts get lower, intensity gets less (from 10 lux to 5 lux) and colour shifts from white (5300K) to warm white (3500K) to yellow (2700K) to orange (2200K) to red (1700K).

### TRANSITION ZONE



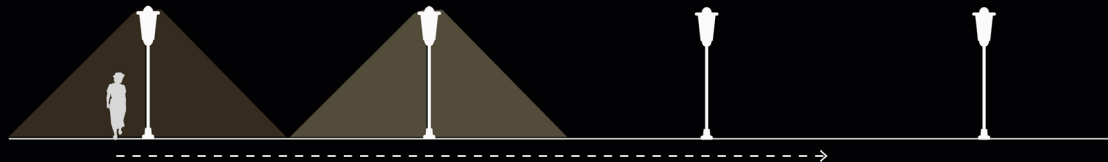


13 Interactive light should not blind people or feel like a spotlight  
Scenario's

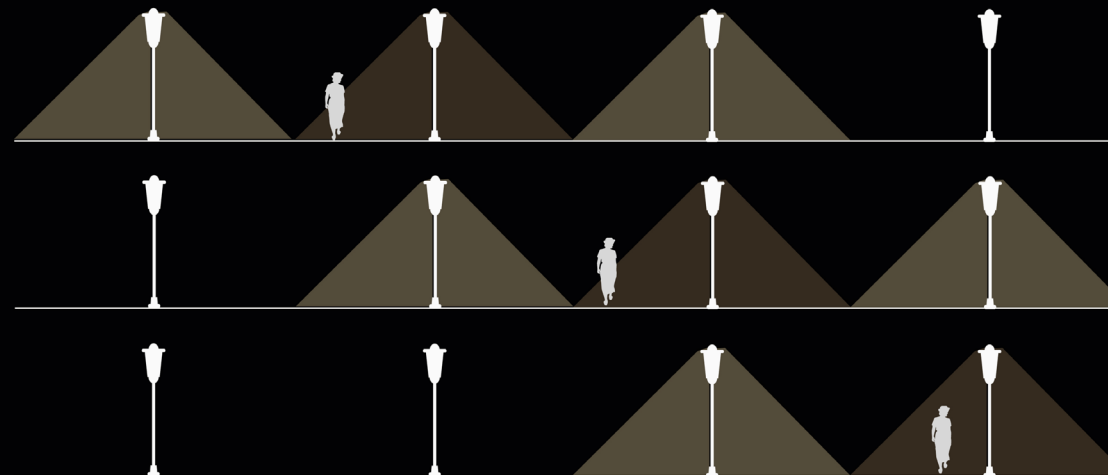
Scenario 1:  
No people present. Lights  
are off



Scenario 2:  
Someone approaches, the first light is faintly on, the  
next light is brightly on



Scenario 3:  
As the person moves, the faint light moves with them,  
never blinding or mimicing 'spotlights', as the 2 lights next  
to the position of the person are brighter



As interactive light is being developed, most lights turn on when motion sensors detect people. However, this can cause people to be blinded by light and causes a 'curtain of light' in which potential threats can not be seen outside the curtain of light. To prevent this, light should act as surrounding light. Sensors should be places next to light posts to determine the position of a person.

# Chapter 05

## IMPLEMENTING GUIDELINES IN DESIGN

*If the stars should appear one night in a thousand years . . .*  
- Ralph Waldo Emerson (1836)  
(found in Bogard (2021). p3)

## 5.1. ANALYSIS OF THE SITE

Light pollution profoundly impacts nocturnal ecology and human health and is becoming an increasingly pressing issue worldwide. A landscape analysis of light pollution is necessary to understand the extent and effects of light pollution. The analysis involves the examination of the sources and distribution of artificial light, as well as the existing different lighting zones in the design area. This analysis aims to provide a comprehensive overview of light pollution in the area and its spatial impact on the environment to create a more sustainable and harmonious relationship between humans and the (nocturnal) natural world.

To conduct the analysis, specific data was collected to examine the positions and height of light poles within the site. Given the site's urban character, a multitude of roads of varying types intersect the region. The regional road is particularly important, which serves as a vital artery for the area. Therefore, it is imperative to create a nocturnally friendly lighting atmosphere that is still sufficiently illuminated to facilitate traffic safety while also benefiting the environment. However, during a nighttime excursion, the harsh and predominantly white lighting was found to be overwhelming and unsuitable for the area's needs, as

illustrated in Figure 4.1.

Currently, white light remains the standard in many parts of the city. However, there is a pressing need to transition towards a darker and warmer red light to improve the city's nocturnal ecology and enhance the overall human experience of the dark. To achieve this, lights between 590-740 nm, which represent the red spectrum of light (see Figure 2.5), are recommended. This approach has minimal impact on most nocturnally active animals and significantly reduces skyglow for humans. By implementing this type of lighting, the nocturnal experience of the area will be markedly different from the current situation, which overlooks the importance of nocturnal health and overuses white light.

Moreover, the current lighting zones (as depicted in the bottom layer of Figure 4.2) are based on different neighborhoods and types of roads, with varying lamp post heights that remain high and bright. This creates direct glare and leads to unpleasant effects. Therefore, it is essential to consider adjusting the lamp post heights and the type of lighting used to avoid any direct glare and ensure a more pleasant lighting experience for all.

Another important aspect is the illuminance of the light sources. This

is the intensity of the light. Specifically for The Hague, most streetlights in neighborhoods are 1 or 2 lux above the national norm (RIS, 2010). The aim is to have a maximum of 5 lux, but measurements in the fieldwork showed that most streetlights exceed over 5 lux. Lights on the President Kennedylaan and the neighborhoods were 8 lux, and the light at the Sportlaan was 10 lux (figure 4.3.). Some lights next to the new buildings were even 21 lux (figure 4.4.). These lights were very blinding. During this

fieldwork some red lights were also measured and they were only 5lux (figure 4.5.) and very pleasant to walk and bike through. When interpreting the lux levels, it is important to know that moonlight normally fluctuates between 0,05 up to 0,1 lux (Christopher, 2017). This illustrates how much artificial light is added nowadays. People are so used to light that we do not notice when it is too much. It is time to change that.

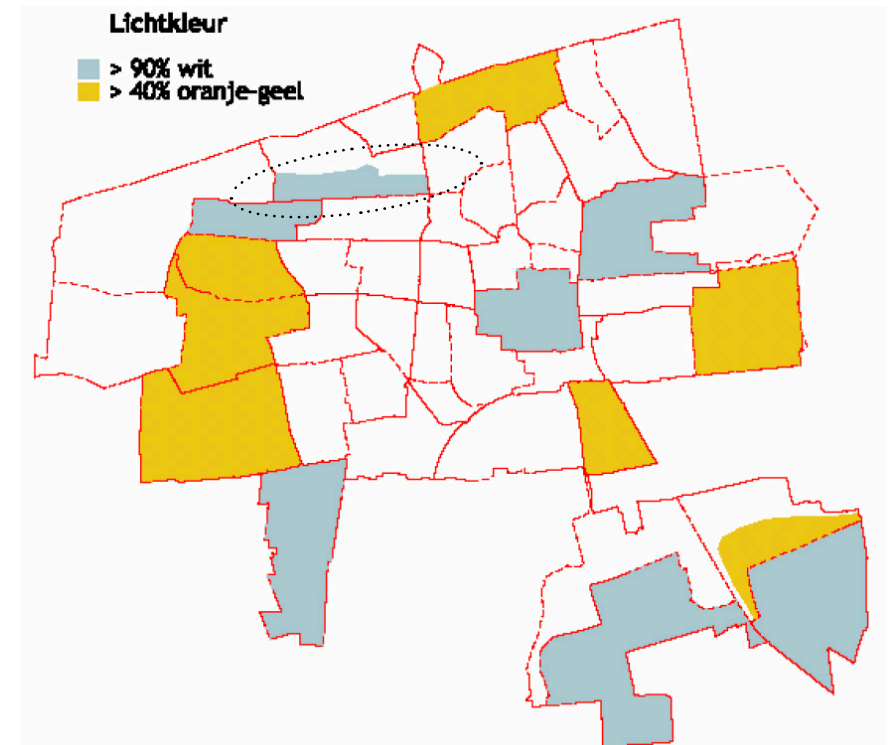


Figure 4.1. The design site contains mostly white light (RIS, 2010).



## Current lighting zones and important layers

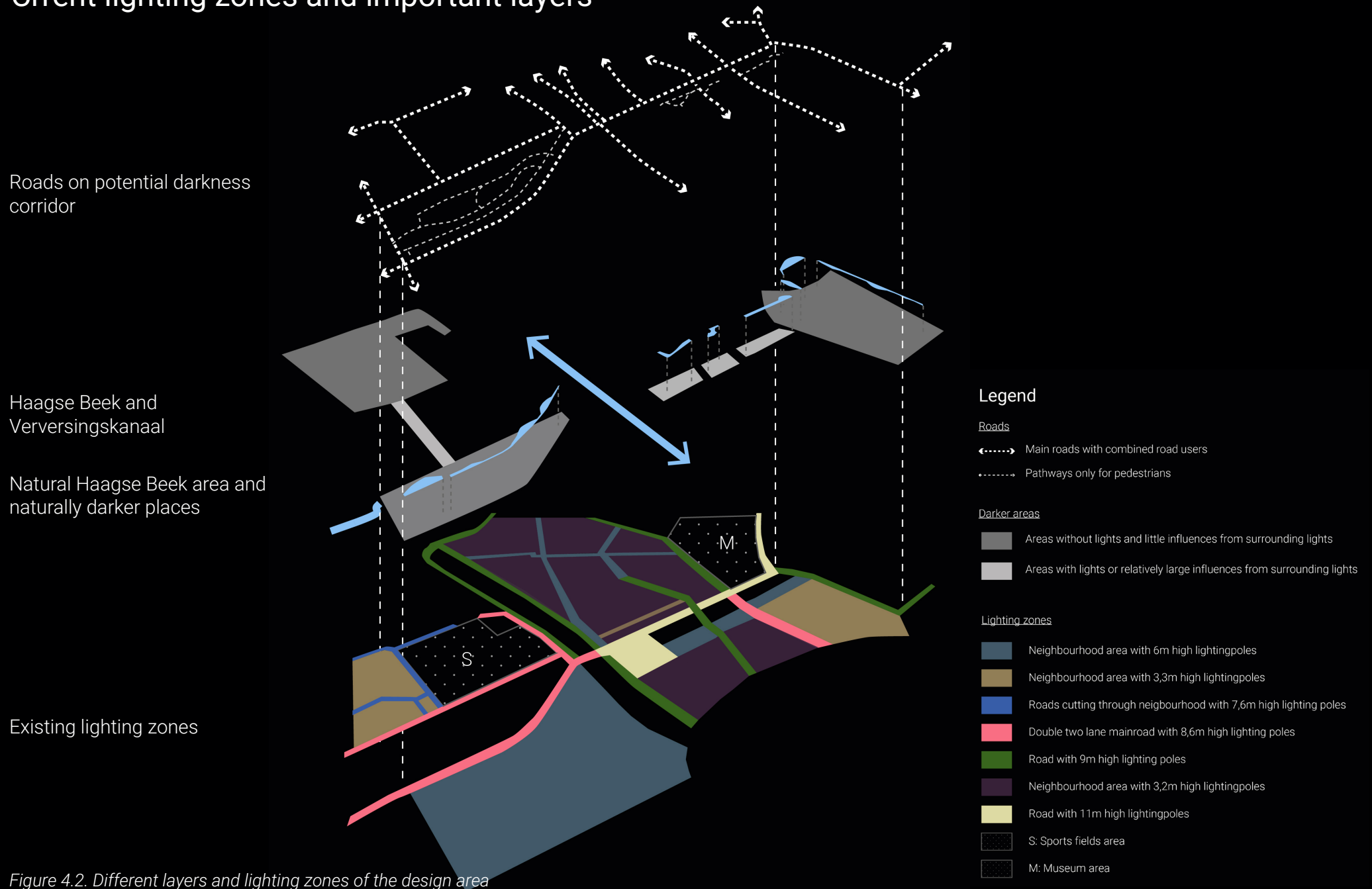


Figure 4.2. Different layers and lighting zones of the design area



Figure 4.3. 8 lux and 10 lux streetlights measured during fieldwork



Figure 4.4. 21 lux near buildings



Figure 4.5. Presumably batlights. 5lux was measured

### The green-blue-dark connection

The overarching goal for the design site is to establish a connection between the Bosjes van Poot and Zorgvliet areas, through the creation of a new darkness corridor, which adheres to the guidelines, developed in this thesis project. The precise location of the darkness corridor, along with its focus areas, are illustrated in Figure 4.6. This map highlights the areas that require interventions in order to create a unified darkness connection, and ultimately attract more nocturnal life. To optimize the connection and minimize potential bottlenecks, it is necessary to reinforce the designated areas. Specific issues that require attention are indicated by the various colored dots on the map. For instance, the purple dots indicate existing flying routes that are in close proximity to sources of light, necessitating a transition of lighting in

this region. The orange dot identifies a heavily trafficked intersection that lacks a strong structure, resulting in a significant bottleneck for nocturnal life. To address this, a dark-green connection should be introduced on the bridge. The blue dots denote areas where substantial gaps exist, necessitating hop-overs to bridge them, while the black dots refer to park-like areas that lack undergrowth due to mowing maintenance. To promote overall nocturnal (and diurnal) ecology, the latter could be enriched with a variety of nocturnal flowering plants and diverse vegetation

The Hague, a city known for its innovative spirit, is at the forefront of experimenting with dynamic lighting systems and LED lights. With an estimated energy use reduction of up to 90%, the adoption of LED lights is a promising development towards achieving sustainable energy consumption. Moreover, dynamic lighting systems offer the possibility of adjusting the light intensity according to the time of the day, the weather, or even the level of pedestrian traffic, resulting in increased safety and comfort for residents and visitors alike. Although these technologies are still in development and have not been implemented on a large scale, the potential benefits for the city are vast. For instance, in addition to

reducing energy consumption and cost, dynamic lighting can enhance the city's aesthetic appeal, promote tourism, and even improve the health and well-being of residents by aligning the light cycle with their natural circadian rhythm. In my opinion, the city should explore all the possible ways to utilize dynamic lighting, not only for its financial advantages but also for the numerous benefits it can bring to the people and the environment. By doing so, The Hague can set an example for other cities and contribute to a sustainable future for all.







## Darkness corridor and roads

The concept of a darkness corridor is a critical aspect of preserving the nocturnal landscape, as it provides a protected space for nocturnal animals to migrate, forage, and interact without being negatively impacted by artificial light. However, the effectiveness of the darkness corridor can be significantly influenced by the lighting conditions of the surrounding areas. As such, it is important to consider the impact of nearby roads and their lighting conditions on the darkness corridor.

Figure 4.7 illustrates the roads that influence the darkness corridor and their lighting conditions. The figure reveals that the area is highly illuminated, and numerous lights are causing blinding effects. This high level of illumination extends even to supposedly dark areas, such as those near the Haagse Beek. The impact of these lights on the darkness corridor is potentially devastating, as it can disrupt the natural behaviors of nocturnal animals and limit their ability to move through the corridor.

To address this issue, guidelines for transition areas should be implemented. Red lights or gradual transitions from light to dark should be incorporated on the roads that influence the darkness corridor. By doing so, the corridor can be better protected, and the natural

behaviors of nocturnal animals can be preserved. Additionally, these guidelines will help reduce the unpleasantness of the blinding lights in the area and create a more comfortable and enjoyable experience for human observers.

In summary, the implementation of the guidelines explained in Chapter 4 is critical to preserving the darkness corridor and the nocturnal landscape. These guidelines should be incorporated on the roads that influence the darkness corridor to reduce the impact of artificial lighting on the natural behaviors of nocturnal animals and to create a more enjoyable experience for human observers.

## 5.2. MASTERPLAN

The design described in the report combines landscape architecture and industrial design engineering to improve the experience of nocturnal landscapes. The author used her understanding of lighting design and interactive technology to create three new lighting zones that enhance the green-blue-darkness structure of the area (Figure 4.8.). These new lighting zones not only improve the human experience of the area at night but also promote nocturnal ecology. To minimize the disturbance to nocturnal animals, a warm light with a color temperature of 1700K is used in the

darkness corridor, which is marked by red on the map. The transition from the red light into the white/yellow spectrum is achieved through the implementation of transition zones, which are indicated by the gradient on the map. The design also includes a new nocturnal flower meadow and stronger connections and hop-overs where gaps exist. The author also designed a dark-green connection on the bridge, going over the Verversingskanaal, to ensure that the nocturnal landscape can continue and a strong connection is made. By implementing this design, the area will have a more diverse and ecologically friendly nocturnal landscape, while also providing a better experience for humans who visit the area at night.

## Roads on potential darkness corridor

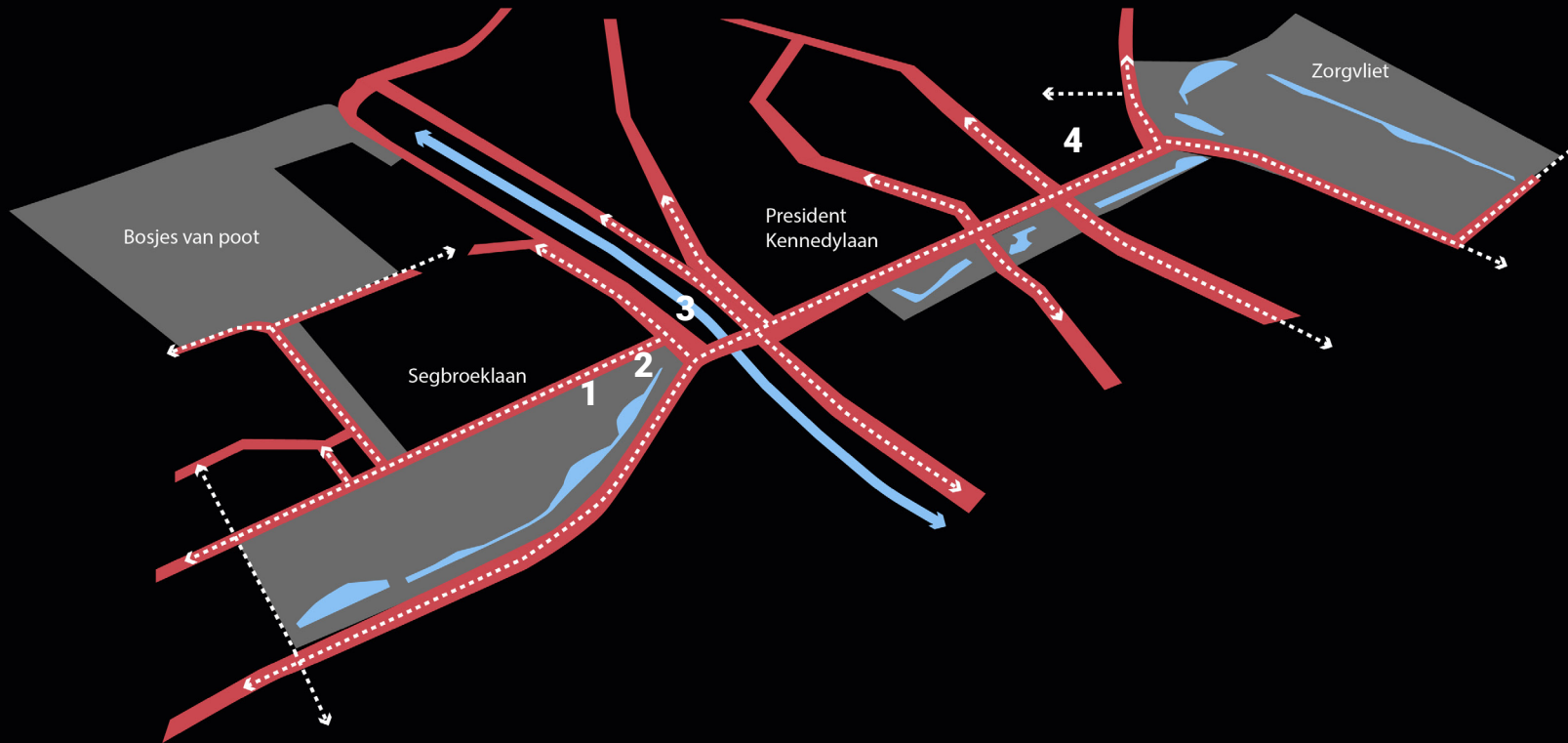


Figure 4.7. The significant roads and their influence on the area



# Masterplan with new lighting and implemented guidelines



Figure 4.8. The design includes a warm-colored darkness corridor to minimize disturbance to nocturnal life, transition zones to gradually shift from a white to red spectrum, a new nocturnal flower meadow, and stronger green-blue-dark connections for animals and human experience. Overall, the design aims to improve the human experience at night and to create a more ecologically friendly nocturnal landscape through lighting zones and new interventions, based on the developed guidelines illustrated in this report



### Intervention 1: nocturnal flower meadows

The first intervention site located near the President Kennedylaan is currently a relatively green area with sporadic trees and the Haagse Beek flowing through (Figure 4.9.). The banks of the stream are soft and nature-friendly, with a lot of reed growth. However, the landscape is monotonous with neatly mowed grass, resulting in little variation in vegetation and attracting a limited diversity of insects and animals.

During the day, the atmosphere in the area is pleasant due to the green space. However, at night, the space becomes overly illuminated, with surrounding lights penetrating the areas that should be dark, causing disturbance to the nocturnal landscape for both human experience and nocturnal ecology (Figure 4.10).

To address these issues, the intervention aims to cease the mowing of the area and introduce night-blooming flowers from the plant list described in the previous chapter. The inclusion of these flowers will enrich the area and attract a diverse range of nocturnally active insects, which are an essential food source for most nocturnal animals, including bats. Additionally, bat-friendly and insect-friendly red-spectrum lights will replace the current lighting system, reducing skyglow and minimizing

disturbances to the nocturnal life. Furthermore, the edges of the area will be densified with vegetation to block out most light, giving visitors a better experience of a pure night and enabling them to see the night sky. The half-open landscape enriched with night-blooming flowers will create a suitable habitat for nocturnal insects, bats, and many other nocturnal animals, including birds. Visitors will be able to smell the sweet scent of the plants and observe the night sky, resulting in a contemplative landscape experience

Figure 4.11 illustrates the new section with the implementations, which will transform the nocturnal experience seen in Figure 4.12 into Figure 4.13. The improved landscape will be enjoyed by both humans and animals during the day and night, catering to the needs of both in the design.



Figure 4.9. The first location for intervention near the President Kennedylaan





Figure 4.10. The highly illuminated and monotonous area of the Haagse Beek. Made by author Oktober 2022



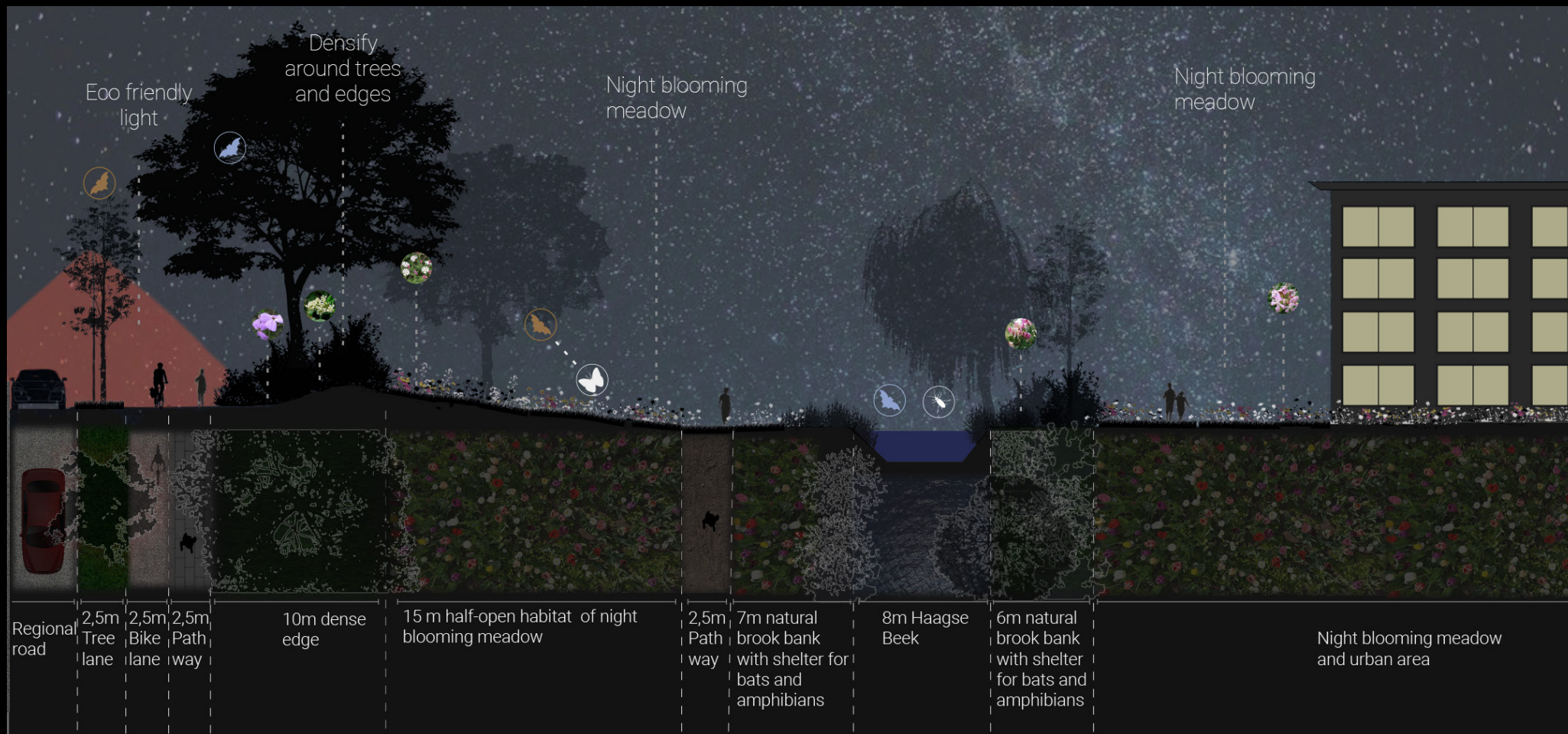


Figure 4.11. Section of the new situation in which the nocturnal landscape for both humans and ecology can thrive









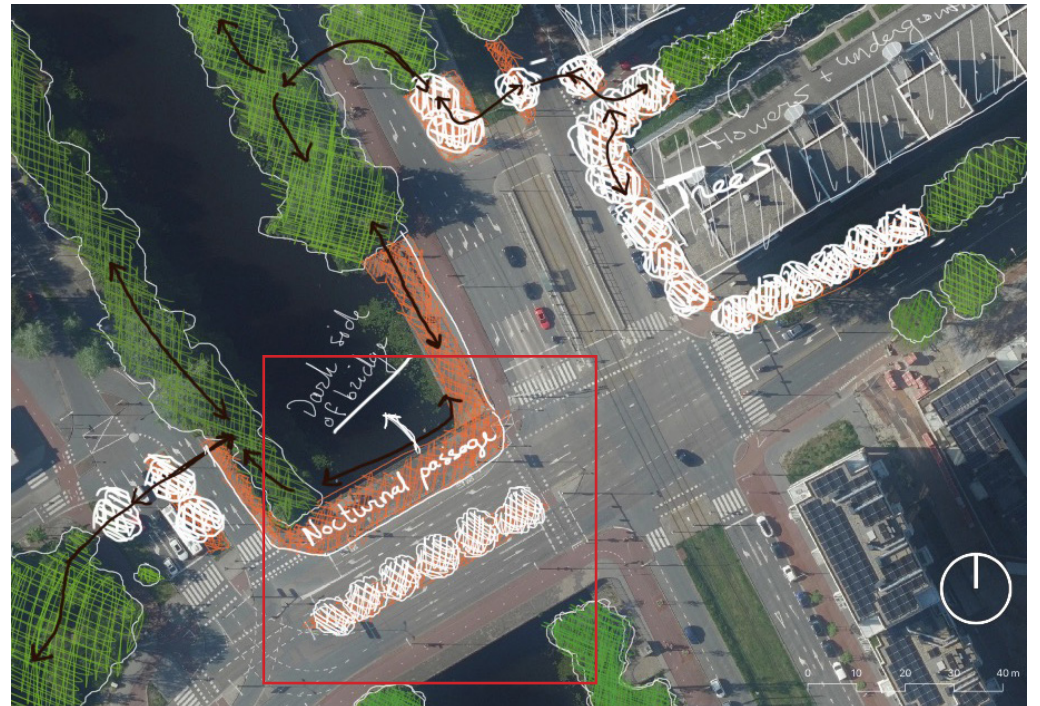


Figure 4.15. Current situation that shows lack of connection and green space and desired connections with a nocturnal passage on the bridge, creating a dark side of the bridge to improve both nocturnal landscape experience and nocturnal and diurnal ecology, contributing to the overall green-blue-dark network on bigger scale





Figure 4.16. Current atmosphere on the bridge. Made by author Oktober 2022







Figure 4.17. Map with the location and corresponding section of the new situation where space is created to make a small park that will improve nocturnal experience and ecology





Figure 4.18. Current atmosphere and lack of green-dark connections





Figure 4.19. New atmosphere with a strong green-dark connection



### Intervention 3: Atmosphere of transitioning lighting

The third intervention pertains to the changing ambiance of lighting in the surrounding atmosphere. As per the recommendations provided in the report, this area should be modified in accordance with the established guidelines.

This example is located near the neighborhood alongside the Houtrustlaan. This is one of the arteries to connect the Haagse Beek area to the Bosjes van Poot dunes and forest. This area has an excellent linear green structure (Figure 4.20). An important flying route for bats is located alongside this artery, so transitions from normal light into red light should be made here. This way, nocturnal life will not be disturbed and the human nocturnal experience will be improved alongside this area. Figure 4.21. shows the current situation, and figure 4.22 shows how it looks like at night.



Figure 4.20. Transition in lighting is needed for the nocturnal experience to move from the neighborhood area into the darkness corridor alongside the green structure, leading to Bosjes van Poot





Figure 4.21. Current situation





Figure 4.22. New nocturnal situation with transition in lighting

### 5.3. CONCLUSION

The widespread use of artificial light at night has brought numerous benefits to modern life. However, it has also led to the disappearance of the night and created significant problems such as light pollution, which has negative effects on both the nocturnal ecology and the human experience of the night.

This MSc thesis started with the author's fascination for the night sky and has explored the intersection of landscape architecture and industrial design engineering to design for nocturnal landscapes and connections. The author has employed two frameworks to understand the human experience of nocturnal landscapes and the importance of nocturnal ecology, specifically on bats. Through extensive research on the negative impact of artificial light at night (ALAN) on humans and the environment, the author has developed a set of guidelines to maintain dark urban places and preserve the night for ecological and human benefits to create darkness corridors. The project has utilized various research methods, including a literature study, questionnaire, and interviews, to understand the nocturnal landscape experience. Furthermore, the author has taken courses in lighting design and

interactive technology design to explore technology and lighting design better.

The importance of preserving darkness in urban areas cannot be overstated. As the world continues to urbanize, more and more people are living in cities where light pollution has become a major issue. The guidelines provided in this report offer a starting point for those seeking to address this issue in their designs.

While the guidelines are intended to be flexible, it is important to remember that they are based on a deep understanding of the ecological and human impacts of ALAN. By incorporating these guidelines, designers, planners, and policymakers can create sustainable and vibrant environments where the night is preserved, connected and celebrated. The potential benefits of preserving darkness are manifold, ranging from increased biodiversity to improved human health and wellbeing.

It is worth noting that the guidelines provided in this report are not the final word on the subject. As new developments and research emerge, it will be important to revisit and revise these guidelines to ensure that they continue to reflect the latest understanding of the impacts of ALAN. Moreover, each context presents unique challenges and

opportunities, and designers and planners will need to adapt these guidelines to suit the specific needs of their projects.

Ultimately, the goal of preserving darkness is to create environments that are both ecologically and socially sustainable. By prioritizing the preservation of darkness, designers and planners can create spaces that promote health, wellbeing, and biodiversity. With the guidelines provided in this report, designers and planners have a starting point for creating vibrant, sustainable environments that celebrate the beauty and value of darkness at night. Through a case study for The Hague, this report has illustrated the potential of incorporating the guidelines into urban environments. By three example interventions, the practical use of the guidelines and improved landscape experience is given. Ultimately, the successful implementation of these guidelines will lead to a better quality of life for all inhabitants, including both humans and nocturnal animals. Lets protect the night and look up to the stars!



# Chapter 06

## CONCLUSION AND DISCUSSION

## Introduction

As a student in landscape architecture, I find it interesting to think outside of the box. I always try to avoid 'standard' ideas and topics. However, this makes my choices somewhat difficult at times. So was the case with this topic. I started with no knowledge about lighting design and light pollution, yet I continued this rocky path.

As I delved deeper into the topic, I quickly realized that lighting design and light pollution are incredibly complex and multifaceted issues with many knowledge gaps. Navigating the vastness of the subject matter proved to be a daunting task, and at times, I felt lost amidst the broadness of the topic.

The graduation process for me was more like an explorative journey. Every day I would discover new aspects about the topic and oftentimes felt a little bit lost in the broadness. However, the topicality and endless possibilities in this subject made the graduation very engaging.

## My view on landscape

I view landscapes as a complex whole of layers on top of each other. A beautiful way to look at the landscape is described by Spirn (1998). Spirn explains that even before humans developed spoken or written language, the language of

the landscape was first understood. Humans were looking at plants, the sky, the water and the earth. It was a great way to read the world around us. The landscape can be metaphorized as a book. In this sense, the landscape elements are the words that create full sentences. The sentence would be the scene of the whole landscape itself. Just like words in a text, our environment is also in a constant dialogue, the dialogue between humans and nature. This dialogue intrigues me and asks designers for balanced conversations with nature. To consider landscapes in this way, allows me to approach assignments with an open mind. This allows interpretation and transformation (Corner, 1991). In this way, new possibilities to perceive, represent and discover the landscape arise, like poems, myths, literature and art.

The interpretations and views of the landscape are highly personal. Yet, a common understanding of the landscape can be accomplished. Ideologies, economic benefits, institutions, corporations, design methods, technologies and many types of organizations can be the summarization of these opinions about the landscape (Relph, 1993). However, when the common understanding of the landscape pays little attention to topics like light pollution, it becomes a problem. This

is when advocates of important, yet underexposed topics, should stand up. As equally important as standing up for relatively unknown topics, it is crucial to always include ecology into design. Human kind has always tried to overcome the forces of nature. Sometimes, this is done by excluding nature itself. However, we are creating a growing gap between nature and humans. This is a problem because we need nature in order to survive. Nature is not separate from us, it is our co-tenants of the universe and also participating in evolution, passing of time and involved in shaping our future (Mcharg, 1967). Therefore, landscape architects should use their ability to connect. People in this profession are able to perceive and create new synergies between humans and nature. In my opinion, current landscape architects and students should use this 'power' to close the gap between nature and the human world. Ultimately, it is about finding a balance between the artificial and natural landscape elements.

Landscapes also include thinking about different circumstances. Different seasons and day and night rhythm play a huge role in the ever changing landscape. Since my graduation project is about light pollution and its effects, it is very important to me that landscape architects will also consider this

aspect of landscapes and develop a way to think differently about places at night. This subject is often forgotten or left out. As Philips (2002) puts it, landscape architects must have the vision to look at the problem as a whole and create balance between technology and visual fulfilment.

## Graduation studio Flowscapes

The theme of my graduation studio, Flowscapes, is centered on the concept of flows within landscapes across various scales. Light pollution is also a subject that can be examined and comprehended through different scales and flows. The impacts of light can occur at a local level, such as the effects of a single streetlight, or on a global scale, such as reduced visibility of stars worldwide. Additionally, there is a flow within the nocturnal ecology, where the impacts of artificial light on individual organisms can have a ripple effect on the entire population at the local, regional, national, and even global level. As such, the chain of effects can permeate through different scales, countries, and time.

## The graduation process

The graduation process started with my personal fascination for the night sky. Though I could never have imagined that this thesis subject would be both very interesting as well as very complex. As I went down the rabbit hole of light pollution, more



and more questions arose (Figure 7.1).

The topic of light pollution is relatively new, and as such, there has not been an extensive amount of research conducted on the subject. Recently, there has been a shift in the development of streetlights, as dynamic and interactive smart lighting is being developed. However, this research and development is still in its early stages, leaving the possibilities of the future endless. Due to this, my thesis subject and personal research were challenging. While I came across a lot of information about the effects of light on nature, there are still many uncertainties and gaps in scientific research. Nonetheless, writers, scientists, and associations for darkness are raising awareness for the importance of darker nights, and it seems that the topic is gaining more interest, which is an exciting development. I hope this thesis project can contribute to this.

Since 'dark urban landscape experience' is not really an existing term, I touched upon a new topic of the experience of a night landscape. In order to do research, I made a questionnaire and combined the answers with my own experiences of a dark landscape. This was difficult to do since it was hard to find people who would go outside at night. There were 4 people who filled in

the questionnaire, which is not a high number. In order to have a more specific set of design criteria, a bigger research should be carried out in future research. Next to that, I talked to many people about their personal experience of darkness at night, which was very inspiring. I did not document all these conversations, as they took place in informal settings with friends, family and other students. Two documented conversations were with musician Ruben Hein, during Earth Hour 2022, and author Marjolijn van Heemstra. The interviews will be added in the appendix. As the conversations were going along, I noticed that people have romanticized ideas about darkness and associate the night with stars, dreams, peace, contemplation, art, bats, lights, sleep, stillness and imagination. I found this really fascinating and corresponded with my own ideas about the night.

From the start of the graduation, it was my plan to have two final products to answer the RQ: *How can a new spatial darkness corridor and lighting strategy contribute to a dark urban landscape experience and evoke awareness for the importance of darkness, while improving the nocturnal ecology (with the focus on bats).*

1. Guidelines of how to create a darkness corridor, with a spatial lighting masterplan for my

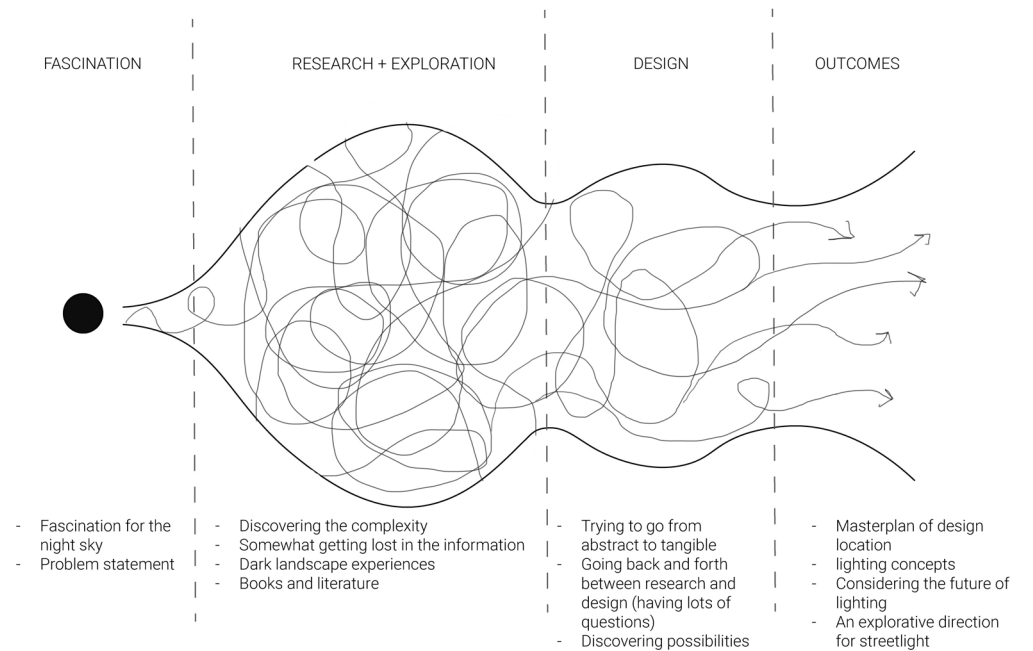


Figure 7.1. My graduation experience

chosen location as example and implementations to the local scale

2. Prototype of the designed lighting concept(s) to show the desired effects

As I had the ambition to combine Industrial Design Engineering (IDE) with landscape architecture, I wanted to make a prototype and understand the effect of lighting design. To do this, I followed 2 courses: *Interactive Technology Design* and *Lighting Design*. These courses gave me great insight in design for interactions and how to design with light. Since I did not know how to develop a lighting design, I was lucky that my second

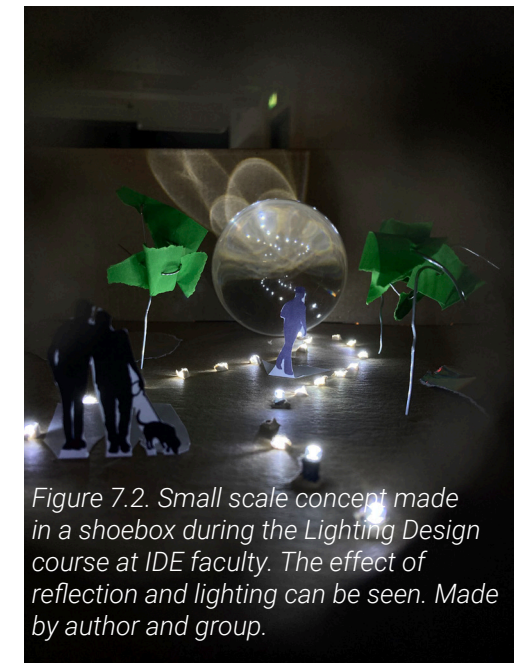


Figure 7.2. Small scale concept made in a shoebox during the Lighting Design course at IDE faculty. The effect of reflection and lighting can be seen. Made by author and group.

mentor, Aadjan van der Helm, pointed out the course of *Lighting Design* at the faculty of IDE. The course helped me to think in terms of light strategy, lighting concepts and how light is perceived. This helped me to develop my lighting concepts and masterplan. During this Lighting Design course, our group made a shoebox of a lighting design (Figure 7.2.) and shows the effects of light and reflective surfaces. However, in the end, the prototype is not made. I discovered that there were a lot of technical aspects involved in making a good presentable prototype, and I had to focus on the products for the design for Landscape Architecture. However, this does not mean that any future prototypes could not be made after my graduation.

With the combination of IDE and landscape architecture, it was important not to lose my focus. My main direction had to be landscape architecture and not IDE, since I am a graduate student of landscape architecture with an interest in Industrial Design Engineering. There were times where I was more focussed on the IDE courses and groupwork, and found it hard to combine the extra courses with my own graduation simultaneously. Time management-wise it was very difficult to do during graduation. However, the courses helped me to immerse into lighting design and interaction.

These courses definitely enriched my knowledge and my thesis topic.

### Design outcomes

To find an answer to my research question, I gained knowledge through literature, a questionnaire about the dark landscape experience, followed Industrial Design Engineering (IDE) courses at the TU Delft, made nightwalks to experience the dark urban landscape myself and held interviews and interesting conversations with many people. All this information forms the body of the thesis. To make it tangible, I choose to use The Hague as a case study to go back and forth between research and designing and applying the guidelines to. The outcomes are an experimental future lighting strategy for an area in The Hague and guidelines that can be used globally in the urban context for city planners and designers to use as a spatial tool.

One of the important outcomes is the need for transition zones in streetlighting. This concept does not (yet) exist, thus some assumptions had to be made. Calculations for the length of the transition zone need to be developed in further research. This thesis report suggests to use existing calculations that are being used for the transition in light intensity (Nederlandse Praktijkrichtlijn Pr- NPR13201, 2016). However, the Bat Conservation Ireland (2010)

suggests a bufferzone of at least 50m around a natural area, in which the possibilities of the new idea of transition zone can be implemented. Thus one single answer can not be given. I think it is the most important to look at the specific situation and species of a specific area. The new developed elements that are described in this report (chapter 4) should be taken into consideration for developing new calculations for the length of transitional zones. However, I did not do that, since I do not have the mathematic knowledge for this. Therefore, lots of assumptions have to be made and details of the exact properties of transitional zones are difficult to give.

In order to create darkness corridors in the urban context, the developed guidelines from this thesis outcome can be used. It is my goal to contribute to a spatially healthy and experiential night all over the world. The transitions from dark to light and light to dark play a crucial role for the human experience and is needed for societies to accept more darker spaces in the urban setting. Future researchers can take up this work and elaborate and add to the guidelines with new findings, new experiences and new information about the effect of light on nature and humans.

### Conclusion

The graduation year was an exploration full of surprises, questions, more questions and interesting discoveries. From the beginning of the graduation, I did not have a clear direction of where to go. The topic is very abstract and appeals to the imagination. As I followed courses about interaction and lighting design, a little direction was discovered. As I realized that softening boundaries by adding transition is really important for the human experience, I tried to think about how to establish that.

This graduation year taught me to stop hesitating, since a single 'good' answer does not exist. I can lose focus, but learnt how to bring it back. Sometimes I am too hesitant to make a design and get stuck easily. In order to gain an overview, displaying the drawings and findings together works best, since losing the thread is one of my pitfalls. In terms of future developments and research, I think this topic and my thesis report can contribute to a good starting point of looking at darkness corridors and transitions in streetlight.

So, to conclude, possibilities for the research question can be given; *How can a new spatial darkness corridor and lighting strategy contribute to a dark urban landscape experience and evoke awareness for the importance of darkness, while improving the*



*nocturnal ecology (with the focus on bats).*

There is no single answer to the research question, but a set of possibilities how to formulate one of many answers to the question. It is about the combination of multiple factors that will create a darkness corridor that contributes to a dark urban landscape experience and evokes awareness for the importance of darkness, while improving the nocturnal ecology. This thesis report illustrates the practical, atmospheric and important aspects of the guidelines and how to implement those, given in three main interventions. This way, nocturnal landscapes can thrive.

# Appendix



## The appendix

In this appendix, you can find the given answers of 4 participants and the original booklets that were used to illustrate the landscape experiences.

## Questionnaire

Thanks to the help of Marjolijn van Heemstra, this questionnaire was spread amongst people who enjoyed her night walking experience in the Vliegenbos in Amsterdam. The questions are related to the human senses and used in the thesis process to formulate three main landscape experiences for the night, a new concept developed by the author. Next to the answers of the participants, I also used my own experiences of the night to formulate the general landscape experiences.

# Onderzoek naar de beleving van het nachtelijke landschap

Beste lezer,

Hartelijk dank voor uw deelname aan deze enquête!

Mijn naam is Aileen Hallie en ik studeer momenteel af bij de Master Track Landschapsarchitectuur aan de TU Delft. Mijn afstudeer onderwerp is lichtvervuiling en de belevenis van het donker.

Het doel van mijn onderzoek is het ontwerpen van een nachtelijke beleving waarbij de mens, nachtelijke ecologie (vleermuizen) en de sterrenhemel weer worden verbonden in grote steden. Ik ben op zoek om dit op een ruimtelijke manier vorm te geven, en daar kan ik uw hulp goed bij gebruiken!

In deze enquête gaat het om de zintuiglijke beleving van de nacht; zien, horen, ruiken, proeven en voelen. In deze enquête zal ik dan ook vragen stellen over de zintuiglijke ervaringen die u tijdens een nachtwandeling heeft ervaren. De data die ik verzamel in deze enquête zal alleen gebruikt worden voor het onderzoeken van mogelijke (ontwerp) strategieën en als leidraad om nieuwe mogelijke nachtelijke ervaringen in het landschap te maken.

Enorm bedankt voor uw tijd!

Met vriendelijke groet,  
Aileen Hallie

Duur: minder dan 10 minuten

Het is niet verplicht om uw naam in te vullen, deze enquête mag u anoniem maken.

## Participant 1

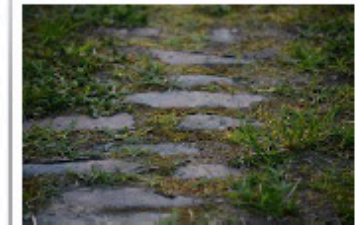
Categorie 1: ZIEN. Wanneer uw ogen waren gewend aan het donker, wat zag u tijdens de nachtwandeling? Probeer dit zo gedetailleerd mogelijk te omschrijven. (Denk hierbij aan Scherpe vormen of juist vage vormen, wel of geen schaduwen, kleuren van planten en paden en de zichtbaarheid van de sterren) \*

Tijdens mijn nachtwandeling door een bos vielen de bomen me veel meer op dan overdag, ze kwamen veel dreigender over, en staken als donkere, wiegende wezens af tegen de hemel, die niet helemaal donker werd die nacht. Tijdens een andere nachtwandeling door een park was het wel helemaal donker, en ging ik extra opletten of ik sterren zag. Sommige gebieden in dit park leken extra op te lichten, omdat ze een lichtere kleur hadden, het waren bijvoorbeeld witte bloemetjes, die een extra contrast vormden tegen de donkere grond.

Op wat voor een pad liep u? (Meerdere antwoorden mogelijk) \*



☐ Een makkelijk te bewandelen pad (bijvoorbeeld met rechte tegels of goed afgewerkt asfalt)



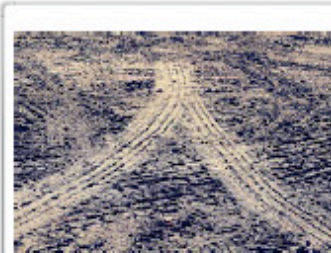
☐ Een pad met scheve stenen of beschadigd asfalt



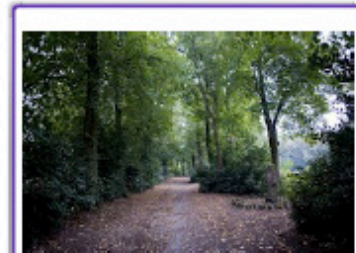
☐ Een onverhard zandpad



☐ Een graspad



☐ Een modderig/glad pad



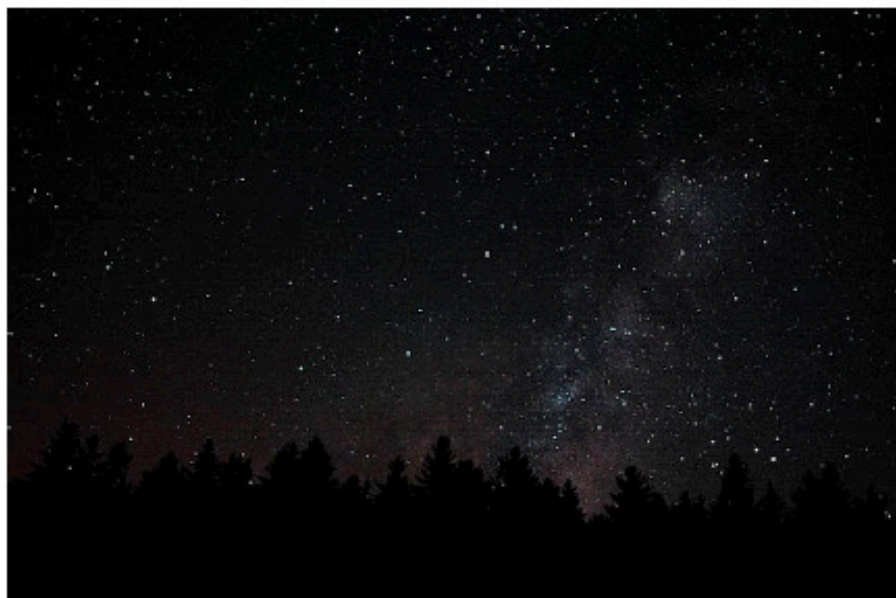
☒ Een semi-hard bospad

☒ Anders:  
Een onverhard bospad gedeeltelijk

Was het pad waar u overheen liep moeilijk te bewandelen in het donker en waardoor kwam dat? (Was het pad bijvoorbeeld niet goed zichtbaar, of lag het aan het materiaal van het pad en de weersomstandigheden?) Of was het pad juist fijn om overheen te lopen (omdat het goed zichtbaar was?) \*

Het was deels slecht zichtbaar toen het onverhard was (misschien alleen wat kiezels). Vooral de grenzen waren slecht te zien omdat alles donker was en het pad een donker materiaal had.

Heeft u tijdens de nachtwandeling naar de sterren gekeken/gezocht? Hoe was deze ervaring voor u? \*

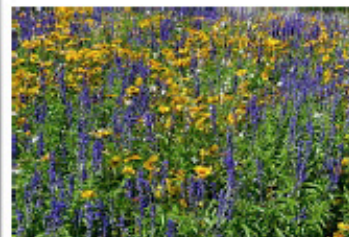


Ja, bij één van mijn wandelingen was de nacht helder en kon ik de sterren goed zien. Ik liep toen door één van de donkerste stukjes van Amsterdam, het was een hele verstilde, magische ervaring

Waren er veel of weinig sterren zichtbaar en waardoor kwam dat? \*

Veel, het was een plek met wat minder lichtvervuiling (Vliegenbos) en de nacht was helder

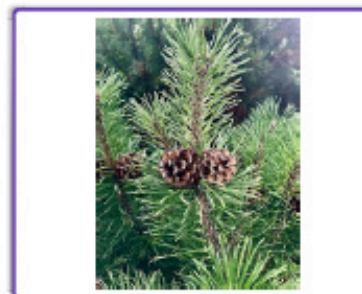
Categorie 2: GEUR. Wat rook u tijdens de nachtwandeling? (Meerdere antwoorden mogelijk) \*



☐ Geurende bloemen



☐ Gras



☒ Specifieke bomen

☐ Niets

☐ Anders:



Kunt u de geur die u rook zo nauwkeurig mogelijk omschrijven? (Was het een aangename geur en viel de geur meer op omdat het nacht was?) \*

Ik lette minder op mijn geur, maar het rook een beetje vochtig denk ik, de geur die je alleen in oude natuur ruikt..

Categorie 3: HOREN. Welke geluiden hoorde u tijdens de nachtwandeling? (Meerdere antwoorden mogelijk) \*

- ☒ De wind door de boom bladeren
- ☒ Geritsel in bosjes
- ☐ Auto's
- ☐ Dierlijke activiteiten, zoals vogels
- ☐ Vleermuizen
- ☐ Voetstappen van dieren
- ☐ Mensen (zoals stemmen of voetstappen)
- ☐ Anders: \_\_\_\_\_

Hoe heeft u de geluiden ervaren? Waren de geluiden bijvoorbeeld hinderlijk, rustgevend of juist verontrustend? Wellicht was er een geluid die u overdag nooit hoort. \*

Mysterieus, de wind door de bomen gaf me ook een gevoel van rust en puurheid en verbondenheid met de natuur

Categorie 4: VOELEN. Heeft u tijdens de nachtwandeling met de handen of met de blote voeten uw omgeving ontdekt? \*

- ☐ Ja
- ☒ Nee
- ☐ Weet ik niet meer
- ☐ Anders: \_\_\_\_\_

Wat voelde u? (Meerdere antwoorden mogelijk)

- ☐ Zachte elementen van het landschap (zoals zachte bladeren en zand)
- ☐ Stekelige elementen van het landschap (zoals stekels op planten)
- ☐ Gladde elementen van het landschap (zoals gladde bladeren, bast of muren)
- ☐ Harde elementen van het landschap (zoals de bast van de bomen, stenen en muren)
- ☐ Vocht op de huid vanwege een koude/dampende nacht
- ☐ De wind door de haren of op de huid
- ☐ Gras
- ☐ Koude elementen van het landschap (zoals steen)
- ☐ Scherpe elementen van het landschap
- ☐ Mos op de boomstammen
- ☐ Anders: \_\_\_\_\_

Kunt u zo nauwkeurig mogelijk omschrijven wat u voelde en hoe dat gevoel uw ervaring tijdens de nachtwandeling beïnvloedde?

\_\_\_\_\_

Laatste categorie 5: PROEVEN. Heeft u tijdens de nachtwandeling planten/bessen of andere elementen uit het landschap geproefd? \*

- ☐ Ja
- ☒ Nee
- ☐ Weet ik niet
- ☐ Anders: \_\_\_\_\_

Als u elementen uit het landschap heeft geproefd, hoe heeft u dat ervaren?

\_\_\_\_\_

Enorm bedankt voor het invullen van de enquête! Als u nog overige opmerkingen/ervaringen heeft over het nachtelijke landschap, hoor ik die graag. \*

\_\_\_\_\_

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## Participant 2

Maakt u wel eens een avondwandeling door het park/bos? Waarom wel of waarom niet?

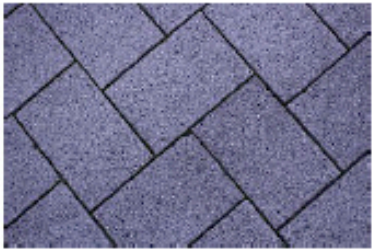
Bijna niet. Te ver weg, niet aantrekkelijk s avond om alleen te doen. Vaak wel tijdens vakanties.

Categorie 1: ZIEN. Wanneer uw ogen waren gewend aan het donker, wat zag u tijdens de nachtwandeling? Probeer dit zo gedetailleerd mogelijk te omschrijven. (Denk hierbij aan Scherpe vormen of juist vage vormen, wel of geen schaduwen, kleuren van planten en paden en de zichtbaarheid van de sterren) \*

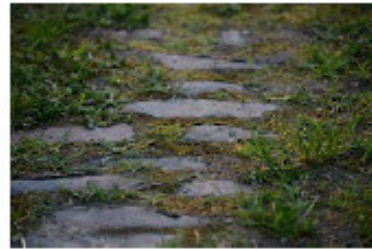
In het donker zag ik veel verschillende tinten tussen zwart, grijs, blauw en paars. De contouren van bomen/struiken waren zichtbaar maar vloeiden ook af en toe in elkaar over. Planten met lichte kleuren staken scherp af tegen de vaak wat donkere achtergrond.



Op wat voor een pad liep u? (Meerdere antwoorden mogelijk) \*



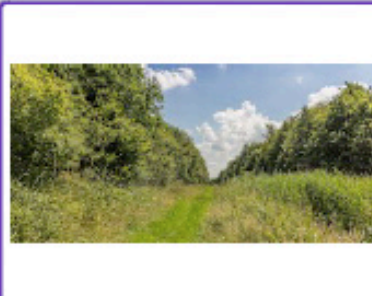
☐ Een makkelijk te bewandelen pad (bijvoorbeeld met rechte tegels of goed afgewerkt asfalt)



☐ Een pad met scheve stenen of beschadigd asfalt



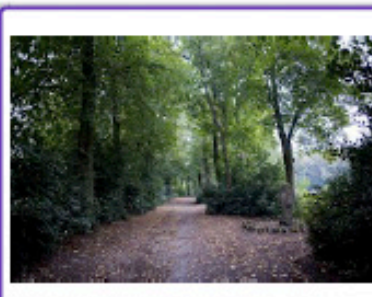
☒ Een onverhard zandpad



☒ Een graspad



☒ Een modderig/glad pad



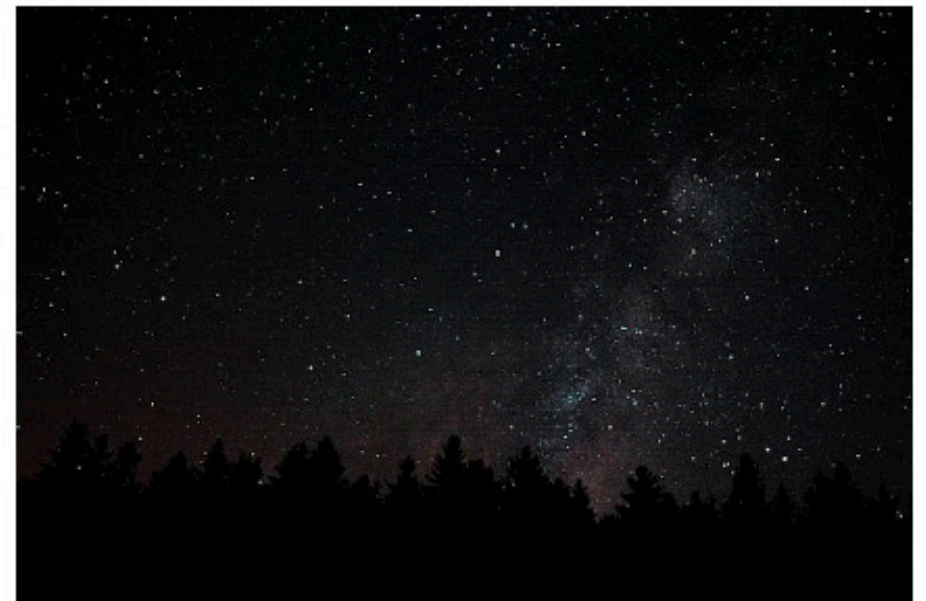
☒ Een semi-hard bospad

☐ Anders:

Was het pad waar u overheen liep moeilijk te bewandelen in het donker en waardoor kwam dat? (Was het pad bijvoorbeeld niet goed zichtbaar, of lag het aan het materiaal van het pad en de weersomstandigheden?) Of was het pad juist fijn om overheen te lopen (omdat het goed zichtbaar was?) \*

Het pad was fijn om over te lopen en was zichtbaar. Ook hoogteverschillen/stukken met boomwortels. Het lastigs vond ik de overgang van een natuurlijk pad naar een brug over het water.

Heeft u tijdens de nachtwandeling naar de sterren gekeken/gezocht? Hoe was deze ervaring voor u? \*



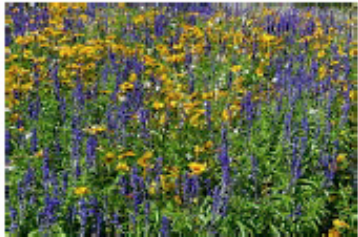
Ja en daardoor best weer wat sterren gezien en ervaren. Dat heeft altijd wat magisch omdat dat midden in de stad waar ik woon niet zichtbaar is.



Waren er veel of weinig sterren zichtbaar en waardoor kwam dat? \*

In het begin weinig -1 felle- later tijdens de wandeling steeds meer. Het kwam omdat het later en donkerder werd, er minder licht vanuit de omgeving kwam en mijn ogen waarschijnlijk meer ingesteld waren op het zien van sterren.

Categorie 2: GEUR. Wat rook u tijdens de nachtwandeling? (Meerdere antwoorden mogelijk) \*



☐ Geurende bloemen



☒ Gras



☐ Specifieke bomen

☒ Anders:  
Een nattige dikke geur

☐ Niets

Kunt u de geur die u rook zo nauwkeurig mogelijk omschrijven? (Was het een aangename geur en viel de geur meer op omdat het nacht was?) \*

Zoals al boven aangegeven een warme nattige dikke geur van water gemengd met groen

Categorie 3: HOREN. Welke geluiden hoorde u tijdens de nachtwandeling? (Meerdere antwoorden mogelijk) \*

- ☒ De wind door de boom bladeren
- ☒ Geritsel in bosjes
- ☐ Auto's
- ☐ Dierlijke activiteiten, zoals vogels
- ☒ Vleermuizen
- ☐ Voetstappen van dieren
- ☒ Mensen (zoals stemmen of voetstappen)
- ☐ Anders: \_\_\_\_\_

Hoe heeft u de geluiden ervaren? Waren de geluiden bijvoorbeeld hinderlijk, rustgevend of juist verontrustend? Wellicht was er een geluid die u overdag nooit hoort. \*

De geluiden waren fijn. Ze gaven de beweging om me heen aan. Daardoor voelde het soms zelfs dat het geluidsniveau van de koptelefoon te hard was - ik liep al met 1 oor onbedekt-.

Categorie 4: VOELLEN. Heeft u tijdens de nachtwandeling met de handen of met de blote voeten uw omgeving ontdekt? \*

- ☒ Ja
- ☐ Nee
- ☐ Weet ik niet meer
- ☐ Anders: \_\_\_\_\_

Wat voelde u? (Meerdere antwoorden mogelijk)

- ☒ Zachte elementen van het landschap (zoals zachte bladeren en zand)
- ☐ Stekelige elementen van het landschap (zoals stekels op planten)
- ☒ Gladde elementen van het landschap (zoals gladde bladeren, bast of muren)
- ☐ Harde elementen van het landschap (zoals de bast van de bomen, stenen en muren)
- ☒ Vocht op de huid vanwege een koude/dampende nacht
- ☐ De wind door de haren of op de huid
- ☒ Gras
- ☐ Koude elementen van het landschap (zoals steen)
- ☐ Scherpe elementen van het landschap
- ☐ Mos op de boomstammen
- ☐ Anders: \_\_\_\_\_

Kunt u zo nauwkeurig mogelijk omschrijven wat u voelde en hoe dat gevoel uw ervaring tijdens de nachtwandeling beïnvloedde?

Bladeren strijkend langs je hoofd; omringd worden door de natuur, vocht hangend aan bladeren of aren van planten> geeft het gevoel dat je leeft schrikt je op, maakt je wakker en verfrist.

Laatste categorie 5: PROEVEN. Heeft u tijdens de nachtwandeling planten/bessen of andere elementen uit het landschap geproefd? \*

- ☐ Ja
- ☒ Nee
- ☐ Weet ik niet
- ☐ Anders: \_\_\_\_\_

Als u elementen uit het landschap heeft geproefd, hoe heeft u dat ervaren?

Nvt

Enorm bedankt voor het invullen van de enquête! Als u nog overige opmerkingen/ervaringen heeft over het nachtelijke landschap, hoor ik die graag. \*

Het was een intense ervaring. Ook om dit temidden met een groep onbekende mensen te doen, die door de nacht vervagen tot contouren. Maar die jou en jij hen in de gaten houden om bij elkaar te blijven. Zo vorm je bijna 1 organisme.

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## Participant 3

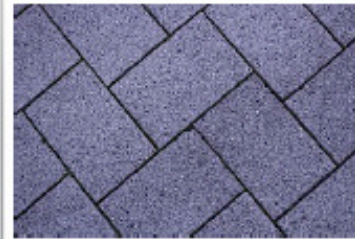
Maakt u wel eens een avondwandeling door het park/bos? Waarom wel of waarom niet?

Nee

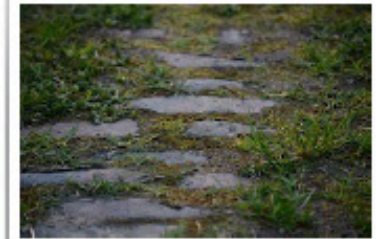
Categorie 1: ZIEN. Wanneer uw ogen waren gewend aan het donker, wat zag u tijdens de nachtwandeling? Probeer dit zo gedetailleerd mogelijk te omschrijven. (Denk hierbij aan Scherpe vormen of juist vage vormen, wel of geen schaduwen, kleuren van planten en paden en de zichtbaarheid van de sterren) \*

Contouren van de bomen , het riet , het pad .... De lucht ....

Op wat voor een pad liep u? (Meerdere antwoorden mogelijk) \*



☐ Een makkelijk te bewandelen pad (bijvoorbeeld met rechte tegels of goed afgewerkt asfalt)



☐ Een pad met scheve stenen of beschadigd asfalt



☐ Een onverhard zandpad

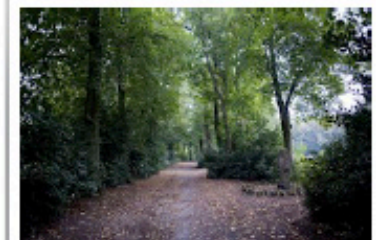


☒ Een graspad



☐ Een modderig/glad pad

☐ Anders:



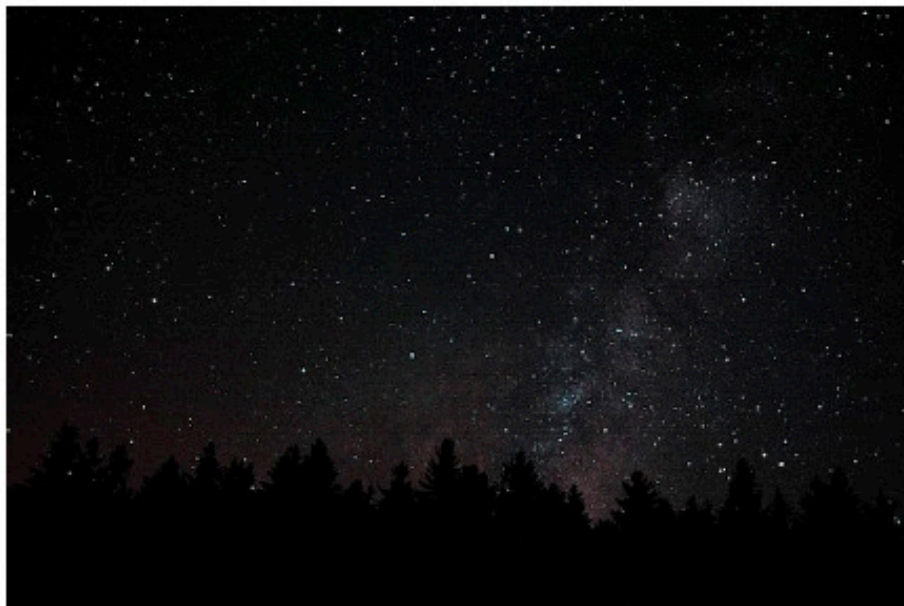
☐ Een semi-hard bospad



Was het pad waar u overheen liep moeilijk te bewandelen in het donker en waardoor kwam dat? (Was het pad bijvoorbeeld niet goed zichtbaar, of lag het aan het materiaal van het pad en de weersomstandigheden?) Of was het pad juist fijn om overheen te lopen (omdat het goed zichtbaar was?) \*

Een smal pad , het was nog niet zo donker ( juni )

Heeft u tijdens de nachtwandeling naar de sterren gekeken/gezocht? Hoe was deze ervaring voor u? \*

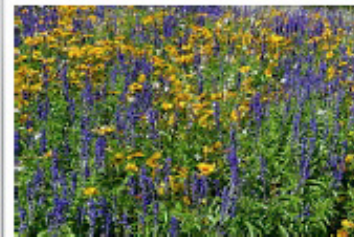


Jawel , maar de nacht was nog niet echt ingevallen ...

Waren er veel of weinig sterren zichtbaar en waardoor kwam dat? \*

Weinig

Categorie 2: GEUR. Wat rook u tijdens de nachtwandeling? (Meerdere antwoorden mogelijk) \*



☐ Geurende bloemen



☒ Gras



☐ Specifieke bomen

☐ Niets

☐ Anders:

Kunt u de geur die u rook zo nauwkeurig mogelijk omschrijven? (Was het een aangename geur en viel de geur meer op omdat het nacht was?) \*

Als in een park ...

Categorie 3: HOREN. Welke geluiden hoorde u tijdens de nachtwandeling? (Meerdere antwoorden mogelijk) \*

- ☒ De wind door de boom bladeren
- ☐ Geritsel in bosjes
- ☐ Auto's
- ☒ Dierlijke activiteiten, zoals vogels
- ☐ Vleermuizen
- ☐ Voetstappen van dieren
- ☐ Mensen (zoals stemmen of voetstappen)
- ☒ Anders: Muggetjes

Hoe heeft u de geluiden ervaren? Waren de geluiden bijvoorbeeld hinderlijk, rustgevend of juist verontrustend? Wellicht was er een geluid die u overdag nooit hoort. \*

Het was mooi en rustig ( mooi weer )

Categorie 4: VOELEN. Heeft u tijdens de nachtwandeling met de handen of met de blote voeten uw omgeving ontdekt? \*

- ☐ Ja
- ☐ Nee
- ☐ Weet ik niet meer
- ☒ Anders: Af en toe takjes aangeraakt ...

Wat voelde u? (Meerdere antwoorden mogelijk)

- ☐ Zachte elementen van het landschap (zoals zachte bladeren en zand)
- ☒ Stekelige elementen van het landschap (zoals stekels op planten)
- ☐ Gladde elementen van het landschap (zoals gladde bladeren, bast of muren)
- ☐ Harde elementen van het landschap (zoals de bast van de bomen, stenen en muren)
- ☐ Vocht op de huid vanwege een koude/dampende nacht
- ☐ De wind door de haren of op de huid
- ☐ Gras
- ☐ Koude elementen van het landschap (zoals steen)
- ☐ Scherpe elementen van het landschap
- ☐ Mos op de boomstammen
- ☒ Anders: Het natuurpad onder mijn gympen

Kunt u zo nauwkeurig mogelijk omschrijven wat u voelde en hoe dat gevoel uw ervaring tijdens de nachtwandeling beïnvloedde?

Rustig en fijn met natuur om me heen ...

## Participant 4

Laatste categorie 5: PROEVEN. Heeft u tijdens de nachtwandeling planten/bessen of andere elementen uit het landschap geproefd? \*

- ☐ Ja
- ☒ Nee
- ☐ Weet ik niet
- ☐ Anders: \_\_\_\_\_

Als u elementen uit het landschap heeft geproefd, hoe heeft u dat ervaren?

\_\_\_\_\_

Enorm bedankt voor het invullen van de enquête! Als u nog overige opmerkingen/ervaringen heeft over het nachtelijke landschap, hoor ik die graag. \*

Het was een mooie ervaring !

\_\_\_\_\_

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Maakt u wel eens een avondwandeling door het park/bos? Waarom wel of waarom niet?

Soms

\_\_\_\_\_

Categorie 1: ZIEN. Wanneer uw ogen waren gewend aan het donker, wat zag u tijdens de nachtwandeling? Probeer dit zo gedetailleerd mogelijk te omschrijven. (Denk hierbij aan Scherpe vormen of juist vage vormen, wel of geen schaduwen, kleuren van planten en paden en de zichtbaarheid van de sterren) \*

Vooraf vormen, geen of weinig kleur. Alles lijkt zachter, minder scherp en het is net of alles meer samenhangt

\_\_\_\_\_



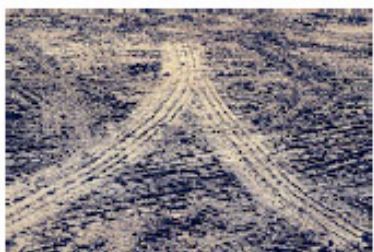
Op wat voor een pad liep u? (Meerdere antwoorden mogelijk) \*



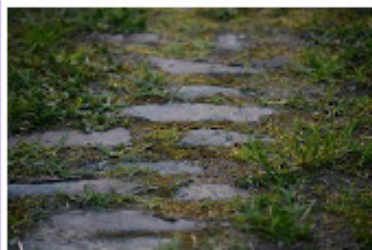
- ☐ Een makkelijk te bewandelen pad (bijvoorbeeld met rechte tegels of goed afgewerkt asfalt)



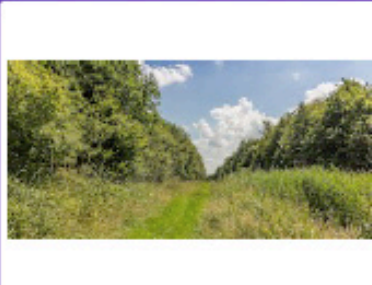
- ☐ Een onverhard zandpad



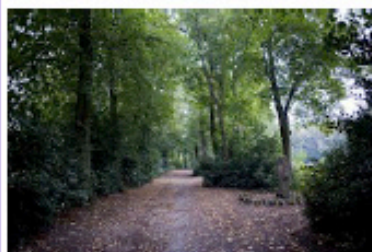
- ☐ Een modderig/glad pad
- ☐ Anders:



- ☒ Een pad met scheve stenen of beschadigd asfalt



- ☒ Een graspad

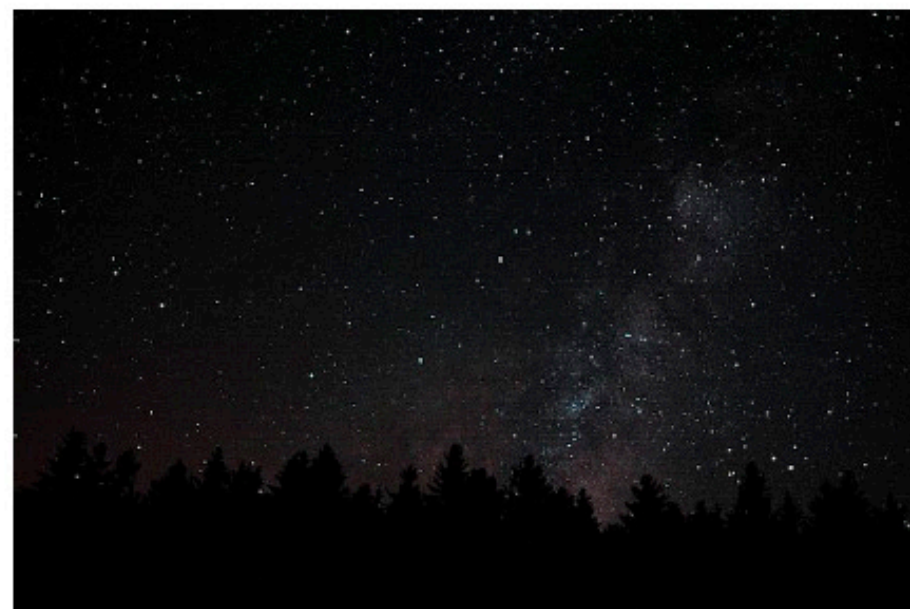


- ☒ Een semi-hard bospad

Was het pad waar u overheen liep moeilijk te bewandelen in het donker en waardoor kwam dat? (Was het pad bijvoorbeeld niet goed zichtbaar, of lag het aan het materiaal van het pad en de weersomstandigheden?) Of was het pad juist fijn om overheen te lopen (omdat het goed zichtbaar was?) \*

Als je eenmaal gewend bent aan het donker, blijkt het helemaal niet zo donker en is er goed te wandelen

Heeft u tijdens de nachtwandeling naar de sterren gekeken/gezocht? Hoe was deze ervaring voor u? \*



Buiten de stad zie ik nog regelmatig veel sterren, dat kan overweldigend zijn

Waren er veel of weinig sterren zichtbaar en waardoor kwam dat? \*

Buiten de stad is er minder lichtvervuiling (in oost Nederland) en zie ik veel meer sterren

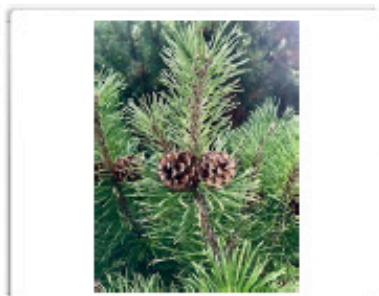
Categorie 2: GEUR. Wat rook u tijdens de nachtwandeling? (Meerdere antwoorden mogelijk) \*



☒ Geurende bloemen



☒ Gras



☐ Specifieke bomen

☐ Niets

☒ Anders:  
Water

Kunt u de geur die u rook zo nauwkeurig mogelijk omschrijven? (Was het een aangename geur en viel de geur meer op omdat het nacht was?) \*

Doordat het donker is en je minder op zicht vertrouwt staan je andere zintuigen op scherp. Ik rook gemaaid gras, en vooral het water. Een licht rottende geur, gronderig, vissig.

Categorie 3: HOREN. Welke geluiden hoorde u tijdens de nachtwandeling? (Meerdere antwoorden mogelijk) \*

☒ De wind door de boom bladeren

☐ Geritsel in bosjes

☒ Auto's

☒ Dierlijke activiteiten, zoals vogels

☐ Vleermuizen

☐ Voetstappen van dieren

☒ Mensen (zoals stemmen of voetstappen)

☒ Anders: Gezoem van insecten

Hoe heeft u de geluiden ervaren? Waren de geluiden bijvoorbeeld hinderlijk, rustgevend of juist verontrustend? Wellicht was er een geluid die u overdag nooit hoort. \*

Geluiden van verkeer waren hinderlijk, verder niet. Geluiden van vogel en insecten hoorde je duidelijker dan als het licht is.

Categorie 4: VOELEN. Heeft u tijdens de nachtwandeling met de handen of met de blote voeten uw omgeving ontdekt? \*

☐ Ja

☐ Nee

☐ Weet ik niet meer

☒ Anders: Soms even met handen een tak tegenhouden o.i.d



Wat voelde u? (Meerdere antwoorden mogelijk)

- ☒ Zachte elementen van het landschap (zoals zachte bladeren en zand)
- ☒ Stekelige elementen van het landschap (zoals stekels op planten)
- ☐ Gladde elementen van het landschap (zoals gladde bladeren, bast of muren)
- ☒ Harde elementen van het landschap (zoals de bast van de bomen, stenen en muren)
- ☐ Vocht op de huid vanwege een koude/dampende nacht
- ☐ De wind door de haren of op de huid
- ☒ Gras
- ☐ Koude elementen van het landschap (zoals steen)
- ☐ Scherpe elementen van het landschap
- ☐ Mos op de boomstammen
- ☐ Anders: \_\_\_\_\_

Kunt u zo nauwkeurig mogelijk omschrijven wat u voelde en hoe dat gevoel uw ervaring tijdens de nachtwandeling beïnvloedde?

\_\_\_\_\_

Laatste categorie 5: PROEVEN. Heeft u tijdens de nachtwandeling planten/bessen of andere elementen uit het landschap geproefd? \*

- ☐ Ja
- ☒ Nee
- ☐ Weet ik niet
- ☐ Anders: \_\_\_\_\_

Als u elementen uit het landschap heeft geproefd, hoe heeft u dat ervaren?

\_\_\_\_\_

Enorm bedankt voor het invullen van de enquetel! Als u nog overige opmerkingen/ervaringen heeft over het nachtelijke landschap, hoor ik die graag. \*

Geen \_\_\_\_\_

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Transformative dark landscape experience



Contrasting dark landscape experience

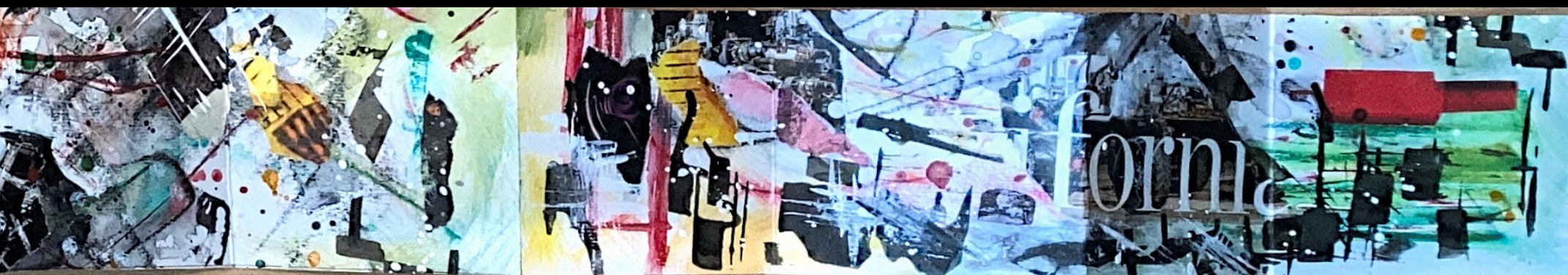


Contemplative dark landscape experience



Actual sizes 1,25m by 10cm. Made on 16 August 2022





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Figure 3.8: Korsten, E. (2022). *Wat doen vleermuizen eigenlijk voor ons?* De Zoogdiervereniging. Found: <https://www.zoogdiervereniging.nl/nieuws/2022/wat-doen-vleermuizen-eigenlijk-voor-ons>  
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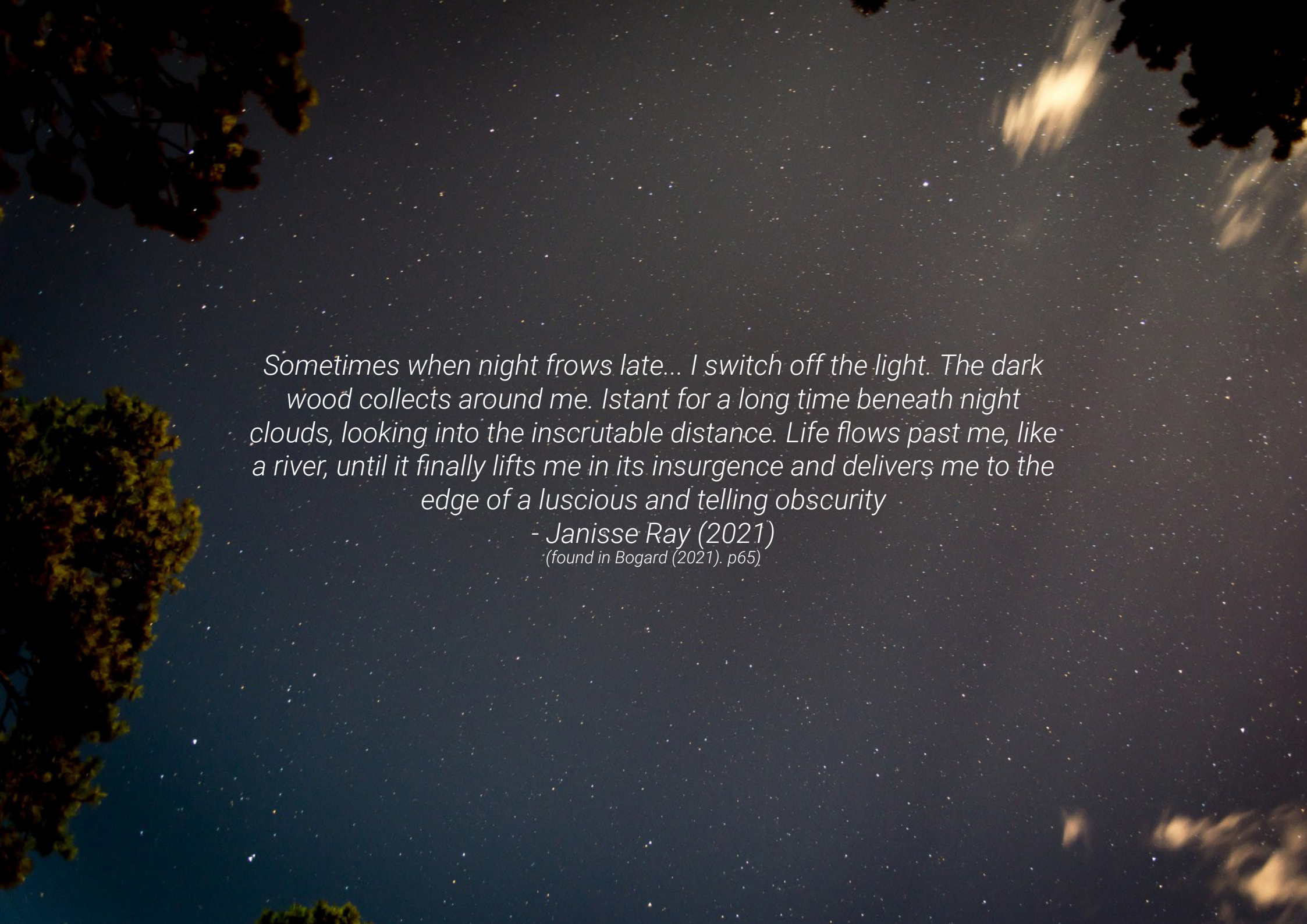
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## Figures:

Figure 2.3: Y. Smith & B. Pharm. (2021). *What is the circadian rhythm?* Found:





*Sometimes when night frows late... I switch off the light. The dark  
wood collects around me. Istant for a long time beneath night  
clouds, looking into the inscrutable distance. Life flows past me, like  
a river, until it finally lifts me in its insurgence and delivers me to the  
edge of a luscious and telling obscurity*

*- Janisse Ray (2021)  
(found in Bogard (2021). p65)*