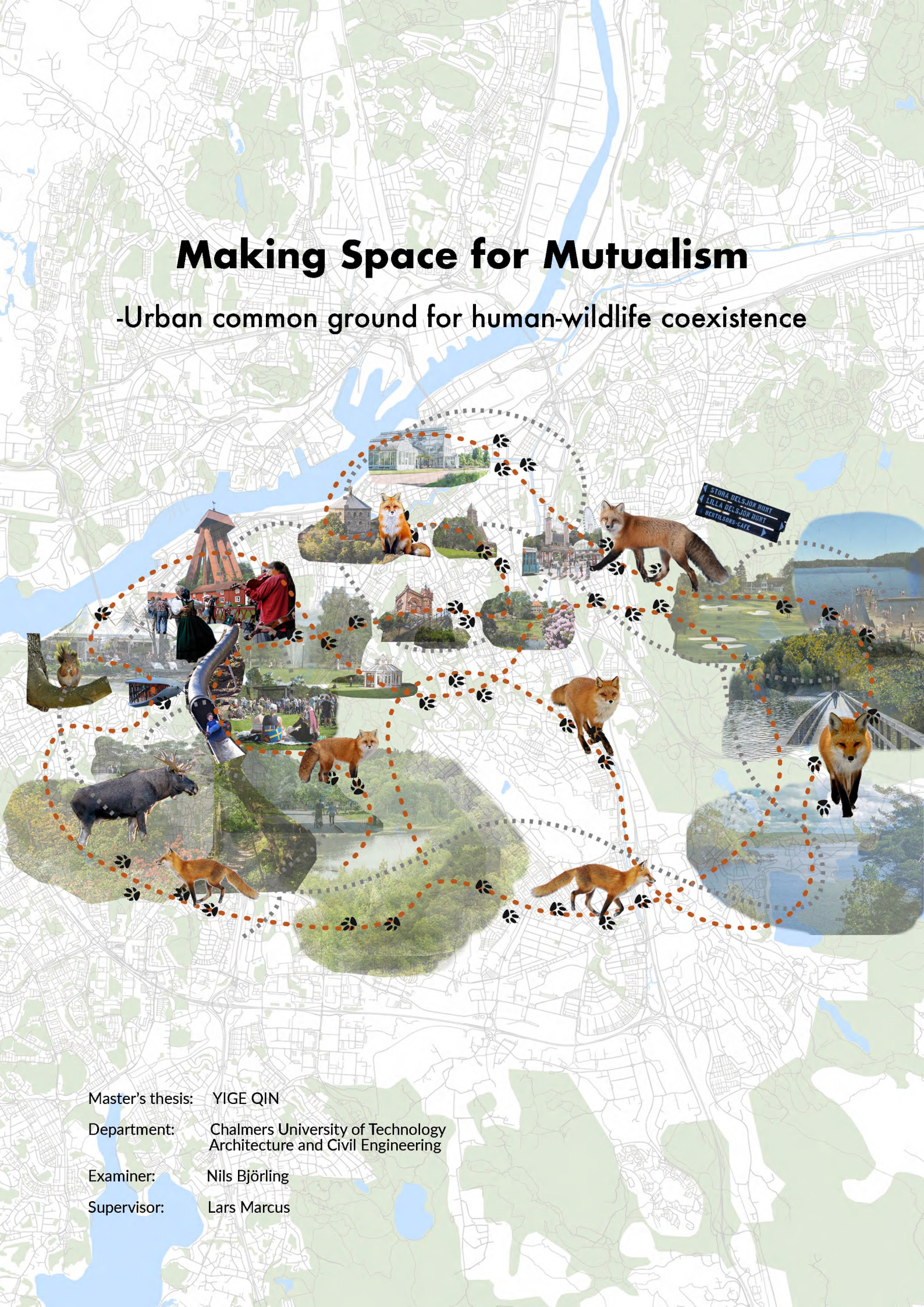


# Making Space for Mutualism

-Urban common ground for human-wildlife coexistence



Master's thesis: YIGE QIN

Department: Chalmers University of Technology  
Architecture and Civil Engineering

Examiner: Nils Björling

Supervisor: Lars Marcus



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## Abstract

The natural environment and habitats around the city were disturbed due to urban growth, resulting in a reduction in biodiversity. Not only do humans migrate to cities to search for a better life, but certain wildlife also adjust their behavior and adapt to urban environments. City life provides "fast food" and shelter for wildlife, but due to the built environment and pressure from human activity, urban life is difficult for them. Urban wildlife could aid in the recovery and increase of urban biodiversity, providing numerous benefits such as aesthetic value and cures for mental health issues. However, there are human misunderstandings and concerns that wildlife brings disease, injury, and property damage.

Making common ground for human-wildlife coexistence in the urban area is the topic of this thesis. The thesis aims to understand the relationship between the city, ecosystem, humans, and wildlife, as well as how they interact and influence one another, as well as to promote interaction and connection between humans and wildlife, and foster mutual trust. The research for design method was adopted. This thesis is built on the Social-ecological Urbanism theory and is guided by the principles of Landscape Ecology and the theory of Animal-Aided Design. The thesis analyzed the green network in Gothenburg's central urban area

to understand the ecological connectivity and how the green mosaic functions as a system. The red fox has been selected as the keystone animal, and to research the critical needs of the red fox and then analyze suitable locations from the red fox's perspective in Gothenburg's central area. A series of essential sites for habitats were identified, followed by recommendations for rethinking and transformation to offer habitats for urban animals to survive and thrive and achieve the purpose.

Urban green infrastructure is essential for urban wildlife to thrive. As a result, when we are in the position of urban planning, we should have a holistic and systematic view, understand how the green infrastructure functions as a system, and take the aspects of wildlife into consideration. The focus of the thesis is the process of exploring the problem, the application of theory to mapping and analysis, and the outcome of the thesis shows a strategic plan outlining the directions and suggestions for the transformation of the red fox's crucial places in central Gothenburg that supports their "urban life" and movement, allows human-wildlife interactions and coexistence, and contributes to the social-ecological outcome.

## About the author

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## Thesis outline

Chapter 1 will introduce the background and framework of this master's thesis. Beginning with social phenomena and the impact of urbanization on natural ecosystems. Followed by an introduction to urban ecology, which provides the first insight into the theme of human-animal coexistence in the city. Finally, through three perspectives, we reflect on the relationship between humans, nature, and non-human species. The thesis's framework includes thesis questions, discourses, delimitations, and the methodology that has been used. This chapter is completed with a schematic illustration of the process of the thesis, which shows the structure of the master's thesis.

In Chapter 2, the theoretical framework of this master's thesis will be introduced. The work is founded on the theory of Social-ecological urbanism. Understanding the urban ecological network is assisted by the principles of Landscape Ecology. Animal-Aided Design shows us how to include a wildlife perspective into the urban design process, guiding us in the creation of habitats where humans and wildlife may coexist.

In chapter 3, the theories will be applied to the analysis. Ecological analysis to comprehend the urban green mosaic in the center of Gothenburg, followed by species mapping to know which wildlife is living with us. The red fox has been selected as the keystone animal, and further research and analysis have been undertaken from its perspective. Finally, identify the territory circle for further design.

Chapter 4 offers suggestions for the transformation of locations and connections to become ecological habitats and help wildlife movement while enriching city dwellers' activities and creating multifunctional, integrated spaces for human-wildlife coexistence. A strategic plan will be present.

The final chapter of this master's thesis includes reflections on the process and refers back to the research questions and aims. A discussion about the advice for interdisciplinary cooperation for urban planners in the future. There are also references to books, papers, and photos, as well as sketches in an appendix.

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## Chapter 1: Introduction

This chapter will introduce the thesis's background knowledge. Beginning with social phenomena such as the impact of epidemics on wildlife and the impact of urbanization on natural ecosystems, then discusses commonly held misunderstandings about wildlife. Followed by an introduction to urban ecology, including a brief overview of urban ecosystems, wildlife conversation, and the coevolution of humans and other organisms in urban environments, which provides the first insight into the theme of human-animal coexistence in the city. An argument from the aspect of urban ecology will talk about the "coupled relationship between humans and other organisms in urban areas". Finally, through three perspectives, namely the philosophical approach, the typological perspective, and

the historical perspective, the relationship between humans, nature, and non-human species will be reflected.

The thesis's framework includes and positions the work within the relevant discourses. The chapter is completed by presenting the thesis questions, delimitations, and the methodology that has been used. A schematic illustration of the process of the thesis will show the structure and process of the master's thesis, starting from the different investigations and reflections, to the development of the research question, and then the theoretical system as well as the analysis and suggestions for the transformation

## Mutualism

noun

1. the doctrine that mutual dependence is necessary to social well-being.
2. BIOLOGY  
symbiosis which is beneficial to both organisms involved.

## Thesis background

The story started with a deer I met around Chalmers, and I saw several posts on social media, that some other friends have also seen the deer around their dormitory and they were all overjoyed. I have never seen such size mammal walking freely in urban areas before. This incident made me start thinking about why this deer was wondering in the city and what dangers it would face such as traffic, where does it sleep, how would it move around? In order to find answers to my curiosity, I decided to develop my master thesis based on these questions, focus on the social ecological aspects of sustainability - the topic of human-wildlife coexistence.

When I started to research the topic of human-wildlife coexistence in the urban area, I realized this is a vast subject that encompasses many fields, such as knowledge of urban planning, urban ecology, and animal studies. So the background introduction starts from the phenomenon and reflects on the relationship between man, nature and the city, the history of urbanization, urban ecology, and Evolutionary Biology

are approaches to the theme of human-wildlife coexistence. Ecology is an essential aspect of sustainable development, but our understanding of ecology in cities may still be limited to greenery which can mitigate the heat island effect and reduce soil erosion. Ecosystem service has been mentioned in recent years in the urban design process with the aim of providing a healthier living environment for people, but urban environment is also vital to non-human life and should be a higher priority in urban planning and design process.

I hope that through this essay, we will gain a better understanding of the urban environment and realise that it is not just a living space for humans, but that if we can provide living space for other creatures to flourish together and live in mutual symbiosis, we will have a healthier living environment and many environmental crises may be mitigated.



Image 1: A Roe deer moving around the campus of Chalmers



Image 2: A Roe deer moving around the campus of Chalmers

## Phenomenons

### -The influence of the Covid pandemic

When I met the deer in campus, I thought maybe because of the pandemic, when human activity is reduced, streets are quiet and empty, so wildlife has the opportunity to explore the cities, walk along the streets, visit our residential area, or swim in the harbor and waterways. BBC news wrote that *"Wild animals enjoy freedom of a quieter world - Coronavirus lockdowns globally have given parts of the natural world a rare opportunity to experience life with hardly any humans around."* This Phenomenon is found in major cities around the world, for example, Dolphins are coming further up to the harbor than usual, in Istanbul, Wild boars in Haifa, Israel, bird community is getting stronger in Shanghai. (Coronavirus: Wild Animals Enjoy Freedom of a Quieter World - BBC News, 2020)

### -Imagine a post-human era

There are also extreme situations, such as the Chernobyl disaster and Nuclear Contamination in Fukushima, nature has flourished in the absence of humans, trees, plants, and wildlife are taking over the place, ecosystem started to revive. People imagine a post-human world in literature and film, for example the Hollywood films *Twelve Monkeys* (1995) and *I Am Legend* (2007), and the best-selling books like *The World without Us* (2007), which show how nature reclaims its dominance over the Earth in a postapocalyptic world. (Alagona, 2022)



Image 3: Dolphins are coming further up to the harbor than usual, Istanbul

### - The influence of urbanization

During rapid industrialization between 1920 and 1950, urbanization was also at a high growth rate. Urban growth disturbed and broke the natural environment, leading to habitat fragmentation. Wildlife habitats were squeezed and taken over by the built environment. In those days, the number of wild animals in cities was particularly low, and people thought that wild animals should not be in the towns except in zoos. From 1950 to 1990, the period of suburbanization and counterurbanization, the massive spreading of urban populations to the suburbs has made lifestyle more dependent on cars. Forests, wetlands, and swamps were converted into motorways and roads, habitats were divided into smaller uncontinuous patches, which caused biological extinction. Also, the expansion of car emissions led to further destruction and loss of wildlife habitats. Some large cities have seen a decline in downtown areas due to suburbanisation, such as Detroit in the USA, and some wildlife has settled into the cities. Since the 1990s, during the period of reurbanization, the city government and public sector began to actively develop declining areas of the city center to increase the level of living quality in the city, and to achieve re-growth of the city's population. At that time, the concept of "Green city", "Rewilding the City" has been bring on, more and more city parks were constructed, the public's concern for the environment is also



Image 4: Wild boar in Haifa, Israel

gradually increasing, and more wildlife has returned to the city because of the improved quality of the environment, especially in Gothenburg, in Sweden, where people often observe all kinds of wildlife, such as deer, hares, and owls.

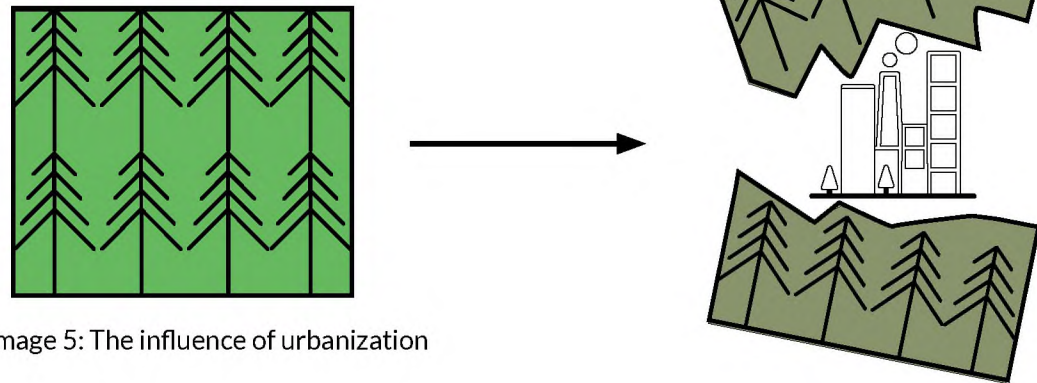


Image 5: The influence of urbanization

There are misunderstandings that wildlife only belongs to wild nature reserves or forests outside the city. People used to think that Ecosystems are constant and stable, the behavior of most creatures was fixed, and that behavior would change very slowly. However, it turns out that the ecosystem is a dynamic system that constantly changing, and a considerable number of creatures have shown themselves to be more flexible than people thought (Poon, 2022). Wildlife is coming to the city to find food, and shelter, adapting to the city environment, so the city becomes a particular habitat for them.

### -Urban exploiters, urban adapters and urban avoiders

One way of looking at species response to urbanization is to place organisms into one of three categories: urban exploiters, urban adapters and urban avoiders. Urban exploiters, such as rats, sparrows and pigeons, who live in cities and depend on cities, use human waste as a food source and roofs or sewers as homes, they have a close relationship with humans, but are often considered as pests. Urban adapters coming to cities for resources, for instance, coyotes, groundhogs, jays, robins, crows, cardinals, red foxes, and raccoons. These species often roam between cities and suburbs, They can

take advantage and utilize cities as shelter and “fast food store”, yet they rely on natural resources, often nurture the next generation in the suburbs. The urban avoiders are the most sensitive group to environmental changes and are not usually seen around cities. They are large mammalian grazers such as bison and elk, large mammalian predators such as bears, wolverines. They also migrate between patches of natural habitats, with roads, dams and other large structures often being a barrier to them. (Rose, 2012)

Urban wildlife has evolved as it has adapted to the urban environment, learning to use resources and avoid danger, becoming increasingly intelligent. (Osterloff, 2019) For example, urban foxes have been known to prevent vehicles, some nocturnal creatures, like owls, learned to avoid light pollution, and raccoons and crows have learned to rummage through bins for food. There is a “coupled relationship between humans and other organisms” in urban areas; humans and wildlife can bring mutual benefits and promote coexistence and co-evolution.

## Misunderstanding and wrong impression of urban wildlife

There are also wrong impressions of urban wildlife, that they are aggressive, will attack pets, disspread disease, damage property, but study from researches showed that those situations caused by urban wildlife are minor. Actually, urban life for wildlife is challenging, they are vulnerable than we think.

### -Urban wildlife attack on domestic pets

-Attacks or injury by urban wildlife are rare. Predatory, territorial and defensive attacks by wildlife to humans are rare in urban areas (Soulsbury et al., 2015). The reasons for attacks could be when individuals are protecting young animals, or over food. Even though situations of attacks and injury are rare, but people still fear of wildlife attacks. A research showed that 15% respondents feared of attack by red fox (König, 2008; Soulsbury et al., 2015).

-Risks of attack on pets seem to be minor or absent.

Perceived threat of urban wildlife attack on domestic pets is often significant. (Harrison 1998; König 2008; Spacapan 2013; Soulsbury et al., 2015) But this situation is depending on species, for instance, urban foxes, which are usually perceived to kill pets, attack pets rarely. Diet analysis shows that 4.5% of the gut volume of foxes in Zürich is made up by pets, including hens, cats, dogs, rabbits and cattle (Contesse et al. 2004; Soulsbury et al., 2015), 2.4% of the content of fox scats in Bristol, UK (Ansell 2004; Soulsbury et al., 2015). The interactions between pets and wildlife happen not randomly, so it is important to manage pets appropriate, in order to reduce the risk of attack and conflicts (Soulsbury et al., 2015).



Image 6: Urban wildlife attack on domestic pets

### -Disease

60 percent of human pathogens are derived from animals, according to research (Bengis et al. 2004; Soulsbury et al., 2015). The direct transfer of disease from wildlife to humans may be rare, but pets are often an important element of the disease cycle and can serve as a link between wildlife and humans. (Deplazes et al. 2011; Soulsbury et al., 2015). Zoonotic diseases should be taken seriously in urban settings, and there is a continuing need to investigate zoonotic illnesses in urban areas due to the high financial burden of the introduction or reemergence of zoonotic and vector-borne illnesses and the harm it poses to humans, companion animals, and wild animal populations (Bradley, Altizer 2007; Soulsbury et al., 2015).



Image 7: Disease

### -Nuisance and property damage

Most damage or problems caused by urban wildlife are minor (Soulsbury et al., 2015). Common damage includes damage to the landscape, such as lawns or fences (Harris 1985; FitzGibbon and Jones 2006; Urbanek et al. 2011; Soulsbury et al., 2015), loss of crops in gardens (Harris 1985; Soulsbury et al., 2015) or low-level damage to cars or property (Herr et al. 2009; Soulsbury et al., 2015), depending on species. Urban wildlife living in colonies or have semi-permanent den sites are often been reported with problems such as bin-raiding (Harris 1985; Clark 1994; Belant 1997; McKinney 2011; Soulsbury et al., 2015), fouling and noise (Gorenzel and Salmon 1992; Belant 1997; Clergeau et al. 2001; FitzGibbon and Jones 2006; Phillips et al. 2007; Soulsbury et al., 2015). Some wild animals may disrupt the aesthetics of buildings or streets, but they do not cause actual serious damage (Coluccy et al. 2001; Soulsbury et al., 2015). Although, most of damage caused by urban wildlife are minor, but once it happens, it can cause considerable economic damage and impact, so education and mediation on urban wildlife is necessary to reduce conflict and misunderstanding (Soulsbury et al., 2015).

## Urban ecosystem and Evolutionary Biology

Why should we design for wildlife in urban areas? One of the greatest modern challenges is wildlife adapting to our artificial environment, and as human beings, we have to learn to live with wildlife in urban areas and respect them.

### -Urban ecosystem

At first, we need to be clear about the impact of urban development on nature and ecosystems. A city is a man-made physical and social mechanism that provides places and services for the activities of dense populations. In a jungle of artificial steel and concrete, nature and the ecosystem survive in the cracks and present a highly patched and fragmented spatial structure compared to the rural ecosystem. Due to the isolation and the homogeneity of patches, urban species are more vulnerable to extinction. (Alfsen et al., 2011) Urban development has been claimed to eradicate large proportions of native flora and fauna and cause the extinction of local species. (McKinney, 2002; Kotze et al., 2011) Land-use changes rapidly in urban areas which have a strong influence on biodiversity.

Intensive human activities put a lot of pressure and disturbance on the fragile natural environment in urban areas, such as the 'heat-island' effect - the temperatures in the central city are higher than the surroundings. As a result, the ecological successions in urban green spaces are altered, inhibited, or truncated by human-induced disturbances, which affects the urban climate and leads to abnormal growth cycles for plant communities (Kotze et al., 2011).

### -Ecosystem services in urban areas

Even if humans are always destroying nature and negatively impacting ecosystems, In reverse, ecosystem services provided by the natural environment have a great positive impact on the health and quality of life in the urban environment. The Millennium Ecosystem Assessment (MA), identified four major categories of ecosystem services: provisioning, regulating, cultural, and supporting services. Provisioning services support the basic need of our daily life, such as food and drinking water, plant fibers that can be used to make clothes, and energy sources that keep society running, such as wood fuel, natural gas, and oil. Regulating services maintains and sustains the environment's functioning and makes life possible to thrive. For instance, urban green parks can regulate urban climate, clean air, filter water, and reduce the urban heat island effect: green roofs and green walls have the potential for lowering urban temperatures (Alexandri & Jones, 2008; Alfsen et al., 2011); vegetation may reduce noise levels, bees and butterflies can pollinate flowers, Plant rhizomes prevent soil erosion. We can receive cultural services from interaction with nature, and obtain aesthetic, spiritual, and psychological benefits. A review by Bird (2007) mentioned that a large number of health indicators relating to the accessibility and contact with green spaces, such as treatment for children with poor self-discipline, hyperactivity, and Attention Deficit Hyperactivity Disorder (ADHD), treatment for dementia among elderly care, reduction of anxiety and stress, improving concentration ability and work efficiency, increasing sense of mental health and well-being. Lastly, the most fundamental service is the supporting service, which includes photosynthesis, nutrient cycling, the creation of soils, and the water cycle, without those natural processes, the whole system will collapse (Alfsen et al., 2011).

### -Wildlife conversation

Wildlife is recognized to play an important role in urban ecosystems (Cohn, 2005; Strohbach, et al., 2014), What kind of effects does wildlife have on urban ecosystem services, and what do they provide for ecosystem services? Research showed that companion with animals can benefit to human health (Friedmann et al. 1980; Barker and Wolen 2008; Friedmann and Son 2009; O'Haire 2010; Adams, 2014). The most intuitive benefit for people to experience nature is to interact with wildlife, possible interactions in the city such as birds visiting, bird feeders, or indirect interaction like observation of deer, hare and squirrel in backyards or in parks, could delight and relax our mind and body. Urban wildlife bring us also audio enjoyment beside visual aesthetics, bird song is a cure for stress. Those are cultural services that urban wildlife bring us. There are also regulating services from urban wildlife, for example, some arthropods control pest insects and pollinate plants in gardens and vacant lots (McDonald et al., 2013), fur and droppings of small mammal can help deliver seeds.

Thus in urban planning and urban design process we should include wildlife's aspect, their needs should also be equally considered as human being. The ability to attract and retain wildlife in urban areas also provides an ideal opportunity for outreach, education, and public involvement to help develop an understanding and appreciation of ecological relationships and conservation goals (Hess et al., 2014). In urban areas, wildlife should be a part of park management, open space management, street tree management, stormwater and watershed management, and even backyard management. Landscapes that are visually attractive to people can be created to benefit wildlife as well. Many landscape architects recognize audio aesthetics, as well as visual aesthetics and bird song, ranks high as a sound people enjoy (Hess et al., 2014).



Image 8: Property damage



Image 9: Urban sanitation

### -Coevolution of humans and other organisms in urban areas

In urban ecosystems, humans, more than human species and abiotic elements are tightly linked together and interact with each other. While humans are at the top of the food chain, affecting the genetic and cultural inheritance of other species, vice versa, more than human organisms are also influencing mechanisms of human evolution. Human society has always developed at the cost of the natural environment, from the industrial age to the modern cities, we remove forests and vegetation cover to build up artificial environments for human activities, we have developed a food industry that has removed a large part of the population from their relationship with nature (e.g. no longer hunting or gathering. The urbanisation, the constantly changing of landcover caused pollution, fragmentation and degradation of landscape, which have huge impact on the survival, population structure, reproduction, behaviour, and evolution of more than human organisms. During human evolution, the relationship between man and animal is in constant flux, our position changed from prey to predators and then caretakers of other animals. In the past people used livestock as a means of transport and they were also involved in farming work. In modern society, where developed animal husbandry provides food and nutrition for humans and pets provide us with emotional value. In urban areas, urban parks provide habitats for many animal species, who could benefit with living in proximity to humans; their presence is a means of access to nature for humans and contributes to our physical and mental well-being(Clucas&Marzluff, 2011).

*"Coevolution occurs in nature when two species are interlocked in evolutionary interactions that drive reciprocal selection between the species. When humans select for certain phenotypic traits in other species that, in turn, affect human phenotypes, we can call this coevolution."*

The dual inheritance system of humans and other social animals can be interpreted as the mutation, natural and cultural selection, and drift influencing genetic inheritance over time. The same happens to cultural inheritance, which develops through time in response to innovation, natural and cultural selection, learning, and drifts. Human activities modify the configuration and function of the physical environment, which affects the evolution of local organisms; the environment's responses to those changes and the consequences of the process influence the cultural and natural selection of humans. In other words, the environment changes in response to humans' natural and cultural selection, which in turn affects human behavior, meme frequency, culture, and genetic inheritance (Laland et al., 2000; Clucas&Marzluff, 2011). This process of 'ecological inheritance' occurs not only in the relationship between humans and the physical environment but also between humans and socially-behaving wildlife. Many animals have social behaviors; they acquire information through social learning and develop traditions that meet the culture's social-learning definition (Avital & Jablonka, 2000; Clucas&Marzluff, 2011). Suppose human behavior affects the daily activities of a particular animal and changes the animal's behavior and memes, resulting in cultural evolution in the animal, which affects the cultural fitness of human memes(Clucas&Marzluff, 2011). In that case, human and animal memes may become coevolved. Cities should not be designed exclusively for humans. The commensal relationship between humans and wildlife is essential, contributing to genetic and cultural evolution. Thus we should create and transform our urban areas for wildlife existence.

### Coupled relationships between humans and other organisms in urban areas

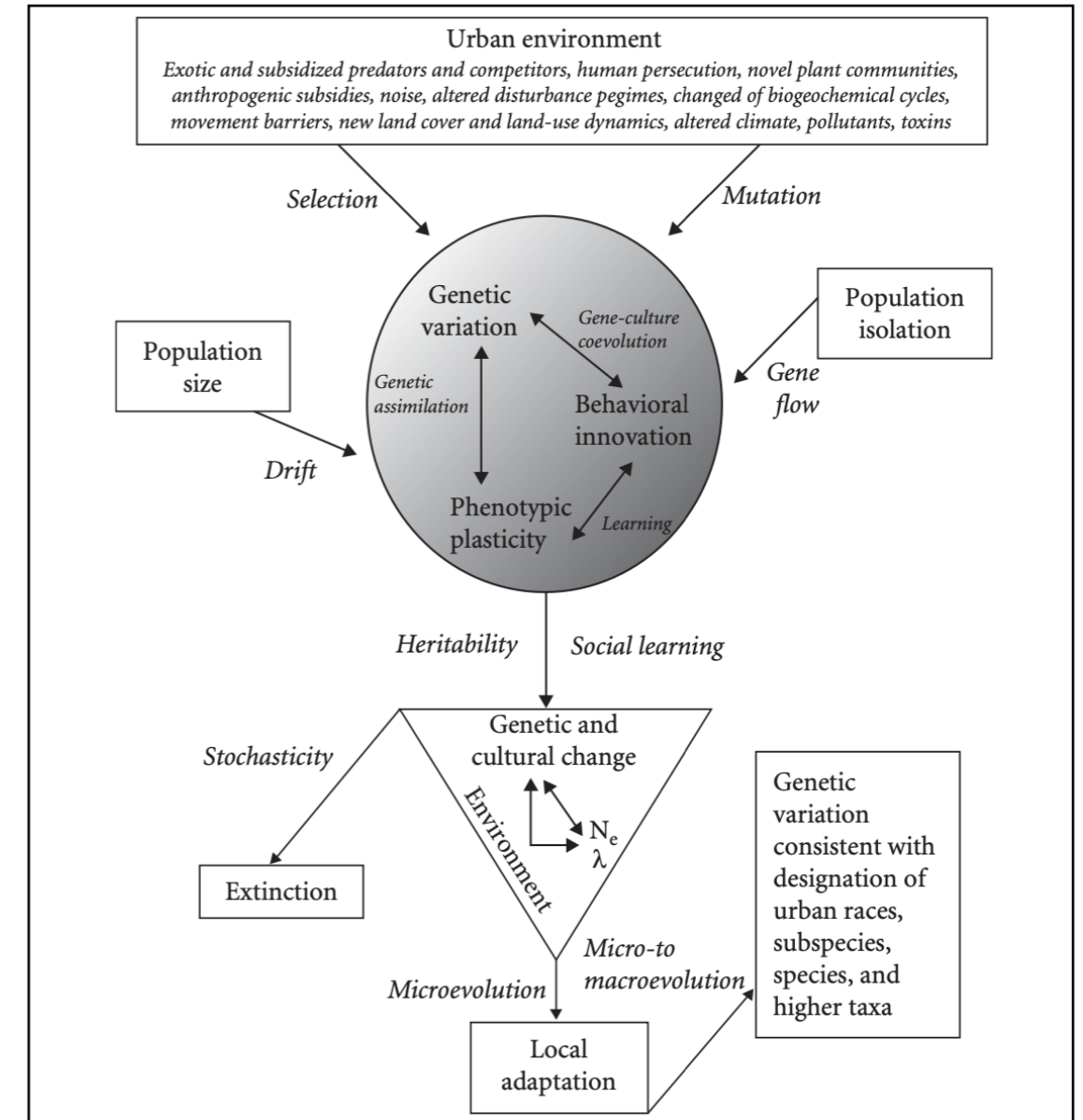
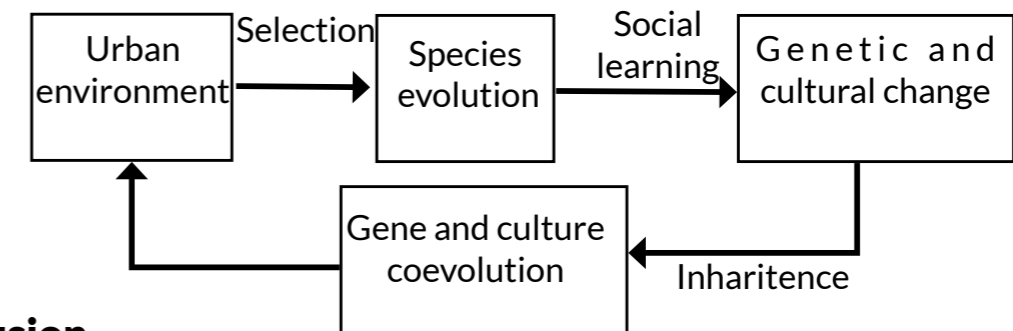


Image 10 : Key process and interactions of contemporary evolution in urban ecosystems



### Conclusion

From the research above, I gained an initial understanding of urban wildlife and urban ecology, and learned that humans do not exist in isolation in urban ecology, that other species are involved in our development and evolution, and that we are in a mutually

beneficial symbiotic relationship. This began to make me reflect on the history of our urban development and the evolution of our relationship with nature and other species in the process of urban development.

## Reflection about the relationship between humans, nature, and more-than-human species

Take three approaches to reflect the relationship between humans, nature, and more-than-human species. From a philosophical perspective, a concise overview of the process of perception alteration in humans. From the notion that humans are the center of the universe and that all natural resources are for human use to the acknowledgment that humans are equal to all natural things. From a typological perspective, briefly describe the changing spatial relationships between humans and animals. A transition has occurred as human perceptions have evolved, civilization has developed, and cities have spread, resulting in various spatial relationships. With the historical view of the evolving social ties between humans and wildlife, from isolation to symbiosis, from prey cattle to companion animals. I hope that reflecting on these three avenues will further our understanding of the theme of human-wildlife coexistence in the city more in-depth and concretely.

### A philosophical approach

#### -Reflection of the relationship between Human and Nature

#### Anthropocentrism

- Human-centered
- Only humans have moral standing
- Human life and well-being have final value while other species and nature have instrumental values which can be used and sacrificed to achieve final value for human-being
- All humans are equal

#### Animal ethics

- Expand the moral concern to all sentient animals
- Animal rights: all animals that have the capacity for consciousness, preferences, memory, expectation, etc, should have moral standing
- All animals are equal

#### Biocentrism

- Expansion of the moral concern to all life: humans, other sentient animals, non-sentient animals, and plants
- Humans are not special
- Biolife-centered
- Other life should be respected, avoid the harm to them

#### Ecocentrism

- Shift of focus from the individual to the whole and to the groups
- Radical: only the landscape or the ecosystem have moral standing
- Individuals only have instrumental value by maintaining the function of the ecosystem
- Ecosystem, the entire Earth is a super-organism
- Humans should minimise their impact on the ecosystem

(Hedenus et al., 2018)



Image 11: EGO



Image 12: ECO

## A typological approach

-Study of the spatial relationship between humans and animals

From 19 century, the modern urban areas are designed for human activities, wild animals are regarded as inferior uncivilized creatures and therefore excluded from cities, while you can still find domesticated animals in certain spaces in cities.

### Animal spaces: (human-dominated)

a specific area for animals, which has been controlled and classified by humans, for instance, Zoos, farms, pets in apartments or courtyards.

### Beastly spaces: (Animals-dominated)

“Wild animals seeking to stay wild in their wild places, getting on with their own lives and worlds without anything to do with us humans, performing their specific forms of agency to one another, creating their own worlds, their own beastly places, without reference to us.” (Philo, 2000)

### Nature spaces:

Nature reserves for animals with less human activities

### Culture spaces:

Artificial space for human activities and need, in contrast to nature spaces.

### More-than-human-space:

Zoos, residential courtyards, parks, gardens, green spaces in the city where animal activities can be observed and interactions between humans and animals can happen, those spaces can't be simply divided into nature or culture space. A culture-space has been created by animals, therefore the boundary of nature-culture space has been questioned. (Hauck et al., 2017)



Image 13: Zoo, human-dominated spaces



Image 14: Nature spaces



Image 15: Culture spaces: New York City

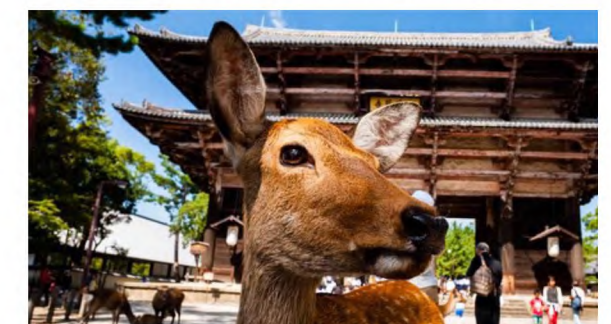


Image 16: More-than-human spaces: Nara in Japan

## A historical approach

-Changes of boundaries between humans and animals along with the societal development

### Before the 19th century

Before industrialization and urbanization

-The city wall blocked some “wild people” and “wild animals” out of the city

-Animals for pleasure and status for instance dogs and rare animals

-Livestock, like pigs, chicken, geese for self-sufficient lifestyle at that time

-Horse-carriage and donkey as transportation on the street

-Liminal animals such as mice and rats, some pigeons also live in cities

-Sanitation and hygiene conditions were poor which led to diseases

### 19th century

-With rapid urbanization, the boundary of space between humans and animals was clearly separated.

-The new residential buildings are only designed for human beings, the animals are excluded.

-For the upper class, animals are pets that provide emotional and aesthetic needs

-For the lower class, there were various interlaced spaces between humans and animals, for instance, the courtyard for poultry in cities; outside cities, public spaces such as streets and squares were occupied by animals.

-Cognitive changes of animals: the shift from superstitious to science: from “animal blood represents strength and vitality” to “fear of bacteria in animals’ body”

-Because of the hygiene problems, animals are excluded from public space in cities

### The first half of the 20th century

-Le Corbusier 5 points to the new architecture, but animals were not mentioned

-Pets are banned in apartments in some European cities

-Law on protecting the rights of animals

### The second half of the 20th century

-From 1950, livestock disappeared in cities, the car completely replaced the horse

-Animal products are industrially produced out of the city

-Small-scale household farming in cities showed up, but for educational and recreational propose.

-1970-1990, animals become an element, and theme for green landscape design with ecological revolution, nature protection, animal and ecological issues are taken seriously

### Millennium

-Co-existence of human-animal

-indoor biome

-Ecosystem services

(Hauck et al., 2017)

## Conclusion of the background

We discovered from the reflection that we have shifted our attitude from a human-centered to a holistic understanding that the ecosystem is dynamic, the entire earth is a super-organism, and all living beings should be treated equally.

To summarise the background, during the Covid pandemic, ecosystems in cities were restored due to less human activity, and wildlife appeared in cities. When we look back at the history of urbanization, we can see that people have been destroying animal habitats while opening up nature to develop modern cities. People living in cities are isolated from nature and, rightfully, feel that cities are human territory and those wild animals should not be in cities, that zoos are their urban habitat, that they carry disease, destroy public infrastructure, eat garbage, and are uncivilized and barbaric. Cities, on the other hand, are special habitats for wildlife because to their abundant food resources, which attract urban adapters to live here, but the animals are neglected in the urban planning process.

With urban growth, urban ecosystems have become fragmented, separated, and homogenized, with invasive non-native species threatening native species' existence. The extinction of native creatures, particularly plant groups, destabilizes the local environment and results in an ecological crisis. With the development of urban ecology, it has become clear that

ecosystem service is relevant to all aspects of human life, from water, air, and food to physical and mental health, and that urban planning and design are increasingly incorporating ecosystem service to provide people with a more comfortable and healthy living environment. However, wildlife in cities has usually been neglected due to its unpredictability and the difficulty of conducting research. According to evolutionary theory, humans and urban wildlife constitute a co-evolutionary mechanism, from genetics to cultural transmission, in a mutually beneficial relationship. To develop mutual trust and coexistence with wildlife in the city, we should perhaps modify our way of thinking and look outside the fixed human-centered mindset.

The following chapter will define the aim of the research and develop the research questions, identify the primary research subjects, determine which topics will be explored in depth and which will not be discussed, set delimitations, define the research approach, and lastly offer a thesis process framework.

# Thesis framework

## ? Research Question

**What is the relationship between the city, the ecosystem, humans, and wildlife, and how can we better understand the urban green network and include wildlife into city planning?**

**To achieve the social-ecological goal, how could we redesign and transform spatial elements of urban green public spaces so that the city becomes a wildlife refuge and promote human-wildlife coexistence?**

### Aim and Purpose

The thesis seeks to understand the relationship between the city, ecosystem, humans, and wildlife, as well as how they interact and influence one another. The aim is to understand the green mosaic in the urban area, discover where the ecological corridors are and how the green mosaic can support the ecosystem; provide suggestions and guidelines for redesigning and transforming spatial elements in the urban area to provide habitats for urban wildlife; and create an active and dynamic environment in the urban context to improve urban life quality and wellbeing for humans and non-human species in order to achieve the social-ecological outcome.

The purpose is to increase and promote human-wildlife interaction and connection, to provoke and arouse thinking and reflection about the relationship between humans and non-human species, and nature in the city, and to build mutual trust through common ground for both human activities and wildlife in the city.

### Delimitation

#### -Not about

This thesis will focus on social and ecological aspect of sustainability, the economical aspect will not be discussed. This paper's philosophical stance is that humans are equal to other organisms, and philosophical ethics will not be discussed in depth. While the subject of disease control for wildlife in cities, inevitably conflicts with pets, and health issues are certainly important, this field requires additional research and will not be addressed in depth in this thesis, it is only mentioned in the background.

#### -Limitation

Since wildlife's reactions to human activities are uncertain, a substantial amount of local observational data and research is necessary. While local observational studies of keystone species are limited, this thesis will depend on current studies of keystone species' behavior in other regions of Europe. Animal behavior can vary depending on geographical conditions, hence the statistics will be biased. Knowledge from Ecology and animal studies are critical to understanding human-wildlife coexistence, but they are separate disciplines that cannot be fully investigated in the time available. This thesis will conduct analysis from an urban planning perspective,

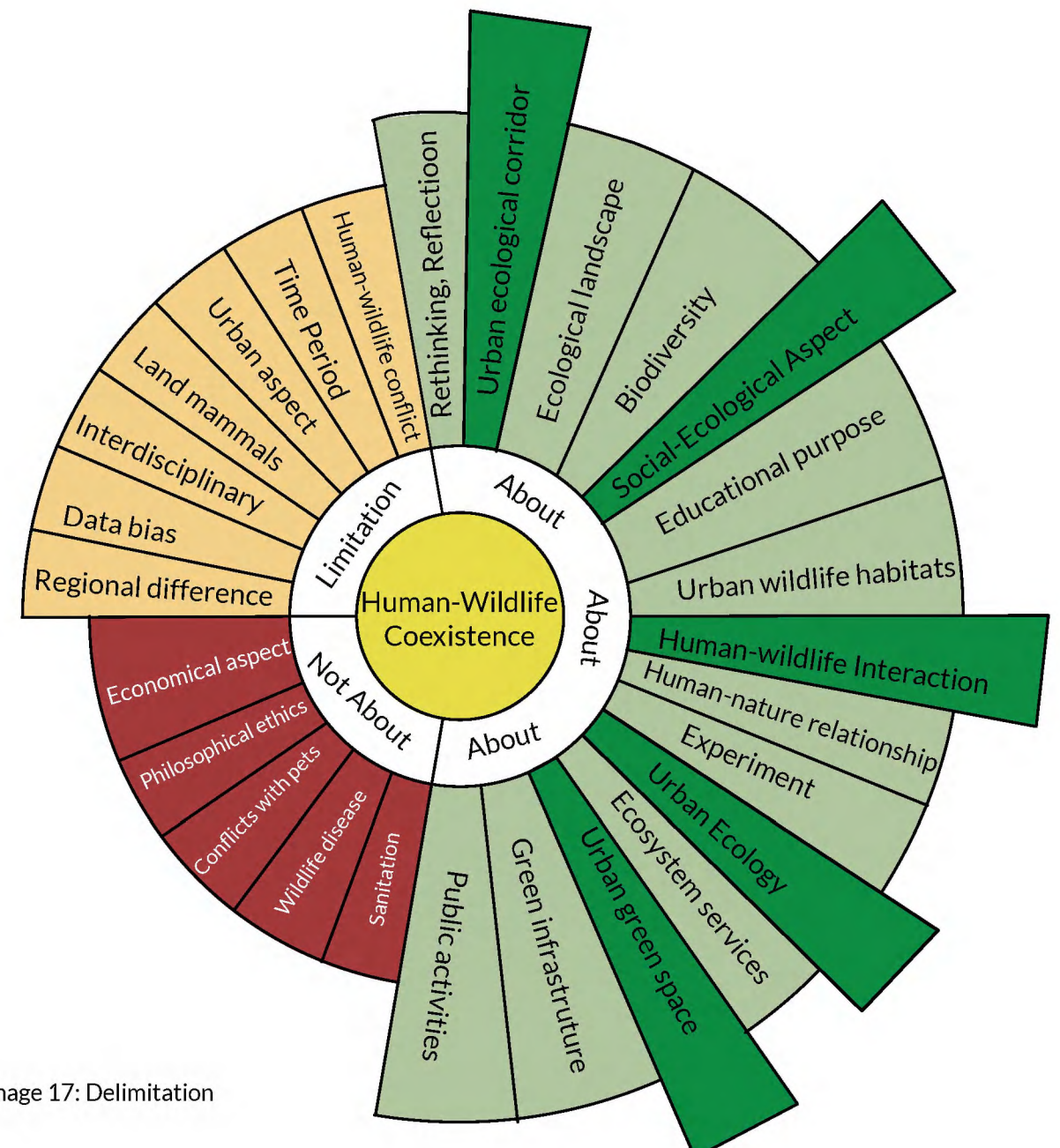


Image 17: Delimitation

combining knowledge from ecology and animal studies with theories and research methods summarised by earlier authors.

#### -Outcome

This thesis will not present the detailed design work of urban green space. While there is a lot of discussion on ecological issues and the coexistence of human and non-human species in cities. However, there does not seem to be a comprehensive set of principles to guide planning and design. This thesis focuses on the collection and integration of relevant theories, intending

to construct a logical chain that will provide an in-depth understanding of the subject and help in addressing the environmental challenges of urban planning.

The analysis of Gothenburg's central area is used to identify useful suggestions and provide a new perspective - a new urban plan that values the presence of wildlife and is designed from the perspective of wildlife, increasing human-nature interaction and achieving a cohesive coexistence future.

## Discourse

Four main subjects for further research were extracted: the city, ecosystem, humans, and wildlife. The thesis seeks to determine the relationship between these four subjects, as well as how they interact and influence one another. As a result, urban planning, urban ecology, and urban wildlife are all relevant topics.

The first discourse is on human-nature relationships in urban settings. Mankind has taken advantage of nature by constructing modern cities out of steel, concrete, and asphalt to suit our demands and keep society running at fast pace. Urbanization has also brought a number of environmental issues, including pollution, soil erosion, increased extinction of species, and biodiversity loss. Urban planners attempt to solve these challenges by incorporating natural elements into the city structure. Although artificial cities are encroaching on nature's territory and disrupting natural balance to a certain extent, man and nature are not oppositional and man is part of the ecosystem, so the initial intentions of this paper are to explore how to balance urban development and nature in a mutually beneficial and mutually supportive relationship.

The second discourse concerns the urban green network. We know that nature benefits city dwellers and helps to alleviate environmental crises. The thesis will utilize GIS to explore how the urban green network supports the ecosystem, how wildlife may move around urban areas, and how the green network functions as a system. Also, to understand how human activities like transportation networks and land use affect the urban ecological system.

The last discourse is urban wildlife. The thesis focuses on how urban wildlife would survive in urban areas and how people may coexist with them. As cities encroach on natural and wildlife territories, some wildlife is forced to find new natural territories,

while others choose to adapt to the new urban environment; nonetheless, the urban system segregates habitats and leads to the isolation of species groups, which causes homogeneity and accelerates the extinction of some species. Wildlife has been neglected in the urban planning process, and this thesis will investigate from the perspective of wildlife, as well as how to change the city into a shelter for wildlife to thrive with humans.

To achieve the purpose of this thesis, which is to create an active and dynamic environment in the urban context to increase interaction and connection between humans and wildlife, as well as to build mutual trust through the common ground for both human activities and wildlife in the city. The thesis attempts to bring together theoretical knowledge and research from several related domains to formulate a clear and reasonable train of thought that can be applied in the process of urban planning.

The 17 Sustainable Goals set by the United Nations are the guiding lights for sustainable development. The focus of this paper on human-wildlife coexistence in cities includes the following goals: Good Health and Well-being, Sustainable Cities and Communities, Climate Action, Life On Land.

Including a wildlife perspective into the urban planning process can support ecosystems and restore biodiversity. A functional urban green network could help tackle the climate change crisis and create a healthier ecological environment that can benefit residents' health and assist heal psychological disorders. In addition, by Integrating a wildlife perspective into the urban design could improve education, awareness-raising, and institutional capacity on climate change problems, allowing us to make our cities and communities more sustainable.

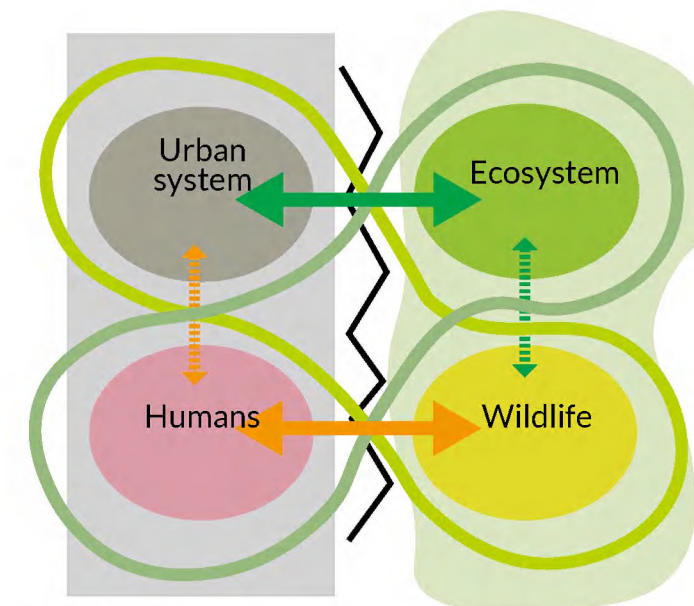


Image 18: Discourse



Image 19: Sustainable Development Goals

## Methods and Methodologies

The method used for the thesis is research for design. The thesis begins with a collection of social phenomena, observations, and reflections in order to comprehend the discourses and begin to collect research and theories in the relevant fields. The major method is literature study, and the content of the literature covers several aspects, the first of which is the theory of Social-Ecological Urbanism, which is the foundation of this thesis. By conducting relevant studies, we can better understand the interaction between the urban system and the ecosystem.

The following step is to understand the urban green network; the leading theory for this step is landscape ecology. Understanding the various patterns and how they affect the environment. Further research on the theme of wildlife in cities with the study of zoologist observations to understand the habits of keystone species. With the theory of Animal-Aided-Design guide, we will learn how to integrate wildlife into design plans, and how to encourage coexistence between humans and wildlife. The study of the green

infrastructure will provide inspiration and guidance for the design proposal.

In addition to literature studies, case studies are used to better understand how urban planners put theory into practice. Field study finds inspiration in the city, in children's play spaces, urban green parks, where there are many tiny facilities constructed by residents using local materials, using natural materials such as dead wood to build places for children to play, and wildlife shelters.

The main method of study is GIS analysis. The tool for ecological analyses is Morphological Spatial Pattern Analysis, which was developed with ecology and geographic information to assist planners in carrying out ecological analyses in the regional range. The suitability analysis is used to find suitable sites for design. I focused on the Gothenburg urban region to better understand the function of the urban green network, how ecological corridors are built, and how the urban green network might facilitate animal mobility.

The design part of the thesis is based on the analytical results and will propose ideas and suggestions for improvements to transform our public areas into urban wildlife shelters and promote coexistence between humans and wildlife. There will be no in-depth comprehensive design, however there may be some sketches if time allows.

### Process of the thesis

The figure depicts the process and logical flow of thought of the master thesis, beginning with the phenomenon and continuing towards reflection, research questions, extracting discourses, studying theories, analysis, and eventually providing suggestions for improvement.

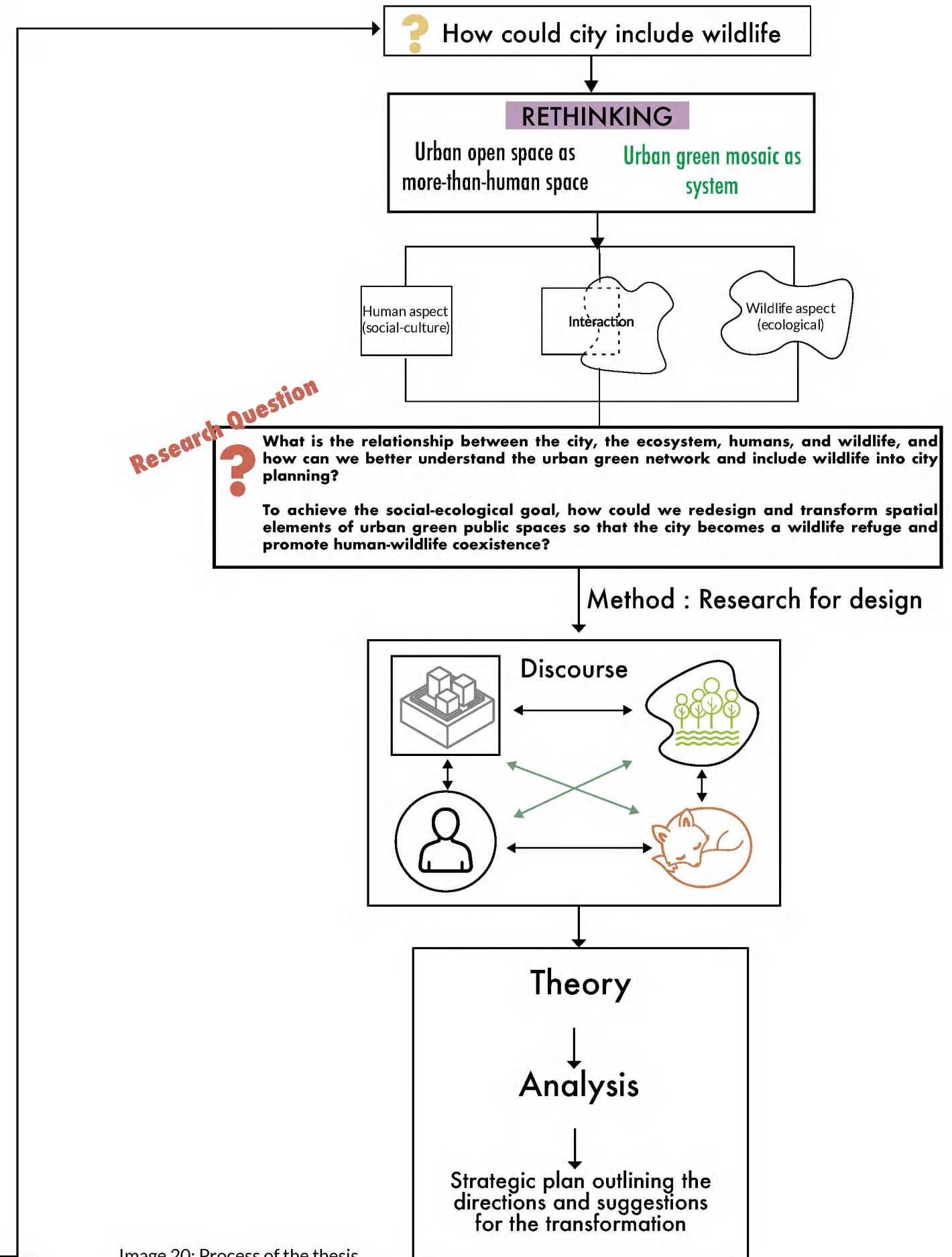
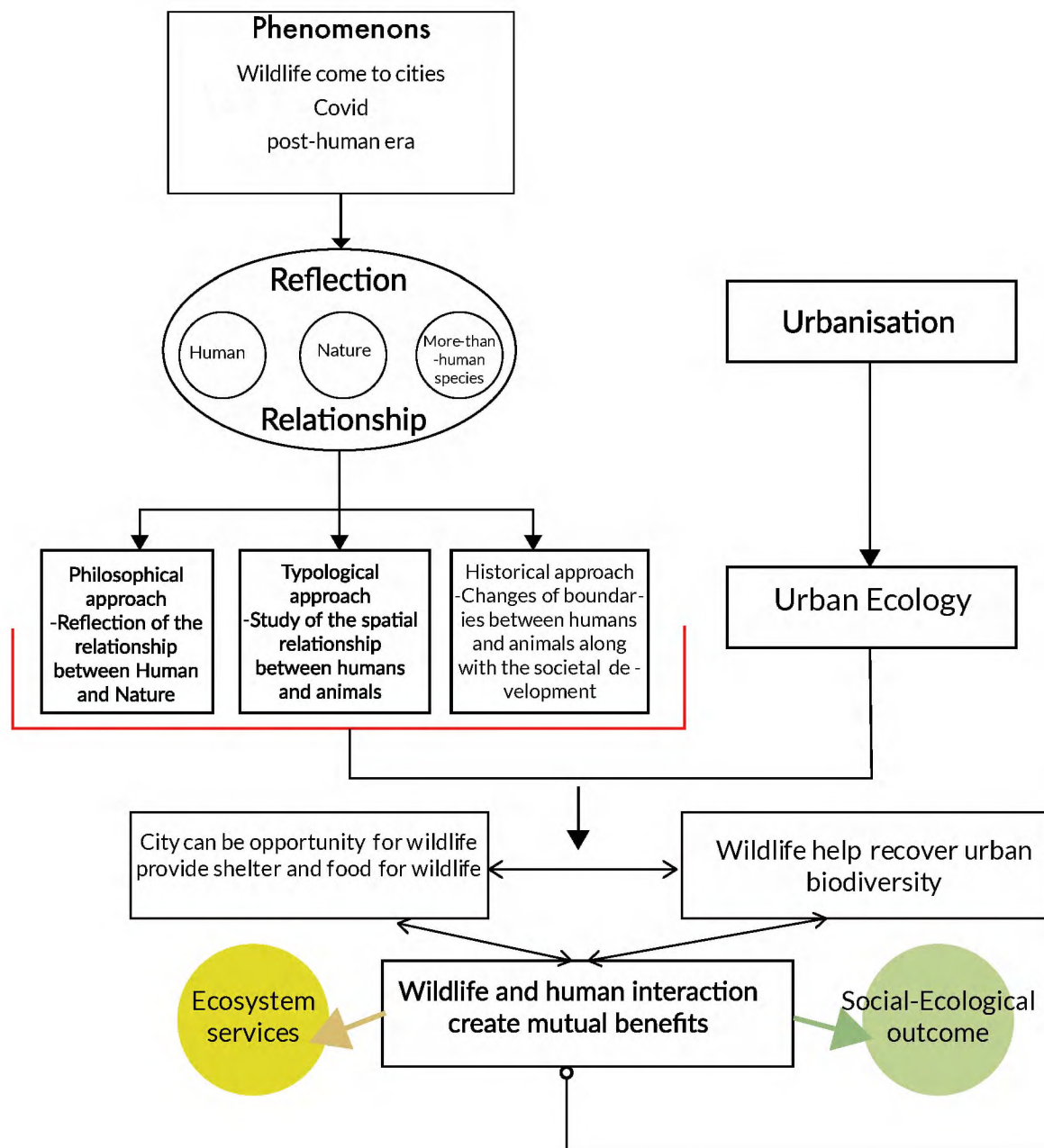


Image 20: Process of the thesis

## Chapter 2: Theories and Methods

This chapter introduces the three theories and two analytical tools that guided the thesis. Refer to the aim of the thesis, socio-ecological achievement is the purpose and the theoretical basis for the topic of human-animal coexistence in cities. Through analogies between urban systems and ecosystems and case studies based on this theory, to understand how the social and ecological aspects would be integrated and planned to achieve the purpose.

In response to the first research question, Landscape Ecology theory assists us in understanding the components of the urban green network. Ecologists, geoinformaticians, and planners have developed an ecological research tool, MSPA, for regional ecological study based on this theory. This tool will be used in the thesis to conduct an ecological analysis of the Gothenburg metropolitan region. The Animal Aided Design methodology shows us how to incorporate a wildlife perspective into the urban planning process, helping us create environments where people and wildlife may coexist.

## Theory: Social-Ecological Urbanism

*“There is increasing evidence suggesting that mental health and emotional stability of populations may be profoundly influenced by frustrating aspects of an urban, biologically artificial environment. It seems likely that we are genetically programmed to a natural habitat of clean air and a varied green landscape, like any other mammal. The specific physiological reactions to natural beauty and diversity, to the shapes and colors of nature, especially to green, to the motions and sounds of other animals, we do not comprehend and are reluctant to include in studies of environmental quality. Yet it is evident that in our daily lives nature must be thought of not as a luxury to be made available if possible, but as part of our inherent indispensable biological need.”*

-Frederick Law Olmsted, in *Biography*, by J.E. Todd, 1982

We usually think that modern cities are isolated from nature. It is believed that urban development has brought various ecological crises, such as loss of biodiversity, and climate change issues, the built environment is the antithesis of nature. The challenge we are facing today is to reconnect and integrate nature and ecosystems into urban development to increase the resilience of the city for a sustainable future.

Social-Ecological Urbanism is a theory that links the urban system with the ecosystem to absorb the conflict between cities and ecological systems from a systemic perspective. Social-ecological urbanism seeks to integrate the characteristics and services of ecosystems into urban systems and enhance the adaptability and resilience of urban systems, using urban design and planning tools to create an urban environment that promotes the well-being and health of the citizens. According to the research question, the purpose and foundation of this thesis is socio-ecological achievement, on which the subject of human-animal coexistence in the city is built; the

social system and the ecology do not exist in opposition to each other in the city, but they affect each other. But what do the urban and ecological systems have in common, and how are they linked and work together? The following texts will answer the questions by explaining an analogy of both systems and a case study of Albano resilient Campus to show the synergy of social-ecological systems.

### Analogy of urban systems and ecosystems

But what do the urban systems and ecological systems have in common, and how are they linked and working together? The following texts will answer the questions by explaining an analogy of both systems and a case study of Albano resilient Campus to show the synergy of social-ecological systems.

*Queto: “Ecological systems are characterized by time and space. Social systems are too characterized by time and space” -Linking Social and Ecological Systems, in book Urban Ecology*

First, ecosystems are complex organisms where all parts are interconnected and essential. It is wrong and dangerous to isolate parts from the whole system. If we were to extract and optimize one of these parts individually, it would have an irreversible effect on the whole. The same is true of urban systems, which is a spatial network of economic-ecological-social aspects, for example, if we have to construct new roads in the forest or change the land use, demolish old residential areas, and build new commercial areas for economic development. All of these measures have far-reaching effects on urban systems, where local ecological patches become fragmented and cause further damage to biodiversity, rising rents from commerce and gentrification will create more social problems(Holling&Goldberg, 1971).

Secondly is the historical quality. The ecosystem is a dynamic system that always tends to be stable. If we reclaim an open field, the vegetation in it will go through an evolutionary process with a series of successional stages, eventually reaching a steady state - this is the historical process of the ecosystem. The cities also share the same dynamic stability. The response to events and crises and how cities handle them is a cultural heritage with a historical legacy. It is a response from historical memory, developed based on past experience (Holling & Goldberg, 1971).

Lastly, spatial interactions in the system. Ecosystems are heterogeneous complex systems. One example was the pest infestation due to abuse of DDT in the cotton ecosystem in Peru, chemically harmful substances spread through the food web, thereby damaging crops throughout the region, which shows that local intervention could cause global chain reactions. Our city has a structure of a semilattice system, in which everyone is spatially connected with each other. We live and work in this system, every decision we make has an impact on the whole system, a holistic view and systematic thinking are essential, especially as urban planners (Holling & Goldberg, 1971).

We understand the similarity between the urban system and the ecosystem, but how to connect these two systems reconnect people in artificial cities with nature? According to environmental psychology, our personality and behavior are largely shaped by the environment around us as human beings. (Patrik Sörqvist, ) We learn from what we see, what we hear, and what we feel. The case study of Albano Resilient Campus showcased the practice of Social-ecological urbanism to reconnect people in cities with the biosphere.

### Case study: Albano Resilient Campus - Based on Social-Ecological Urbanism

Albano located in the National Urban Park of Stockholm, it is part of the great Gustavian palace project surrounding Brunnsviken. Thus, it has both ecological and cultural potential and values for development. Albano is also part of university facilities, however, Albano is a brownfield today, isolated from the rest of the city, and divided by the road Roslagsvägen into two parts, which caused social and ecological barriers.

The inhabitants in Albano are mainly urban adapters, such as birds, pollinating insects, small mammals and amphibians.



Image 21: Albano Resilient Campus relation to education centers.

For their long-term survival in this semi-urban area, the small habitats should be connected and integrated into green networks at the regional scale to make sure exchange between their population. Albano project has the potential to preserve the quality of ecological habitats and reconnect these small biotopes to prevent biodiversity loss.

Pollination, water services and seed dispersal are the main ecosystem services objectives that the project focused on. Wild bees and butterflies are becoming extinct as a result of habitat loss and frequent land use change. Amphibians are losing their wetlands as a result of urban growth, land hardening, and isolation caused by road construction, which creates barriers to movement. Seed dispersal is critical for the ecosystem's sustained reproduction of organisms. The Albano Resilient Campus project intends to increase ecosystem services, restore the connectivity of ecological corridors, and protect existing habitats by modifying the area's parks, buildings, land use, and street structure.

Albano has the potential to serve as a hub for intellectual and cultural exchange, connecting several organisations and university departments due to its geographical location. However, because

of the area's low accessibility and security difficulties, educational resources and academic institutions do not adequately serve the public, and academic exchange is limited.

The main objectives of social service include exchange of knowledge, publicity, recreation, place-based learning, adaptability. Instead of being a purely academic centre, the campus should be incorporated into the urban fabric, become more appealing to the general public, and encourage public engagement as a destination. The cultural and ecological background has a high potential for developing public places that encourage various recreational activities, as well as experience and social exchange. Place-based learning and adaptability are also crucial components in ensuring the resilient development of this area. Adaptive management, which includes local knowledge, is linked to place-based learning. Self-governance is strengthened by dividing the land into management units with varying user rights. Management and administrative divisions must adjust to changing situations. Smaller units and better local expertise are essential, but they require administrative freedom and flexibility because they may lack the skills and resources to implement big changes. (Barthel et al., 2013).

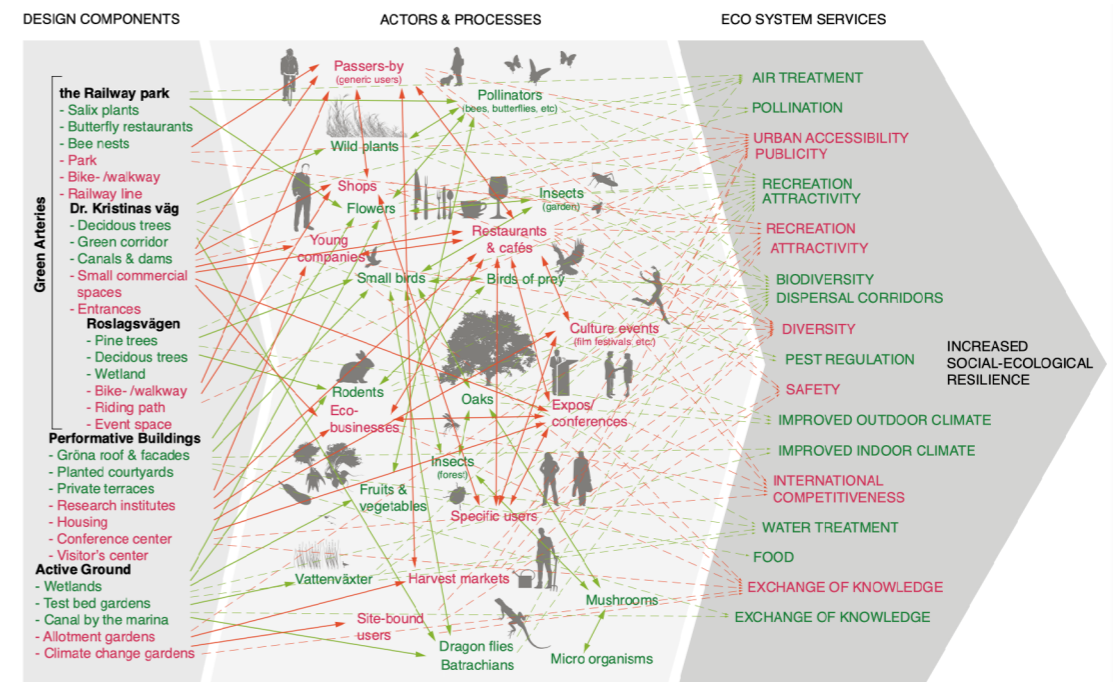


Image 22: The figure illustrates how spatial morphology can be designed to create high quality urban areas and services while at the same time supporting local ecosystem services.

Spatial design components such as green arteries, active ground, and performative buildings are created to connect the services of the ecological system and the social system. Green arteries incorporate various sizes and functionalities of flows that will assist services such as publicity and recreation by increasing urban accessibility and attractiveness. In addition, interconnected ecological corridors for seed dispersal, pollination, and wildlife movement provide ecosystem services. Varied participants, including human activities, plant communities, various biotopes, and animals, will coexist in spaces of green arteries. By dividing and actively managing the land into different scales, such as microhabitats for pollinators, a system of wetland and ponds for amphibians, and varying sizes of gardens and parks for animals, active ground creates a general structure that allows for variety and diversity. Active ground also allows for different functions for various user groups, residential spaces, public services, and shops and restaurants, all of which are connected to campus areas and can promote social connection and meetings. Performing buildings can host activities that have a long-term social influence and give chances for social and cultural exchange. The common areas of performing buildings can be used for gatherings, public services like libraries and museums, and academic institutions. Green roofs and walls may be able to enclose pollinators and birds, improving ecosystem services and biodiversity. (Barthel et al., 2013)

## Conclusion of the theory Social-Ecological Urbanism

The analogy of ecosystems and urban systems leads to three conclusions: To begin, all parts of the urban and ecological systems are interconnected and essential. Second, isolating parts from the total system is wrong and harmful since they are dynamic systems in which past actions influence future events. Finally, because every change causes a chain reaction in time and space, the problem should be viewed holistically and comprehensively. The theory of Social-Ecological Urbanism links the urban system to the ecosystem to absorb the conflict between cities and ecological systems from a systemic perspective, using urban design and planning tools to produce an urban environment that supports residents' well-being and health. The case study of Albano Resilient Campus demonstrates how social-eco systems can be integrated through urban planning to positively benefit urban development, resident health, and the environment.

**To bring forward:** Through studying the theory and synergy of the case study, we learned how to combine local resources to develop the direction of a project, in this case, the local resources are natural parks and research institutes with educational resources. Before proceeding to more extensive design, it is critical to identify the appropriate ecological and social actors and to utilize spatial design components to integrate and influence social and ecological services.

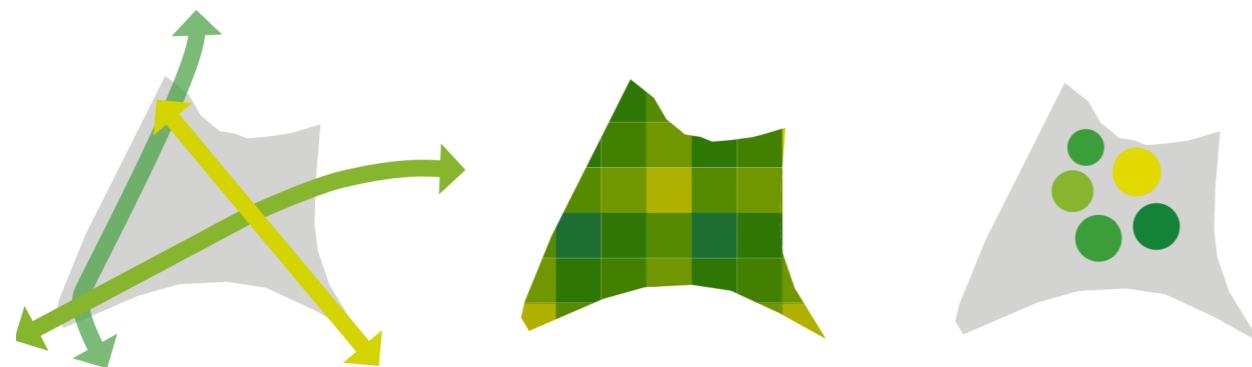


Image 23: Green arteries, active ground, and performative buildings

## Theory: Landscape Ecology

Landscape ecology is the leading theory for answering the research question: how to understand the green network in the urban environment. Landscape is the key to holding all movement from humans to animals to energy flow. But how exactly the flow forms, the tool of Morphological Spatial Pattern Analysis will be introduced to analyze the ecological corridors in Gothenburg's urban area, to find out how they might maintain the ecosystem, how wildlife can possibly move around the urban areas, and how the green mosaic functions as a system. By analyzing the centrality and network betweenness to determine the impact of human activities on the green network.

In modern cities, we are facing different kinds of crises caused by the sprawl of urban areas and population growth, especially environmental crises, such as land degradation, fertile soil erosion, biodiversity loss, water shortage, seawater rich oxidation... Urban development planning is always taking place piece by piece separately, we are comfortable thinking of small spaces in a short time, which made urban development uneven and the natural landscape fragmented, exacerbating various crises. We learned that the urban system is a complex and dynamic system, in which the individual actor interact with each other in time and space. Hence, land planners and landscape architects should change the way and mindset of urban planning, and take systematic and holistic analysis and approaches to provide new solutions for urban development and society.

The landscape ecology theory focused on particular spatial patterns in terms of landscape, where biological organisms interacted with the physical environment. Landscape structures provide the basis for the living system. Movement and flows of animals, plants, water, wind, materials, and energy occur within the network. The

structure should also allow changes and alterations in spatial patterns and have the ability to function over time. Patches, corridors, and matrices are the extracted structures of the patterns of the ecological landscape according to the theory, they control movements, flows, and changes among all actors(Dramstad et al.,1996).

*Queto: " Changing a mosaic by adding a hedgerow, pond, house, wood, road, or other element changes the functioning. Animals change their routes, water flows alter direction, erosion of soil particles change, and humans move differently. Removing an element alters flows in a different manner. "*

-In book *Landscape Ecology Principles*

For urban development, designers and planners must understand the mosaic of patches and corridor networks and how they work as a whole system. Then, the design of the green infrastructure to support and hold the landscape network together, reduce the landscape fragmentation and degradation, prevent them from falling apart, and promote long-term planning and decision-making in society and the ecosystem.

Each of the four spatial pattern types will be introduced: Patches, Corridors and connectivity, Edges and boundaries, and Mosaic are the extracted structures of the ecological landscape patterns.

**Patches:**

Plant and animal habitats are becoming increasingly fragmented in a world with a high population density. Patches might be as large as a national forest or as small as a single tree. A patch is a unique piece of habitat that is distinct from its surroundings. In landscape mapping and classification systems, patches are frequently the smallest ecologically distinct landscape features. The location of patches can be advantageous or detrimental to the landscape's overall performance(Dramstad et al.,1996).

**Edges and boundaries:**

An edge is the boundary of a patch where the environment differs significantly from the patch's inside. On the other hand, political and administrative borders denote man-made territorial divisions that do not have to follow biological patterns. The curvilinearity of a boundary influences the flow of water energy and species along and across it. Patches can benefit the environment by modifying their boundary forms(Dramstad et al.,1996).

**Corridors and connectivity:**

Multiple dynamic factors contribute to ecological isolation and extinction through time. The most important spatial processes are fragmentation, dissection, perforation, shrinkage, and attrition, which involve large habitats being divided into smaller dispersed paths, a habitat being divided by artificial barriers, as well as the creation of "holes" within a largely intact habitat, the shrinkage of one or more habitats, and the disappearance of one or more habitat patches. Highways, railways, power lines, canals, and trails are examples of "thoughts" and "barriers." Stream and river systems serve as vital landscape corridors. The value of landscape connectivity is emphasized by ecologists, particularly in the form of animal corridors and stepping stones(Dramstad et al.,1996).

**Mosaic:**

Pattern can be utilised to comprehend and evaluate the structural and functional integrity of landscape as a whole. One indicator of a landscape's ecological health is the total interconnection of its natural systems. Corridors connect to form networks that enclose other landscape features. Networks, in turn, demonstrate connectivity and circuitry while emphasizing the functionality of landscapes. Networks can be used by planners and landscape architects to encourage or restrict flows and movements throughout a land mosaic(Dramstad et al.,1996).

**Patches**

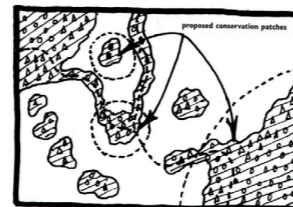


Image 24: Patch selection for conservation

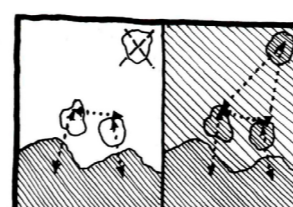


Image 25: Extinction

**Edges and boundaries**

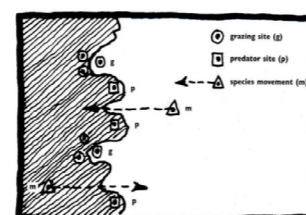


Image 26: Coves and lobes

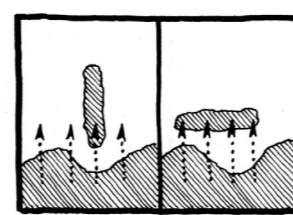


Image 27: Shape and orientation

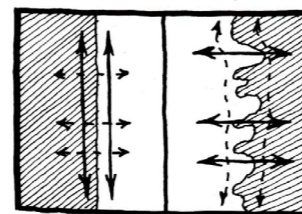


Image 28: Curvilinear boundaries

**Network**

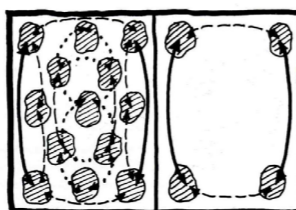


Image 29: Animal perception of scale of fragmentation

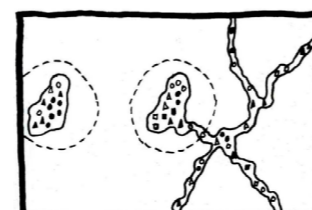


Image 30: Species in a small connected paths

**Corridors for movement**

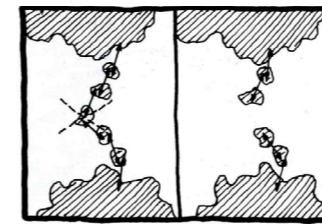


Image 31: Loss of a stepping stone

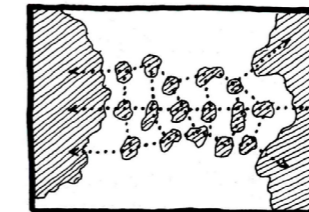


Image 32: Cluster of stepping stones

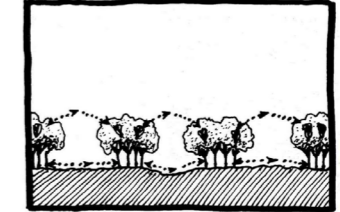


Image 33: Distance between stepping stones

**Understanding the urban green mosaic**

Based on the theory of Landscape Ecology, ecologists, geoinformaticians, and planners developed the MSPA (Morphological Spatial Pattern Analysis) tool for regional ecological analysis. This method will be used in the following chapter to analyse the ecosystem functions of the central area of Gothenburg, where the functions of the city's green areas vary depending on their location, size, and so on, to answer questions such as, where are green patches, where are ecological corridors, wildlife could move between different green areas, where are the barriers and threats? Let's begin with an introduction of this analytical tool.

**The analyse tool MSPA:**

This method emphasizes structural connectivity and relies on land use data, which is reclassified by assuming that natural ecological elements such as forest and wetlands are extracted as foreground and other land types are used as background, and the image is processed to classify the foreground into seven morphologically non-overlapping categories: Core, Bridge, Loop, Branch, Edge, Perforation and Islet.

Different spatial forms and have different ecological meanings. The "Core" implies large scale natural patches with inner connectivity, and wildlife habitats. The "Islet" represent small, isolated and fragmented natural patches that are not connected to each other, such as small urban green areas; "Perforations" are unnatural patches within the core area; "The 'Edge' is the transition zone between the core and built environment; the 'Bridge' is the strip of ecological land that connects the core areas and can be considered as corridors in the regional green infrastructure, supporting the migration of species, energy flow and network formation within the area; The "Loop" represents the ecological corridor connecting core areas; the "Branch" is an ecological patch that is connected to only one end of the core area.

The MSPA method uses mathematical morphological algorithms to capture the structural patterns of natural elements and to analyze the connectivity of natural patches. Research and practice have shown that the MSPA method is suitable for

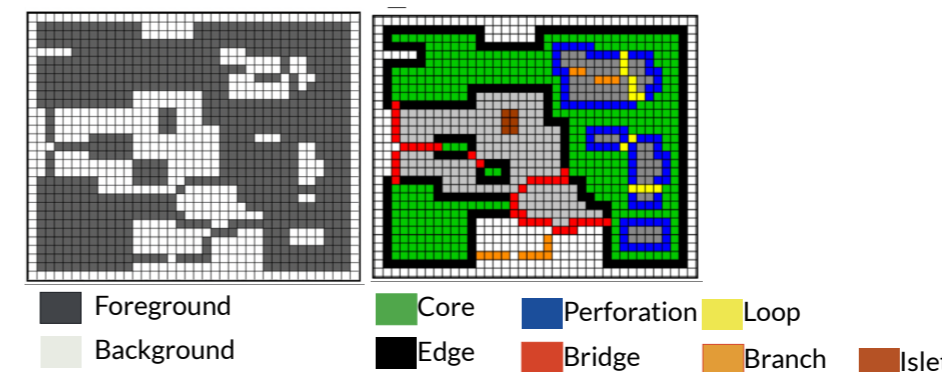


Image 34: Binary map

regional scales and can effectively identify and analyze ecological spatial patterns and their connectivity, providing a new approach to the construction of green infrastructure.

The MSPA tool assists us in analysing green areas and their connectivity, as well as how to use the data to develop effective green infrastructures to achieve social-ecological goals, and what qualities green public spaces should have to promote coexistence for animals, plants, and humans. The following section describes the design guidelines for green infrastructure, covering multifunctionality, connectivity, integration, communicative and socially-inclusive, long-term oriented strategic.(MSPA, n.d.)

### Design guideline: Green Infrastructure

Green Infrastructure is considered to be a landscape ecological approach to achieving functional regional ecological patterns. As a framework for practice and implementation, green Infrastructure integrates different scales and types of ecological construction. "Green infrastructure has been defined as an 'interconnected network of protected land and water that supports native species, maintains natural ecological processes, sustains air and water resources and contributes to the health and quality of life for communities and people" written by Benedict & McMahon in book Green infrastructure: linking landscape and communities in 2006. Green infrastructure support and protect the natural system from the disturbance of urban development, but also balance with the economic and social needs of society (Pauleit et al., 2011).

#### Connectivity:

The importance of connectivity between green spaces for enhancing species dispersal and supporting system dynamics is highlighted by landscape ecological theory. The greening of the matrix of varied urban land uses may be significant for the survival

of many species in the city, and creating a dense network of green spaces near where people live is equally crucial for reducing the heat island effect. Greenspace corridors make it easier to access greenspace and use it for recreation, which might benefit the city's ventilation. Planning for connectivity must be based on a more holistic perspective of a city's green and blue systems(Pauleit et al., 2011).

#### Multifunctionality:

Many urban green spaces are monofunctional in the sense that they are designed and maintained to serve a single purpose. Multifunctional green infrastructure which integrate ecological, social, and economic roles, provides services for a diverse range of users, will support sustainability, and bring more values. For instance, football fields may contribute to rainwater infiltration or heat island reduction. Interconnected green spaces can perform functions that individual green spaces cannot provide, such as enhancing and supporting animal habitats. (Colding 2007) Nonetheless, there may be limitations to multifunctionality, since it is unrealistic to expect tiny green spaces in densely populated places to support both extensive recreational usage and species-rich ecosystems, particularly for disturbance-sensitive species(Pauleit et al., 2011).

#### Integration

Green infrastructure involves a variety of stakeholders and actors since it covers public, institutional, and private green spaces and interacts with other urban structures. Collaboration with all stakeholders is necessary to move the process forward; hence, economists, ecologists, and social scientists must coordinate their land-use change decisions(Pauleit et al., 2011).

#### Communicative and socially-inclusive planning and management

Green infrastructure involves a variety of stakeholders or actors since it covers public, institutional, and private green spaces and interacts with other urban structures.

Collaboration with all stakeholders is necessary to move the process forward; hence, economists, ecologists, and social scientists must coordinate their land-use change decisions(Pauleit et al., 2011).

#### Strategic, long-term oriented approach

Long-term benefits of urban green space can sometimes conflict with short-term economic gains, and single-use landscape change is generally only economically viable for private or corporate interest groups. As a result, the design of green infrastructure should be based on a long-term vision. Rather than creating a static plan, it is important to achieve broad, long-term goals while allowing for new inputs through constant learning and discussion among diverse players in an adaptive planning mode(Pauleit et al., 2011).

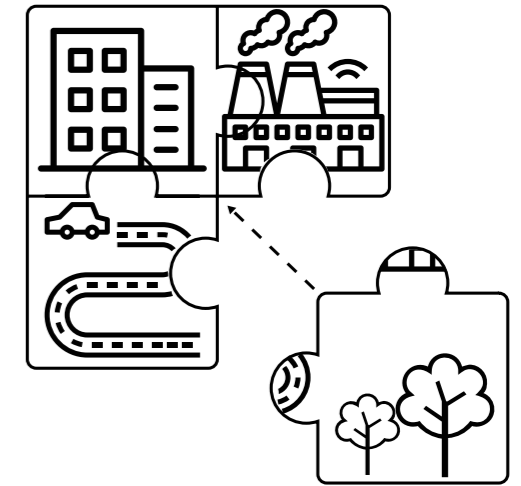


Image 37: Integration

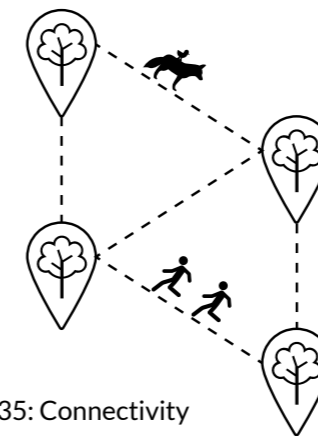


Image 35: Connectivity

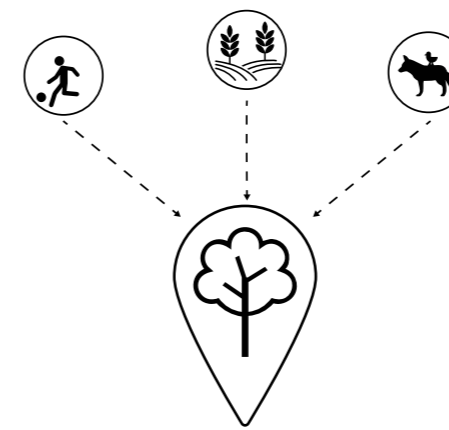


Image 36: Multifunctionality

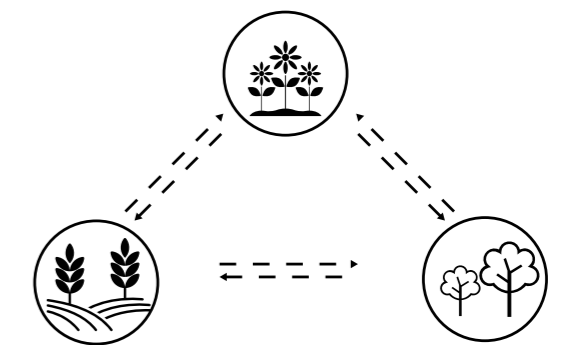


Image 38: Communicative and socially-inclusive planning and management

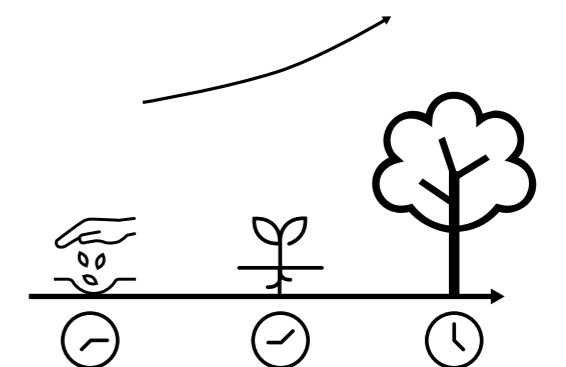


Image 39: Strategic, long-term oriented approach

## Conclusion of the theory Landscape Ecology

We have developed an initial understanding of the green network with ecological landscape patterns: Patches, Edges, Boundaries, Corridors, and Mosaic, and their impact on urban ecology and animal migration by studying the Landscape Ecology theory. Based on this theory, the researcher developed the MSPA analysis tool, which uses land use data to analyze ecological spatial patterns and their interconnectedness, providing a novel method to green infrastructure design. Furthermore, the Green Infrastructure design guideline provides a framework for practise and implementation on how to incorporate different scales and types of green spaces into urban development.

### To bring forward:

The ecological corridor in the center of Gothenburg will be analyzed using the MSPA tool in the following chapter. The five green infrastructure guidelines can be used to suggest improvements for green public places, and to examine whether the adjustments meet the needs of multifunctionality and contribute to economic, social, and environmental value. Is it fulfilled the requirement for connectivity, which promotes animal movement while also increasing accessibility, creating ventilation corridors, and reducing the heat island effect? Is it integrated with other urban facilities to improve the quality of urban life, and is there a long-term adaptable development strategy ready to adapt to change?

## Theory: Animal-Aided Design

To answer the second research question: how could we redesign and transform spatial elements of urban green public spaces so that the city becomes a wildlife refuge and promote human-wildlife coexistence. We need to develop work on a detailed level from a wildlife perspective. Although wildlife plays an essential part in the urban ecosystem, how urban wildlife affects the ecosystem and what they provide for ecosystem services is rarely studied, wildlife is always excluded in the planning process. The theory of Animal-Aided Design requires a reorientation of the planning process that urban wildlife should become an integral part of the planning and design. The need of the local wildlife should be prioritized, and placed on an equal footing with other planning needs.

Animal-Aided Design is particularly applicable to urban areas. It can be used in various planning scales: from the redesign of the built environment to inner courtyards of neighborhoods to the planning of public parks. Animal-aided design bridges the topic of nature conservation and urban development. It provides the methodology for integrating wildlife aspects into design and creating and improving habitats for animals in the city. Through design and planning, improve the quality and attraction of our living environment, help cities restore biodiversity, Increase the possibility of contact with nature and animals, and further reflections on nature.

## Design with the life-cycle

The basis for the practice of Animal-Aided Design for open space is to study the life cycle of the selected keystone species. In cities, some measures have been implemented to recover biodiversity, such as nesting boxes for birds and the installation of insect hotels. But these two measurements only met part of the creature's needs in the nesting and the breeding phase. Other essential needs, for example, food source, shelter against predators, environment, and protection for young animals are not considered. Whether the animals can survive or not is left to chance, the aim of restoring biodiversity will fail (Weisser et al., 2017).

Hence, planners and designers must be acknowledge of the critical needs of the whole life cycle phase of the keystone species and integrate them with design expertise to establish suitable habitats for wildlife with a high degree of permanence and adaptability. To translate the needs of the life cycle into spatial planning and design, critical location factors should be analyzed for each life phase. The essential factors of location include concrete environmental and physical conditions, such as the suitability of temperature and humidity for animal survival, suitable native plant communities, and adequate sources of food and hydration. These conditions are related to various geographical factors, such as vegetation cover, vegetation height, land use, soil moisture, etc. The detailed descriptions of the critical site factors give indications for possible wildlife-friendly planning. Through analysis, we will gain new insights into where wildlife is likely to be found in cities and optimize and improve these places to create conditions for wildlife to survive, increase the possibilities for human-animal and natural interaction and help restore urban biodiversity (Weisser et al., 2017).

## The Animal-Aided Design planning steps

In every phase of AAD planning, both the requirements of animals and the desires of human stakeholders must be considered.

Step A: During the process of analysis and drafting, target species are selected. Potential target species include not just those presently existing at the location, but also those from the neighborhood's areas that may feasibly reach the site. When selecting AAD target species, both biological and sociocultural elements must be taken into account. In order to narrow the selection of target species, both the site's habitat potential and its limits are evaluated. On the basis of these evaluations, the target species are chosen and a spatial design that satisfies their habitat needs is devised. When choosing species, consider the following:

- The species' ecological traits reveal its crucial demands at the project location.
- Sociocultural preferences or aversions for specific species or groups.
- Urban species and dispersion obstacles.

Step B: During the thorough planning and design phase, the animals' habitat-related demands are immediately included into the site design with the aid of the species' key needs. The goal is to create locations where humans may interact with the natural environment.

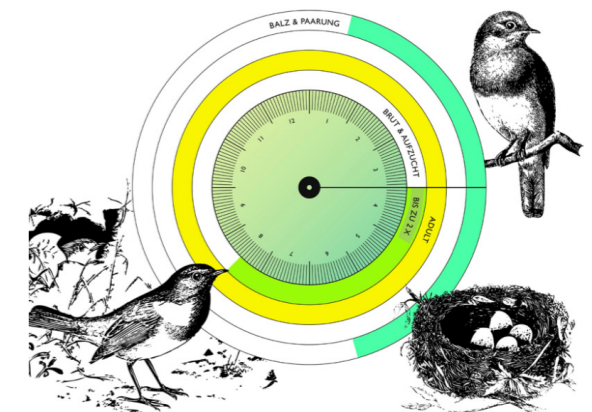


Image 40: Life-cycle of Robins

Step C: During the period of implementation and construction, it is crucial that all requirements be appropriately executed. This may be accomplished, for instance, by implementing a specialised training program for the building company's staff. Throughout the execution and building phase, it is essential to respect existing animal populations; work must be conducted as delicately as possible and at a period when animals are least likely to be disturbed.

Step D: Animal-aided design needs post-occupancy monitoring to succeed. Monitoring and analyzing the project's ecological, social, and economic components allows for adjustments and measurement. The target species accepted the provisions? What do residents think of the programs? Have the projects increased maintenance costs or saved money? If feasible, discuss outcomes with stakeholders. They can be used to improve site structure or optimize planning. (Weisser et al., 2017)

## Conclusion of the theory Animal-Aided Design

Animal-Aided-Design offers a methodology for planning that includes the wildlife perspective. From learning how to select keystone animals to understanding a keystone animal's lifecycle, locating the ideal sites through these factors, and implementing them into planning and architecture to create locations where humans could connect with the natural environment. Finally, in order to achieve our goal of human-wildlife interaction, we must ensure the project's success throughout the post-implementation testing and maintenance phase.

### To bring forward:

Using the Animal-Aided-Design as a guide, following step A and step B of the Animal Aided Design planning steps, a keystone animal will be chosen, and follow the guidance of 'DESIGNING WITH THE LIFE CYCLE' research its critical needs, then analyze suitable locations from the keystone animal perspective in Gothenburg's central area. Important factors affecting the life cycle of animals also help redesign and transform spatial elements to provide habitats for urban wildlife to survive and thrive and fulfill the aim. Step C and step D are about the implementation and later maintenance and testing of the project which will not be discussed.

## Conclusion of the chapter

A flow chart summarises the theoretical chapter and serves as an introduction to the next chapter, the analytical chapter. Three theories are used in the research to help understand and sort out the link between the city, ecosystems, humans, and wildlife. The foundation of this thesis is Social-Ecological urbanism, which reconnects and integrates the urban system with the ecosystem in a systemic perspective to increase city resilience and promote residents' well-being and health.

The theory of Landscape Ecology was introduced to explain how the biological organisms interacted with the physical environment. It concentrated on landscape spatial patterns, patches, corridors, and matrices that control the movements, flows, and changes in the living system. We discovered that the urban system is a complex and dynamic system in which individual actors interact in time and place. The theory assists us in comprehending the mosaic of patches and corridor networks and how they function as a whole system. Green infrastructure design should maintain and hold the landscape network together, limit landscape fragmentation and degradation, keep them from falling apart, and promote long-term sustainable development.

Animal-Aided Design bridges the gap between wildlife conservation and urban development. It provides the methodology for integrating wildlife aspects into design in order to create conditions for wildlife to survive, increase the possibilities for human-animal interaction, and aid in the restoration of urban biodiversity.

### Method: Suitability analysis

Learning about the life cycles of keystone animals and identifying the correct site to plan from their critical needs is a crucial part of the process. Suitability analysis is a tool for determining the best sites. For example, to identify the best location for a new retail store, a commercial developer could weigh the distance to surrounding major roads and the locations of any competitors, then combine the results with land use, population density, and customer information to establish the ideal site for that business. Similarly, we can capture the range of wildlife activity by using ArcGIS Spatial Analyst to overlay several layers to extract information based on factors affecting the life cycle of keystone species. (Suitability Analysis & ArcGIS Pro | n.d.)

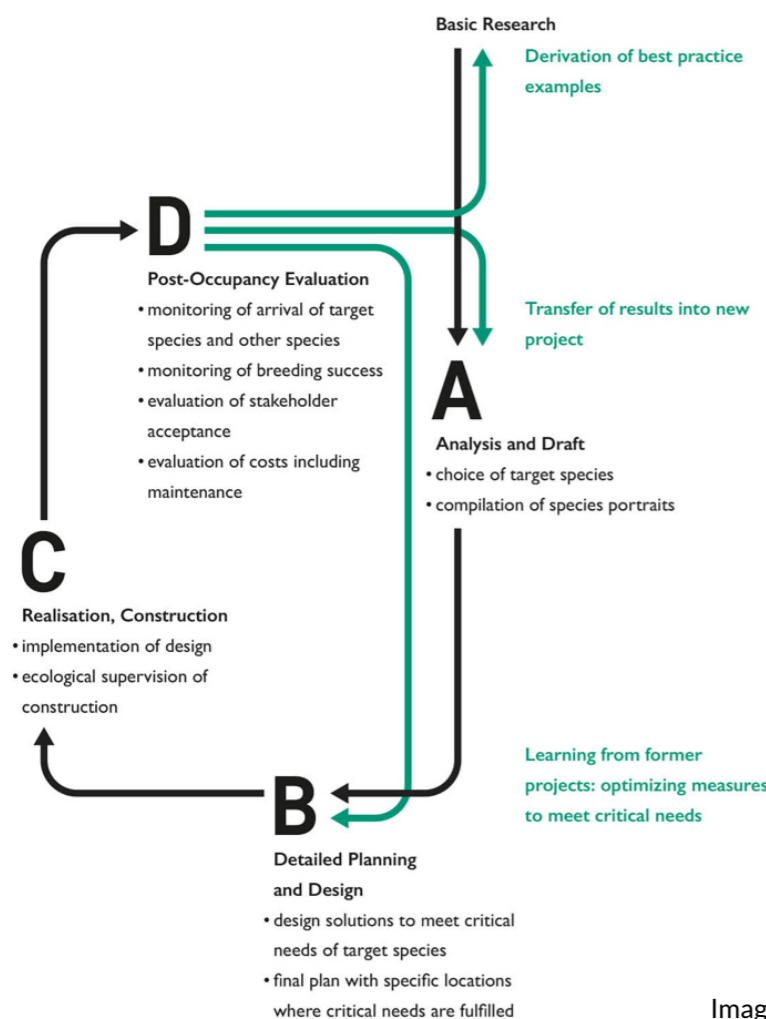
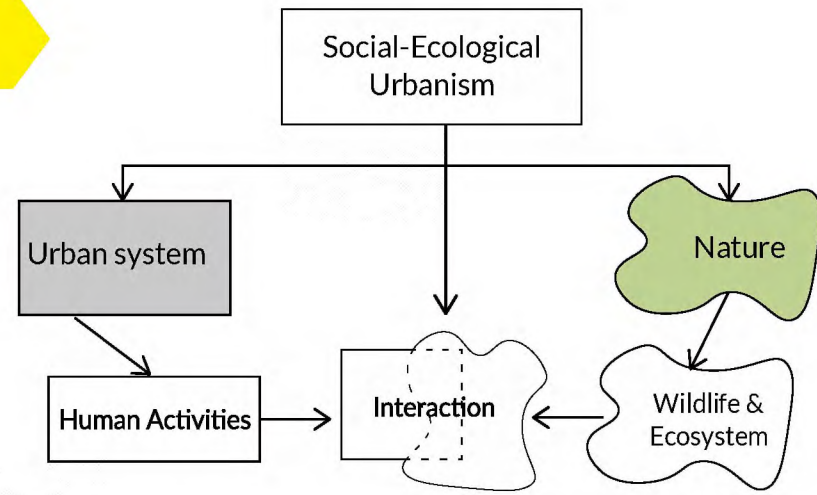


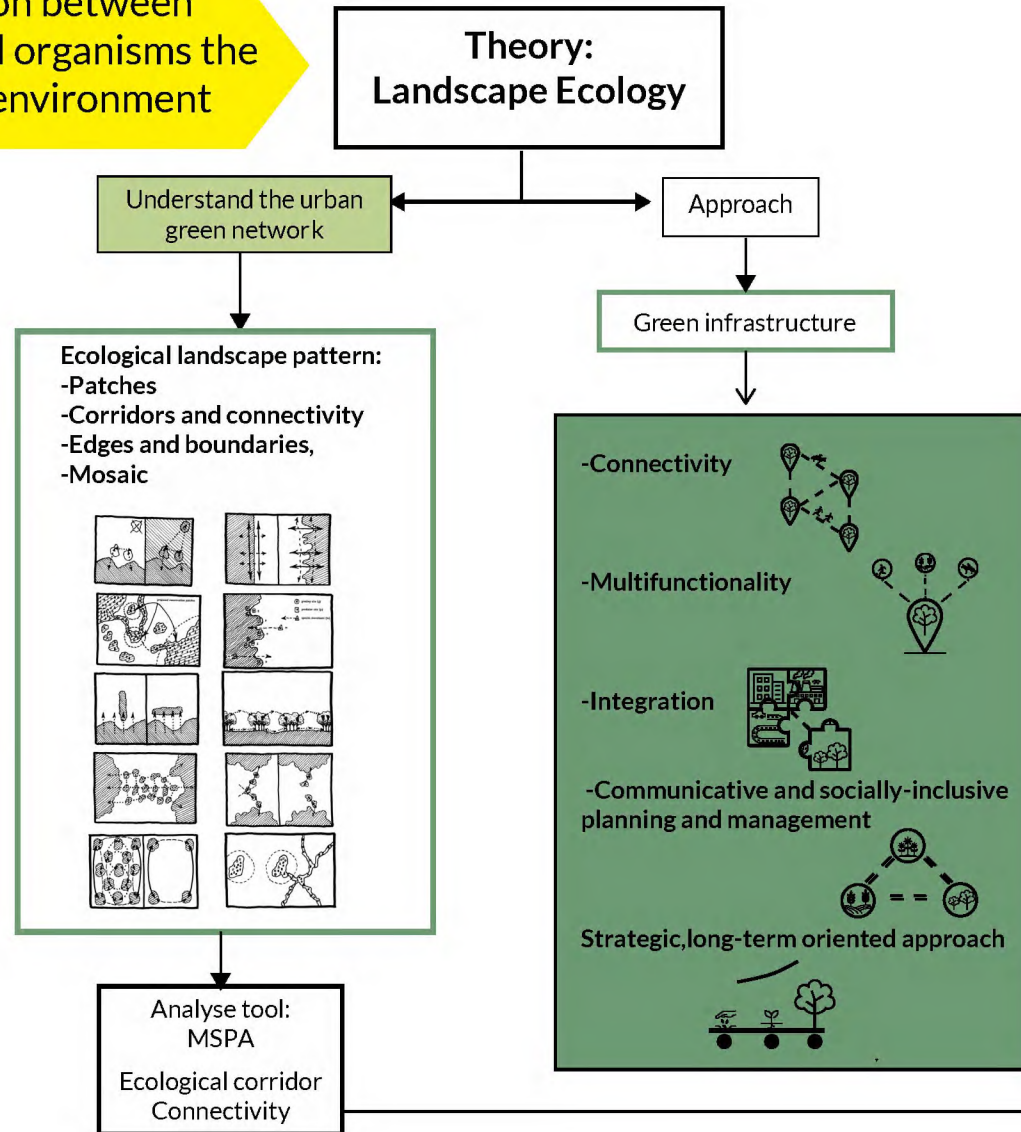
Image 41: The Animal-Aided Design planning steps

# Conclusion of the theory

## Foundation



## Interaction between biological organisms the physical environment



## Interaction between wildlife and urban environment

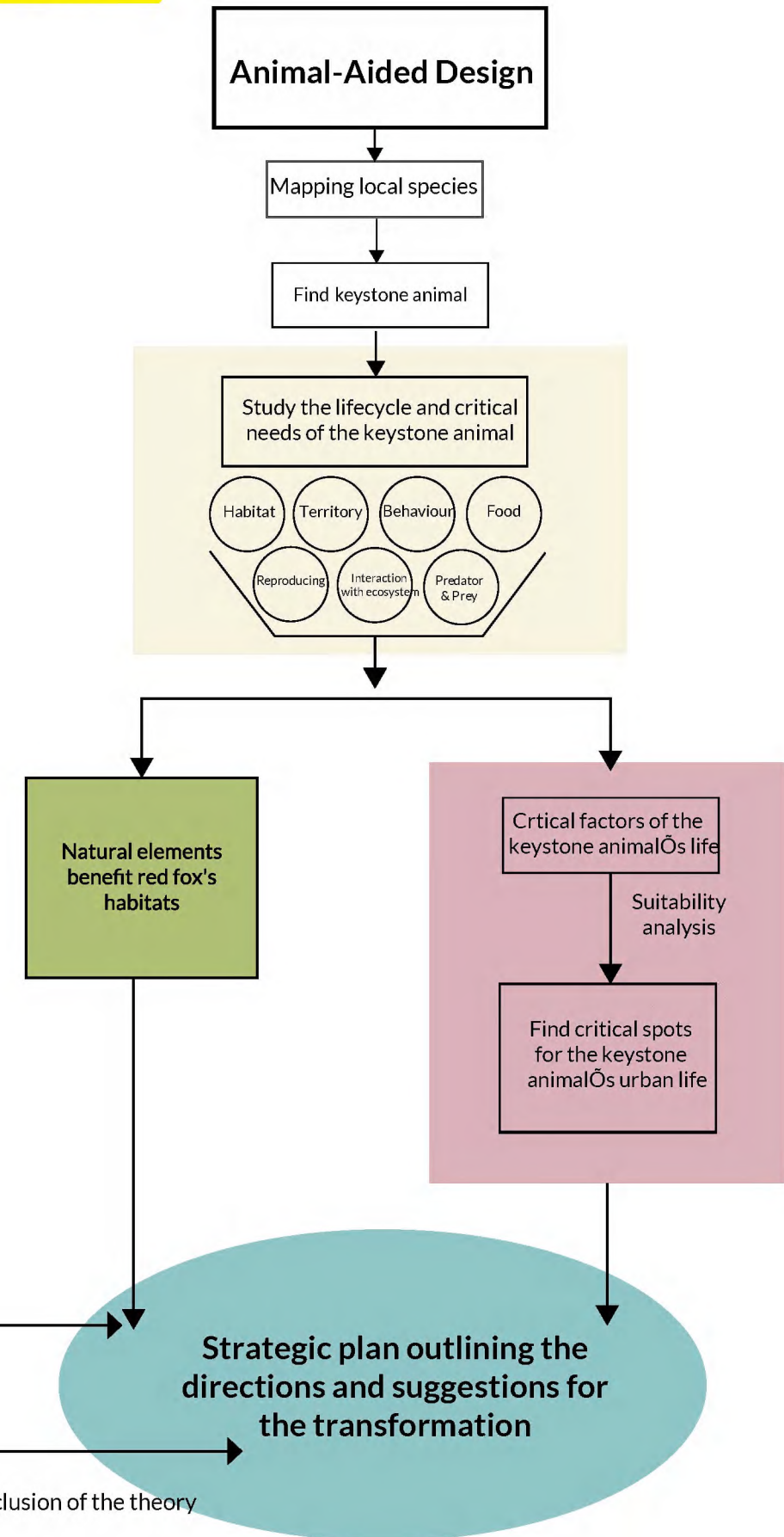


Image 42: Conclusion of the theory

# Chapter 3: The site, The animal

We discussed theory, methodology, and analytical tools in the previous chapter, which we will apply in this chapter. The first step is an ecological analysis using the MSAP technology to understand the network of urban green spaces in central Gothenburg, which is followed by a mapping of wildlife in the city and identifying of keystone animals. A research of the keystone animal life

cycle will be carried out to identify critical aspects that influence the keystone animal's living situation. Finally, we conducted spatial analysis from the keystone animal's perspective in order to define the territory circle for further design.

## The site, The animal Process of this chapter

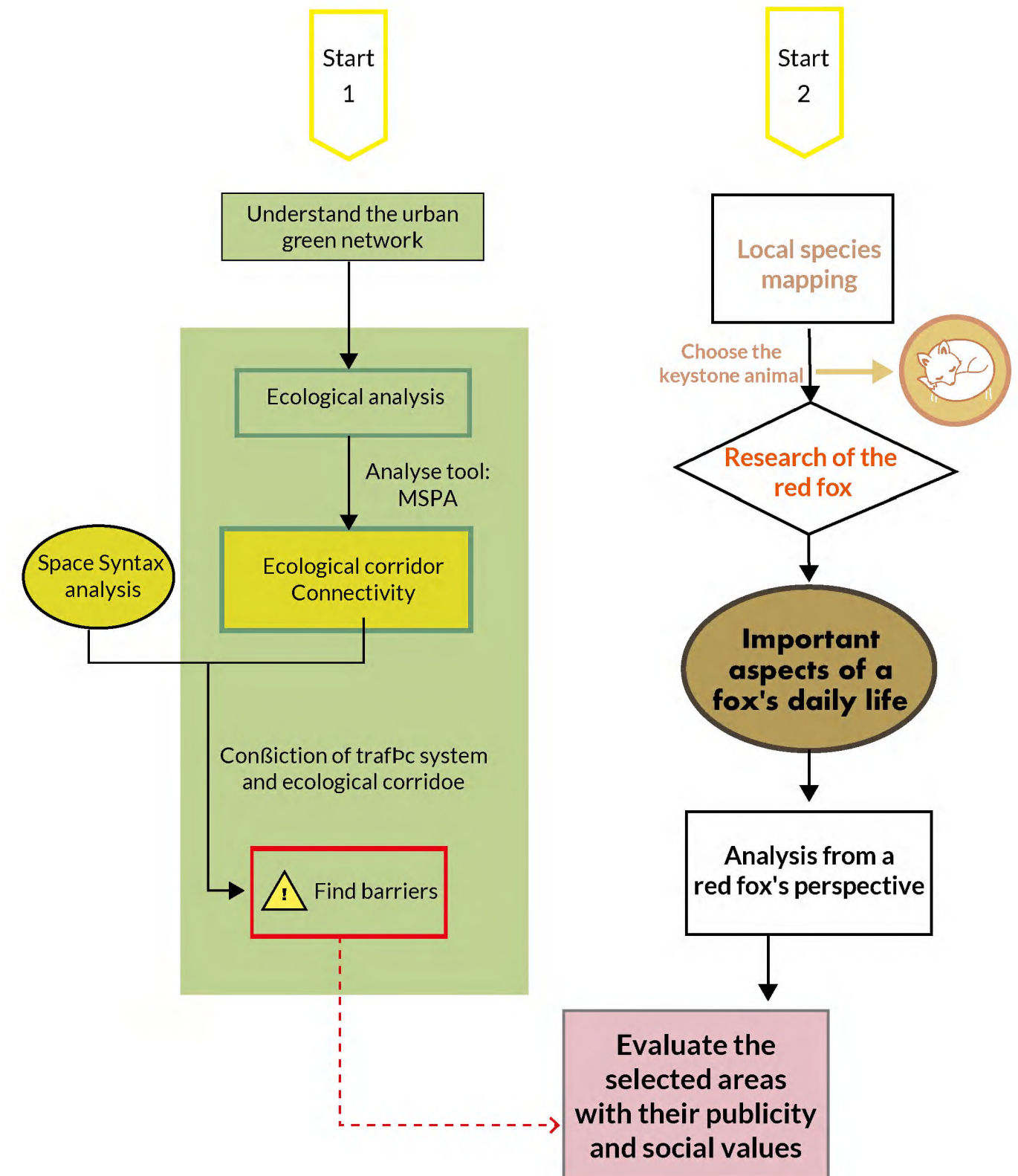


Image 43: Process of the chapter

# Understanding the urban green mosaic

The analyses aim to understand the network of urban green spaces in central Gothenburg. Where are patches, where is an ecological corridor, and how are these elements fabric into urban green mosaic? How are the green patches functioning as stepping stones so that wildlife could move between different green areas, where are the barriers and threats? In order to do that, the ecological analysis method MSPA (Morphological Spatial Pattern Analysis) will be introduced. In order to understand the interaction and influence of human activities on the ecological system, the analysis of centrality and network betweenness with PST will be integrated.

**Steps of ecological analysis:** Numerous researchers have already applied the MSPA approach to regional studies and outlined the more developed study processes. With the help of academic papers, this thesis summarises the four steps required to conduct ecological analysis, and finally to construct an ecological corridor. This flowchart briefly describes the process: Step 1: Identify ecological elements; Step 2: Evaluate the importance and connectivity of the ecological elements; step3: Construct an ecological resistance surface; Step 4: Identify the ecological corridor -Least-cost path analysis. Finally, I've introduced a fifth stage, which overlays the analysis of ecological corridors and network betweenness in order to comprehend the influence and conflict of human activities.

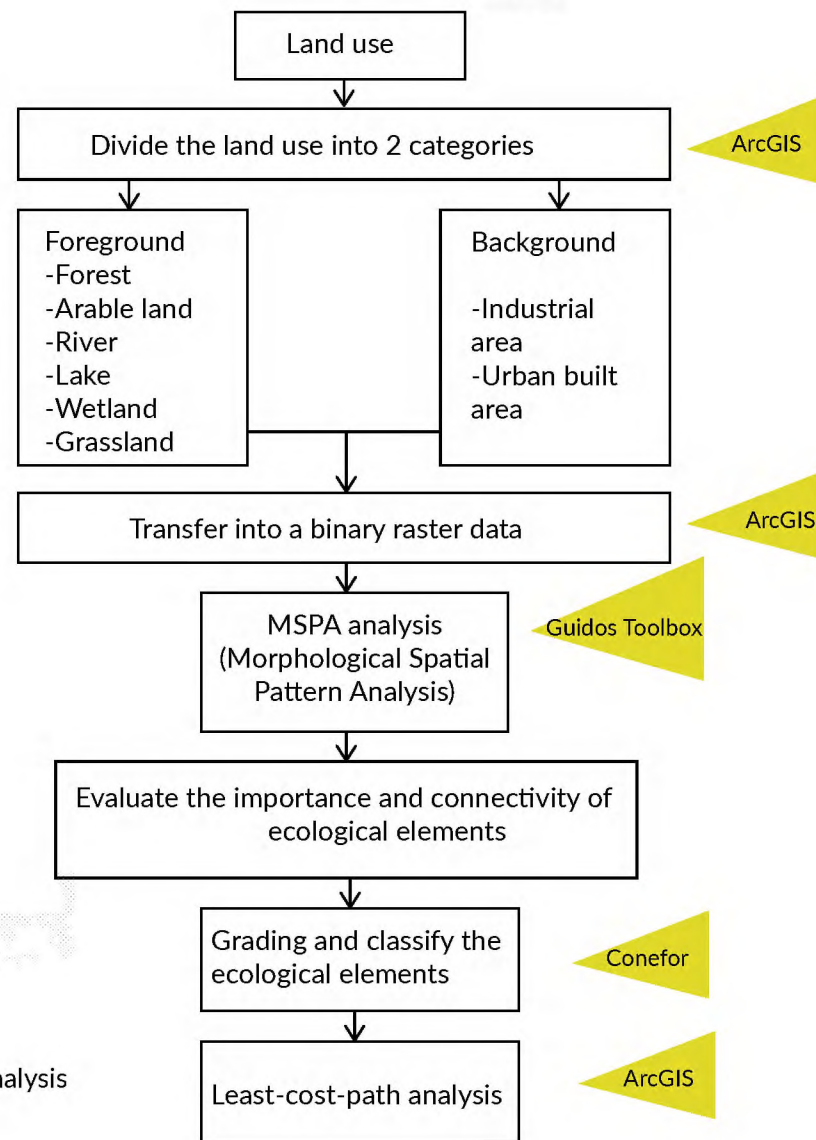
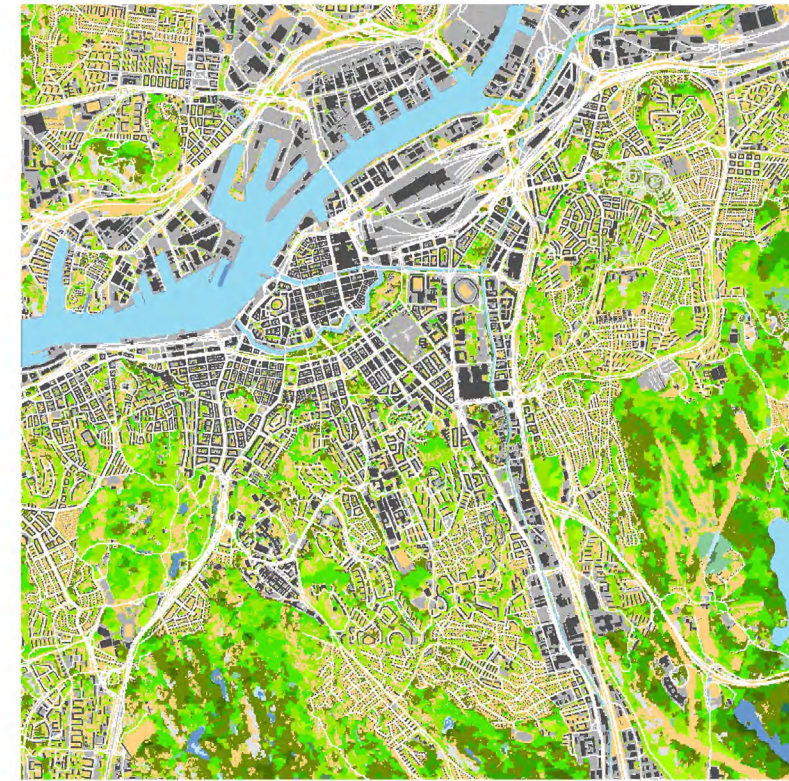


Image 44: Process of the ecological analysis

# Ecological analysis - Step 1



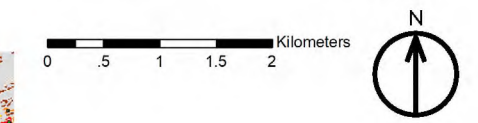
Landuse condition of study area

- Pine forest not on wetland
- Deciduous forest not on wetland
- Deciduous forest with deciduous hardwood forest not on wetland
- Deciduous hardwood forest not on wetland
- Vegetated other open land
- Artificial surfaces, not building or road/railway
- Artificial surfaces, building

MSPA analysis  
(Morphological Spatial Pattern Analysis)



MSPA result

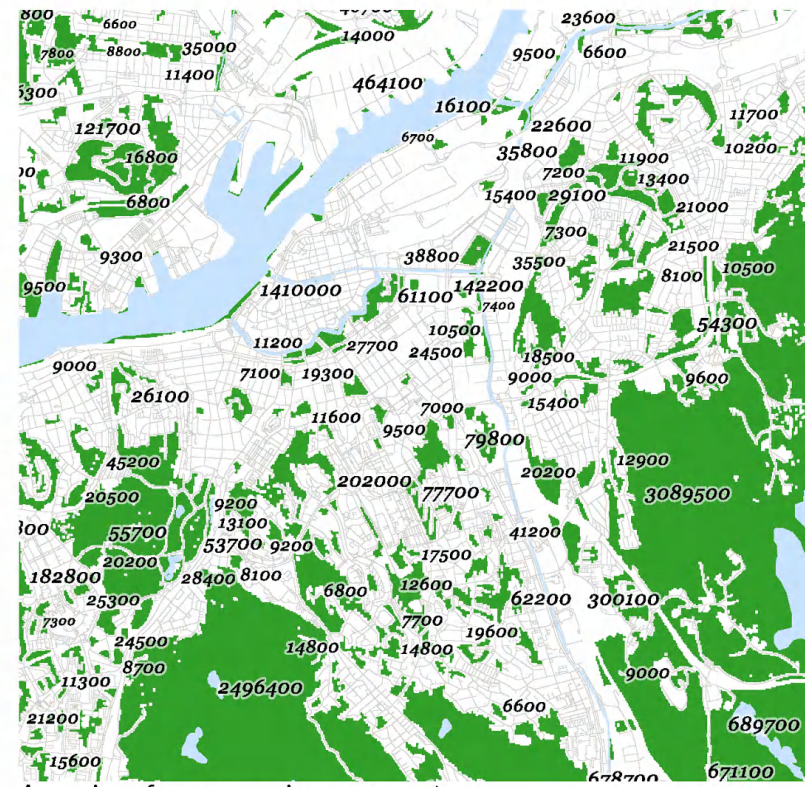


- Core
- Perforation
- Loop
- Edge
- Bridge
- Branch
- Islet

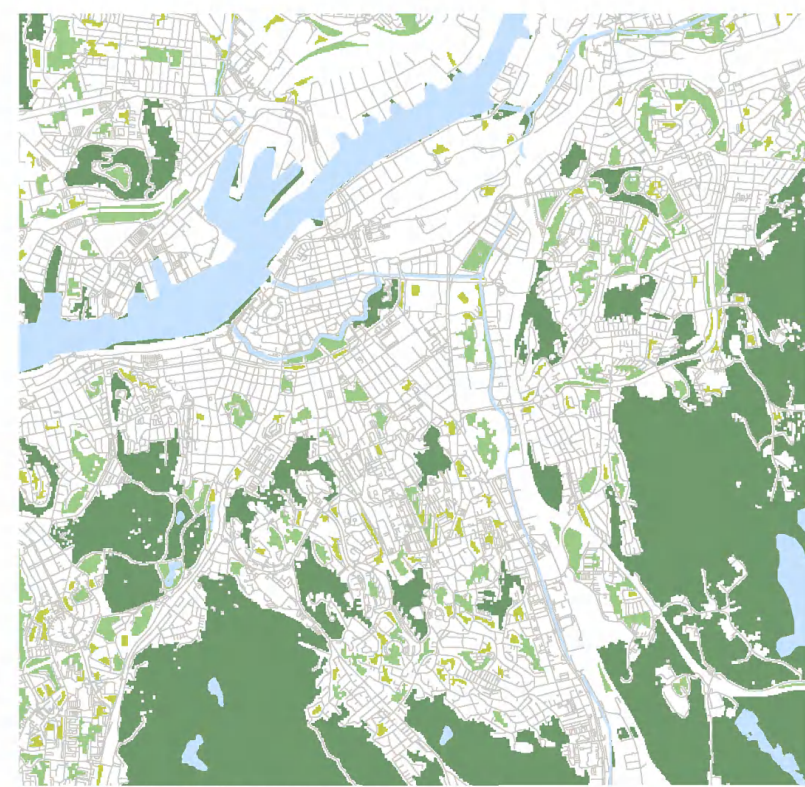
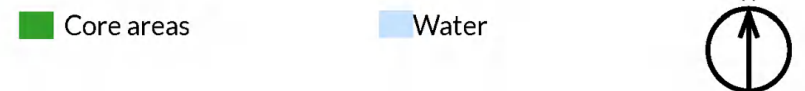


Step 1: identify ecological elements: divide the land use map into 2 categories: foreground with forest, arable land, wetland, grassland, river and lakes, which can generate ecosystem service; background with industrial areas and built environment. Then transfer the map into a binary raster map. Use the MSPA method to extract green infrastructure elements from the current landscape pattern, and use the Guidos Toolbox software to classify the land use into 7 landscape types, which are Core, Bridge, Loop, Branch, Edge, Perforation and Islet.

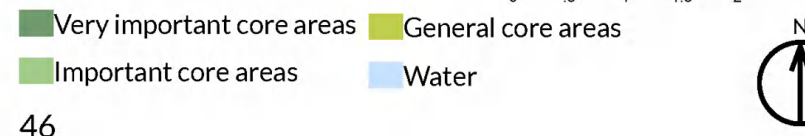
## Ecological analysis - Step 2



Area size of core areas in square meters



Important level of the core areas



Step 2: evaluate the importance and connectivity of the ecological elements. We pick out the core areas, which are the green colored areas in the map, and evaluate them with the Connectivity Index (PC) using the Conefor software. Landscape connectivity is the most fundamental principle and attribute of regional green infrastructure. The higher the Ecological Patch Connectivity Index (PC), the more important the core area is in the regional green infrastructure network.

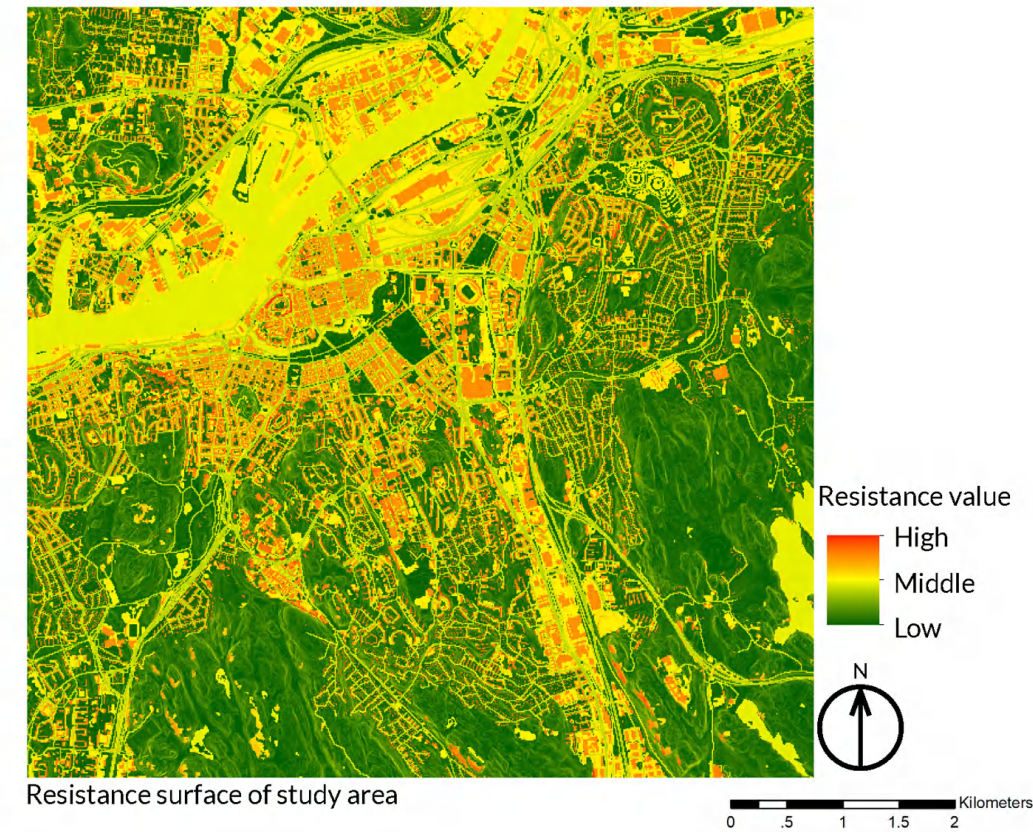
$$PC = \frac{\sum_{i=1}^n \sum_{j=1}^n a_i \cdot a_j \cdot p_{ij}^*}{A_L^2}$$

Footnote:

The calculation formula is as follows: where PC is the possible connectivity index, n is the total number of landscape patches,  $a_i$  and  $a_j$  are the areas of patches i and j,  $p_{ij}^*$  is the maximum probability of species directly spreading between patches i and j,  $A_L$  is the total area of the entire landscape. According to the study, the connectivity threshold was set at 1000m and the probability of connectivity was set at 0.5. The Connectivity Index (PC) of each core area was calculated according to the landscape connectivity analysis software Conefor, and classified into three levels:  $PC \leq 0.08$ ,  $0.08 < PC < 0.61$ ,  $PC \geq 0.61$ . The core areas with a  $PC \geq 0.61$  have the highest landscape connectivity and will be considered as very important core areas in the regional green infrastructure; the core areas with a PC between 0.08 and 0.61 have the second highest landscape connectivity and will be considered as important core areas in the regional green infrastructure; the core areas with a  $PC \leq 0.08$  have the lowest landscape connectivity, will be used as general core areas in the regional green infrastructure

## Ecological analysis - Step 3

Step 3 is to construct a ecological resistance surface, the transport of materials and energy through the landscape is influenced by the topography and land use disturbance. the built environment and transport infrastructure have the highest resistance value, while forest has the lowest.

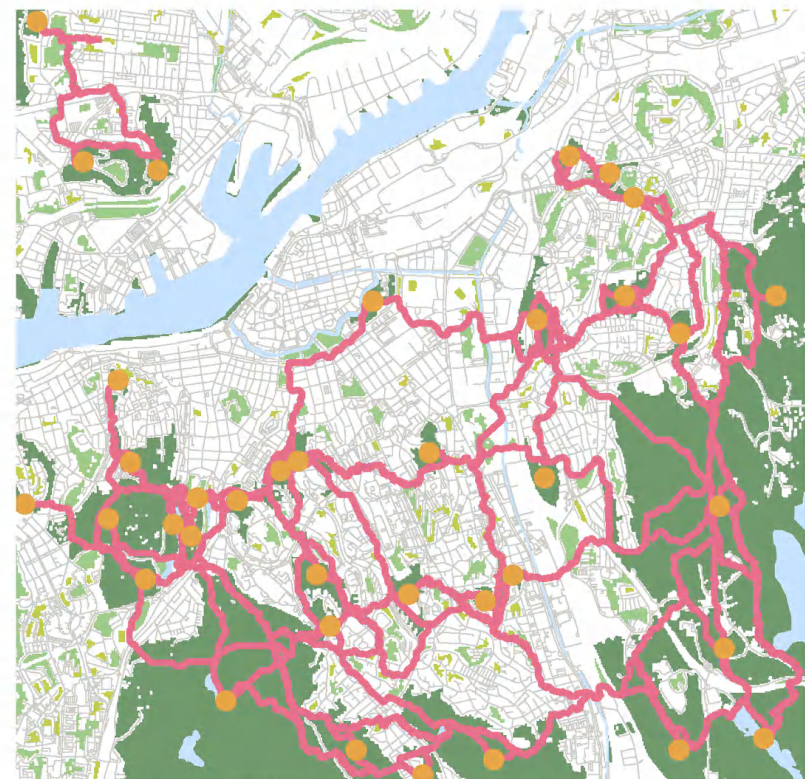


Resistance surface of study area

Table 1: The Resistance value of different landuse

Land use typ	Built environment	Street	Lake	River	Arable land	Woodland
Resistance value (1-1000)	950	700	53		50	1

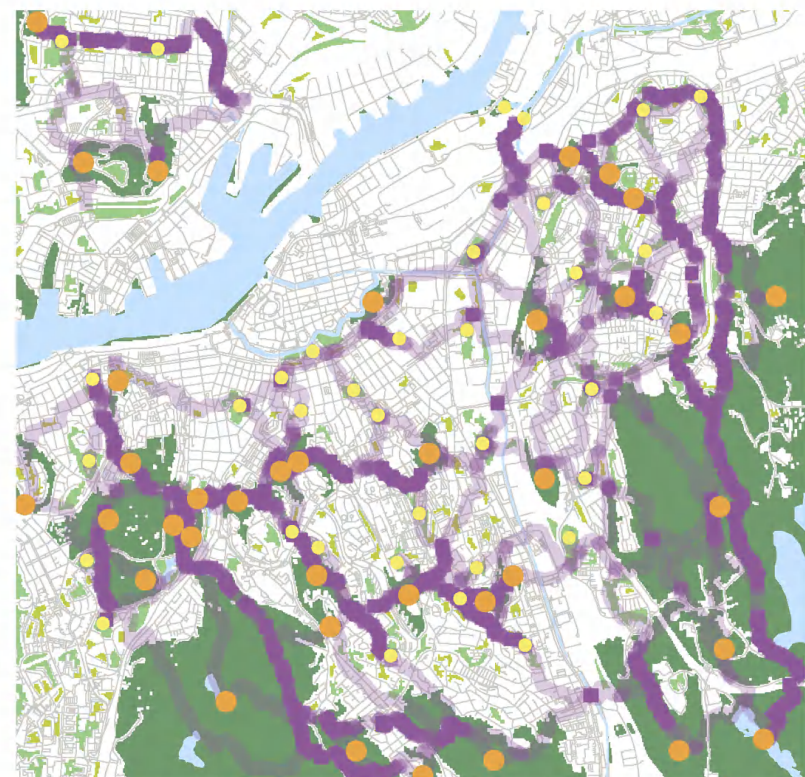
## Ecological analysis - Step 4



Spatial distribution of ecological network\_Pathway between very important core areas

Step 4: Identify the ecological corridor -Least-cost path analysis

The step 4 is to identify the ecological corridor, we simulate the best pathways between the very important core area and the important core area, suppose them as stepping stones, combined with land-use resistance surface, to do a least-cost-path analysis. Least-cost path analysis uses ArcGIS to find the path with the least relative ecological resistance between core areas, it measures the landscape resistance of the entire route between two nodes, or the minimum distance it takes for an individual organism to move between patches. The method identifies potential, more rational ecological corridor alignments by integrating parameters such as landscape pattern, landscape type and ecosystem services.

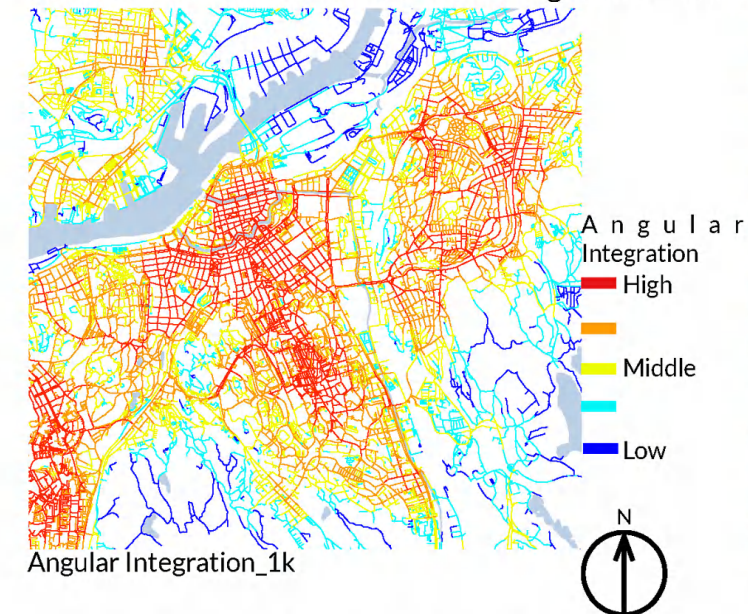


Spatial distribution of ecological network\_Pathway between important core areas

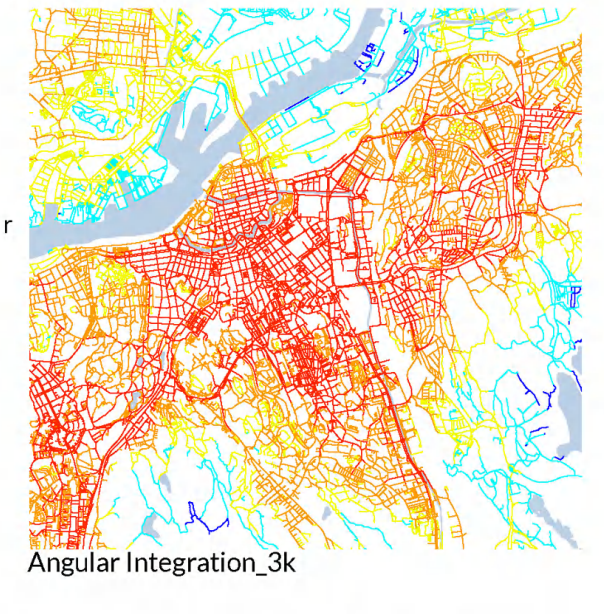
## Ecological analysis - Step 5

Step 5; To understand the influence and conflict with human activities. In order to understand the interaction and influence of human activities on the ecological system, the analysis of centrality and network betweenness with PST will be integrated.

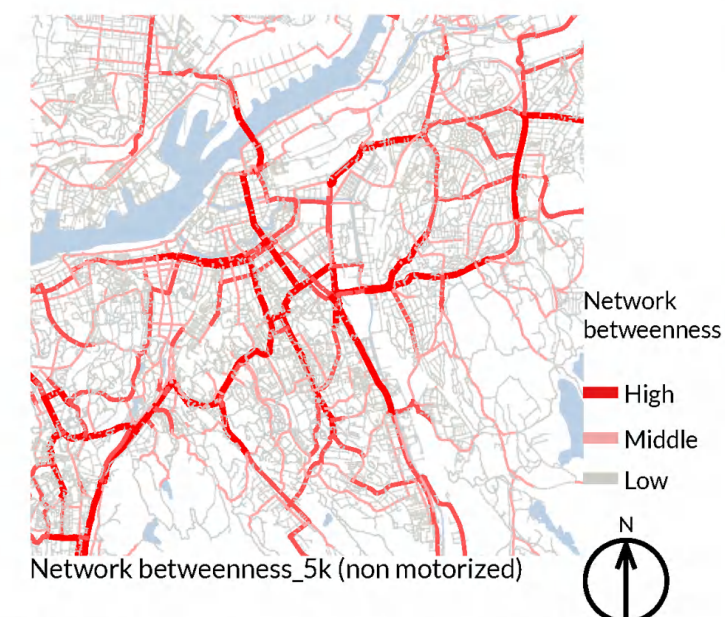
Then overlay the ecological corridor map with motorized network betweenness of 5 kilometers, which indicated the traffic flow of the research area, we can understand the intersection and overlay as barriers for animals to move.



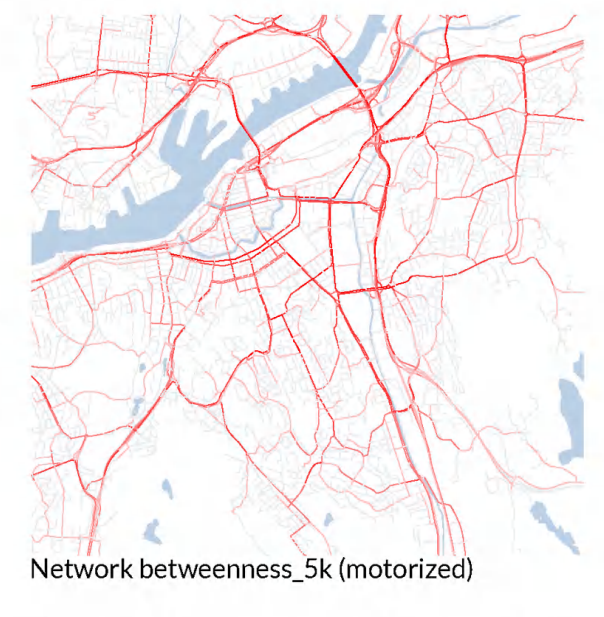
Angular integration 1K: the angular integration map of 1 kilometer shows the accessibility of Gothenburg city, the red color indicates the areas that have high centrality values which have good accessibility for pedestrians.



Angular integration 3k: the angular integration map of 3 kilometers shows that most of the city has good accessibility for people biking, jogging or has short travel distances.

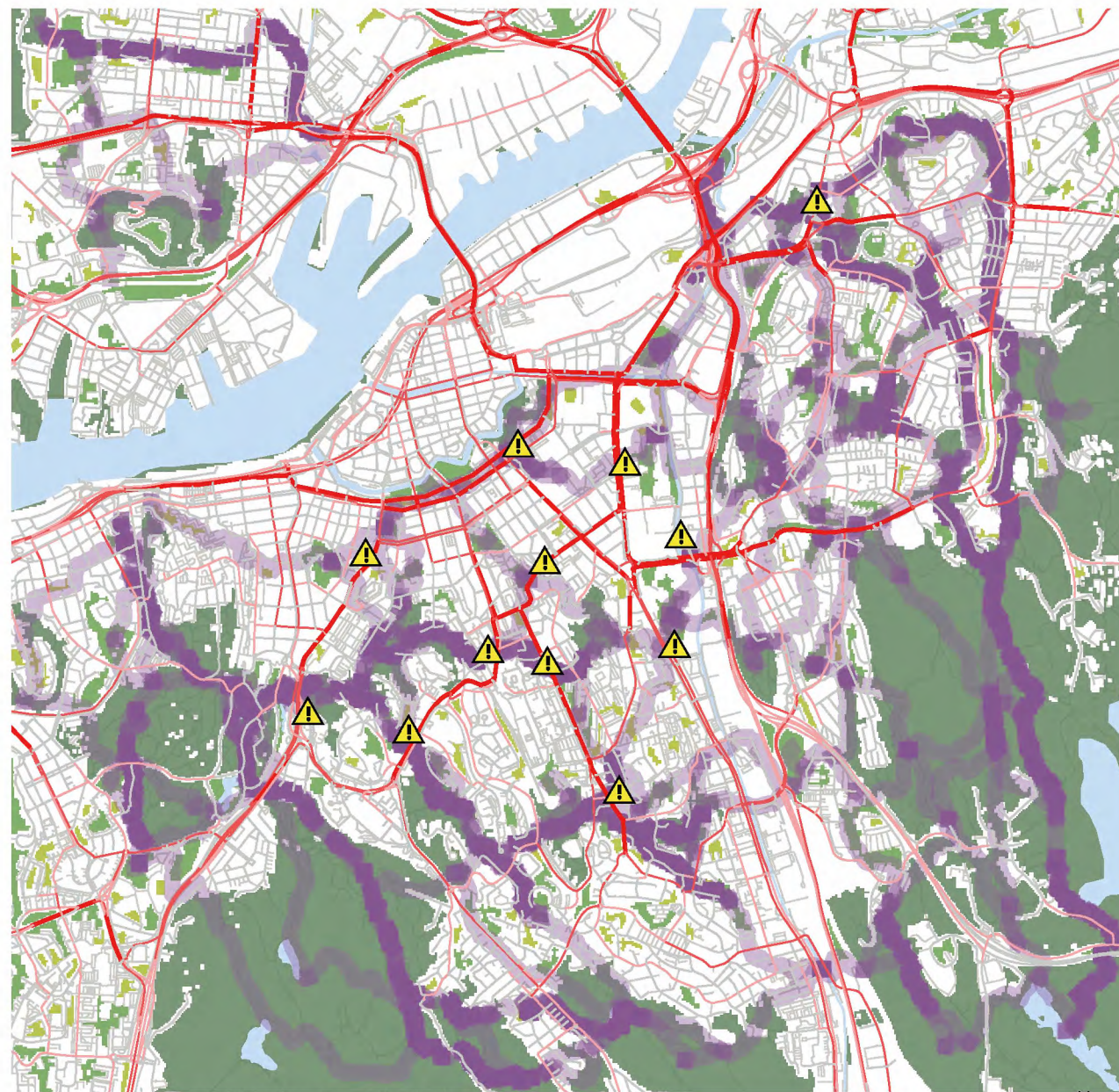


Network betweenness 5k: non-motorized network betweenness of 5 kilometers shows the most central and important paths in the city, red lines are the busiest, most visited streets.

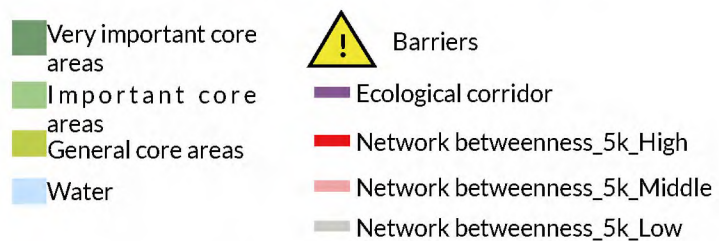


Network betweenness 5k: motorized network betweenness of 5 kilometers indicated the traffic flow of the Gothenburg city area, the red line has higher movement and heavier traffic.

## Understanding the barriers



Spatial distribution of barriers in ecological network



Overlay the ecological corridor map with motorized network betweenness of 5 kilometer, which indicated the traffic flow of the research area, we can understand the intersection as barriers for animals to move.

### Conclusion of ecological analysis

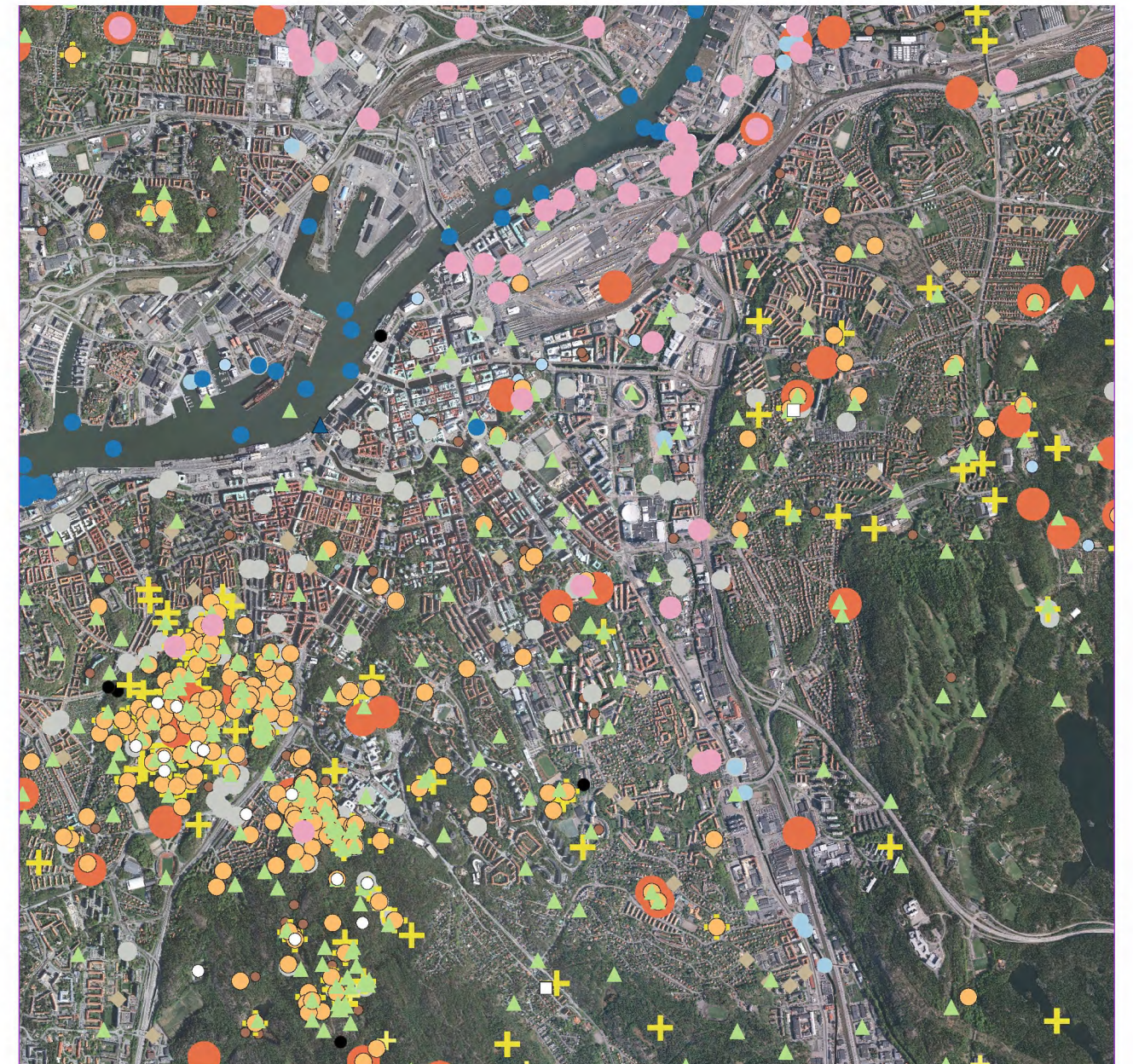
In the ecological analysis, we identified the ecological elements in the city center of Gothenburg, classified them according to the level of importance and the continuity, and then constructed ecological corridors. The ecological analysis allowed us to understand

which green patches could serve as stepping stones for wildlife to move around the city and which were sufficient for their shelter. Finally, by comparing this result with human activity, we know where ecological connectivity is weak and where wildlife migration is impeded, which can be used to inform future design improvements.

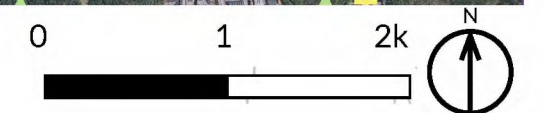
## Local species mapping

Which animals inhabit Gothenburg with us? Where do they usually move around? Which animal should we pick as the keystone animal for our next analysis? At first, we use the Analysis Portal for Biodiversity Data to map animals, to have an overview of what kinds of

wildlife are living with us in the urban area of Gothenburg, and establish a species library for later use.



Species mapping result



The mapping of species will be divided into three categories terrestrial mammals, aquatic mammals, and predatory birds. Most terrestrial mammals consist of rabbits, rats, hedgehogs, and squirrels, followed by foxes, deer, badgers, and stoats. Seals, dolphins, and cetaceans are some of the aquatic creatures that inhabit harbors. Beavers and minks

are typically found near rivers, however they are mostly invasive species and may be detrimental to the local ecosystem, so they were not selected for this study. Additionally, there are flying mammals, such as bats, and predatory birds, such as owls and hawks.

## Mammals on land

Image 45: European rabbit (*Oryctolagus cuniculus*)

Image 46: Mountain hare (*Lepus timidus*)

Image 47: Red squirrel (*Sciurus vulgaris*)

Image 48: European hedgehog (*Erinaceus europaeus*)

Image 49: Roe deer (*Capreolus capreolus*)

Image 50: Moose (*Alces*)

Image 51: Red deer (*Cervus elaphus*)

Image 52: European fallow deer (*Dama dama*)

Image 53: Least weasel (*Mustela nivalis*)

Image 54: European pine marten (*Martes martes*)

Image 55: Stoat or short-tailed weasel (*Mustela erminea*)

Image 56: European polecat (*Mustela putorius*)

Image 57: Red fox (*Vulpes vulpes*)

Image 58: European badger (*Meles meles*)

Image 59: Wild boar (*Sus scrofa*)

Image 60: Ovis

Image 61: Mus (genus)

Image 62: Bat

## Aquatic mammals

Image 63: Castor (*Castoridae*)

Image 64: American mink (*Neogale vison*)

Image 65: Eurasian otter (*Lutra lutra*)

Image 66: Harbor seal (*Phoca vitulina*)

Image 67: Phocoenidae

## Birds of Predator

Image 68: Eurasian eagle-owl (*Bubo bubo*)

Image 69: Tawny owl (*Strix aluco*)

Image 70: Northern hawk owl (*Surnia ulula*)

Image 71: Long-eared owl (*Asio otus*)

Image 72: White-tailed eagle (*Haliaeetus albicilla*)

## Choose the keystone animal

Through the study of Animal-Aided Design theory, we know that the selection of keystone animals is not based on the rarity and endangerment or legal protection. The influence and importance of the keystone species to the ecosystem and human beings should be considered, and biological and socio-cultural aspects should be balanced to ensure people won't reject the species and the biodiversity will benefit from the keystone species.

The keystone animal that has been chosen in this thesis is the red fox. The reason why to choose the red fox, first of all, the red fox stands in the middle of the food chain, design for the red fox can be beneficial also for other land mammals, like squirrels and hares. red fox eats berries, their pops can help plants spread seeds, snails and slugs can attach to red fox's fur to move around, and red fox burry dead prey which can increase soil humus, and help recover urban biodiversity. I think the red fox is the most misunderstood and stigmatized urban wildlife that red foxes are aggressive and cunning, and I want to change the impression of that.

The ecological characteristics of the species and critical needs should be studied and fulfilled so that they be able to live in the designed areas.

## A study of the red fox

### Time cycle for reproducing

The red fox's breeding season in high latitudes spans from November to March, with the most effective mating occurring between December and early February. The gestational period is around 7.5 weeks, or 52 days. A den is the most important habitat during the breeding season, and two weeks before to giving birth, the vixen begins searching for an earth den to give birth and rear the young. Under sheds, gravestones,

and buildings are common places to dig a den in the dirt. In other instances, she gives birth above the earth in the trunk of a downed tree, a dense tuft of grass, or a log pile.

Two to three weeks after birth, newborn cubs are unable to regulate their body temperature and are blind and deaf. The vixen will not leave her babies for the first two to three weeks, not even to get water. She will stay in the den and keep her pups warm until their fur becomes sufficiently thick to offer insulation. At this time, the vixen's father will return with food to nourish her. Fox cubs rely on the vixen's milk for the first four to five weeks of life, but the vixen begins feeding them meat when they are just one day old. The cubs' eyes and ears will open between 10 and 14 days of age, and their upper jaw teeth will begin to develop at six to eight weeks, letting them to eat solid food. Around the month of May, cubs are totally weaned and both parents give food at this stage. At around five weeks of age, the cubs begin to leave the natal dirt cave and play outside near the den. By the time they are eight or nine weeks old, the cubs will leave the nest, rest in surrounding thick shrubs, and attempt to expand their habitat. Parents will continue to hunt food for their cubs for around four months. At that time, their adult dentition is about complete, but due to their lack of hunting abilities, their diet consists primarily of fruits and invertebrates. The young foxes will attain sexual maturity between nine and ten months of age, and their adult size by fall. By the end of December, they will have completed their winter coat. Sons will leave their parents' area to establish other homes, while girls may remain with their parents for some time. In general, red foxes are called cubs until they reach the age of four months, after which they are termed juveniles, and once they reach the age of one year, they are regarded adults. (Red Fox Reproduction - Introduction | Wildlife Online, n.d.)

## Time cycle for reproducing

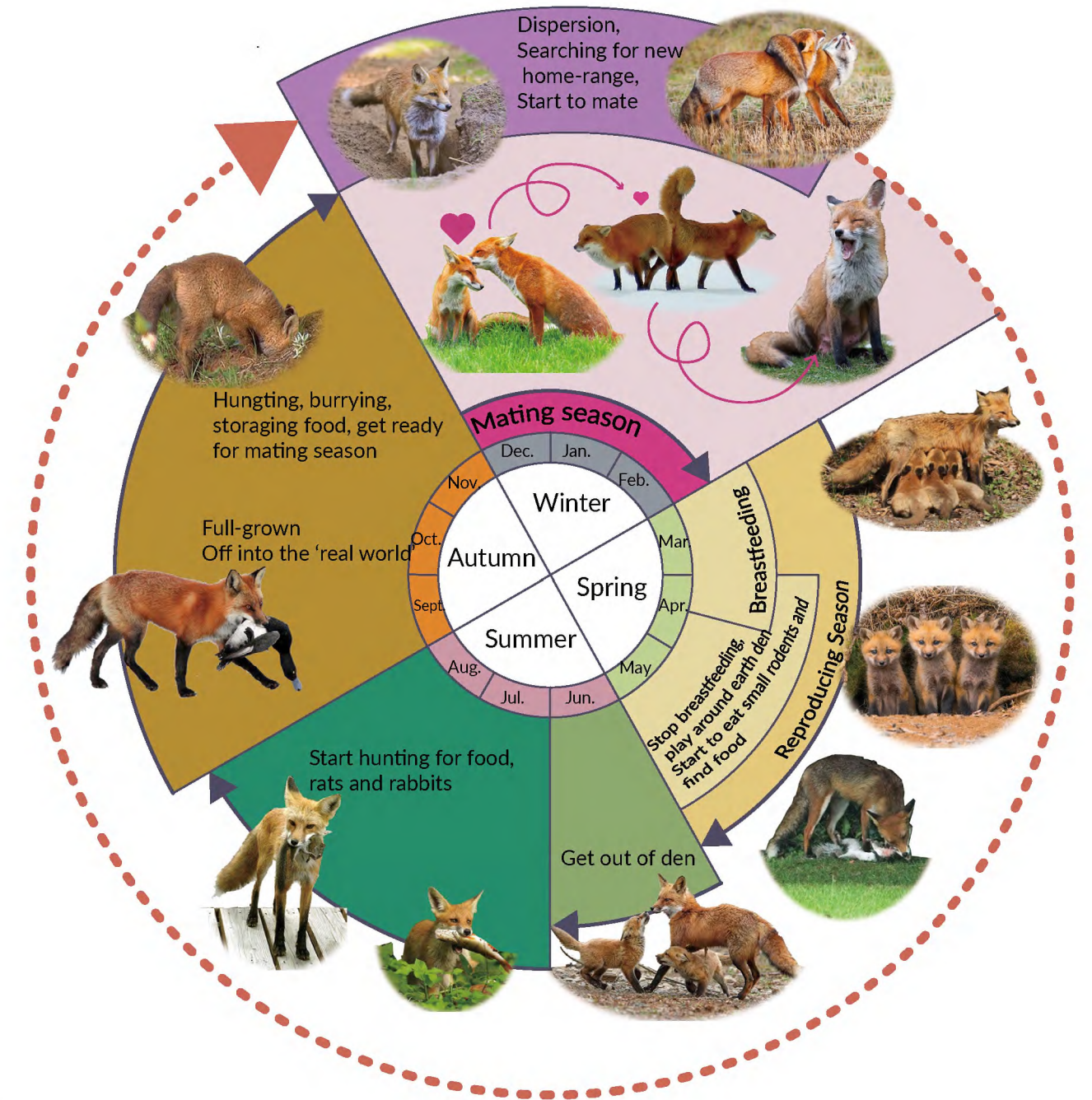


Image 73: Time cycle for reproducing

## Predators and preys

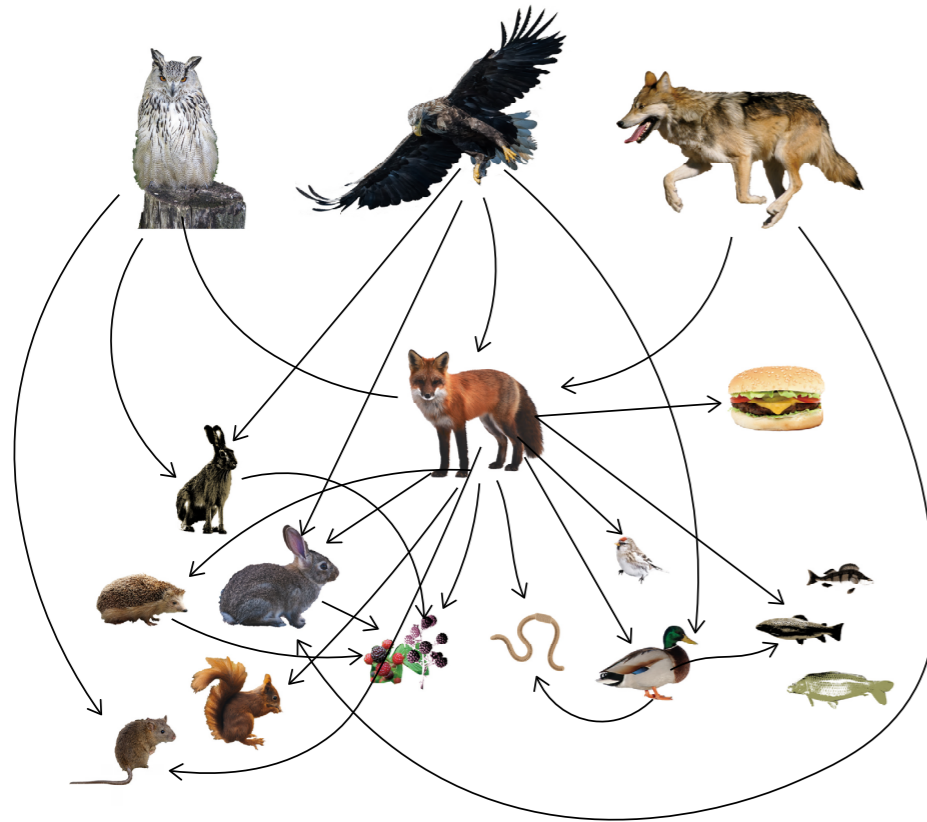


Image 74: Predators and preys

Red Foxes are omnivores, meaning they consume a wide range of foods. Their food includes vegetation, such as fruits, berries, and grasses; birds and small mammals, such as mice, rats, voles, rabbits, and squirrels; and a substantial amount of the red fox's diet consists of invertebrate preys, such as crickets, caterpillars, grasshoppers, and crayfish. The red fox will continue to hunt and then bury any surplus food in soil, leaves, snow, or mud.

Red fox nutrition vary with the seasons and age; they are quite adaptive, switching prey as needed. For the most of the year, animals, particularly rabbits and rodents, are the dominant food; a single fox would require around eight mice per day, with each mouse providing approximately 60 kcal. Red fox parents would hunt birds to feed their children in the spring and early summer, while adults rarely consume birds. Insects and worms are on the summer and fall menu of the red fox. Insect larvae, crane flies,

moths, and earthworms are consumed in considerable quantities, and the growing pups will capture them near the earth. Invertebrate prey can make up 30% or more of the diet.

Fruits and vegetables are key food sources in their fall diet. They prefer *Rubus* genus fruits such as blackberries, blueberries, raspberries, and cherries. They will also consume cultivated fruits, crops, and vegetables such as persimmons, mulberries, apples, plums, grapes, dates, figs, and even acorns, as well as nuts, grasses, sedges, and tubers. Fruit and vegetables comprise approximately 10 to 30% of a fox's diet and might vary geographically and seasonally. Fruits are also significant dietary sources for cubs. Amphibians, reptiles, and eggs are less common meals for red foxes. Because of the high protein and nutritional worth of eggs, red foxes will take eggs from bird nests or reptiles. (Red Fox Diet & Predators | Wildlife Online, n.d.)

## Territory

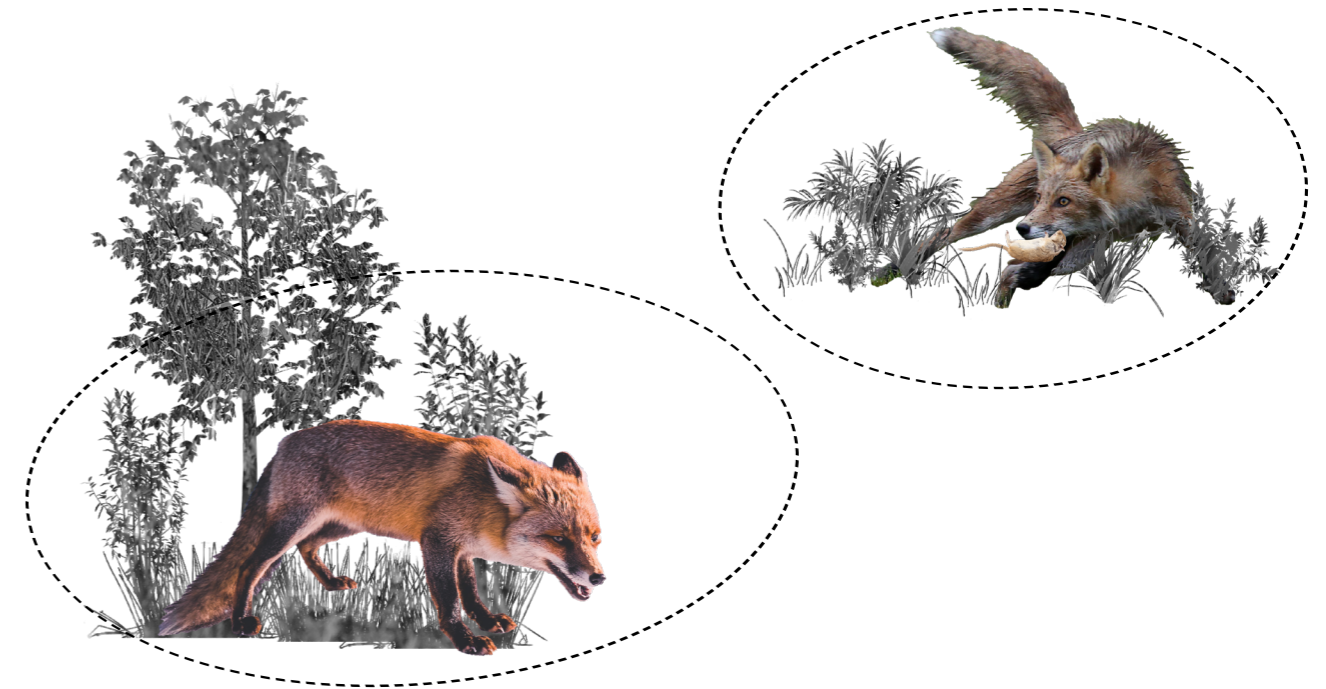


Image 75: Territory

The size and form of a fox's territory varies widely according to food availability, food distribution, and shelter locations. Therefore, the residence range in urban regions is significantly less than in rural or desert places. For instance, the home ranges of foxes in Europe range from 40 ha to 1,300 ha and may comprise a single fox or a small family group of three to six individuals. Due to the shortage of food in desert places, the range can be expanded to 5,000 hectares. Typically, a fox will defend its area against intruders. Nevertheless, because of the abundance of food in metropolitan settings, so many foxes may be attracted to it that guarding it becomes difficult, so, these invaders must either be expelled or tolerated.

In rural regions, such as farmland, red foxes frequently use linear landscape features such as hedges, tree-lines, and roadways to demarcate territorial borders. In metropolitan locations, roadways and barriers are often utilised to demarcate

housing range. Therefore, the continually changing environment and land use in our big cities may result in red foxes shifting their territory. *"The ultimate explanation for drifting is that the city environment is inherently disturbed, by pedestrian and road traffic, habitat management and construction and demolition work."* suggested by David Macdonald and Patrick Doncaster from their Radio-tracking studies of foxes in Oxford city. This type of drifting may end in the death of urban foxes as a result of a shifting terrain. (Red Fox Territory & Home Range | Wildlife Online, n.d.)

## Red fox In the city

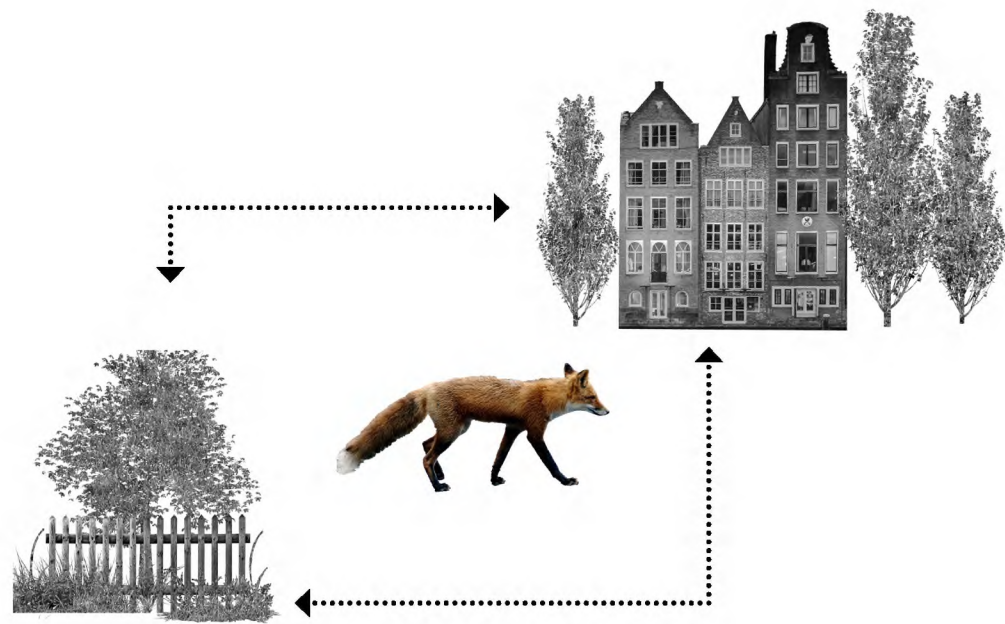


Image 76: Red fox in the city

Human presence has a significant influence on the content of red fox diets. In certain urban areas, homeowners may put out food and water to feed wild red foxes, and the amount of food supplied exceeds the foxes' demands, resulting in red fox territorial alterations. People may believe that urban red foxes rely on dumpsters for food, and that by consuming human leftover food, they get lazy and stop hunting; however, such beliefs are false; red foxes raid bins on a less frequent basis than many people believe. Even if there are plenty of food options in the centre of our cities, foxes continue to hunt birds, animals, amphibians, and insects since it is in their nature.

Red foxes were named the "most urbanised canid" by Mark Cardwine in his 2007 book, *Animal Records*, since they have adapted to city life better than any other member of the canine family. According to Robert Francis and Michael Chadwick's 2011 work in *Applied Geography*, the Red fox is a true synurbic animal, with larger population

densities in urban regions than in rural environments. Their preferred places in cities include city parks, backyards, cemeteries, and golf courses.

With a high number of documented road deaths involving red foxes each year, urban traffic is seen as a significant barrier to animal mobility and dispersal. Red foxes are clever creatures who have learnt to adapt to urban traffic by going out at night when there is less traffic and avoiding automobiles. (The Secret Life of Urban Foxes | Natural History Museum, 2019)

## Behaviour

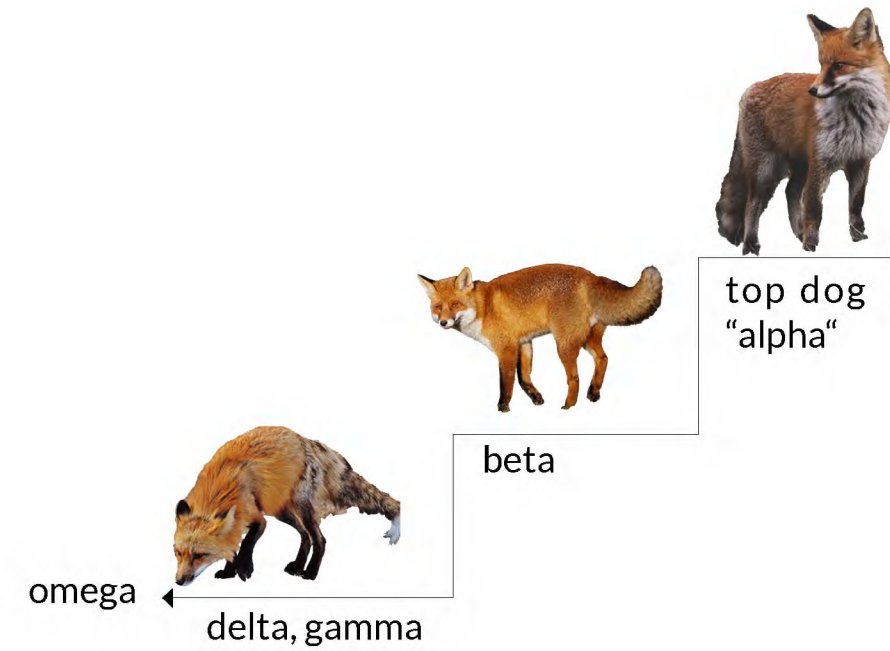


Image 77: Behaviour

Red foxes have a complicated social structure, and hierarchy are not as simple as people believe. There is traditionally a strict hierarchy within the canid social structure, with "alpha" serving as the "alpha dog" and "beta," "delta," "gamma," and "omega" serving as the lowest level. Despite having a nuclear family structure, red foxes have a separate social hierarchy. The hierarchy influences a fox's access to food, the size of their territory, their ability to disperse, their social interactions, and the development of the next generation. However, the hierarchy within the fox group is fluid and subject to shift during fighting.

Scent is the most significant indication for communication in the red fox's society, since they use it to restrict their territory, mark their caches, and smell each other upon meeting. Additionally, vocal and visual signals are utilised to attract a partner and communicate feelings. Due to the disruption of human activities in metropolitan areas, red foxes have modified their habit to become

nocturnal animals, sleeping together during the day and wandering alone at night. While they have cubs to feed in the summer or when they are reproducing in the winter, it is more common to see their daylight activity. (Red Fox Behaviour - The Social Hierarchy | Wildlife Online, n.d.)

## Habitats



Image 78: Habitats

Due to their unspecialized lifestyle, red foxes may thrive in practically all types of ecosystems, including forests, tundra, prairie, desert, mountains, farmlands, and urban areas. Their spread and abundance are determined by the availability of food and breeding sites. In general, red foxes prefer vegetation groups and landscapes comprised of scrub, woodland, and farmland that contain a variety of plant types. In addition, they like settings that provide abundant food and shelter, such as berry bushes, mature conifer plantations, and dense vegetation cover.

*"Areas least suitable for foxes, whether harassed or not, would have some or all of the following characteristics; flat, open country; few woodlands or very open deciduous woodland; neat or simple field boundaries (fences or ditches, e.g.); no scrub or uncultivable land; large field, mainly arable and a high water table."* written by M.A.F.F. scientist Huw Gwyn Lloyd in 1980.



They prefer earth dens excavated into the ground, but also utilise rock cavities, crevices, caves, tree hollows, and tree trunks during the mating season. Occasionally, they occupy the burrows of other animals, such as rabbits or marmots. There is usually a passageway between the main den and additional resting spots, including preferred hunting grounds and food storage areas. (Red Fox Habitat | Wildlife Online, n.d.)

## Interaction with the ecosystem



Image 79: Interaction with plants

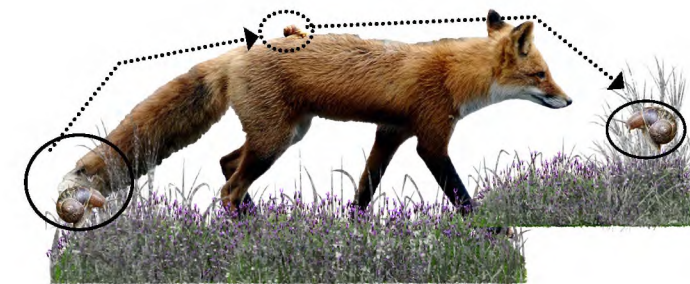


Image 80: Interaction with other species

Through interactions with plant communities and other animals, red foxes might contribute to the recovery of biodiversity in their region. For instance, red foxes consume fruits and berries; undigested seeds in the fox's droppings may spread and colonise new places; fox droppings and decaying prey remnants are fertiliser, which enrich the soil chemistry and stimulate the growth of certain species. Therefore, the plant community surrounding a fox's den is more diverse than that of the adjacent undisturbed ground.

During the construction of a red fox's earth cave, the foxes' activities modify the plant communities, as cubs play with plants, destroying, trampling, and burying them in the soil. When they excavate their den, the soil layers will get muddled. The subsurface soil will be brought to the top, which is richer in minerals and nutrients and has a higher pH (i.e. is less acidic) than the surface soil. The bioperturbation effect can

aid the establishment of herbaceous plants by creating rich soil patches in forests. In his work, Polish botanist Artur Obidzinski describes how foxes alter the local ground flora through long-term monitoring of fox earthe dens.

In addition to their influence on plants, foxes unconsciously aid the movement and dispersal of other species. In 1987, Stella Davies, a biologist, published an article in the Journal of Conchology stating, "...foxes probably offer the best means of transport between habitats for lusitanicus in urban areas. Increases in urban foxes may have had an important influence on the distribution of lusitanicus in Britain." Certain types of slugs may ride on fox fur coats or attach themselves to the tails of domestic cats, likely the fur of the majority of animals, to their new optimum positions. (Red Fox Interaction with Other Species - Plants & Invertebrates | Wildlife Online, n.d.)

## Conclusion: Transformation of urban spatial elements for red fox

To conclude the study of red fox, we summed up the natural elements that could benefit red fox habitats and biodiversity, including dead tree trunks, hollow trees, gravel cracks, and rubble that provide shelter; plant communities, such as fruit trees and berry bushes, that provide food; and water ponds that can collect rainwater and provide water for wildlife. The red fox enjoys playing beneath wooden constructions such as wooden stacks, wooden house basements, and wooden roofs.

For human activities, design elements such as the allotment garden, the built structure

with insect hotel and insect wall, and the handmade wooden shelter with tree branches inspired by a natural playground in Gothenburg. In addition, they provide refuge and food supplies for urban birds, insects, pollinators, and wildlife, and encourage human interaction with nature.

We have discovered that these spatial design components are beneficial to the urban fox, but we need to determine where to deploy the design to optimise their effect. The next step in our research is to analyze from the fox's perspective to identify the optimal position.

### Natural elements benefit red fox's habitats



Image 81: Dead tree trunk provide shelter



Image 82: Hollow tree provide shelter



Image 83: Gravel crack and rubble provide shelter

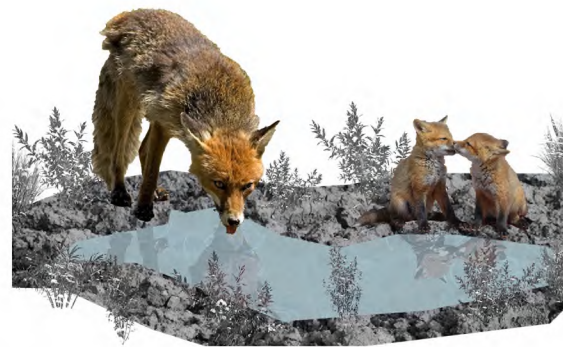


Image 84: Water ponds can collect rainwater and provide water for wildlife



Image 85: Berry bushes provide food source; marquis and scrubwood provide shelter



Image 86: Playing beneath wooden constructions

### Built structure with natural material



Image 87: Handmade wooden shelter with tree branches inspired by a natural playground in Gothenburg



Image 88: Built structure with insect hotel and insect wall



Image 89: Allotment gardens provide refuge and food supplies for urban birds, insects, pollinators, and wildlife, and encourage human interaction with nature

## Analysis from a red fox's perspective

How can we imagine a fox's life in urban areas? Just like human-beings, the urban system support our needs and activities, so we can have a life there. Through the study of the time cycle for reproducing, the territory, the food, the habitats, and the behaviors, we can summarize that there are three important aspects of a fox's life, to make an earth-den for reproducing, hunting and finding food, places for rest and sleep, then we can analyse the urban environment from a red fox's perspective, to understand and find out where are the best place to support their urban life.

Conditions and factors for these three aspects have been investigated, as the illustration on the right-hand page. Through the works of various researchers and biologists, such as following animal observations and faeces analysis, have determined the environmental requirements necessary for the survival of the red fox. The environmental characteristics required for red fox dens, such as slope direction, soil compatibility, and vegetation cover, were summarized by sampling and examining fox dens. The analysis of their droppings and tracking of their daytime and nighttime activities revealed the sites where they typically hunt and rest, as well as the characteristics and environmental conditions of these locations.

For the spatial analysis, the first step is to do the suitability analysis - give each factor weight and overlay them to find the most suitable spots for these three aspects. To do that, I collected the Nationella Marktäckedata (NMD) from naturvardsverket, SLU Markfuktighetskarta (tif) from slu, Höjddata from Lantmäteriet, and geo-data from Social-ecological studio in Chalmers. Then extract the required information from the data, for example, to calculate the slope and aspect from Höjddata, soil moisture from Markfuktighetskarta, etc. And run the analysis step by step with

ArchGis; the basic tools are reclassify and raster calculator.

The second step is to combine the results and find out the territory cycles. An important knowledge to know is that, there must be passways to connect the critical spots of the den, hunting place, and resting place, each fox family have its own home range is about 40 hectare in the urban area, so the critical spots should be included in their territory. The last step is to select design sites by comparing the territory cycles with their publicity and conditions, which means the site have potential to be redesigned and transformed for red foxes living in the city, and promote interaction between human and wildlife. and then combined with the results of the green network analysis, find out which sites locate on the ecological corridor, which are important locations to connect living spots of wildlife for them to move around in the city.

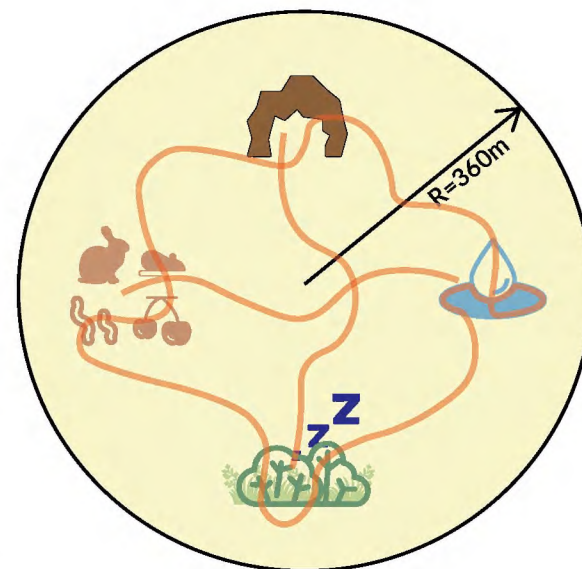


Image 90: Passways connects critical spots within territory

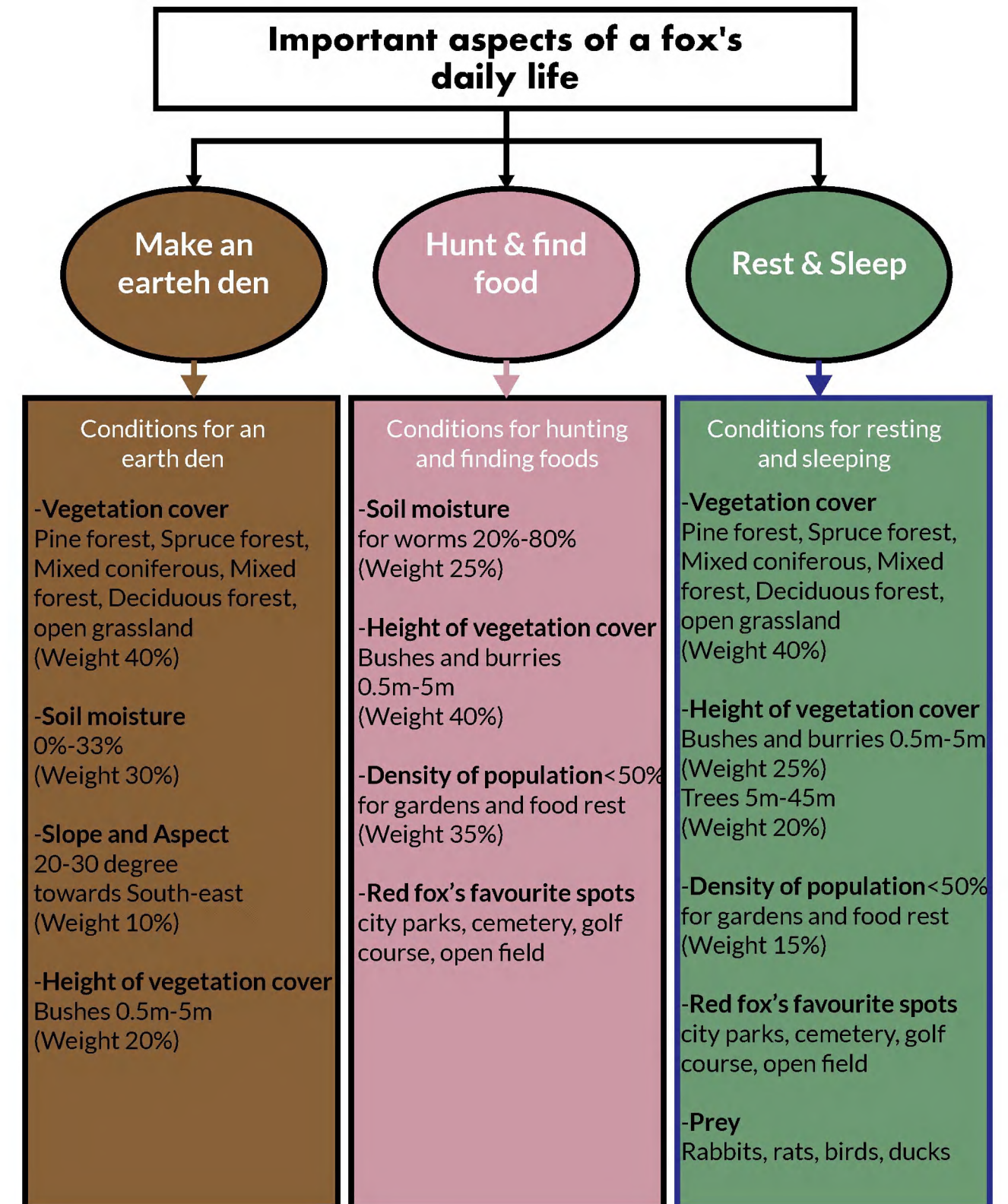
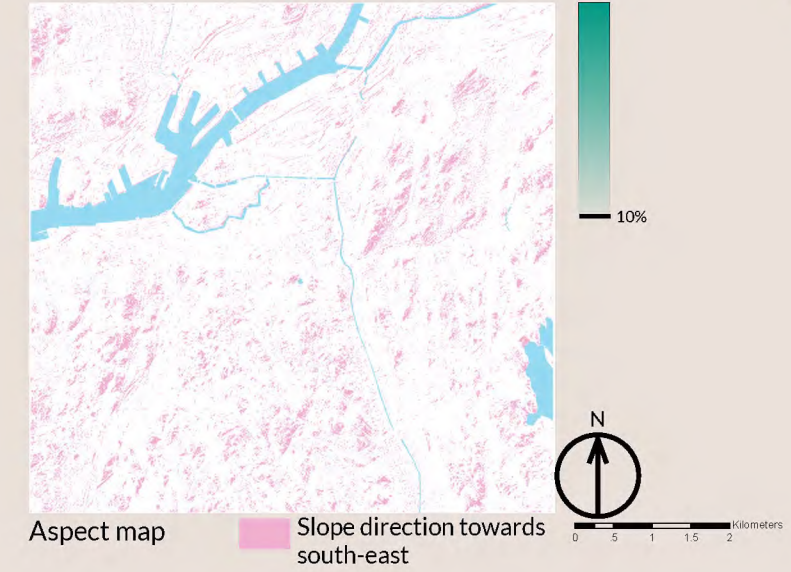
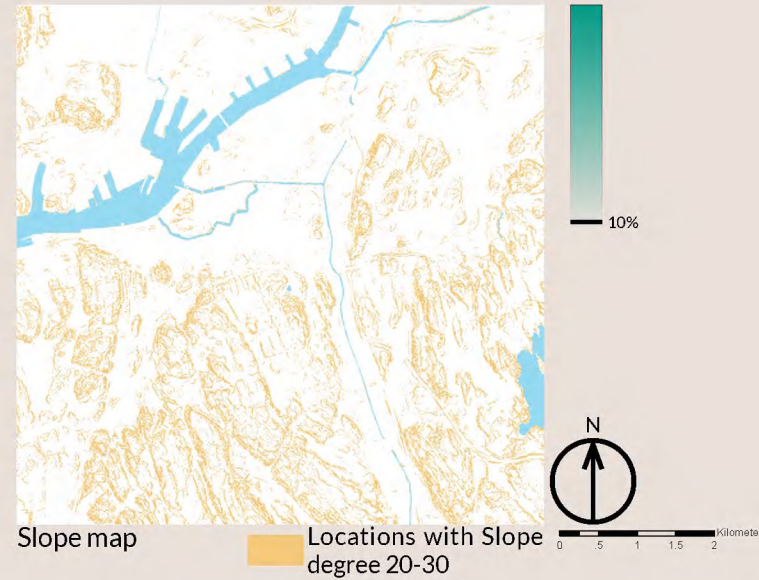


Table 2: Important aspects of a red fox's daily life

## Site analysis matrix from a red fox perspective - Earth Den

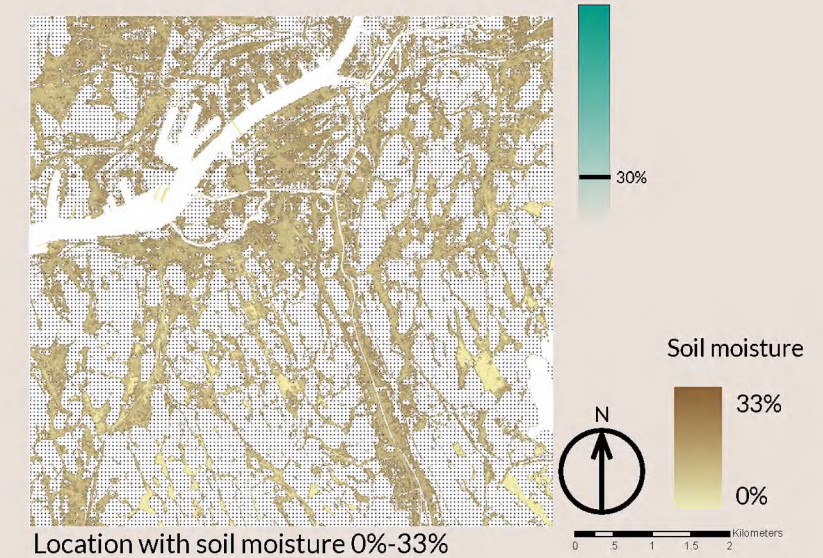
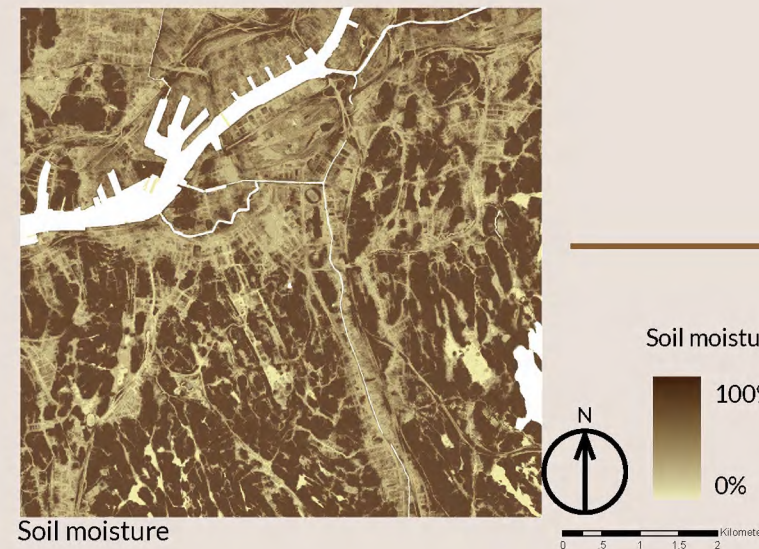
For locations to make an earth den, a study of Michael Stubbe in eastern Germany found that 95% of the 145 earths he researched were on south east-facing slopes with an average inclination of 20-30 degrees. (Red Fox Dens/Earths & Resting Sites | Wildlife Online, n.d.)

**Slope and Aspect**  
 -Slope 20-30 degree  
 -Slope direction towards South-east  
 (Weight 10%)



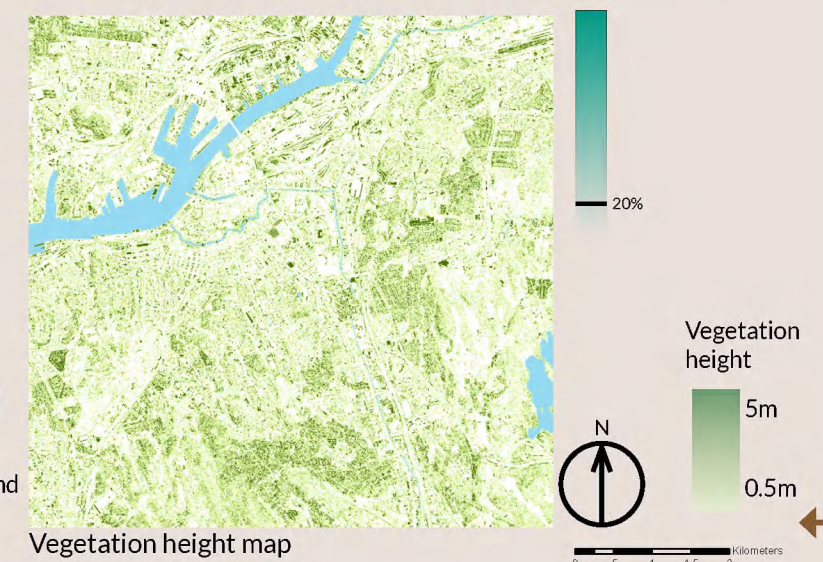
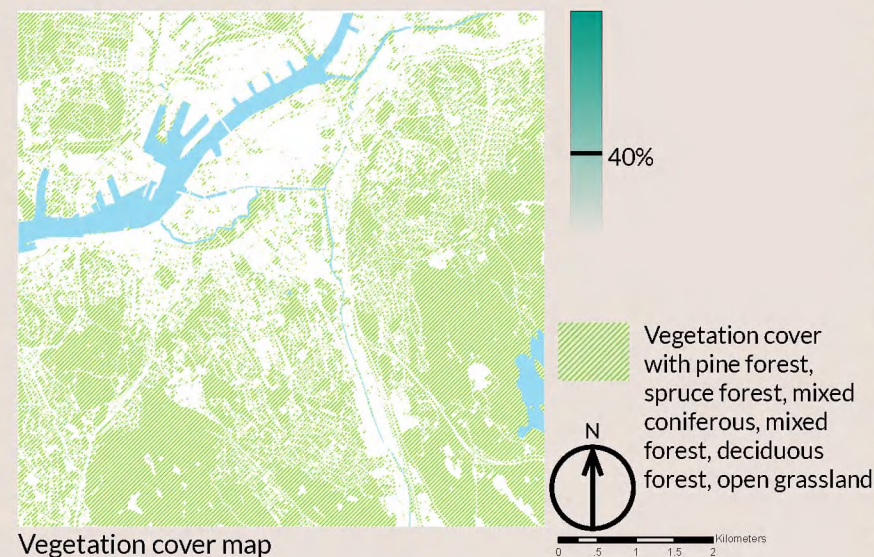
Another study of den-site selection reported that red foxes like to burrow into soil with a low clay content, which means dry clay with 0-33 percent water content, well-drained terrain with loose and easily dug soil is excellent for an earth-den. (Red Fox Dens/Earths & Resting Sites | Wildlife Online, n.d.)

**Soil moisture**  
 Soil moisture 0%-33% for earth with low clay content  
 (Weight 30%)

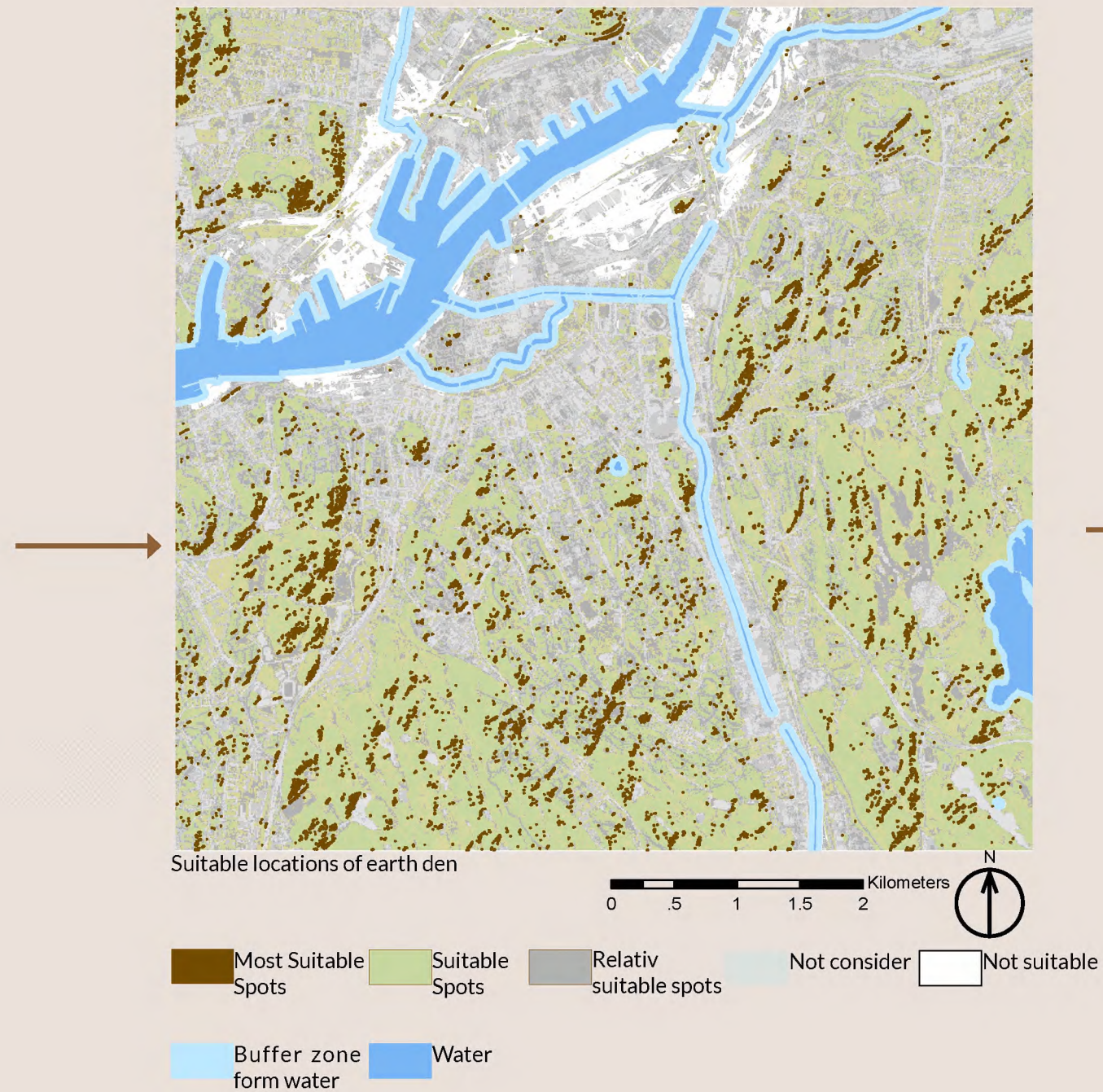


Other favored den sites are typically protected and densely vegetated. Locations beneath buildings and sheltered with low-height vegetation, such as bushes, weeds, or scrub wool, are suitable during cold seasons. Nevertheless, the height of the vegetation is also vital for hiding the den for protection. (Red Fox Dens/Earths & Resting Sites | Wildlife Online, n.d.)

**-Vegetation cover**  
 Pine forest, Spruce forest, Mixed coniferous, Mixed forest, Deciduous forest, open grassland  
 (Weight 40%)  
**-Height of vegetation cover**  
 Bushes 0.5m-5m  
 (Weight 20%)

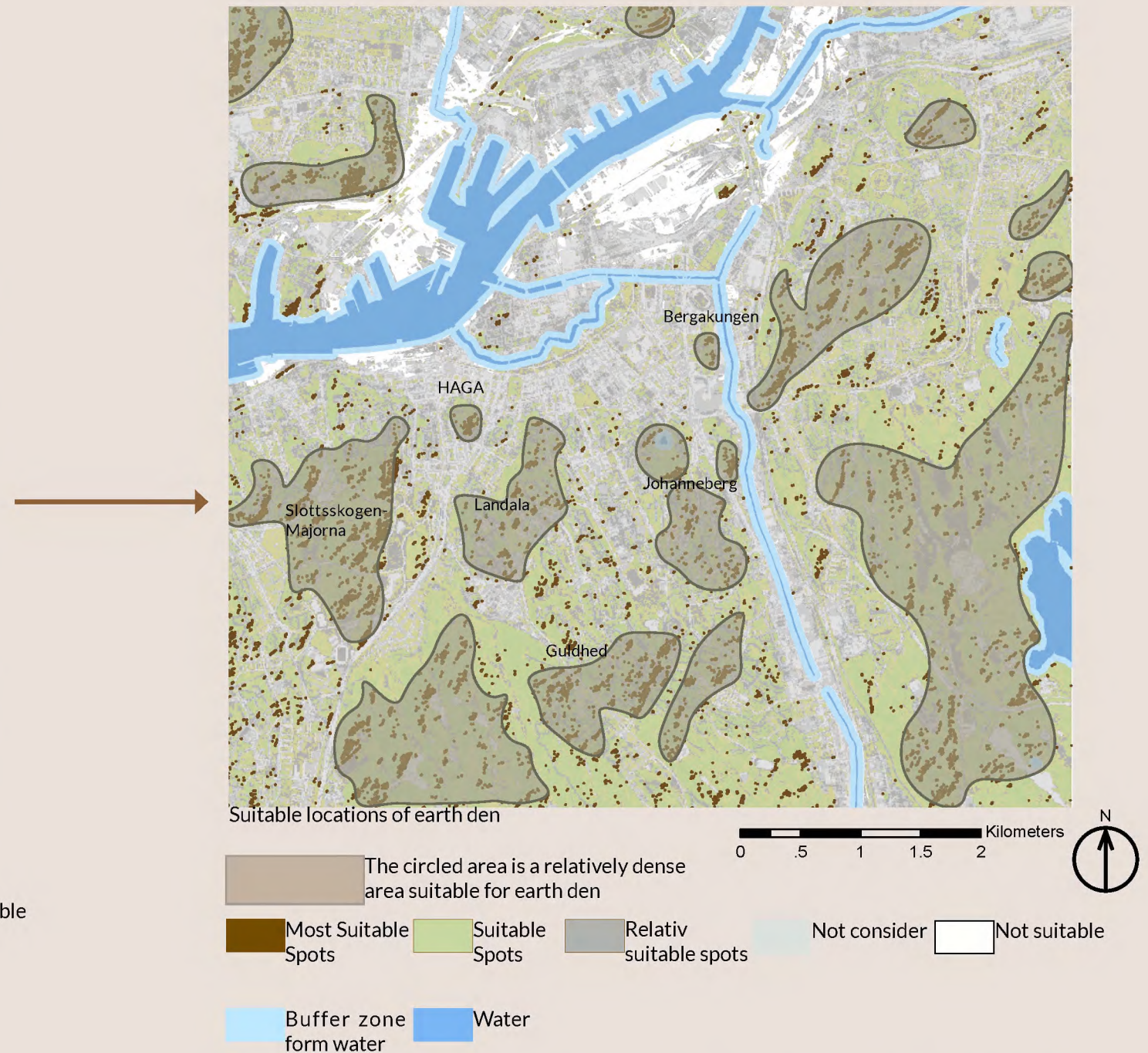


## Result of suitable earth den spots



The distribution of earth den sites was determined by applying the aforementioned three requirements, the slope and aspect, soil moisture and vegetation cover. The brown dots in the graph reflect the most ideal sites for digging an earth den, while the green dots represent suitable sites, which usually locates in the city's largest green areas and natural reserves. The dark grey symbolizes

relatively suitable urban environments, which consist of tiny green spaces. The light grey represents a built-up area in the city as well as hard surface which are unsuitable for den-digging. The white areas are at risk of flooding and will not be considered.

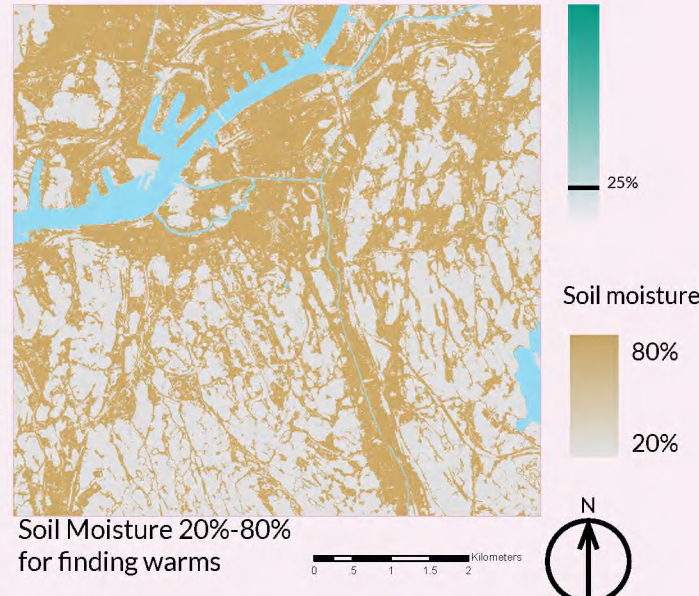


Here, the encircled areas are the densest and most appropriate locations for earth dens. We can see that Gothenburg's urban area has few dense areas due to its flat terrain, hard ground, and built-up environment. The most favorable locations for digging earth dens are almost always located on vegetated hillsides with undulating terrain.

# Site analysis matrix from a red fox perspective - Finding Food

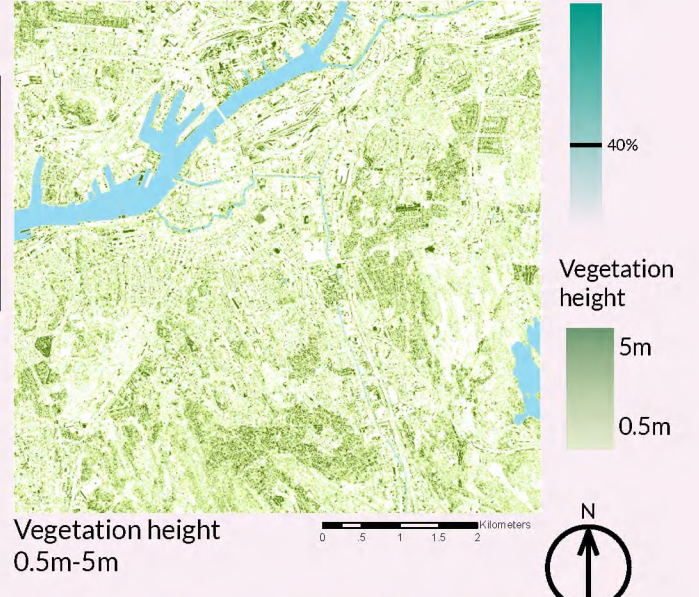
Insects and earthworms are also important food sources. Worms often thrive in soils with 20 to 80 percent soil moisture; therefore, soil moisture is a crucial factor to consider when determining the ideal site for finding food. (Red Fox Diet - What Foxes Eat | Wildlife Online, n.d.)

**Soil moisture**  
for worms 20%-80%  
(Weight 25%)



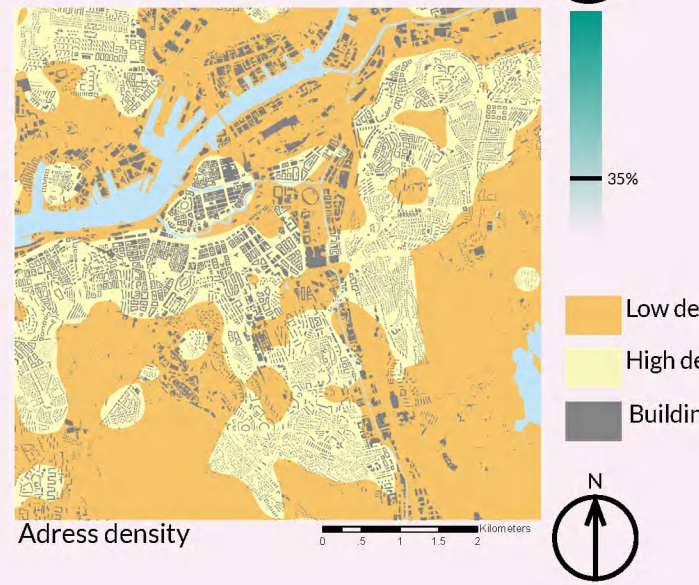
Plant communities, such as berry bushes and fruit trees, are vital food sources; therefore, vegetation height is an essential factor to analyse the most suitable location. (Red Fox Diet - What Foxes Eat | Wildlife Online, n.d.)

**Height of vegetation cover**  
Bushes and berries  
0.5m-5m  
(Weight 40%)



Residential areas with gardens are good places for foxes to find food or be fed by residents, hence population density is a factor that influences food resources. For the study, areas with a population density of less than 50 percent were selected. (Red Fox Diet - What Foxes Eat | Wildlife Online, n.d.)

**Density of population <50%**  
for gardens and food rest  
(Weight 35%)

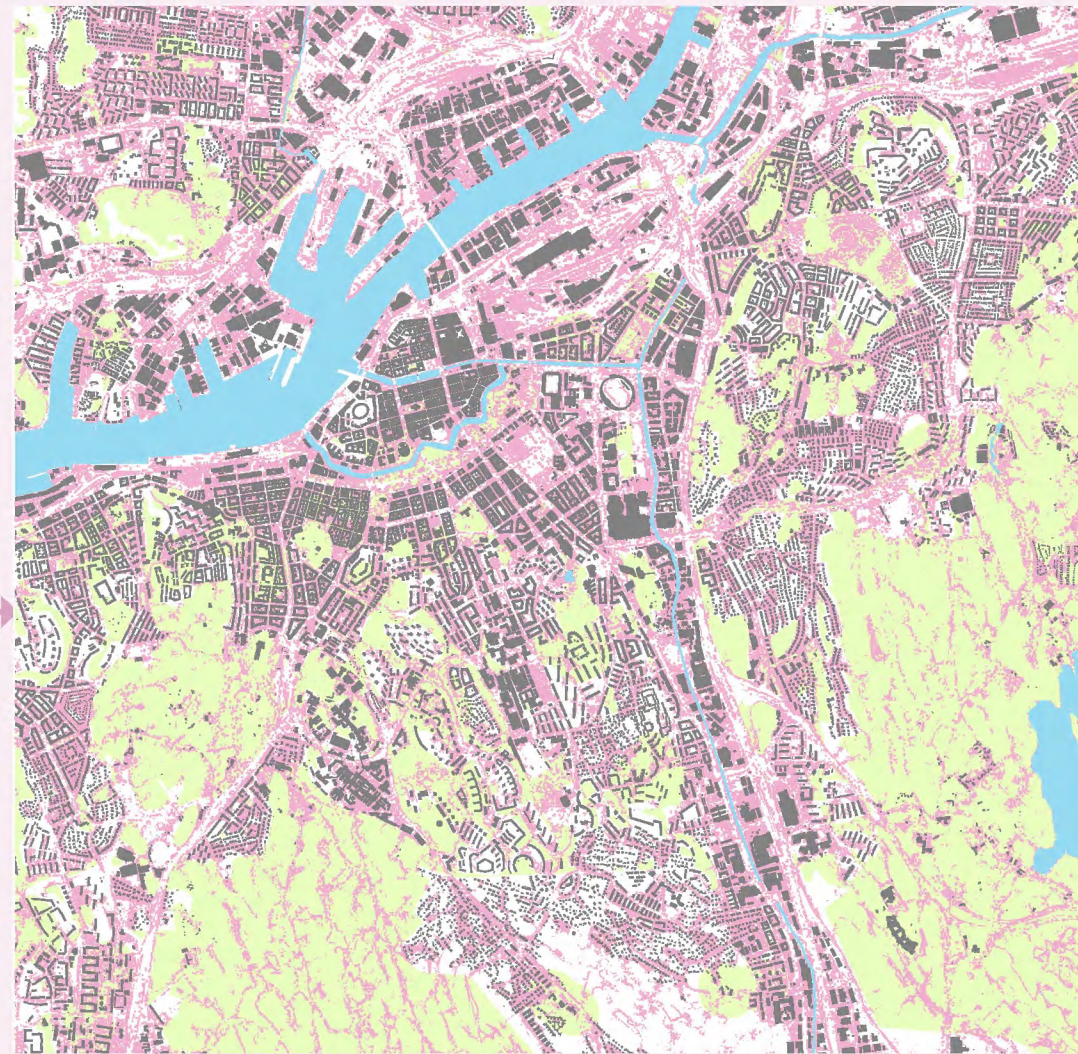


Most Suitable Spots  
Suitable Spots  
Relative suitable spots  
Not consider  
Water



**Red fox's favourite spots**  
Red foxes prefer urban parks, cemeteries, golf courses, open fields, and open grassland for hunting rabbits and mice.

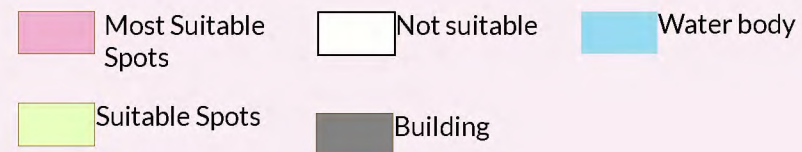
## Result of suitable spots for finding food



Suitable locations of finding food

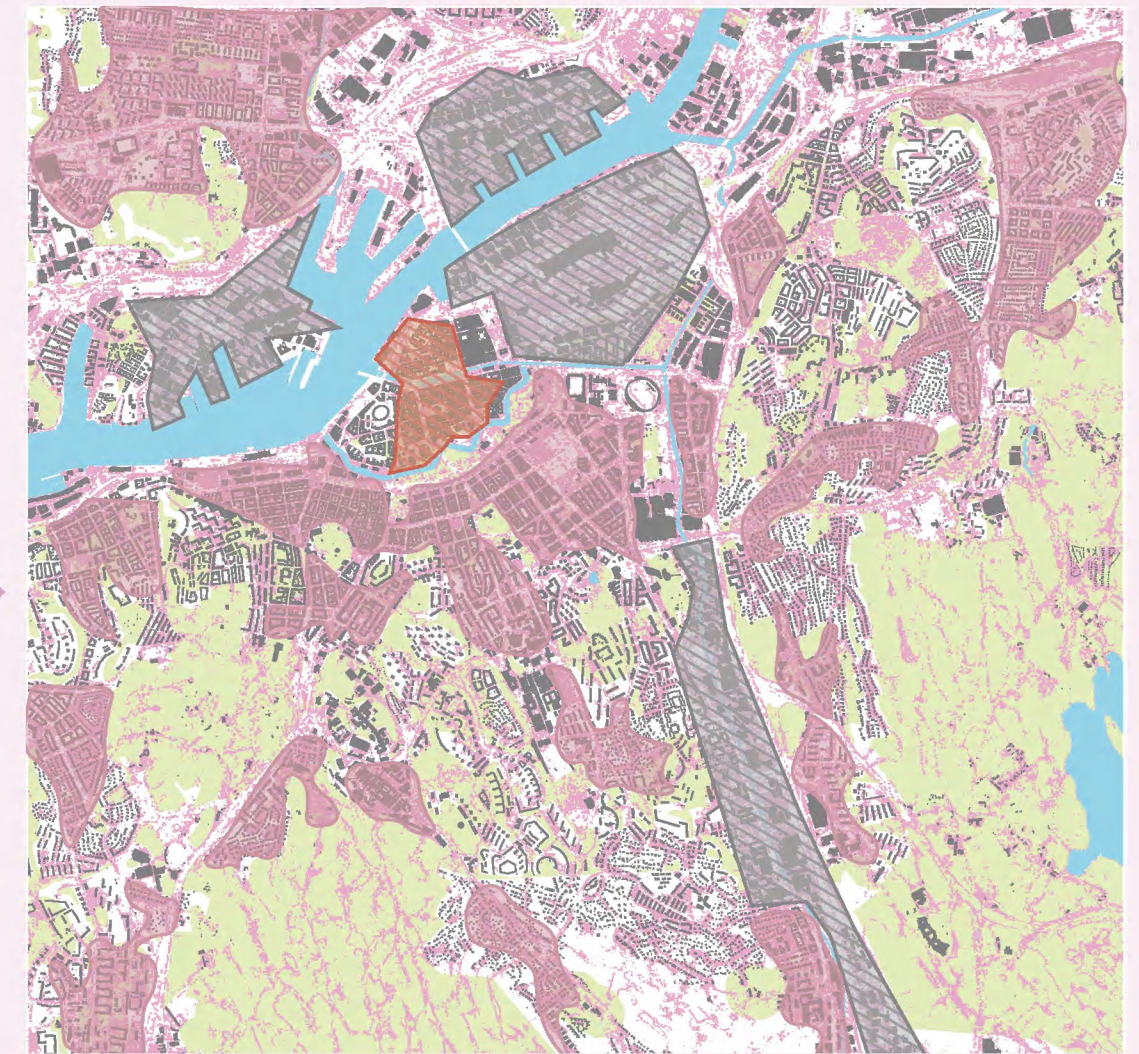
0 .5 1 1.5 2 Kilometers

N



The pink areas in the analysis are the most suitable areas for searching for food, which covered some open fields and residential areas. The yellow-green areas are the appropriate areas to find food, which include the larger green areas in the city as well as the nature reserves on

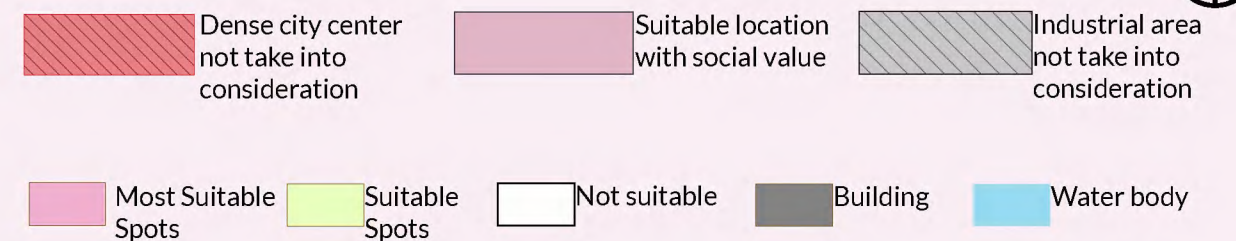
the outskirts of the city. The white areas are industrial sites, which may be polluted and unsuitable for food search and hunting.



Suitable locations of finding food

0 .5 1 1.5 2 Kilometers

N



Here, we have utilised three colours to classify the most appropriate areas. Pink-circled areas are primarily residential and commercial areas with the potential to promote human-animal interaction. The red zones are densely populated urban cores with a high concentration of buildings, commercial avenues, and offices that are

unsuitable for wildlife. The grey-circled areas are industrial sites, railway stations, and docks with large amounts of hard surfaces and the possibility for soil pollution, which are also not taken into consideration.

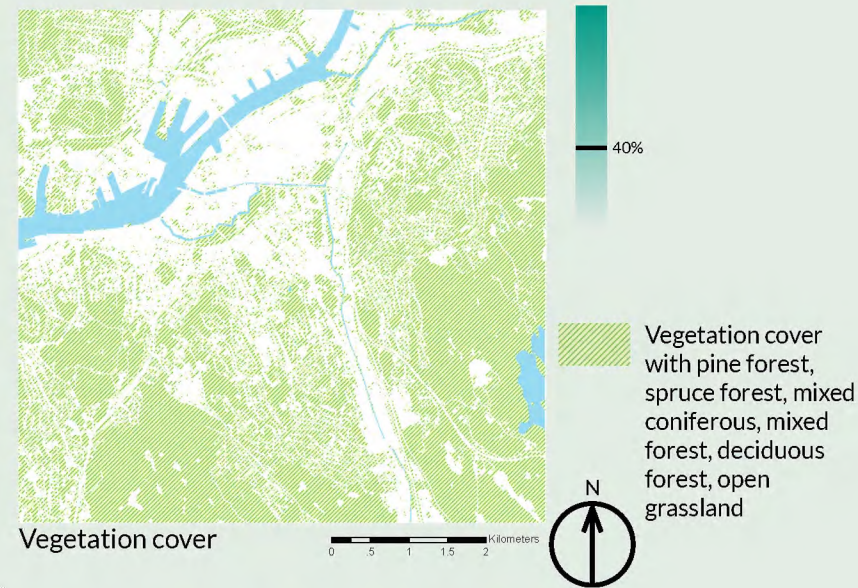
## Site analysis matrix from a red fox perspective - Resting

For the resting spots, red foxes tends to seek out favoured sites within their territory that can provide secure covers, such as high cereal crops or grass, reed beds, bramble, bracken, etc. Vegetation cover is an important influencing factor. (Red Fox Dens/Earths & Resting Sites | Wildlife Online, n.d.)

### Vegetation cover

Pine forest, Spruce forest, Mixed coniferous, Mixed forest, Deciduous forest, open grassland (Weight 40%)

Density of population < 50% for gardens and food rest (Weight 15%)

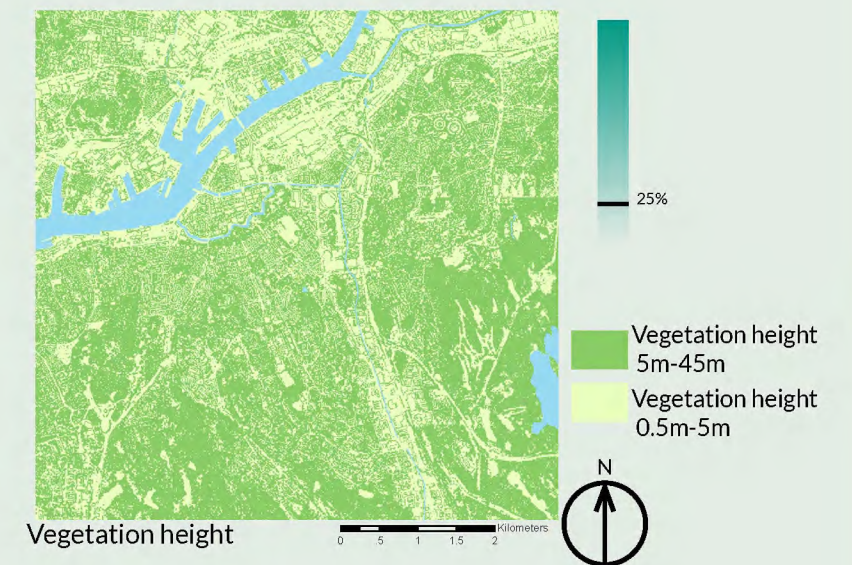
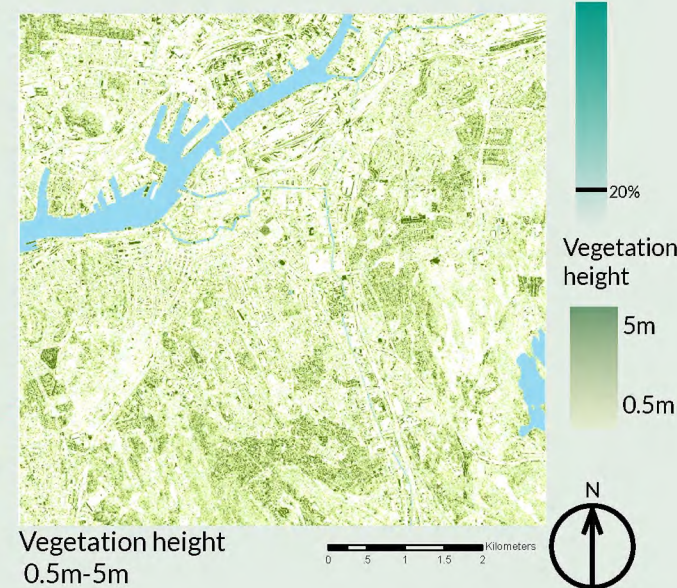


Red foxes are creative at finding resting spots. They are very alert and always on the watch for danger, so they often take up high ground, resting and enjoying the view while preventing danger. In urban areas, places to rest include shed roofs, boulder scree, places with vegetation cover and relative high vegetation height. (Red Fox Dens/Earths & Resting Sites | Wildlife Online, n.d.)

### Height of vegetation cover

Bushes and burries 0.5m-5m (Weight 25%)

Trees 5m-45m (Weight 20%)

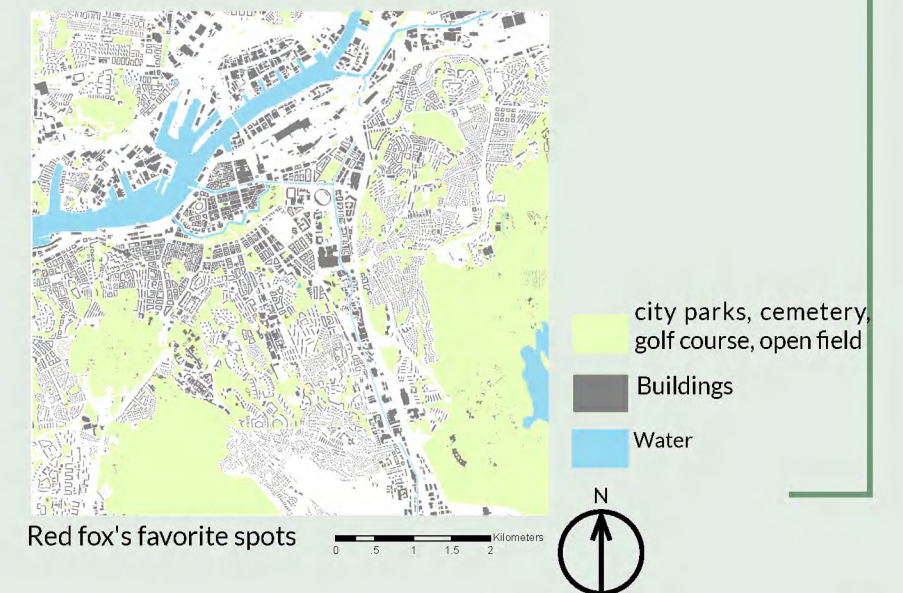
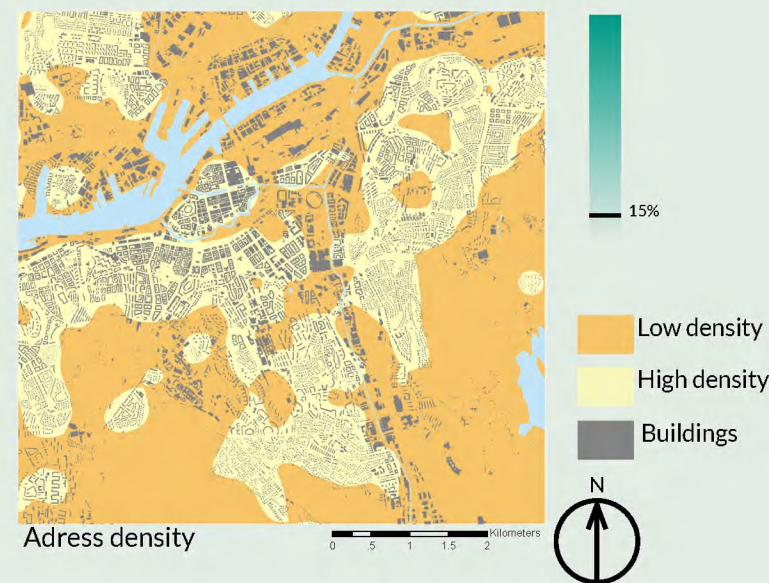


Foxes prefer to rest and sleep in places where there is limited human activity and a low population density, such as open grassland, quiet city parks and cemeteries. (Red Fox Dens/Earths & Resting Sites | Wildlife Online, n.d.)

### Red fox's favourite spots

city parks, cemetery, golf course, open field

Density of population < 50% for gardens and food rest (Weight 15%)



## Result of suitable spots for resting



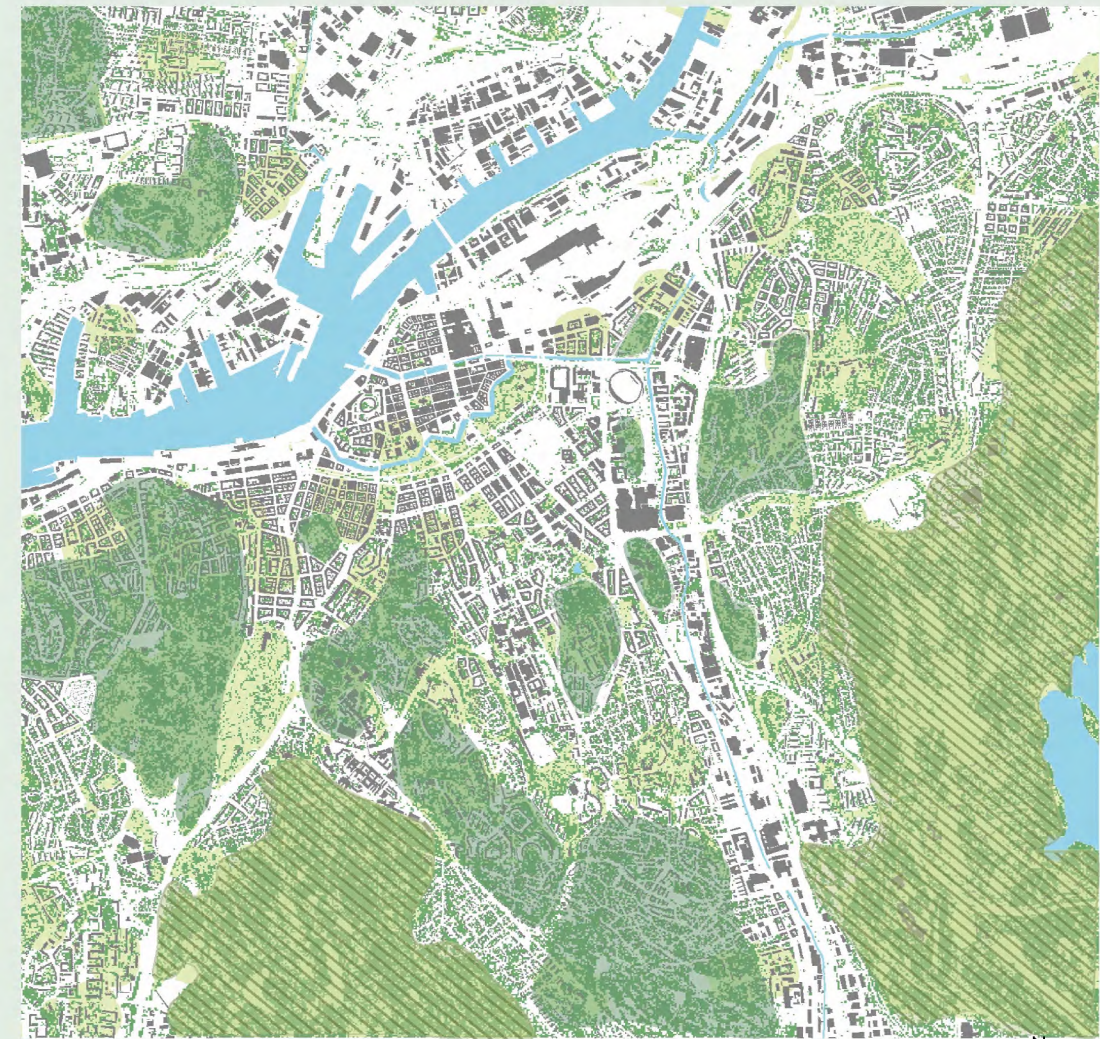
Suitable locations of resting

0 .5 1 1.5 2 Kilometers



Most Suitable Spots
  Suitable Spots
  Not suitable
  Building
  Water body

The dark green dots in the diagram represent the most suitable areas for resting places, and we can see that they are all located in the city on vegetated slopes and woods, while the light green areas are suitable resting areas and are open areas with vegetation covers. The white colour represents unsuitable locations, which are primarily hard terrain and densely built-up areas.



Suitable locations for resting

0 .5 1 1.5 2 Kilometers



Suitable locations for fox to rest (with social value)
  Large scale nature parks for fox to rest
  Most Suitable Spots
  Suitable Spots
  Water body
  Not suitable
  Building

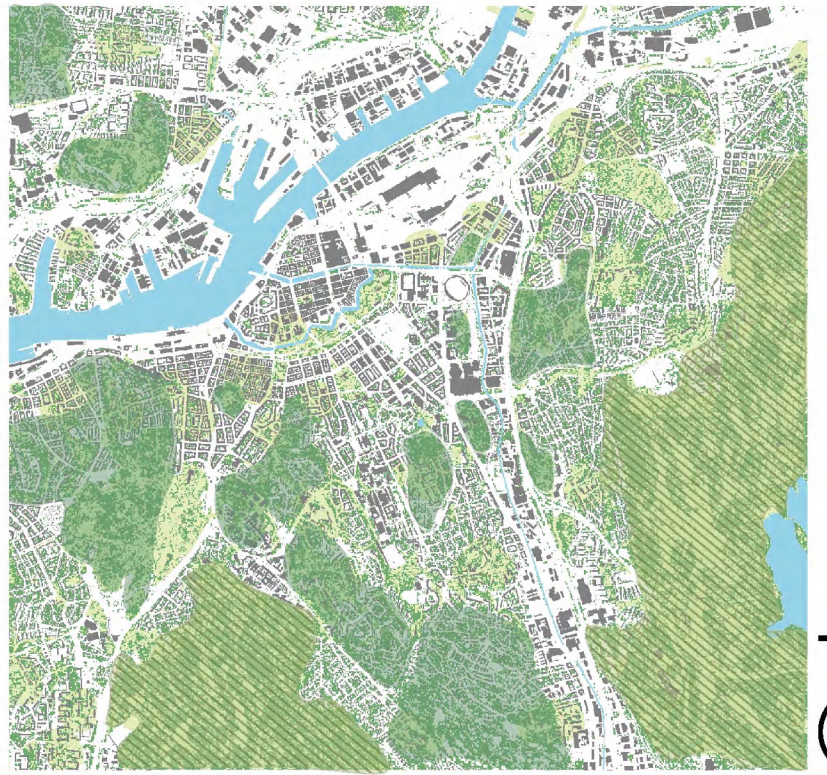
To distinguish the most suitable sites, two sorts of circles are utilized here: dark green circles represent the most suitable areas for red fox resting with public social value, and many urban public green parks are included. Large natural reserves can be found in the light green striped areas. This thesis focuses on urban regions and will not investigate natural areas on the edges of cities.



Suitable locations of earth den

The circled area is a relatively dense area suitable for earth den

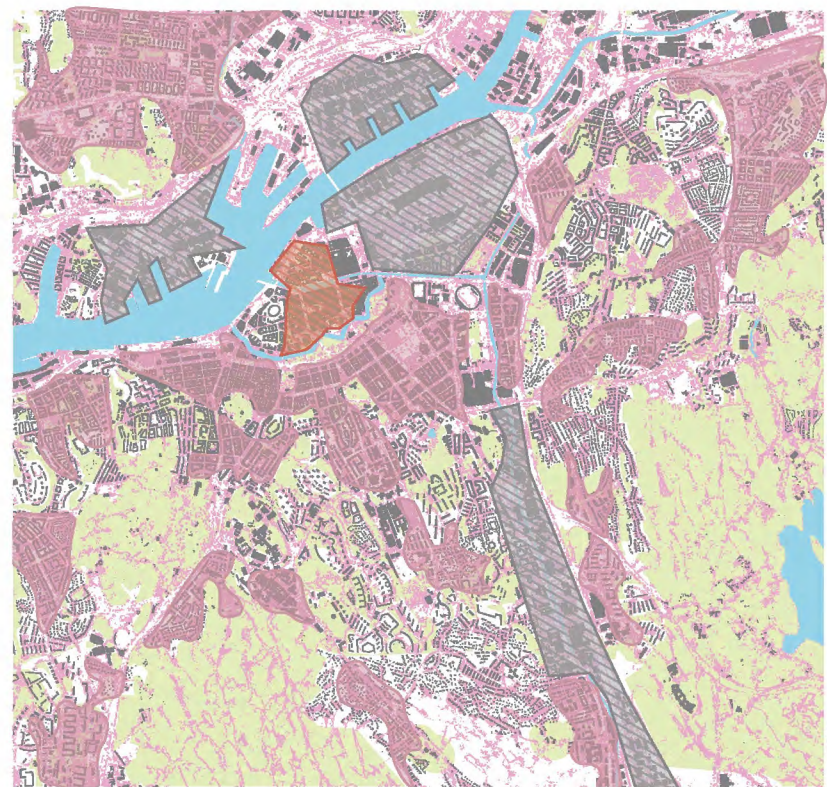
Most Suitable Spots (brown)    Suitable Spots (light green)    Relative suitable spots (grey)  
 Buffer zone form water (light blue)    Water (blue)    Not consider (light grey)    Not suitable (white)



Suitable locations for resting

Suitable locations for fox to rest (with social value) (green)    Large scale nature parks for fox to rest (hatched green)

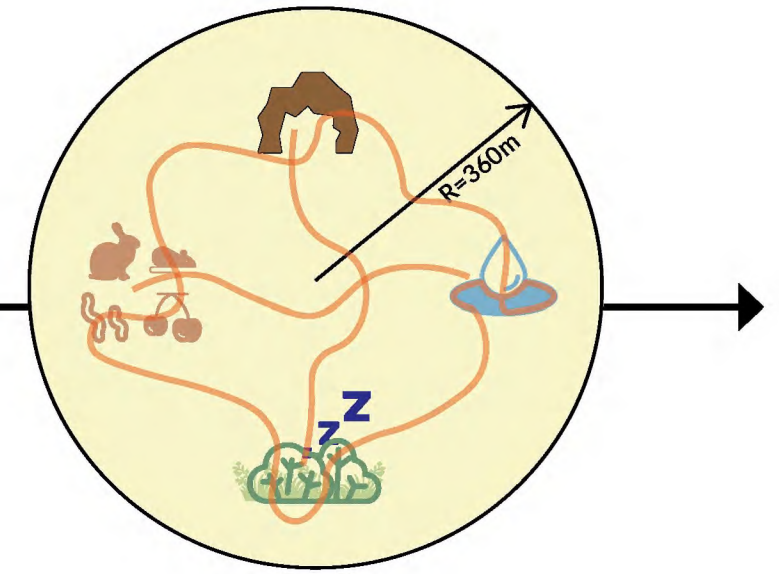
Most Suitable Spots (dark green)    Suitable Spots (light green)    Water body (blue)  
 Not suitable (white)    Building (grey)



Suitable locations of finding food

Dense city center not take into consideration (red hatched)    Suitable location with social value (pink)    Industrial area not take into consideration (grey hatched)

Most Suitable Spots (pink)    Suitable Spots (light green)    Not suitable (white)  
 Building (grey)    Water body (blue)



**Passwsay connects critical spots within territory**

It is crucial to understand that there must be pathways connecting the critical spots of the den, hunting area, and resting location. Each fox family has its own home range in the urban area, which is roughly 40 hectares, thus the critical spots should be included in their territory.



Locations suitable for red fox habitats, met the living conditions



- The circled area is a relatively dense area suitable for earth den
- Suitable locations for fox to rest (with social value)
- Suitable locations for finding food with social value

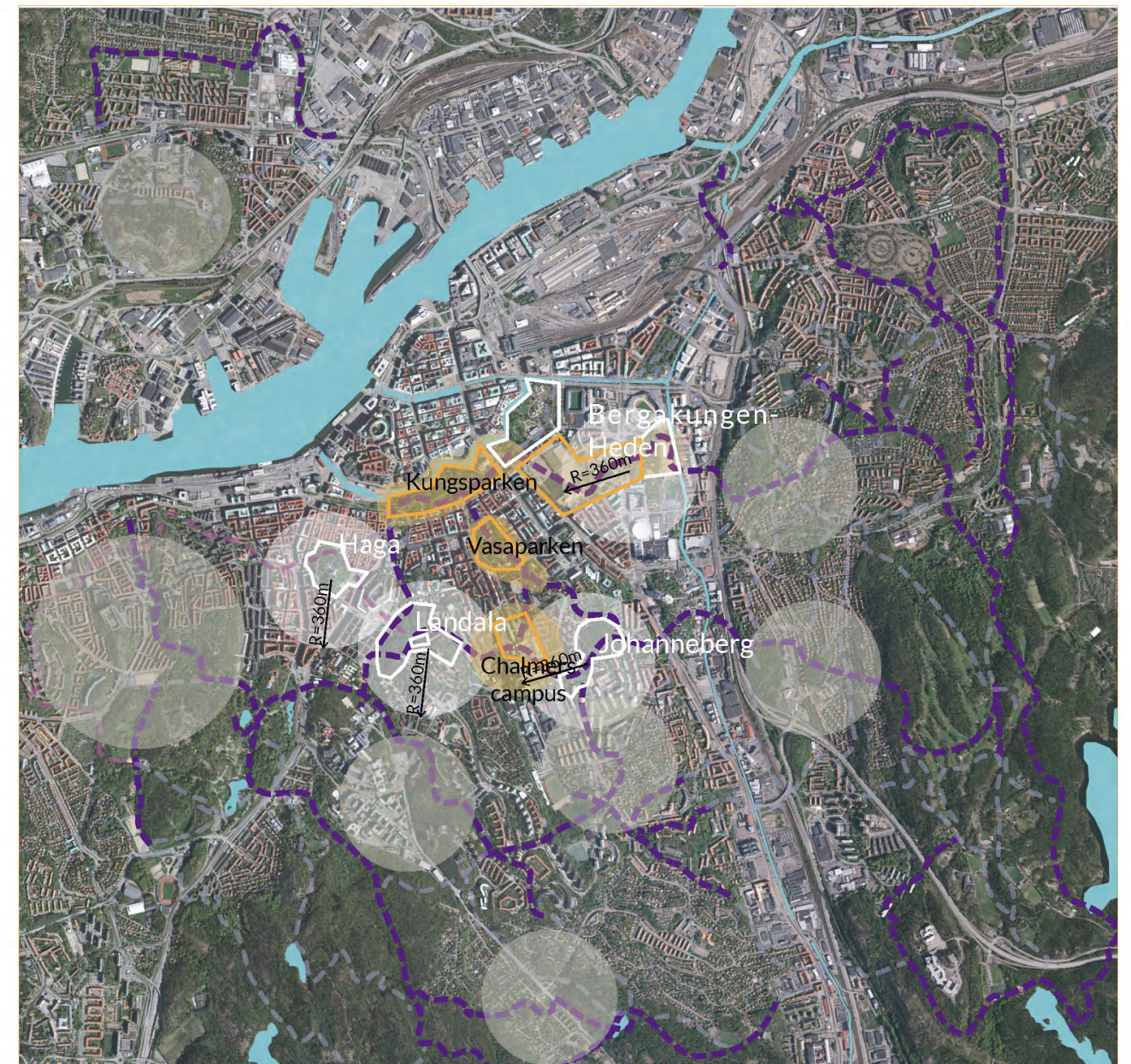
- Large scale nature parks for fox to rest

- White cycle: territory that meet the conditions with social value

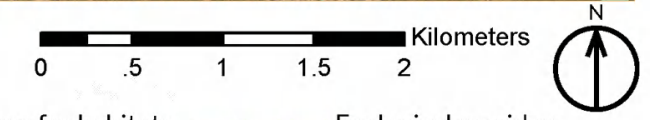
- Grey cycle: territory that meet the conditions, mainly residential areas

Combine the results, place the circled out areas on one map, and determine the most overlapped areas which are the territory cycles. Here are 11 spots in Gothenburg urban areas that meet the conditions, could

become habitats for red foxes, which are Haga, Landala, Johanneberg, Bergakungen-Heden, Guldhed, Slottsskogen-Majorna, Skar, Skår, Lindholmen, Guldhed, and Krokslätt.



Selected design areas for connection and habitats



- Areas for connections
- Areas for habitats
- Ecological corridor

The final step is to choose design sites by comparing the 11 spots' publicity and conditions, as well as combine the results of the green network analysis. Haga, Landala, Johanneberg, and Bergakungen-Heden are urban public green spaces with the potential to be redesigned and transformed for red foxes living in the city, as well as to enhance human-wildlife interaction. While Skar, Skår and Guldhed are all pure residential areas, Slottsskogen is a nature park that is already in good condition. According to the green network analysis, Kungsparken, Vasaparken, and a portion of the Chalmers campus are

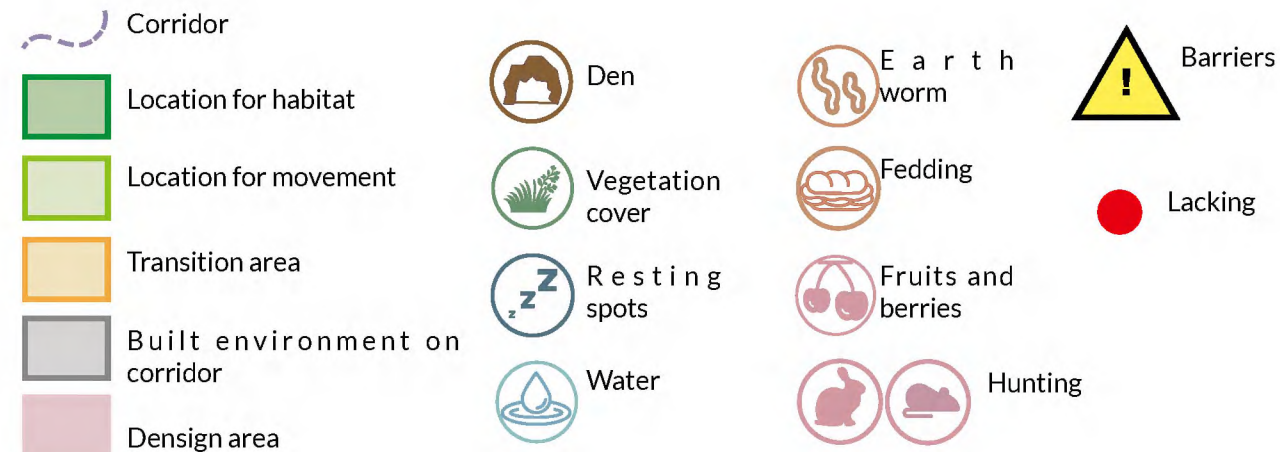
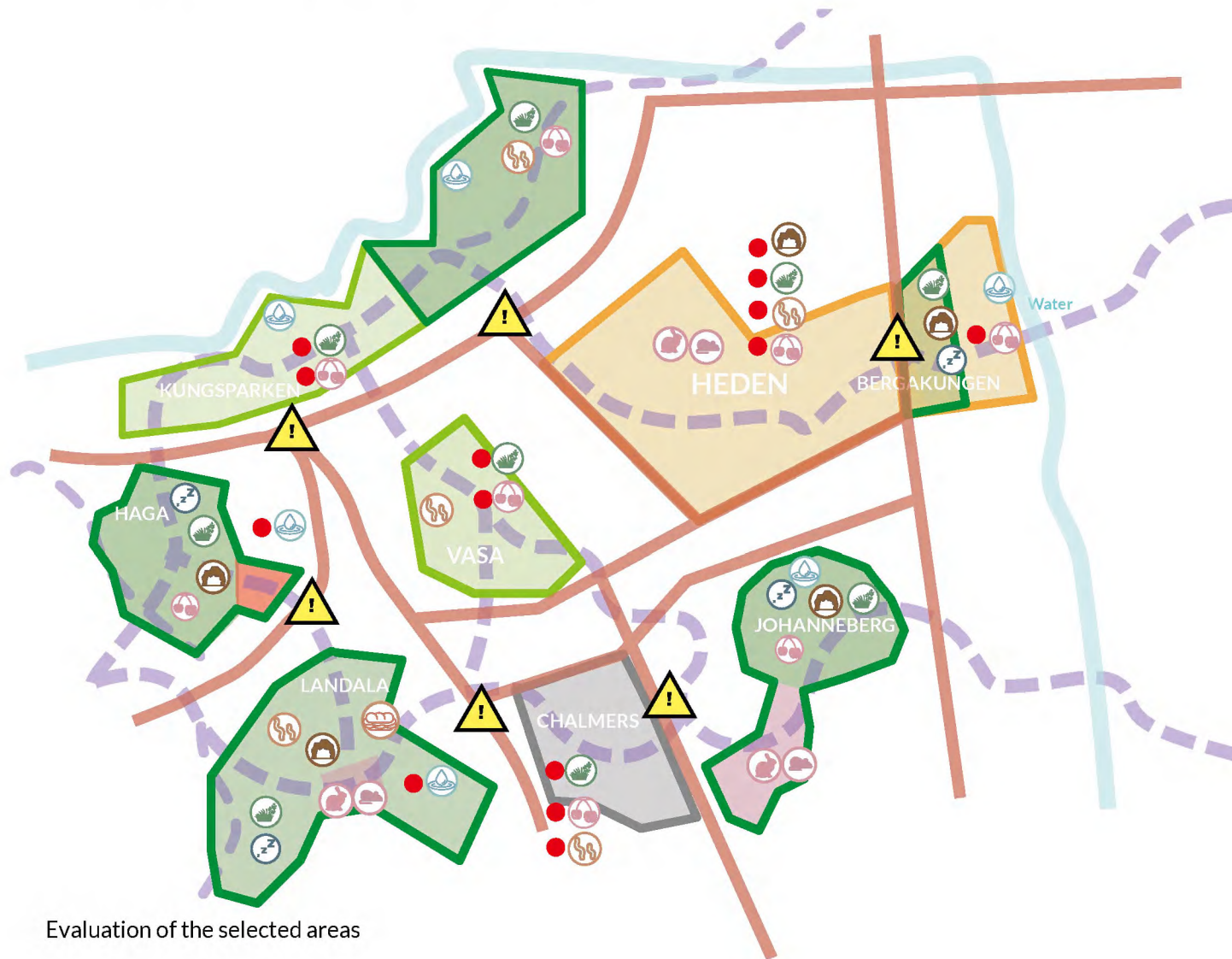
on the ecological corridor in Gothenburg's core region, and they are essential areas for connecting animal living spaces and allowing them to move across the city.

The seven locations: Haga, Landala, Johanneberg, Bergakungen-Heden, Kungsparken, Vasaparken, and the Chalmers campus on Kemivägen formed an ecological network in Gothenburg's central area, a green system where not only humans can enjoy ecosystem services but also vital for urban wildlife to thrive and move around.

## Evaluate the selected areas

The seven locations will be evaluated based on the environmental parameters that affect the red fox's daily activities - denning, hunting, and resting - and will be separated into location, which are the areas mainly

used as habitat, and connection, which are the areas through which the animal moves and migrates.



## Locations

### Haga

Haga's south-east facing slopes and relatively thick soil are ideal for digging dens. The hills have enough vegetation to give protection for resting locations. There is also enough of flora and berries to feed the animals. Although there is no direct water supply, water that gathers on the ground after rain can be used as a temporary source of water.



### Landala

Landala's undulating terrain has many south-west facing slopes with adequate vegetation cover to make it an excellent place for digging dens and resting. There are numerous scattered residences, many of which have tiny gardens on the ground floor, from which wildlife can obtain food. There is also an open meadow with hares and mice on the loose, making it a popular hunting spot. However, because there is no direct water source, the wildlife must rely on precipitation to stay hydrated.



### Johanneberg

Johanneberg is near to an unplanned wild hill with rocky, scree walls that can be used as a den for wildlife, and there is plenty of food to supplement wildlife. Johanneberg is also surrounded by dense residential areas with open green common areas for recreational activities, and it is an ideal spot for red foxes to hunt at night due to the presence of hares and rats. There are watering holes around if they need to rehydrate.



## Connections

### Vasaparken

Vasaparken is a city park with undulating terrain located between the University of Gothenburg and the Vasa Church. It is an important public space for citizens' recreation. The park connects the green spaces of Kungsparken and Johanneberg and serves as an important ecological corridor in the city of Gothenburg's north-south orientation. The park is primarily open green grassland with little shade and a few berry plants that can be used as additional food sources.



### Kungsparken

This is a green stretch along the moat's perimeter that is visited by relatively heavy traffic. It also functions as an east-west ecological corridor in the city, connecting two significant green biological regions, Slottsskogen and Trädgrd Park. It is primarily open green grassland with minimal shelter and is near a stream with plenty of water. It is not a good habitat for red foxes, but it is an important route for them to go across the city.



### Chalmers campus on Kemivägen

The location is on a university campus with small, scattered green areas. It is also situated between two potential habitats, Landala and Johanneberg, and serves as a vital link between them as well as an ecological corridor connecting east and west. However, the area is extensively trafficked, and Aschebergsgatan is located between Landala and Chalmers campus on Kemivägen, which poses a risk for wildlife movement.

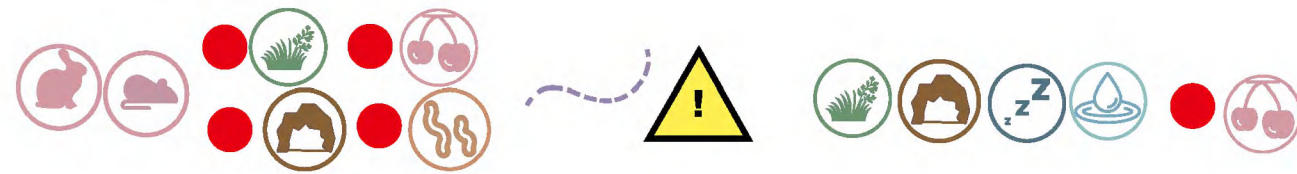


## Connections and Location

### Bergakungen-Heden

Bergakungen is a small hill in the city with a south-east facing slope covered with vegetation where red foxes can make their dens, and it is close to a creek with plenty of water. Heden is an open space in Gothenburg that was once a military training ground but is now filled with many football fields where young football teams often practise for matches.

Heden is largely hard land with minimal vegetation, which does not provide wildlife with cover but can be a suitable hunting ground at night. Bergakungen-Heden is positioned on an east-west ecological corridor and serves as an important wildlife movement route from the city to the huge nature reserve to the east.



## Conclusion of the chapter

This chapter begins with a general analysis of the ecological environment of Gothenburg's inner city using the mspa approach, and then identifies the green areas of the city that can be used as stepping stones for wildlife movement, as well as the ecological corridors, providing an overall understanding of the city's green ecological network. Following that was a mapping of Gothenburg's wildlife and the identification of the keystone animal, which is the red fox. The red fox's life cycle was then studied using the Animal-Aided-Design theory, and three critical aspects that determine its survival were discovered: making an earth den, finding food, and resting. Discovering the territorial cycle for the red fox to survive in conjunction with the environmental factors that influence these three aspects.

Combining with the ecological corridor analysis results, as well as publicity and social value to identify major ecological connection areas.

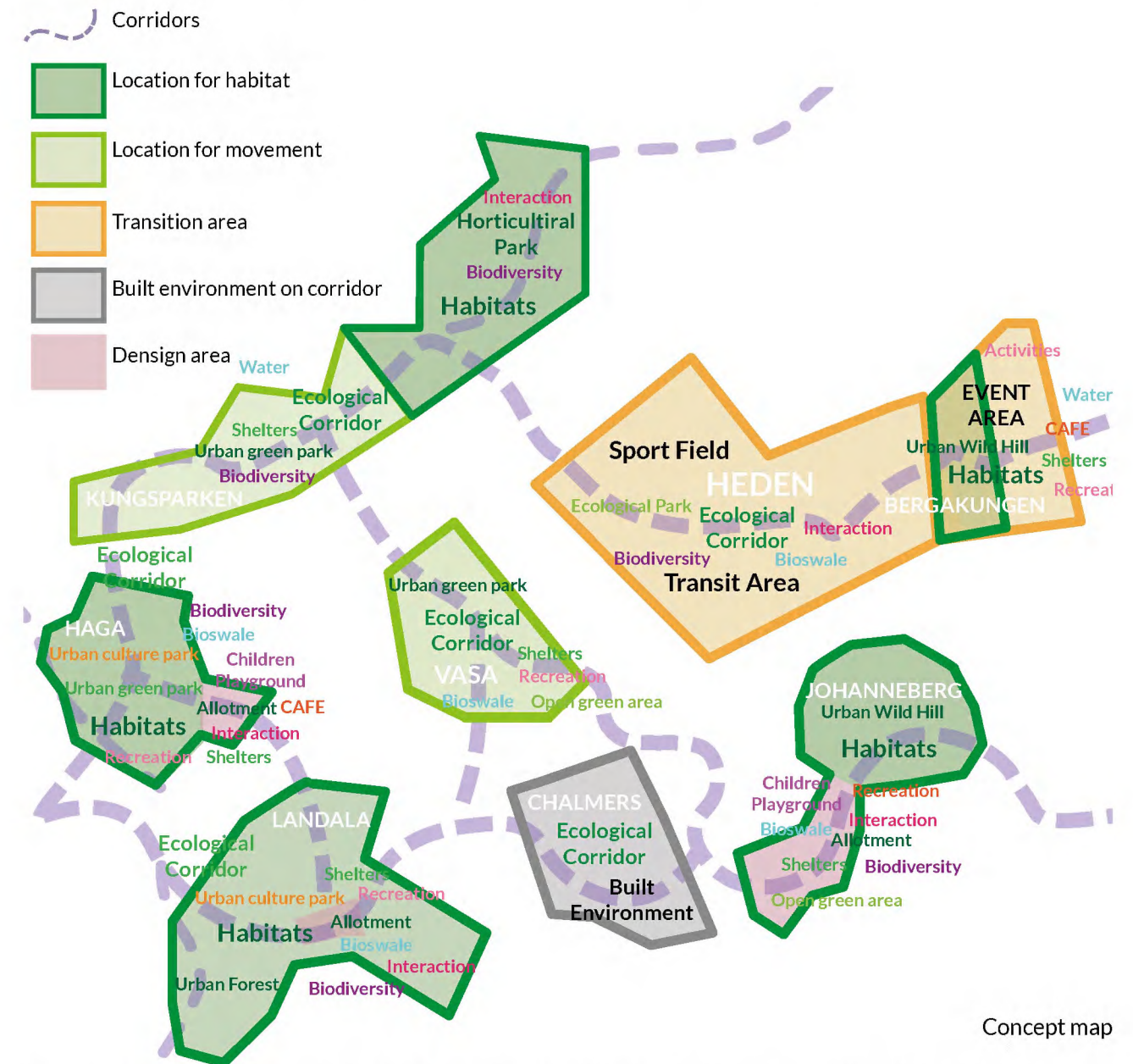
Through theoretically guided analysis and the integration of urban planning thinking into the analysis phase, I believe that the first research question of understanding the green network, and how wildlife lives and moves in the city, has been fully answered. In terms of how to transform and design the space to achieve human-wildlife interaction and coexistence, the following chapter will present a strategic plan, including some suggestions and a framework for improvement.

# Chapter 4:

## Proposal - Urban ecological system

The design proposal is not a complete detailed design, but rather a general proposal and suggestions for each location and connection, on how these green public spaces and green facilities can be transformed to become ecological habitats and aid wildlife movement while enriching the activities of city dwellers and becoming multifunctional, integrated spaces for human-wildlife coexistence.

# Concept map - Functions and activities

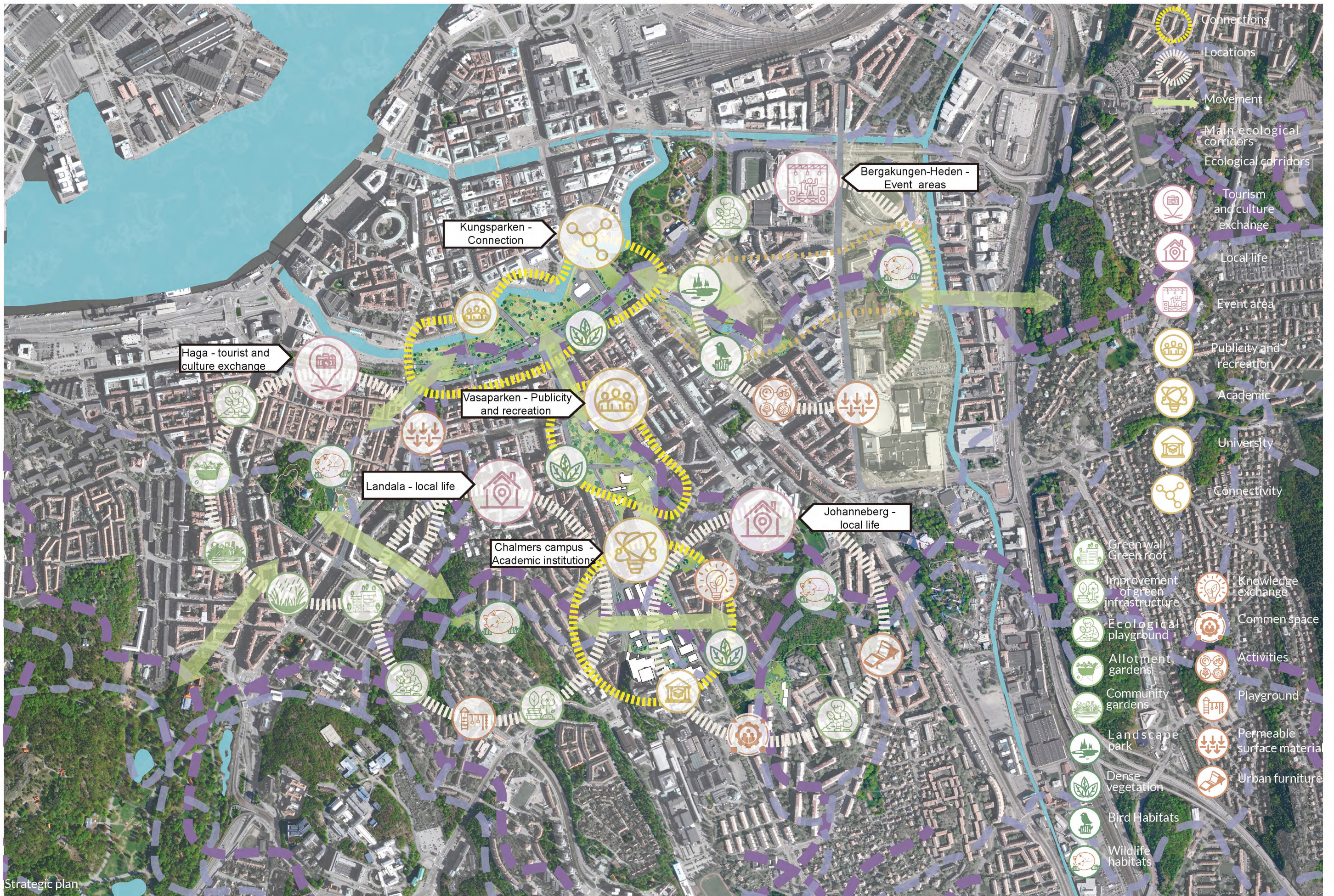


Concept map

The design concept is intended to provide advise and direction for the transformation of the green network system in the core area of Gothenburg. Because of their geographical position, these seven locations perform varied societal functions; one challenge of the design is to integrate diverse human activities with red fox habitats to promote interaction. First, a short overview: Haga is a public park for both locals and tourists but also function as a habitat for wildlife. Landala and Johaneberg are residential areas with urban woodlands nearby. Kungsparken and Vasaparken are public green parks on the ecological corridor, while the

Chalmers campus on Kemivägen is primarily constructed environment. Bergakungen-Heden are transitional event sites that serve as both corridors and habitats.

This will be followed by a strategic plan of the seven sites, as well as a discussion of the specific human activities that can be integrated with each site based on its role in the urban ecosystem - whether it is a habitat for urban wildlife or an ecological corridor - to promote interaction between people, wildlife, and nature, as well as mutual understanding and coexistence between people and wildlife and nature.



## Haga - Tourism and culture exchange



Haga is a historically and culturally significant neighborhood. With its commercial streets, cafes, and restaurants, is a popular tourist destination, attracting a large number of visitors. Our research location is the hill of Haga, a public green park with rocky slopes and dense vegetation cover, as well as the historical site of Skansen Kronen at the summit of the hill, which is a favorite place for locals to walk and rest, as well as a popular destination for tourists. According to our findings, Haga has the potential to become a habitat for urban wildlife since it has a favorable ecological environment and fits all of the requirements for the existence of the urban red fox.

The Skanstorget square, located near the park's entrance, was initially a public plaza in the 1960s, but has become a public car parking lot as the surrounding population has grown and open areas in the city have been reduced. This small square is located on an ecological corridor that connects habitats, but it poses a possible safety threat due to its proximity to a large traffic artery. In terms of the area's social value, which is tourism and recreation, I believe that the Skanstorget square should be transformed into a public ecological park, which could include design elements such as a rainwater garden, which could collect rainwater to provide water for wildlife, regulate the microclimate, cool the area in the summer; also planting native plants to support pollination and restore native biodiversity; allotment gardens can increase social connection for local residents, but can also provide food for wildlife; an ecological playground will provide a place for local inhabitants to socialise and for children to play, as well as promote public education while extending the greenery of the hill and supporting the ecological corridor's connectivity. I recommend changing the hard surface material for crossing the street to a permeable surface material, which can help slow down passing automobiles.

Some wildlife has adapted to city living by moving and foraging primarily at night, we may improve the green infrastructure in this region by planting street trees and shrubs, creating street corners or pocket parks along the road, and installing wall and roof greening to provide wildlife, particularly birds, with a safe spot to rest or hide as they pass by this area.

## Landala and Johanneberg - local life



The locations I have chosen for transformation in Landala and Johanneberg are open meadows surrounded by residential areas and near urban forests. Johanneberg has a playground for children, and due to its proximity to the university, is a popular hangout spot for students. The natural characteristics of the Landala and Johanneberg match the requirements for the red fox's living conditions and provide vital habitats for them in the city.

Elements that can be modified: Johanneberg's children's playground, we may transform the children's playground with natural components such as dead tree trunks and hollow trees, gravel cracks, debris, and bushes, which are red fox's favorite elements for habitat, and could improve the local environment. A playground incorporating these natural features might be educational for children, allowing them to form early relationships with wildlife and nature, and to understand that cities are more than just places for humans to live.

The Chalmers campus in Johanneberg provides several open public spaces, including common grilling areas and numerous seats and loungers for students and lecturers to relax and socialize. Landala has some simple chairs for people to rest on. The open meadow in Landala is primarily used by people for dog walking and sunbathing in the summer. Urban furniture, in my opinion, is also an important component in the remodeling of public spaces. Urban

furniture can also be environmentally friendly and multifunctional. We could design urban furniture that would also benefit urban wildlife.

## Bergakungen-Heden - Event areas



Heden and Bergakungen are event areas with public facilities such as stadiums, playgrounds, and exhibit halls, as well as hosting significant events such as concerts and sports competitions that attract a large crowd. According to the findings of the analysis, an ecological corridor runs through the Bergakungen-Heden area, connecting huge green patches from east to west. Bergakungen has a relatively good ecological setting that fits the requirements for red fox survival and could be converted into habitats. While Heden is now a single functional area for sports with virtually hard surfaces and no vegetation cover.

The Bergakungen-Heden area is under transition. Architectural firms compete actively in the competition to envision a vision for the site. Bergakungen's new project includes the development of a new stadium, a dense residential neighbourhood, and high-class office buildings. We must analyze the original biological conditions and circumstances, as well as be aware of whether or not other species are using the area. Rather than adding greenery and habitats after new construction, we should consider preserving space for wildlife habitats and developing ecological corridors. Keeping in mind that the urban system is a dynamic system, changes in land-use can have a significant impact on the urban ecosystem.

I believe that designing a landscape park along the ecological corridor might be considered in order to facilitate wildlife movement while not distributing the system. The park should be multifunctional, sustaining the local ecosystem and providing a venue for a variety of socio-cultural and

sporting activities, all while reducing the urban heat island effect and regulating the surrounding microclimate. Skånegatan is Gothenburg's main north-south traffic route, running between Heden and Bergakungen, and the road is so wide that heavy traffic may disturb animal movement. Measures such as enhanced greenery, establishing green safety islands in the middle of the road, and modifications in ground material could be explored to slow traffic and prevent conflicts.

## Kungsparken and Vasaparken - Publicity and recreation



Kungsparken and Vasaparken are public green parks that are located on an ecological corridor. The green areas consist primarily of lawns and trees, with a few shrubs that might be used as shelters. Kungsparken and Vasaparken are public gathering spaces that are also wonderful places for people to walk their dogs and relax with their families and friends.

Suggestions for conversion include increasing the abundance of plant communities, including local shrubs, evergreen shrubs, and berry bushes, which can provide food and shelter over the winter. In addition to this, it makes it possible for pollinators to do their work and helps contribute to the restoration of species variety.

## Chalmers campus on Kemivägen - Academic institutions



The Chalmers campus on Kemivägen is largely a built environment, with just a few small patches of green space dispersed about. These green spaces serve as a location for the students and teachers of nearby academic institutions to relax and socialise after lunch. Additionally, it is situated between two possible habitats, namely Landala and Johanneberg, and serves as both

a vital link between these two habitats and an ecological corridor that connects them in an east-west direction.

When establishing their territory boundaries, red foxes frequently make use of linear characteristics in the landscape such as hedgerows, treelines, and roadways. The same thing happens in urban environments, with streets and walls serving as the boundary markers for home ranges instead of natural barriers. Because red foxes prefer to go along linear constructions such as walls and fences, we could plant bushes along the wall to provide cover and space for them to wander about. To prevent wild animals from entering the building's basement, add swaths of vegetation that can act as pathways for them as they move through the area and make their way to the habitat.

animals, and growing plants that help assist wildlife movement to prevent wildlife from straying into dead ends of buildings or basements.

More biological knowledge, such as the study of native plants and more extensive researches of wildlife behaviour, is also required to design in-depth and in a way that benefits and coexists with human and non-human inhabitants of the city. Wildlife is fragile in cities, and any new planning or changes to the environment of the site will have an impact on their activities. To achieve long-term development and a sustainable urban environment, we must plan and build with respect for nature and life.

## Conclusion

Because of their distinct geographical, historical, and cultural backgrounds, each of these locations plays a unique part in today's society of Gothenburg. I have simply provided some basic suggestions for development rather than an in-depth design. These suggestions are based on the themes of each site, the findings of the previous studies and analysis, as well as my personal observations of people's activities while using the sites.

For example, Haga's Skanstorget square is located in an ecological corridor and is crucial for the movement of urban wildlife, so I recommend that it be converted into an ecological park so that the wildlife in Haga is not segregated from the ecological network, but rather integrated into it. It also acts as a recreational space for the surrounding neighbourhood. I advise increasing the planting of berries, increasing the variety and density of native plants, such as evergreens, to provide winter shelter for birds and

# Chapter 5:

## Reflection and discussion

The final chapter reflects on the thesis and offers suggestions for the future. Reflections focus particularly on the thesis' research questions, aim, and purpose, as well as providing suggestions for possible future urban development. There are additional references to books, papers, and photographic sources, as well as an appendix with sketches for each location.

## Reflection

The main outcome of this thesis is not the final design work. Equally important are the research of background knowledge, the learning of theory, and the application of theory to guide the analysis. The primary focus of the thesis is the process of exploring the problem, the application of theory to mapping and analysis, and the implementation of design thinking to the research.

Making space for mutualism - for human-wildlife coexistence in the urban context, is an ambitious topic that encompasses multiple disciplines. I have deconstructed the topic into four main subjects for further research: the city, ecosystem, humans, and wildlife, and located the relevant theoretical studies to understand their relationship. Through studying Social Ecological Urbanism, Landscape Ecology, and Animal-Aided Design, I developed a progressive understanding of the relationship between these four subjects, and these theories led to the subsequent mapping and analysis. The final design proposal consists of only a few ideas for improvement and does not dive further into the detailed design.

### Referring to research questions

I proposed two specific research questions in relation to the theme of making space for mutualism. The first research question is: What is the relationship between the city, the ecosystem, humans, and wildlife, and how can we better understand the urban green network and include wildlife into city planning? This research question addresses, among the four primary subjects, the relationship between cities and ecosystems and between wildlife and cities. Through theoretically guided study, the paper illustrates how this question was approached. In the second chapter of the thesis, the theoretical chapter, we introduced the components of the urban green network, such as patches, corridors, edges, boundaries,

and mosaic, using the theory of Landscape Ecology. We also introduced the analysis tool MSPA, which is used to identify the city's most critical ecological areas and eventually construct an ecological corridor through the city. For incorporating the wildlife aspect into the city planning process, we studied the theory of Animal Aided Design. Following the theoretical guidance, we chose the red fox as the keystone animal, analysed the central area of Gothenburg according to its habits and living conditions, and then identified several territory cycles suitable for their survival.

In response to the second research question: to achieve the social-ecological goal, how could we redesign and transform spatial elements of urban green public spaces so that the city becomes a wildlife refuge and promotes human-wildlife coexistence? I studied the theory of Social Ecological Urbanism which is not only the aim, but also the basis of this thesis; by drawing an analogy between urban systems and ecosystems, I discover that the urban system and the ecosystem do not exist in opposition to one another in the city, but rather, they affect one another. The Case study of Albano Resilient Campus demonstrated how the main objectives of ecosystem services (Pollination, water services, and seed dispersal) and the main objectives of the social system (Knowledge exchange, publicity, recreation, place-based learning, adaptability) would integrate and function together. Design guidelines for green infrastructure provide the framework, which involves connectivity, multifunctionality, integration, communicative and socially-inclusive planning and management, strategic and long-term oriented approach, supporting and protecting the natural system from the disruption of urban development, while maintaining a balance with the economic and social needs of society.

I investigated how to develop urban green spaces that may be integrated into the urban fabric to produce positive impacts and achieve a mutually beneficial symbiosis for human activities and the ecosystem through the above theories, guidelines, and case studies. I obtained territorial cycles suited for red fox survival in the city and the essential routes for their movement by solving the first study question. Because of their geographical location, these sites play different social roles; I extract the themes of each site and propose appropriate spatial elements in relation to local users and public activities that are appropriate for these sites, to meet both the needs of wildlife on the site and to satisfy the purpose of coexistence rather than conflict.

For the second research question, this paper does not provide a full design or comprehensive solution, but rather gives recommendations based on my personal experience. I believe that the discussion in this thesis is still insufficient, and that in order to design the space for human-wildlife coexistence with greater care, we need to observe and study wildlife behaviour and human-wildlife interactions in greater depth, such as by determining which animals are sensitive to the light and sound produced by human activities.

### **Referring to aim and purpose**

Referring back to my purpose, which is to increase and promote interaction and connection between humans and wildlife, as well as to build mutual trust through the common ground for both human activities and wildlife in the city, it was deconstructed into several specific goals, which are to understand the green mosaic in the urban area, to identify ecological corridors, and to provide suggestions and guidelines for the transformation of urban green space. I believe the theoretical study and analysis, as well as the recommendations in the proposal chapter, have achieved the goal. Although there is no specific design or visualisation of human-animal coexistence at the end of the thesis, this is not its primary focus.

Another part of the purpose is to provoke and arouse thinking and reflection about the relationship between humans and species beyond humans, and nature in the city. The necessity for mutualism space is discussed in the first chapter through a background introduction that covers from phenomena to knowledge of urban ecology, as well as historical, philosophical, and typological perspectives for reflections on the relationship between humans and nature and other animals. We discovered that humans do not exist in urban ecology in isolation, that other animals have a role in our development and evolution, and that we are in a mutually beneficial symbiotic relationship.

Humans, on the other hand, have been destroying animal habitats to build modern cities. People living in cities are isolated from nature, and as cities grow, urban ecosystems become fragmented, resulting in the extinction of native organisms, the destruction of local ecology's stability, and, eventually, the ecological crisis. Urban planners should support the restoration of urban ecosystems and habitats for native species, as well as the creation of spaces for the coexistence of humans and wildlife, which will not only significantly improve the living environment of city dwellers, but will also arouse reflections about the relationship between humans and species other than humans in the city, promote public education implications, and for a more sustainable future.

### **Reflection on the thesis's journey**

Throughout the journey of my thesis, I made some compromises, such as removing the native plant library and keeping only the animal mapping. After the midterm, I lost control of the direction of the thesis and spent some time sketching the design of each site, which I have now put in the appendix. This caused me to neglect the summary of the article's theoretical and analytical sections, which are essential components of the thesis.

As I have tried to design spaces for human-wildlife interaction in depth, I believe there is a need for theoretical guidance on human-wildlife interaction as well as more systematic observation of wildlife behavior, such as their responses to different human activities. We must be more cautious in our planning and conduct thorough scientific analysis and research since wildlife in cities is sensitive and unpredictable, and some people are worried about contagious diseases spread by animals, such as rabies.

## **In the future**

### **Advice for planners**

#### **-Strengthening interdisciplinary cooperation**

Planning and designing for urban wildlife and positive human-wildlife interactions is a broad cross-disciplinary subject that demands collaboration among biologists, ecologists, landscape architects, and land-use planners. Throughout the working process, I confronted numerous challenges, such as comprehending multidisciplinary knowledge and understanding complicated inter-species relationships, the difficulty of designing for wildlife while also integrating human activities and having a good influence on society and ecosystems. As a result, I recommend that in the early phases of the planning process, an interdisciplinary team of biologists, ecologists, landscape architects, city planners, and geoinformaticians be formed to work on sustainable urban development.

#### **-Incorporate a wildlife perspective into the planning process**

In the early stages of new planning, it is crucial to determine whether there is local wildlife activity, whether the proposed area is in an ecological corridor where wildlife moves, and whether the new location would impact wildlife migration. New planning projects should respect the local ecological

environment and encourage harmonious cohabitation between human inhabitants and local non-human species through design, as well as serve public education.

### **Further development of the thesis**

The design proposal just provides suggestions for improvement based on personal observation and experience; no in-depth design is performed. There are no visual representations that demonstrate humans and animals coexisting. If the thesis could be explored further, I believe a site may be chosen for a more detailed design. To understand how wildlife reacts to human activity, we need to track and observe wildlife moving about this place. A questionnaire survey of local people and relevant user groups will also be conducted to better understand the general public's attitudes and suggestions. The design must also be guided by theories concerning human-wildlife interaction, as well as analysis and reference of relevant case studies.

## For the current situation

This year, climate change has caused extreme weather around the world in recent years, with high temperatures in cities, heat-related mortality, and forest fires. Ecological corridors are not only vital migration routes for wildlife, but they also provide ventilation for cities by allowing cooler air from the suburbs to enter the city through the ecological corridors and cool the city, potentially reducing the urban heat island effect.



Image 91: Small shelter made of branches in a children's playground

Urbanisation has brought many environmental problems, but it has also brought all species together, opening up many new research fields for scientists to explore. Gothenburg's urban environment is already good and various species have been spotted there; it can serve as a role model for other cities aiming to achieve a social-ecological outcome.



Image 92: Bee Hotel in Chalmers campus on Kemivägen

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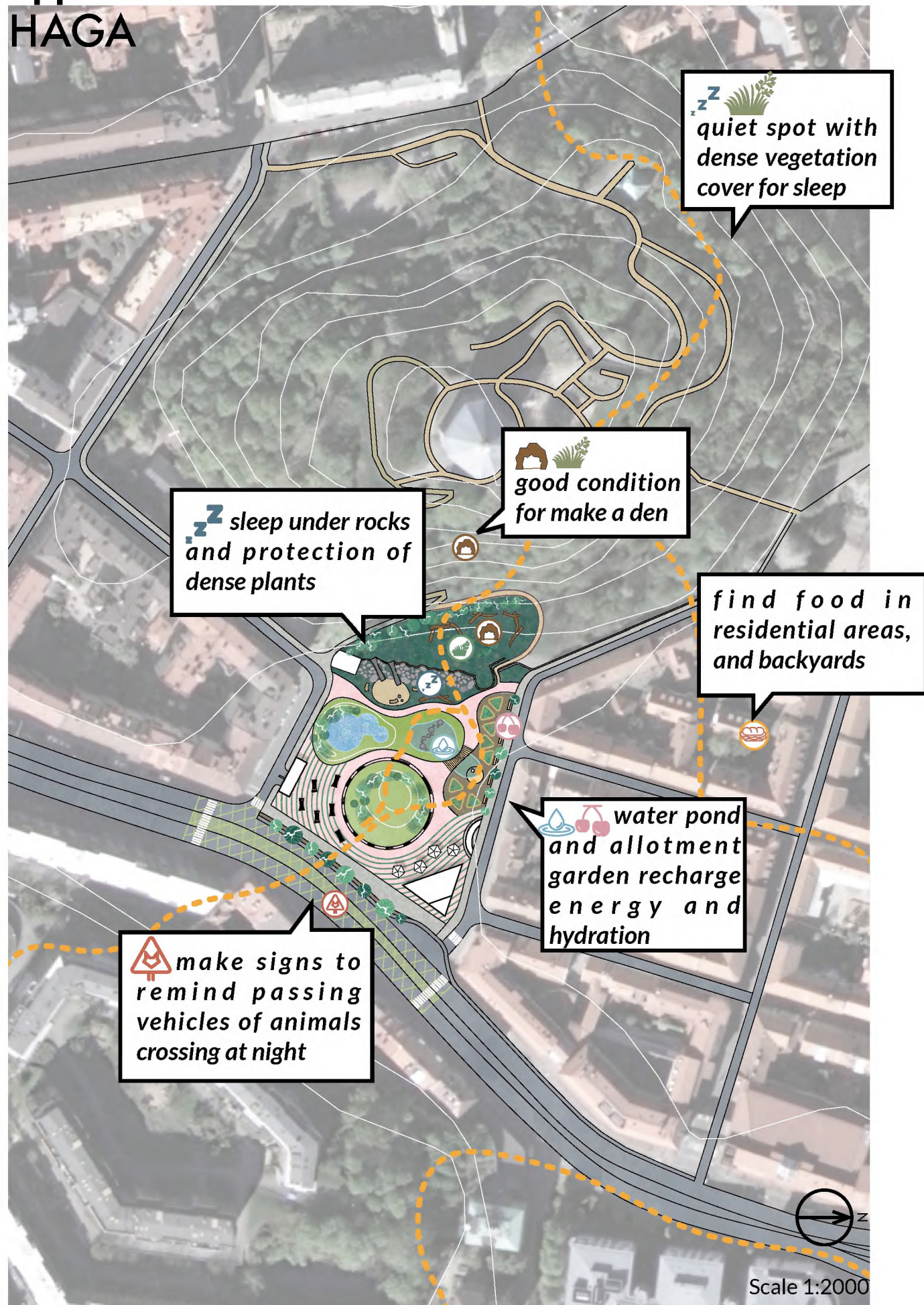
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Image 90: Author's own diagram.

Image 91-92: Author's own photos.

# Appendix HAGA



## Scenarios for possible positive human-wildlife interaction

For Hage, the parking lot is transformed into a public park with water pond, allotment garden, ecological playground and cafe, in order to extend the greenery from the hill and support the connectivity of the ecological

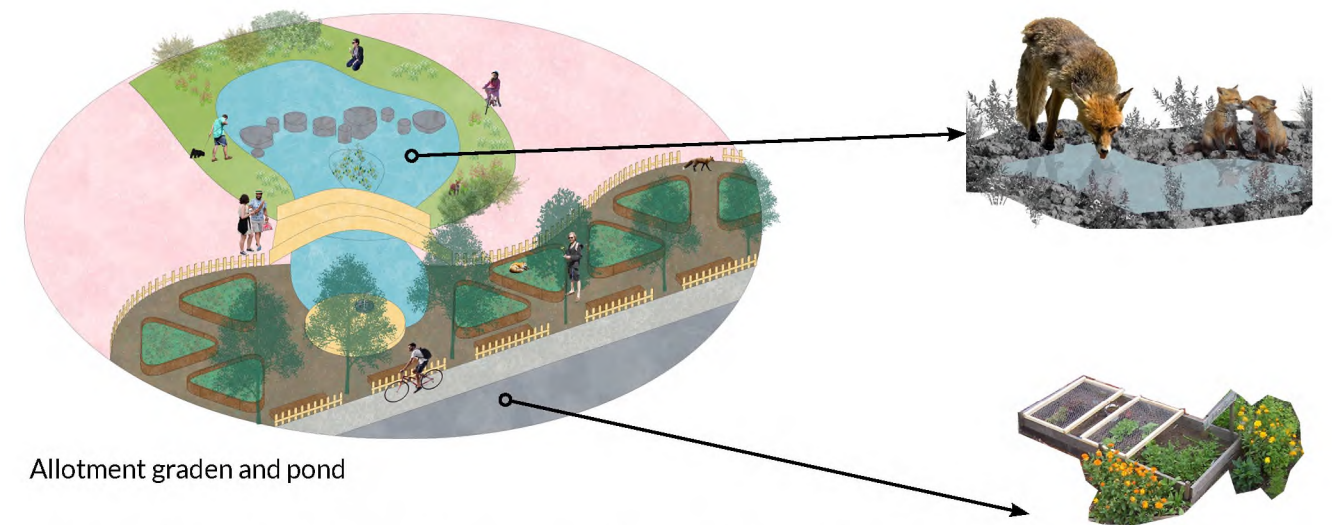
corridor. For crossing the street, I suggest to make signs to remind passing vehicles of animals crossing at night, or change the surface material to slow down the speed of passing vehicles.



Ecological playground for children

Dead tree trunk and hole tree, gravel crack, rubble, bushes are red fox's favourite element for habitat, could also benefit for local ecosystem. A playground with these natural elements could be educational for

children, help the kids build a relationship with wildlife and nature from an early age, knowing that cities are not just places for humans to live.

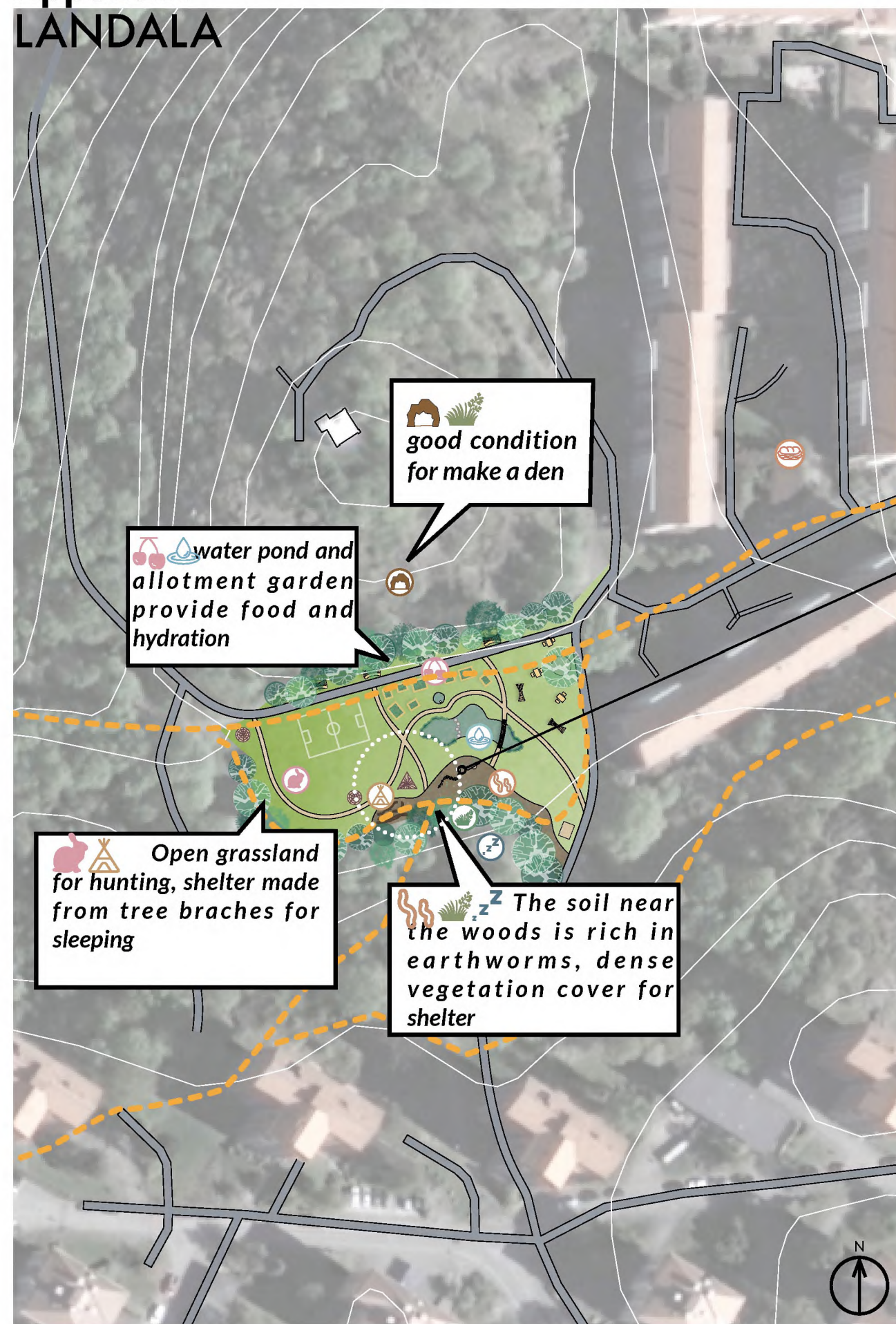


Allotment garden and pond

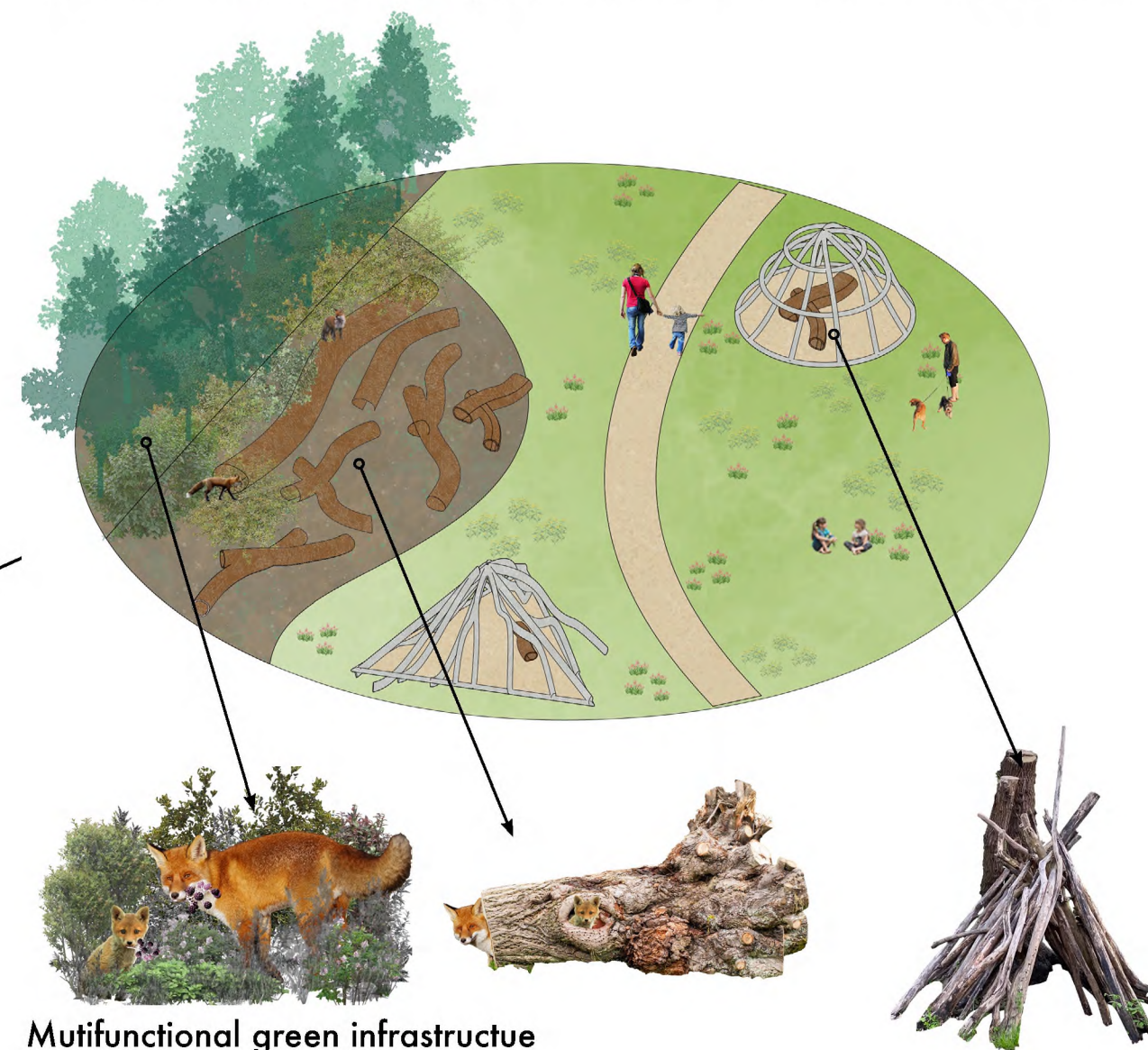
Allotment gardens could increase social connection for local residents, but can also provide food for wildlife. A rain garden

with aquatic plants, which regulates the microclimate, cools the area in the summer and provides water for wildlife.

# Appendix LANDALA



## Scenarios for possible positive human-wildlife interaction



### Mutifunctional green infrastructue

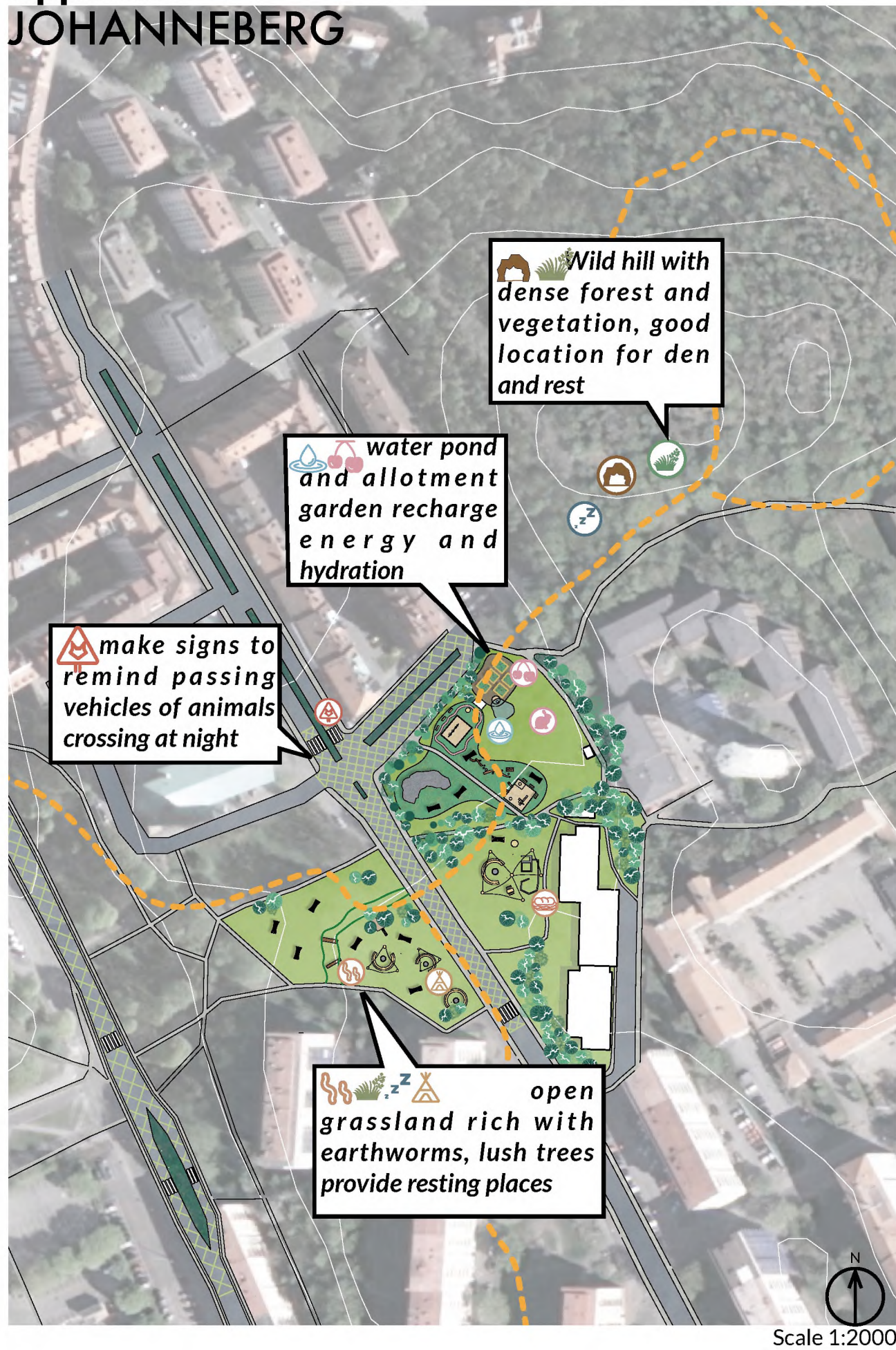
For Landala and Johanneburg, these two locations are open meadows surrounded by residential areas and close to urban forests. We can transform the children's playground with natural elements that could benefit red fox's habitats, like hole trees and small pavillions with tree branches, providing shelter for wildlife in terrible wether conditions. If people, especially children, could observe wildlife while playing or relaxing here, it can build a sense of intimacy with nature and provoke reflection.

The open meadow in Landala is not much used by the residents except for dog walking or sunbathing in the summer. I suggest to

transform the area into mutifunctional green infrastructue, where people can relax or do sports, kids can play, wildlife and find shelter and food.

Pavillions made by tree branches, for kids to play, but also can provide shelter for wildlife in bad wether conditions.

# Appendix JOHANNEBERG

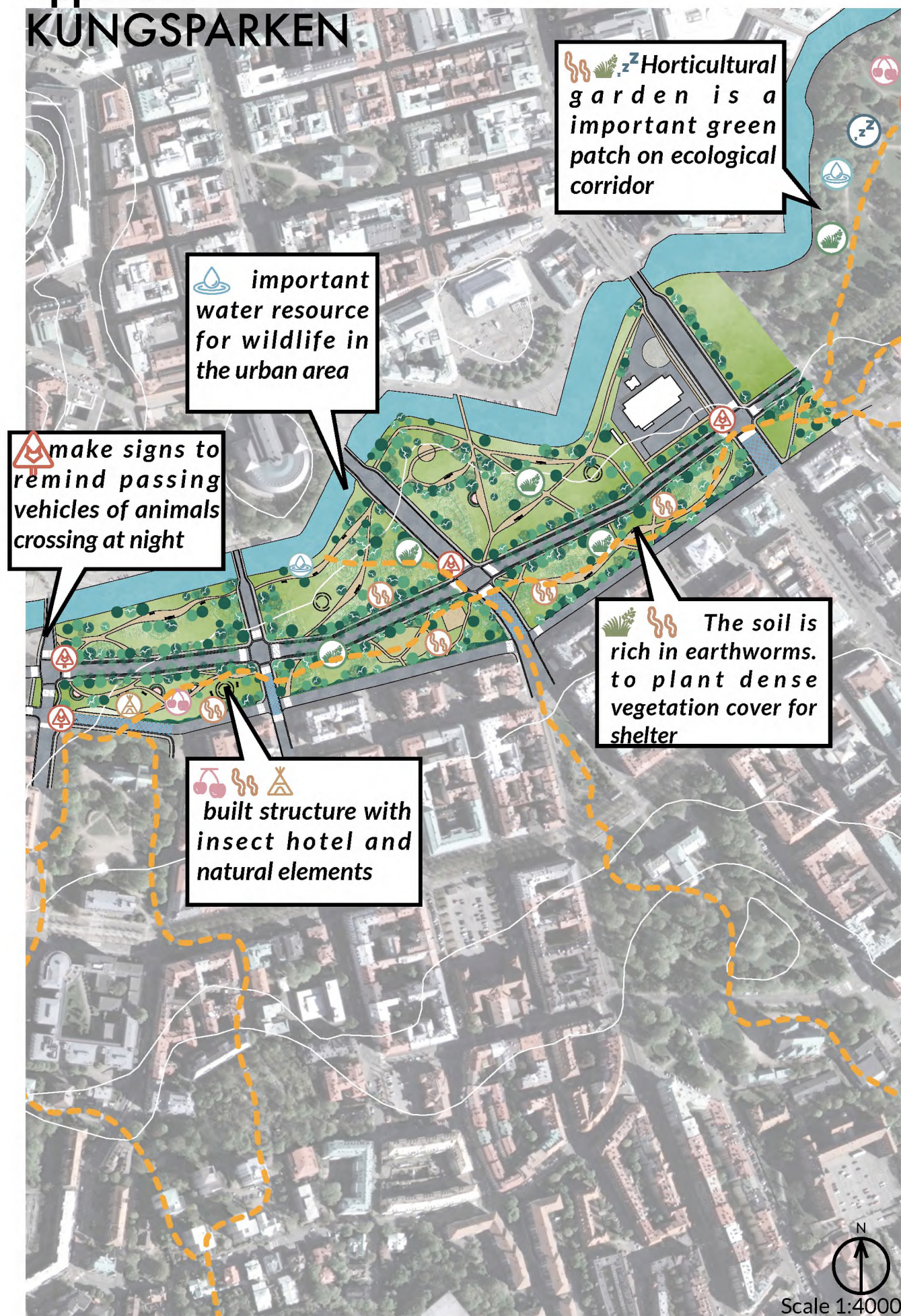


## Scenarios for possible positive human-wildlife interaction

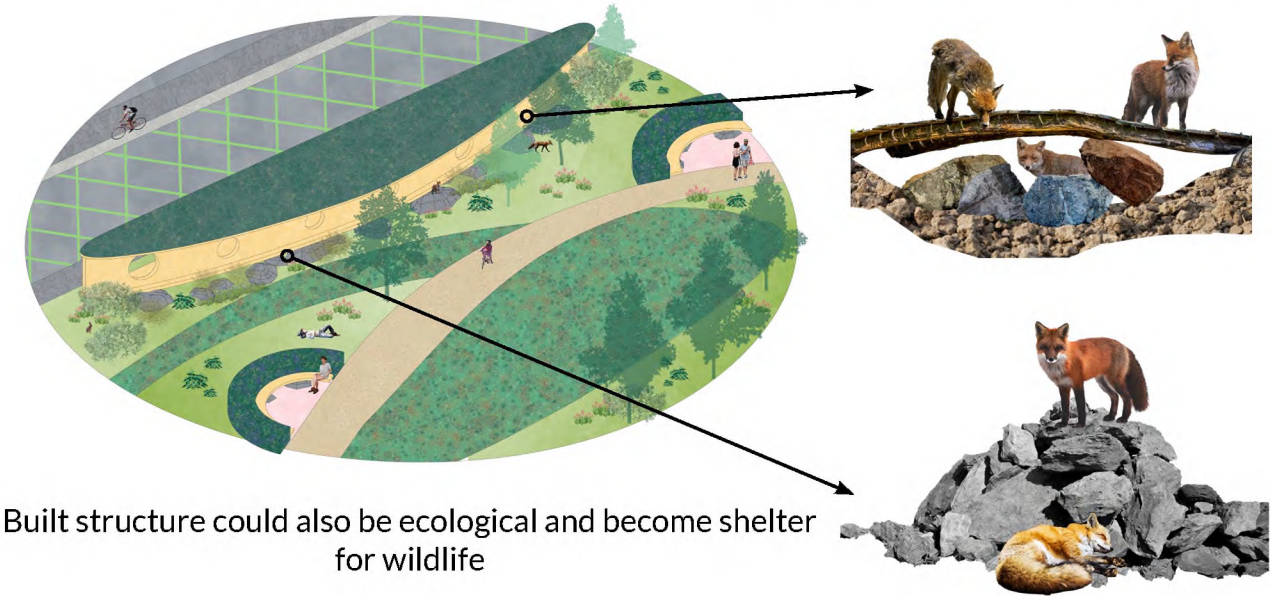


Urban furnitures could also be ecological and multifunctional. Red foxes like to hide under built structure, like wooden roadway and wooden basement. We could build urban furnitures which can also be used by urban wildlife.

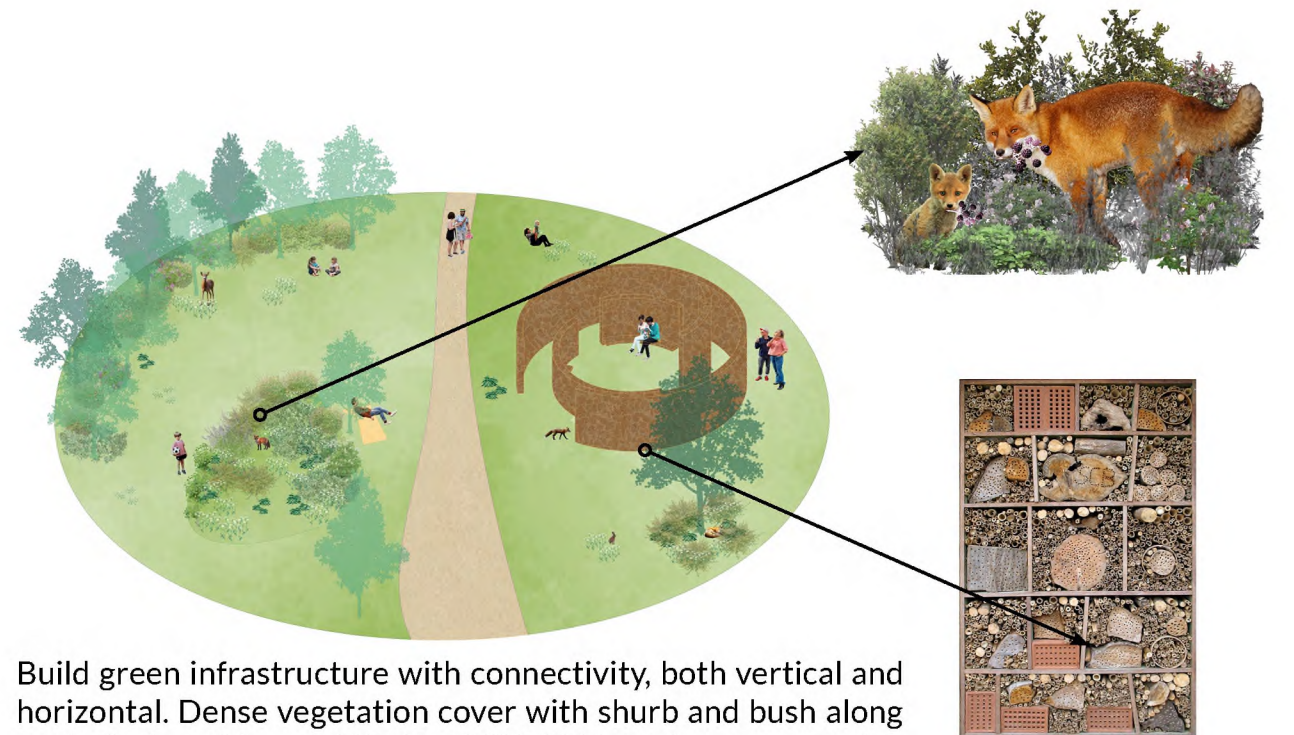
# Appendix KUNGSPARKEN



## Scenarios for possible positive human-wildlife interaction



Built structure could also be ecological and become shelter for wildlife

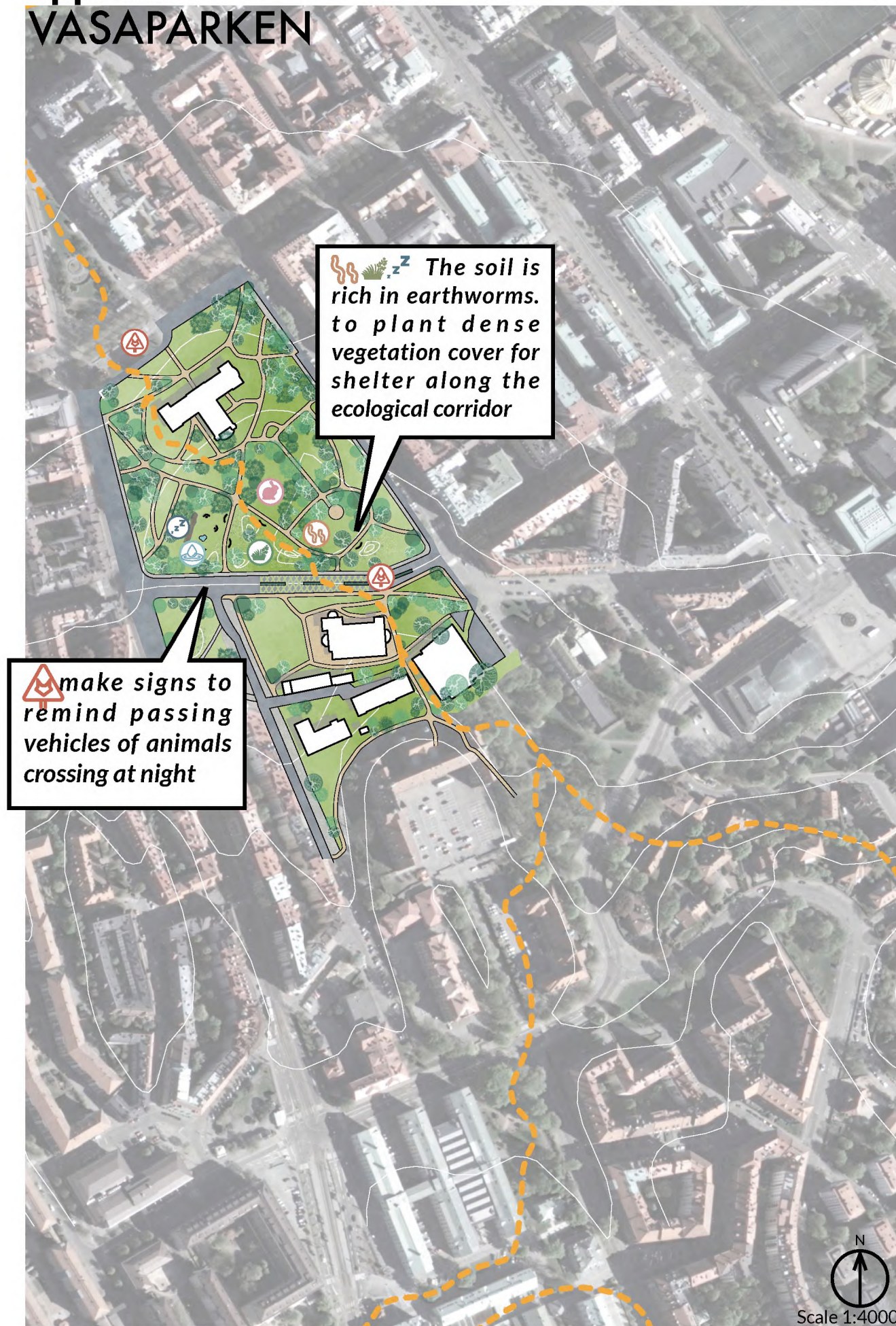


Build green infrastructure with connectivity, both vertical and horizontal. Dense vegetation cover with shrub and bush along ecological corridor could help wildlife hidde and move around.

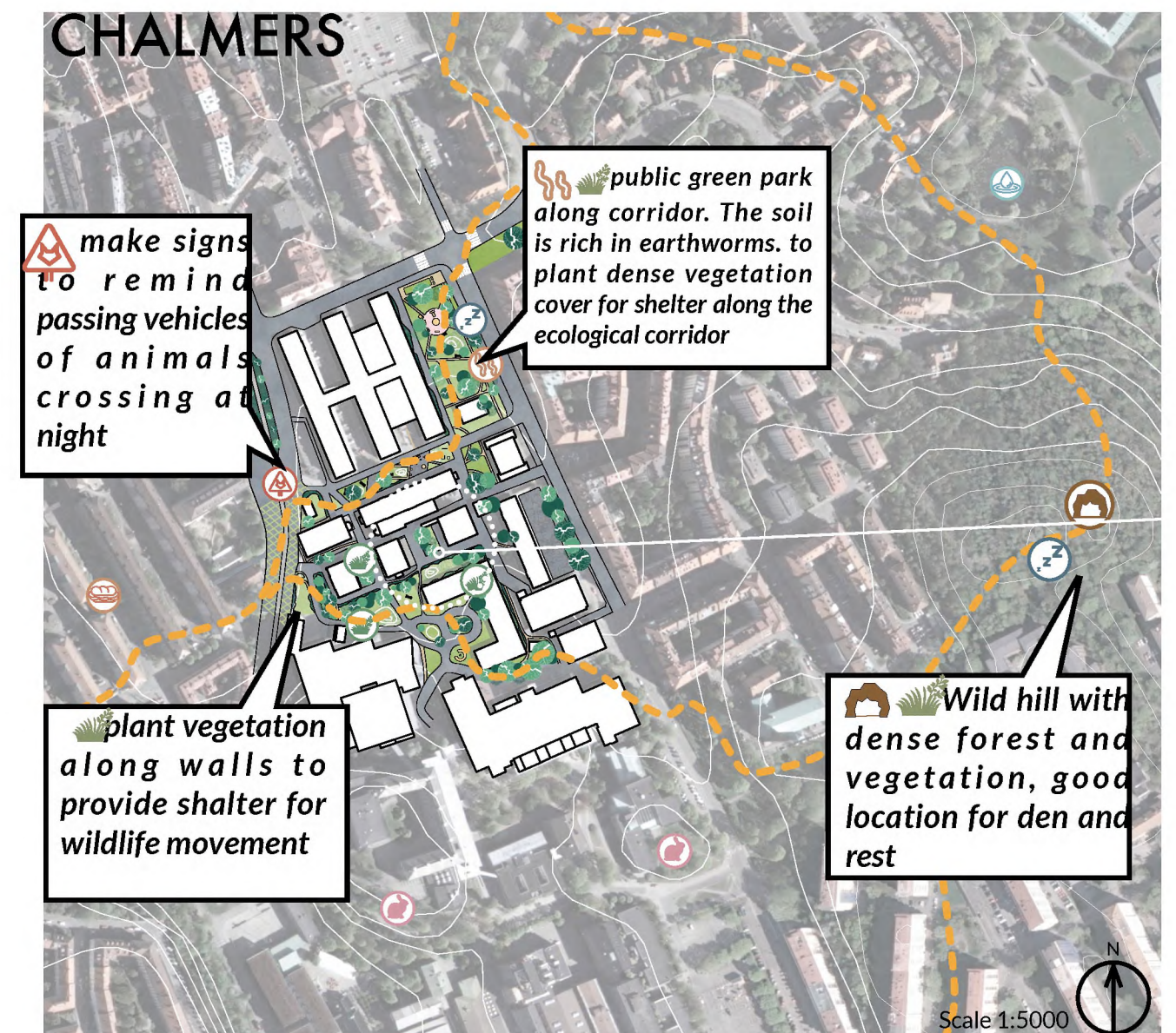
For connections, Kungsparken, Vasaparken are public green parks on the ecological corridor, The green areas are mainly lawns and trees, with few shrubs that could be used as shelder. So I added dense plant commnunity with some local shrubs, evergreen shrubs, and berry bushes, which cloud provide food and shelter, also in winter.

Chalmers campus on Kemivägen is mainly built environment, red fox like to move along linear structures like walls and fences, so we could add bush along the wall for them to move and hide.

# Appendix VASAPARKEN

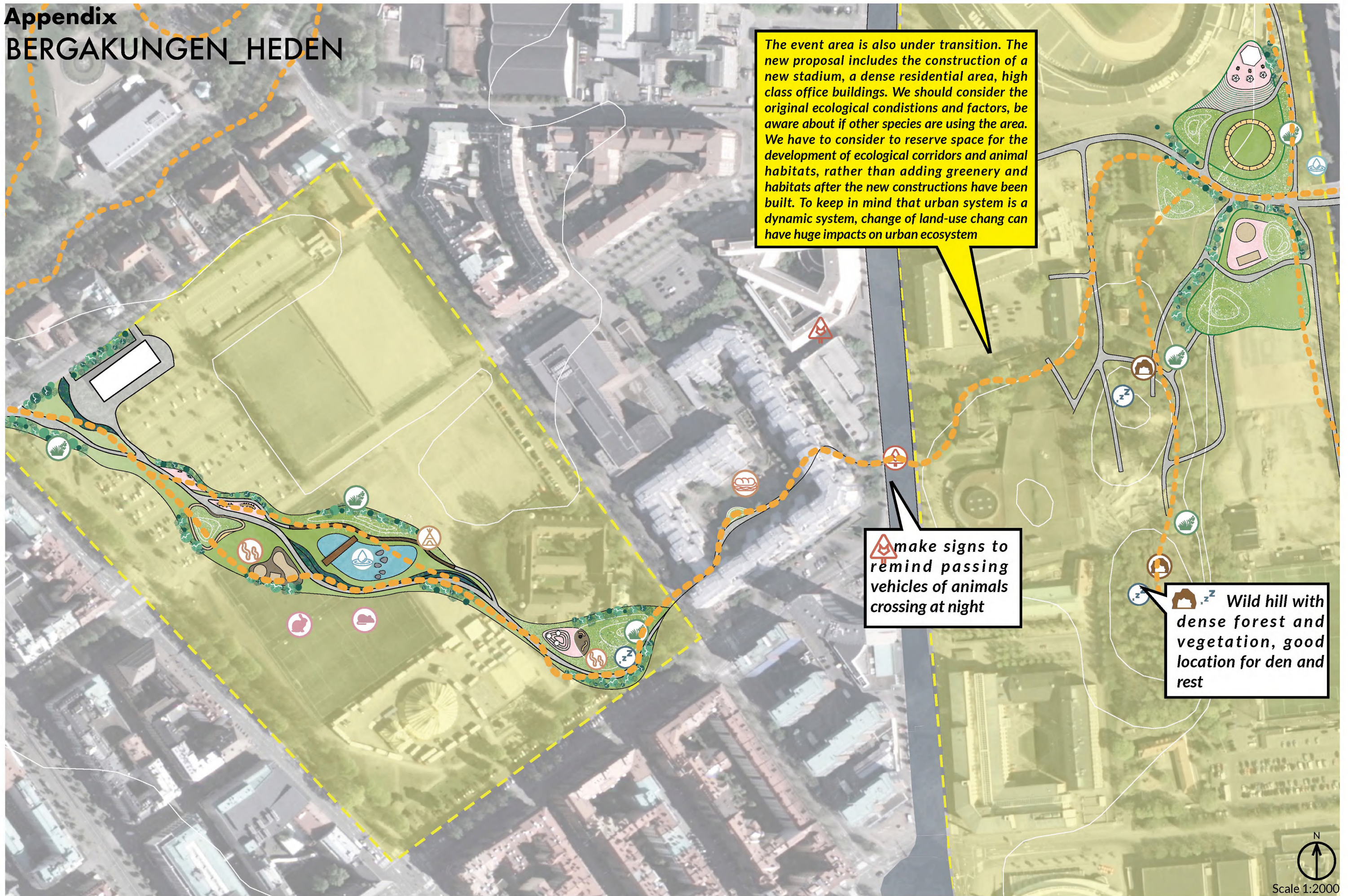


# CHALMERS



Red foxes often use linear features in the landscape such as hedges, tree-lines, roads to delimit territory boundaries. It is the same in urban areas, that streets and walls are used to delimit home range.

# Appendix BERGAKUNGEN\_HEDEN





**CHALMERS**  
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