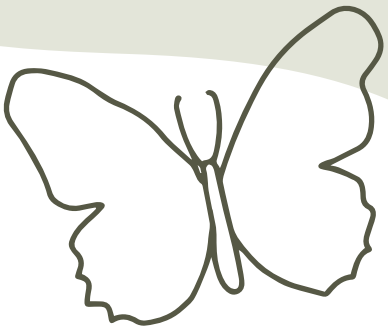
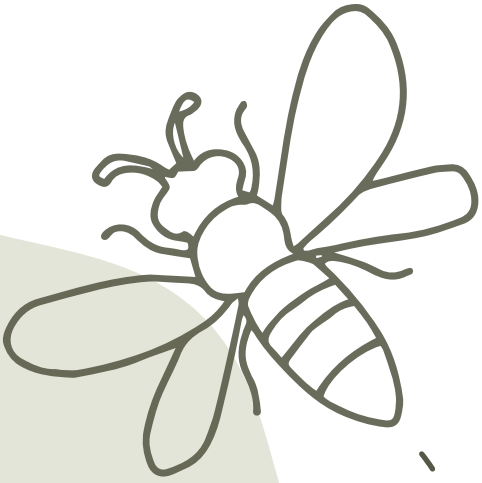
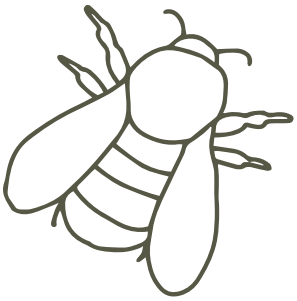


LOST POTENTIAL

- Exploration of how a rooftop can be retrofitted with focus on biodiversity in the urban environment





CHALMERS
UNIVERSITY OF TECHNOLOGY

Daniela Sonehag, 2021
Chalmers University of Technology
Department of Architecture and Civil Engineering
Master's Programme in Architecture and planning
beyond sustainability
Urban Challanges

Examiner: Joaquim Tarrasó
Supervisor: Emílio Da Cruz Brandão

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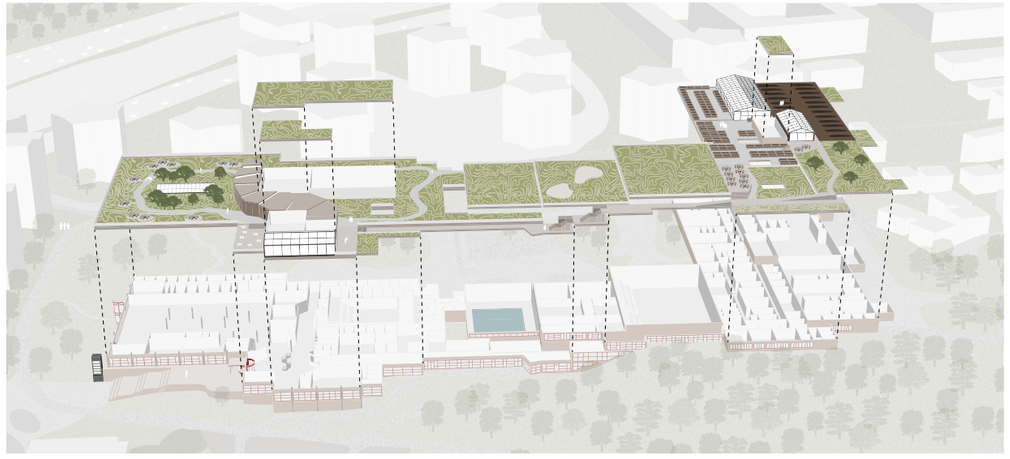
To my dearest **parents** and my partner **Victor**, who have always been there for me and supported me through good and bad times.

To my daughter **Alma**, you are the joy of my life.

Thank you.

Abstract



The rapid urbanization of the cities in the world is causing a severe loss in biodiversity. Areas which are rich in animal and plant species are being replaced by concrete, buildings and grassy lawns with little to provide for animal wildlife. The animals are being trapped in small patches in the city, and are in some cases completely isolated from other patches and colonies. We are depending on the ecosystem services that nature provides, and nature is depending on how we humans plan for a more sustainable future.

In many cities the roofs are covering 40 - 50 % of the total area of the city and therefore lies a great, lost potential in what value they could contribute with in terms of sustainable urbanization. Since 87 % of the buildings in 2050 are predicted to have already been built, one of the challenges is how to retrofit existing rooftops.

Green roofs can have a large impact on ecosystem services such as biodiversity in the city. When taking a step away from the more common, thin substrate sedum roof it is possible to mimic biotopes in the area onto the roof, and thereby provide shelter and food for a number of invertebrates. The roof also holds a great potential of creating meeting spots for people and letting the activities inside of a building extend to the roof.

The project site is the rooftop of Frölunda Kulturhus which is located in Västra Frölunda in Gothenburg. The building contains many activities that are divided into different blocks, such as the library block, gathering block, sport block and a school block that used to be a high school. The project proposal focuses on increasing the biodiversity in butterflies and wild bees, where the landscape prefered by seven different species have been constructed. The other focus is how to promote social encounters and increase learning about nature and farming for people. The roof has been divided into three different areas with butterfly meadows, a workshop classroom and a butterfly pavilion in the south, dry meadows for wild bees in the middle of the building and public urban farming with different farming methods and a greenhouse classroom in the north of the building.

Keywords : Biodiversity, Green roof, retrofitting, urbanization, Insects

About the author

In the autumn of 2013 I began my education in the Architecture program at Chalmers University of technology. I graduated from the bachelor in 2017 and took a break from architectural education to read free standing courses in graphic design and 3D modelling. In the spring of 2019 I started studying architecture again at the master program “Architecture and planning beyond sustainability” (MPDSD), where I developed a deeper interest and understanding for the different aspects of sustainability.

Early in the education I was drawn to questions of environmental sustainability. I made my first green roof in a project during my first year and have worked with integrating green roofs and walls in almost every project since then. The integration of greenery into building has been done mostly with human interests in mind, with the focus of water retention and aesthetic values. Through this master thesis I therefore want to take a different approach to what green roofs can contribute with and for whom.

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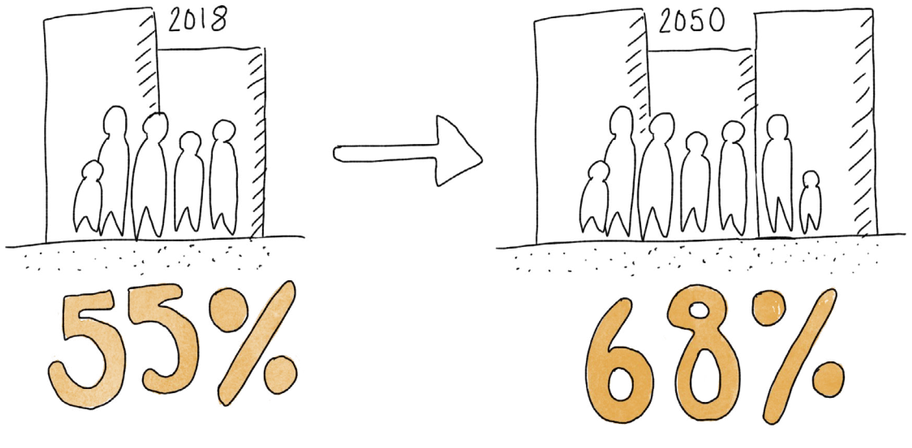
1.
INTRODUCTION

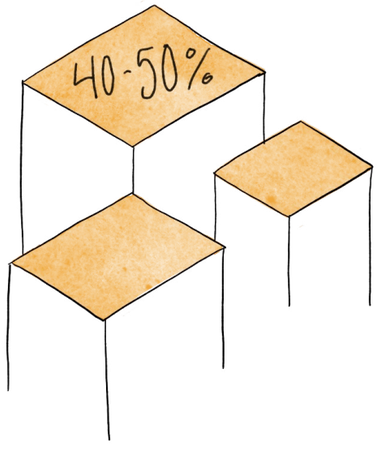
Background and relevance



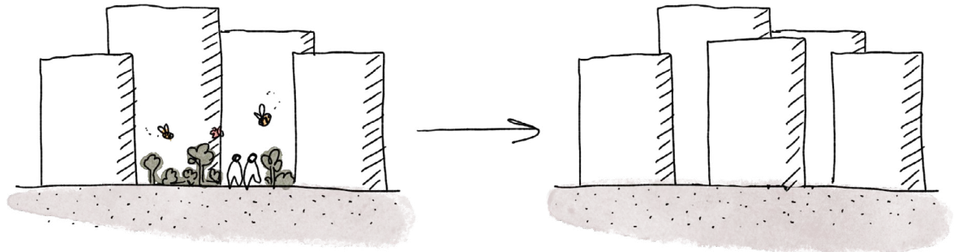
The population of the world is growing and urbanization is increasing. By 2018 55% of the population were living in urban areas and in 2050 it is expected to increase to around 68%. (United nations, 2018). Even though urbanization can bring many positive effects, one pressing issue is how it affects the environment and the ecosystem services in the city. The impact the human race has on the planet has already led to massive issues with climate change, where a global loss of biodiversity due to less green areas is one of the consequences (Luederitz et al., 2015). This brings a big challenge where a successful outcome is depending on how the rapid urbanization is being managed in terms of sustainable development (United nations, 2018).

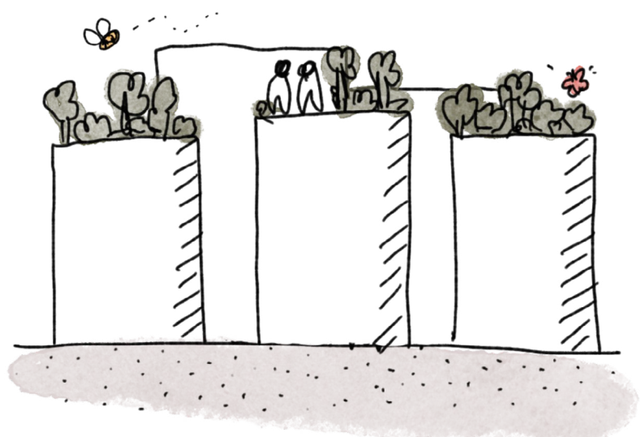
"It is clear that it is in cities where the battle for sustainability will be won or lost."

(Mohammed, 2017)

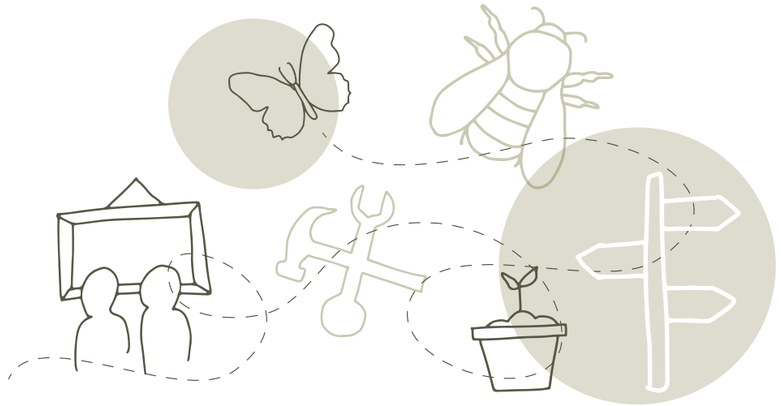


In many cities the roofs are covering 40 - 50 % of the total area of the city and therefore lies a great, lost potential in what value they could contribute with in terms of sustainable urbanization (Stovin, 2010). At the same time 87% of the buildings in 2050 are expected to have already been built, why it is important to focus on retrofitted solutions on those buildings, such as green roofs with a variation of designs to promote ecosystem services (Wilkinson et al., 2016).





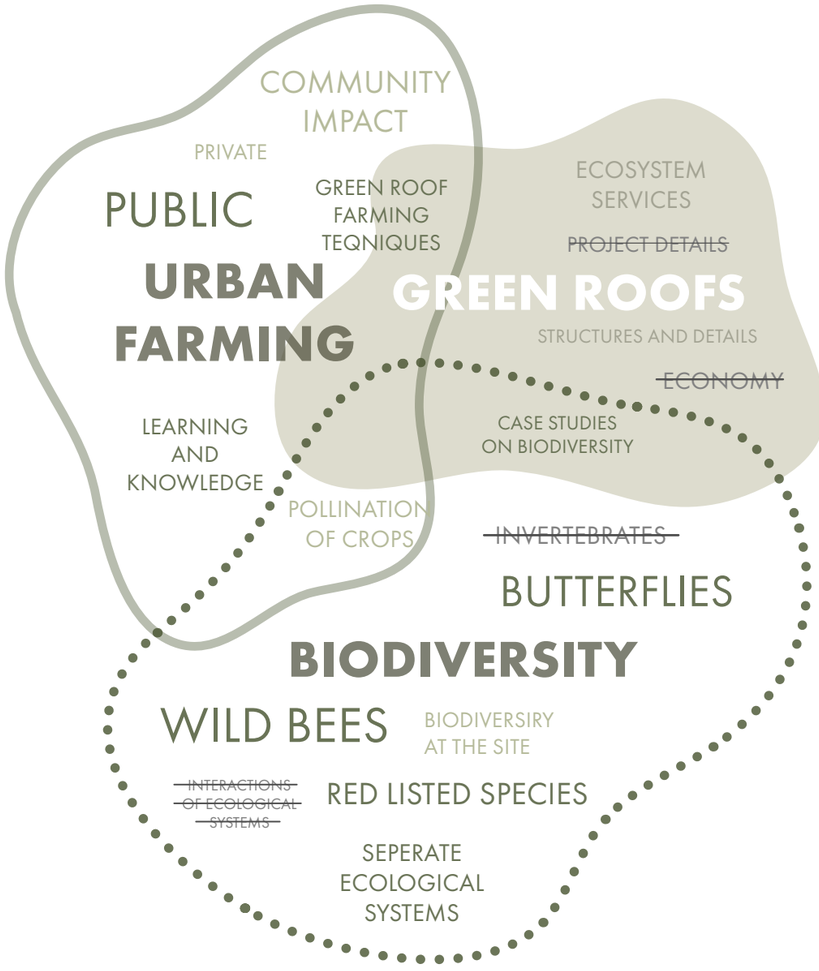
Thesis question and purpose

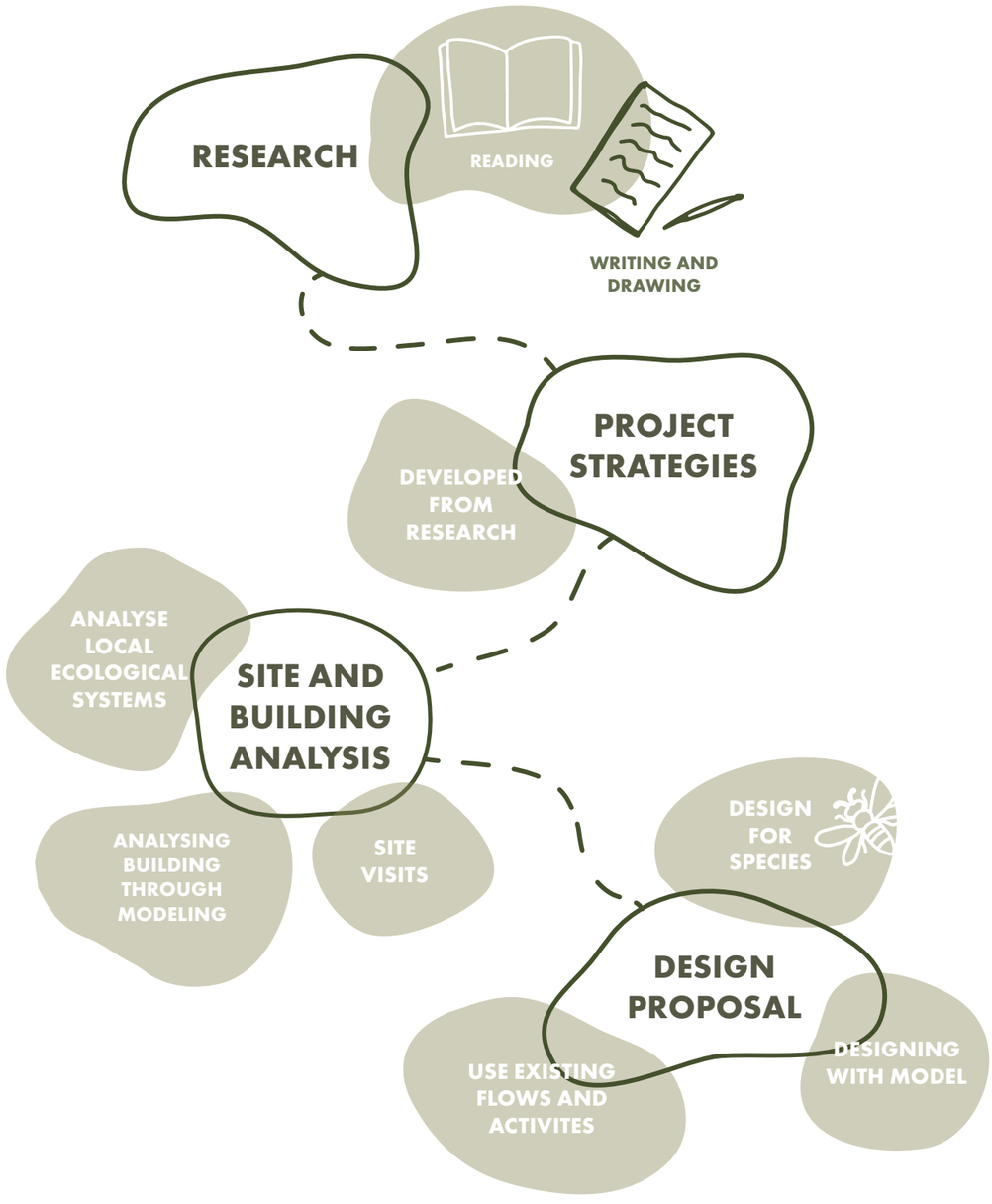


"How can a retrofitted green roof promote biodiversity and encourge social encouters between people?"

The main purpose of this thesis is to explore how to take action to increase biodiversity by retrofitting a green roof to the building Frölunda Kulturhus in Gothenburg. The other purpose is to strengthen the connections within the building and to the community and encourage knowledge and learning about nature. One way of increasing biodiversity is to work with a number of selected invertebrate species that are chosen from a number of parameters such as red listing and species from previous studies of green roofs in Sweden. By working with a number of specific invertebrates and their needs it is possible to benefit a large number of other species and ecological systems as well.

Delimitations




RESEARCH
READING
WRITING AND DRAWING
PROJECT STRATEGIES
DEVELOPED FROM RESEARCH
ANALYSE LOCAL ECOLOGICAL SYSTEMS
SITE AND BUILDING ANALYSIS
ANALYSING BUILDING THROUGH MODELING
SITE VISITS
DESIGN FOR SPECIES
DESIGN PROPOSAL
USE EXISTING FLOWS AND ACTIVITES
DESIGNING WITH MODEL

2.

RESEARCH

Technical details

The structure of green roofs

The structure of the green roof can look different depending on the conditions on the specific site and roof. The general structure is built up with a vegetation layer, substrate, drainage layer, geotextile, root barrier and a waterproofing layer.

Vegetation

The plant species that can grow on the roof are depending on different factors, such as substrate depth and the local conditions on the site. The most common green roof is a low thin substrate sedum-moss roof that can be retrofitted to most roofs (Pettersson Skog et al., 2017). There are three different types defined by FLL as intensive, simple intensive and extensive green roofs. The definition of the different types of roofs are based on the level of maintenance required where the intensive green roof requires intensive care and the extensive roof requires less care and maintenance (FLL, 2018).

Substrate

The substrate is a combination between earth, an additive material and an organic material with the function of holding the vegetation in place and holding moisture and nutrients. It is also important that the substrate has enough space for air in the poores to avoid oxygen deprivation in the vegetation layer (Pettersson Skog et al., 2017).

Drainage layer

The most important function of the drainage layer is to lead away excess water from the roof and thereby prevent heavy puddles and oxygen deprivation in the plants. Another important function for the drainage layer is to hold water and thereby slow down the water retention from the roof to help prevent flood during heavy rainfall. It is possible to use both a material with draining properties, but also a plastic drainage mat with the resemblance of an egg carton (Pettersson Skog et al., 2017).

Geotextile

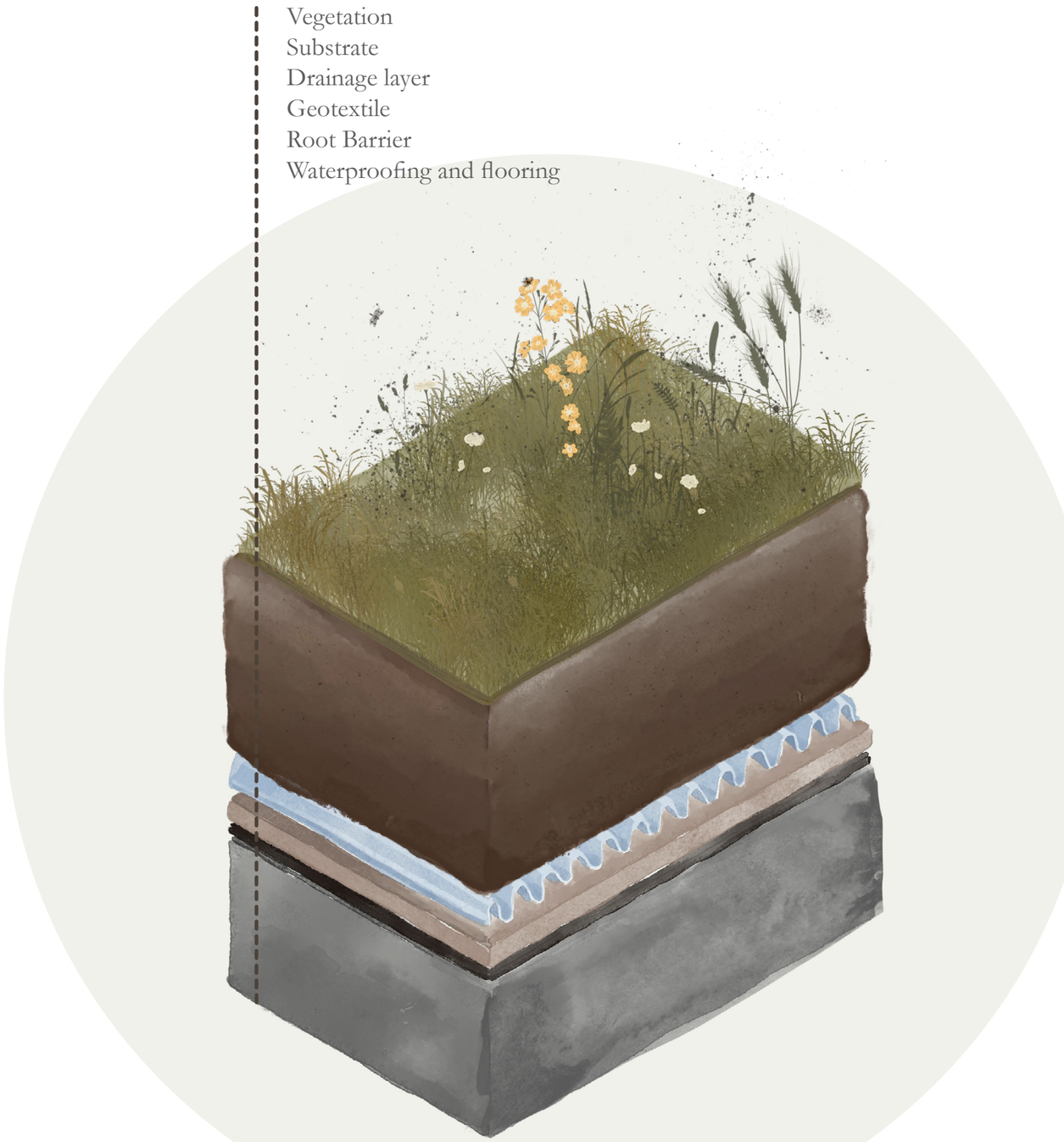
Geotextiles can be used to protect many different layers in the structure. It is used on top of the drainage layer to prevent clogging from the substrate and on top of the root barrier and waterproofing layer to protect it from damage and stress (Pettersson Skog et al., 2017).

Root Barrier

The root barrier layer is installed on the green roof to prevent roots from puncturing the waterproofing layer. This is a very important layer in the structure where extra consideration and work needs to be put in around the joints and edges. The root barrier is sensitive to mechanical damages and therefore needs to be protected with a geotextile (Pettersson Skog et al., 2017).

Waterproofing and flooring

There are many different waterproofing materials and ways to apply them to the green roof such as fluid materials and prefabricated mats. The chosen material and application depends on how the roof will be used (Månsson et al., 2017)



Original image from Grönatakhandboken (Pettersson Skog et al., 2017).

Technical details

Vegetation layer

The appearance of the green roof can be defined by the function it has. If the main function is to handle stormwater retention plants with a high evapotranspiration is preferred. Succulents e.g. do not have a high evapotranspiration but can store a large amount of water in them, which is why they are not a preferred plant species for these roofs. It is also important to work with deep substrate and a high variation in species (Pettersson Skog et al., 2017).

It is not possible to apply former research on how people perceive nature in a park environment on a green roof. The vegetation on the ground is very different from the one that can be grown on a roof and there is no point in trying to copy that nature onto the roof. The green roof must be seen as another kind of nature, where other parameters are important. A few studies have been made on how people perceive nature on roofs, and what kind of plants and colours are prefered from an aesthetic perspective.

The conclusions are that people prefer a green, taller, grassy and flowering roof landscape over a lower, red, sedum one. The perception of the greenery can however be different depending on the subject's relation and knowledge of nature and biodiversity. A person with high knowledge tends to be more positive to a more wild growing and messy green roof with a high biodiversity. (Lee et al., 2014).

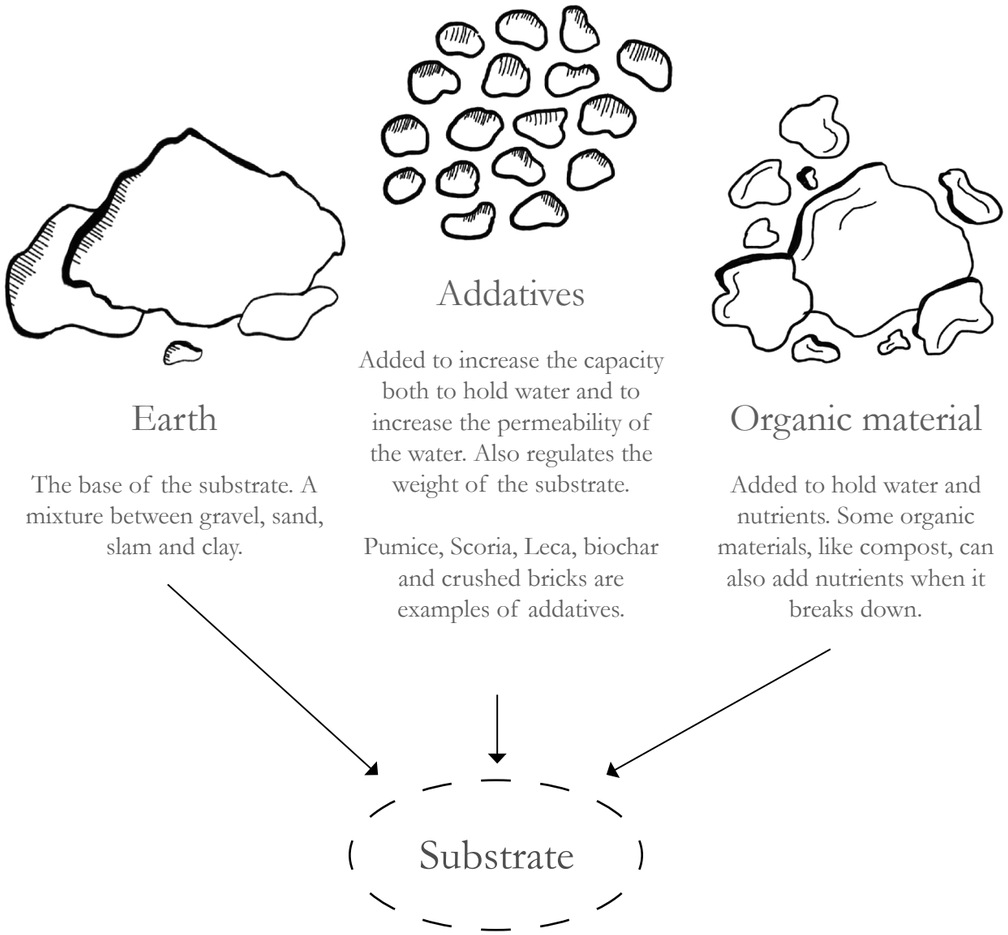
A roof with the intention of providing lost ecological value can look very different depending on the conditions of the site. It is not possible to recreate the lost space exactly as it was on the ground onto the roof, but the lost values can be taken into account when designing. The most effective way is to work with a local biotope from the area. Roofs with a high ecological value often put focus on biodiversity in plants and animals, and by working with an existing biotope nearby nature is more likely to benefit from the green roof (Pettersson Skog et al., 2017).

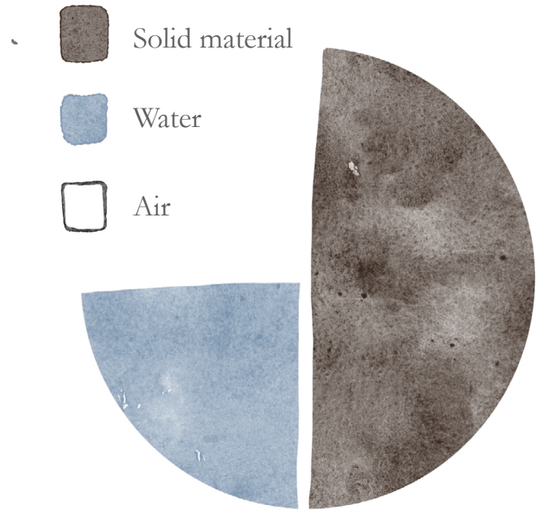
Original image from Grönatakhandboken (Pettersson Skog et al., 2017).

Technical details

Substrate layer

The substrate has many functions on the green roof, such as attaching the plants and storing nutrients, water and air. The composition of materials in the substrate are important for these qualities, but also to ensure that the weight and loads on the underlying structures is not too heavy. There are typically three main components in a substrate, these are the additive materials, the earth materials and the organic materials. It is almost never possible to use ordinary earth without additives on a green roof. Especially not if the substrate depth is lower than 700 mm. Ordinary earth is too heavy and to fulfill the maximum loads accepted and the plant bed is too thin for the plants to survive. By mixing e.g. pumice into the earth it becomes much lighter, can store more water, air and nutrients in its pores and allow the plant bed to be thicker (Pettersson Skog et al., 2017).





Distrubution of water and air

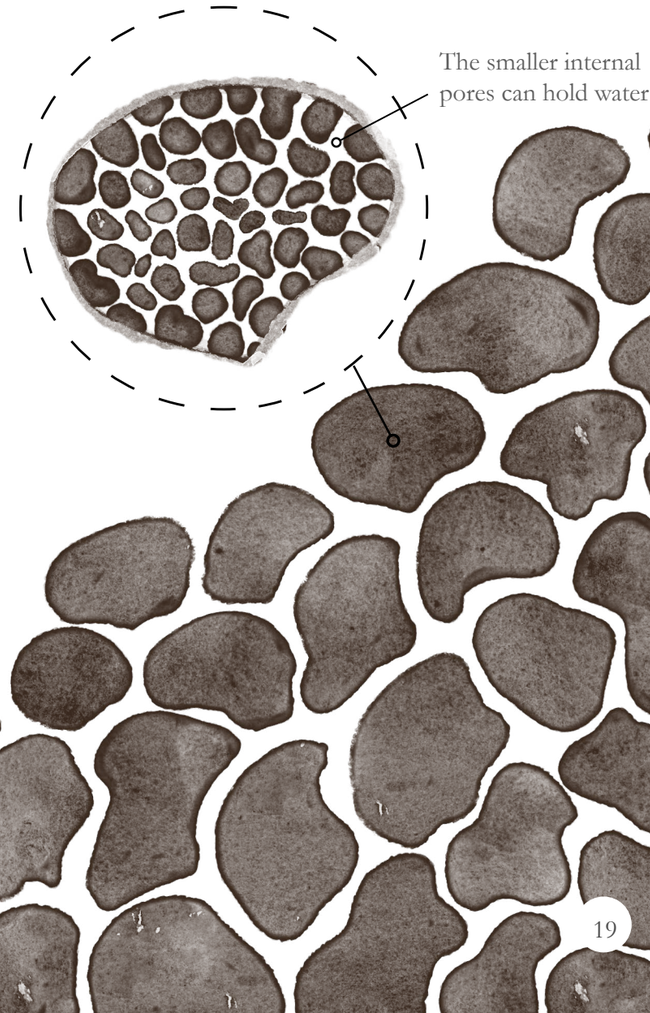
A well balanced substrate has approximately 50 % pores that is filled with 50 % water and 50 % air. A variation in the sizes of the poors is required because the smaller ones can hold water better than the bigger ones that are better at holding air.

Original image from Grönatakhandboken (Pettersson Skog et al., 2017).

Poors in the substrate

The distribution of the poors is one of the most important factors in the plant bed. By adding an addative with internal pores it is easier to satisfy the need to store both water and air in the substrate. In a material without internal pores, e.g. sand, the water and air both need to be stored between particles, which requires a very thick and heavy plant bed for the air to get enough space. Since the internal pores in e.g. pumice are small and thereby better at storing water, the space to store air is bigger and makes it easier for the plant bed to be well balanced.

Original image from Grönatakhandboken (Pettersson Skog et al., 2017).

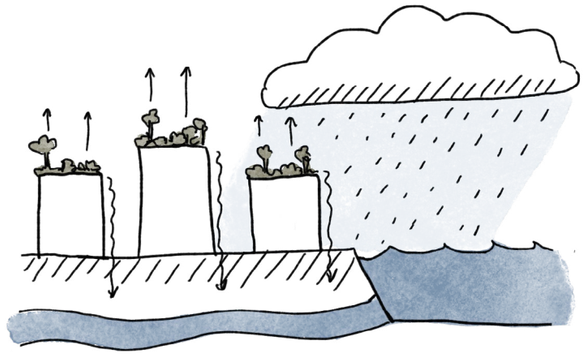


Possibilities and challenges

Possibilites

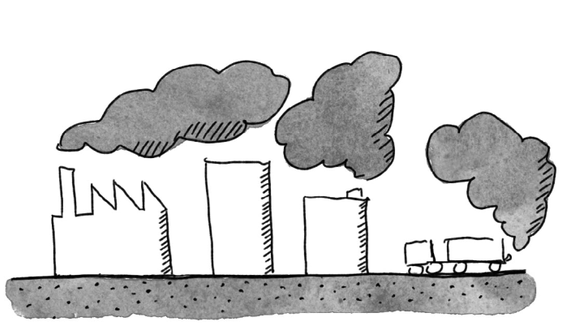
Green roofs can provide many benefits on both city and building scale, for example meeting the need for ecosystem services (Pettersson Skog et al., 2017). Ecosystem services can be defined as the services nature provides that the human race benefits from. The term is used as a tool for us to understand how a working ecosystem is crucial for our well being, and needs to be taken into account in human activities. Ecosystem services can be divided in the four categories; providing, regulating, cultural and supporting ecosystem services (Naturvårdsverket, 2020).

Some of these ecosystem services can be met on the green roof, such as stormwater retention, decreased air pollution, prevention of the urban heat island effect, biodiversity, urban food production and providing recreational space for people (Pettersson Skog et al., 2017). Green roofs can also have a positive effect on the building it is located on by improving the thermal performance, increasing property value and giving the building an environmental classification or an important landmark in the city (Francis et al., 2014).



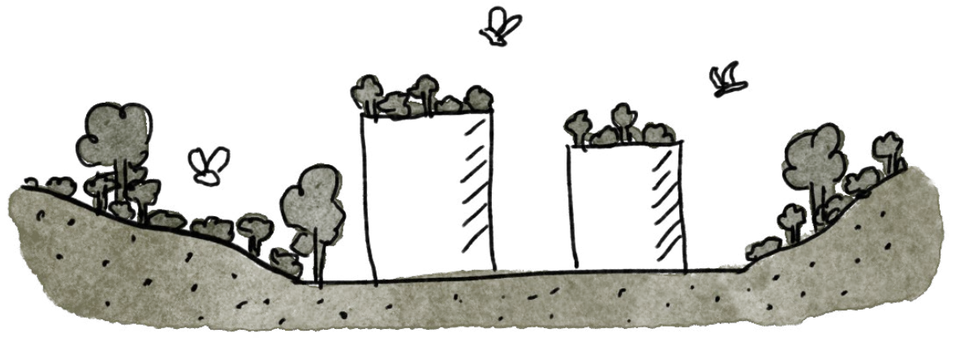
Stormwater retention

Floods are becoming a bigger problem all over the world as a consequence of urbanisation, densification and climate change (Europeiska miljöbyrån, 2020). In most cities the roofs cover about 40-50% of the impermeable surface, and managing the stormwater retention on the roofs, by adding a vegetation layer, could therefore be an effective way of preventing flood (Stovin, 2010). The water on the green roof can be stored in the drainage layer, the substrate, textiles and by the plants. The water can then leave the roof slowly through runoff or evapotranspiration from the substrate and the plants (Lambrinos, 2015).



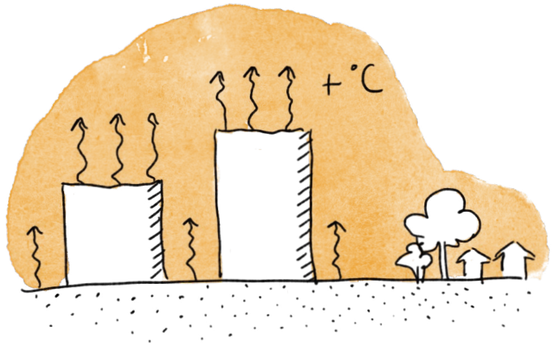
Air Pollution

Green roofs can help decrease air pollution both directly and indirectly. The vegetation can bind the carbon dioxide and thereby reduce pollutants in the air. The green roof also cleans the air indirectly by contributing to lowering the energy consumption inside the building and on a bigger scale by cooling the city and contributing to lowering the urban heat island effect (U.S. Environmental protection Agency, 2018).



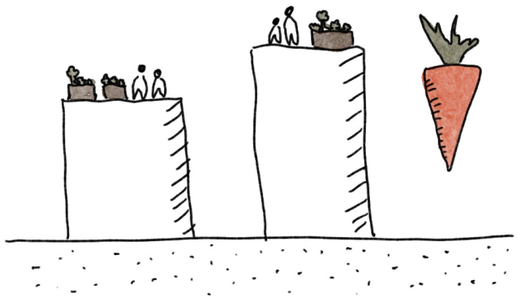
Urban heat island effect

The higher temperatures in the city compared to surrounding rural areas is not just the effect of increased air pollutants, but also the reflective and heat retaining qualities of urban materials and less evapotranspiration from green areas in the city. Green roofs can help prevent the UHI effect both by adding more greenery but also by decreasing the need for air conditioning inside the building (Osmond et al., 2016).



Biodiversity and conservation

Green roofs have proven to hold a great potential in increasing the biodiversity in both animals and vegetation in the city. When the areas with high valued nature are being replaced by impermeable surfaces such as buildings and roads, we need to implement the same kind of nature into the city in other ways, and one way of doing that is by using the rooftops.The green rooftops could also help in strengthening the green corridors in the city and thereby prevent colonies of animals from being trapped in small patches of green areas. It is also possible to use the green roof to preserve and protect endangered species of both animals and plants by for example copying a local biotope on the roof, or working with flowers and places for protection and nesting that specific species prefer.

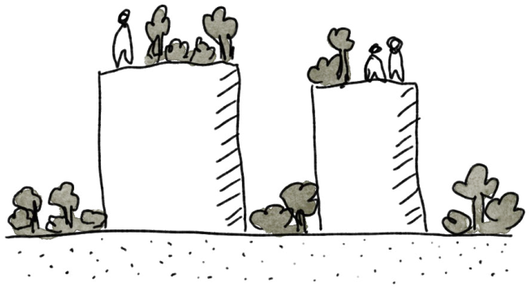


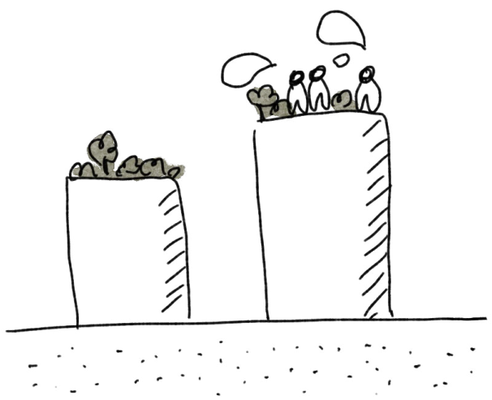
Urban farming

One of the most challenging issues we are facing to reach a more sustainable lifestyle is how we can produce food on a local scale in urban areas. Since most of the area in the city has already been built upon, the space on the rooftops has a great potential to be urban farmland both for urban farmers but also for residents and communities of the buildings (Wilkinson et al., 2016).

Open and recreational space

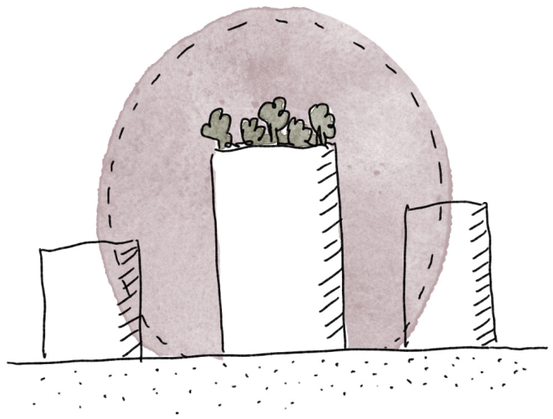
Studies show that being close to nature is important and has recreational value for people. To preserve or create green places in the city is however challenging with the increasing urbanisation and densification. Using rooftops as green places is an effective way of adding more recreational places in the city, as they can be observed from nearby buildings or by visitors if the roof is open for people (Lee et al., 2014).





Social aspects

Studies show that growing food on green roofs can have a great impact on social sustainability, inclusion and community engagement. Some of the studies are from green roofs on University buildings where both staff, students and members of the community have been engaged. The common interest for local and sustainable farming made people network, work together to learn about rooftop farming and created a sense of belonging (Ghosh et al., 2016).

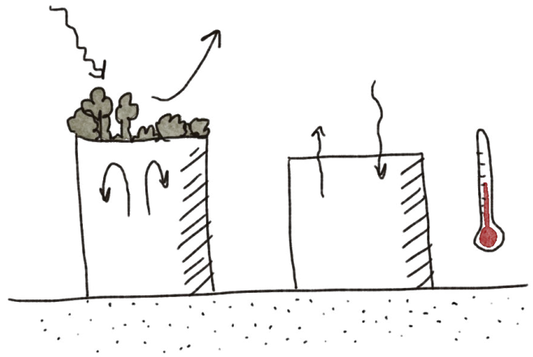


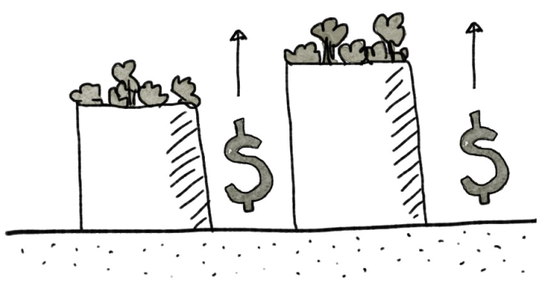
Visual and landmark

A visually appealing green roof can make the building an important landmark in the city or even country, and thereby bring value to both visitors, the people in the city and the owner of the building (Francis et al., 2014). Examples of such buildings with roofs are The ACROS Fukuoka Prefectural International Hall of Japan, The city Hall of Chicago and The Nanyang Technological University in Singapore (Miley, 2018).

Thermal performance

A green roof can improve the thermal performance in a building in many ways. The added layers have an insulating effect that can make the building hold heat and cold in a better way. The effect of the insulating ability is however depending on how well insulated the building is to begin with. A building with no insulation benefits a lot from a green roof while a well insulated building might not notice any differences in energy consumption at all. The green roof also protects the surface of the roof from getting overheated through shading (Wilkinson et al., 2016).





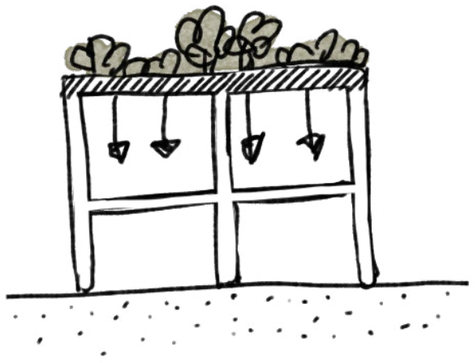
Increased property value

An environmental certification that a green roof could provide might increase the property value of the building together with other beneficial factors the green roof could bring. If the roof is constructed in a way that improves the thermal performance, less energy is required to cool and heat the building and the cost for energy is lower. Another economic benefit is that the green roof protects the surface of the roof and therefore has a longer lifespan than a bare roof has. (Miley, 2018).

Possibilities and challenges

Challenges

There are a number of challenges that need to be considered when choosing a building to retrofit and choosing what kind of roof that should be installed on that building. Even though rooftops hold great potential for green spaces some buildings are not appropriate to retrofit for different reasons. To overcome these challenges and reach the best outcome possible it is important to involve professionals with different kinds of knowledge and make sure that everyone involved is aware of the frames and the desired end result (Pettersson Skog et al., 2017)..

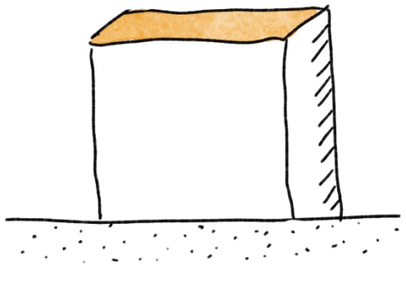


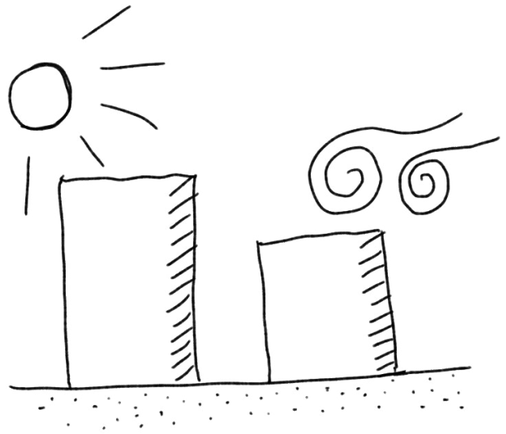
Building structural capacity

The extra weight on building is depending on how thick the substrate is and if people are going to use the roof on other occasions than maintenance. Roofs with a substrate under 100 mm do not generally need any reinforcements in the load bearing structure of the building as long as only maintenance staff is visiting the roof. Thicker substrate and public spaces on the roof generally requires some sort of reinforcement (Wilkinson et al., 2016). One way of working with load bearing structures like pillars in the building is to place the heavier structure above the pillars.

Avaliable space

The total area of available space to add a green roof is an important and challenging factor when retrofitting. The area close to existing structures on the rooftop could be inappropriate to use because of factors like hot waist air from the thermal system in the building (Wilkinson et al., 2016).



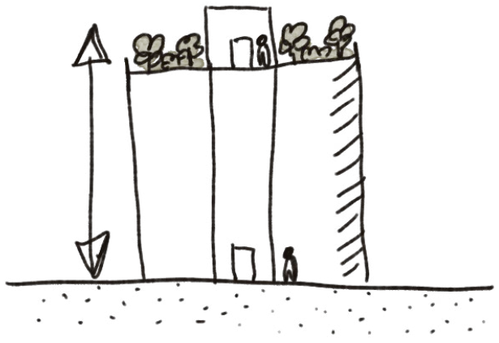


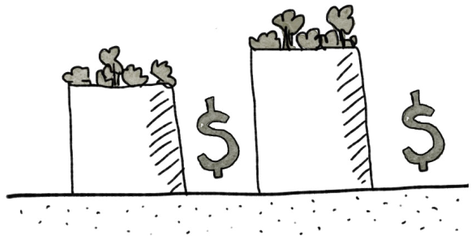
Harsh environment

The environment on the roof is harsh, and only some plant species can survive in the challenging environment of hard winds and intensive exposure to the sun. The height of the building is one of the most important factors to determine how harsh the environment on the roof will be. A roof close to the ground is for example more suitable for a green roof than a high building with harder winds and less chance of overshadowing from surrounding buildings.

Access to rooftop

Access to the roof is always important, but clear and easy access is more important if the roof will be used as a public place. All green roofs require some maintenance and therefore needs to be reached by people on some level. If the roof will be used as a public space it is also important that the roof is accessible for everyone with e.g. an elevator. It is also important to protect from fall hazards by adding for example a fence around the edges of the roof (Wilkinson et al., 2016).



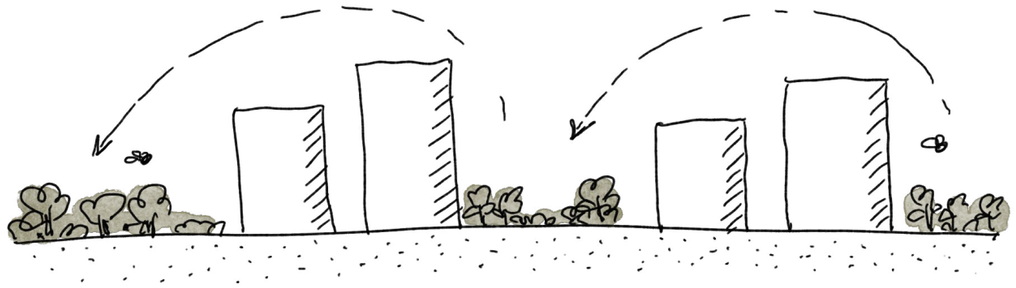


Installation cost

There are many different factors that determine how expensive the green roof will be. The size of the roof, the site location and thereby transport distances, professionals involved and the load bearing capacity of the building are some of the important factors (Francis et al., 2014).

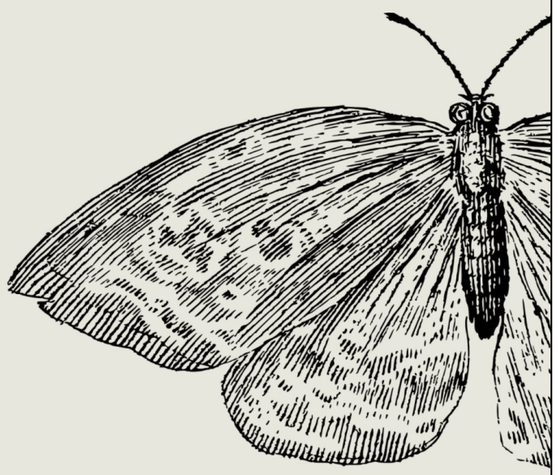
Biodiversity
Background

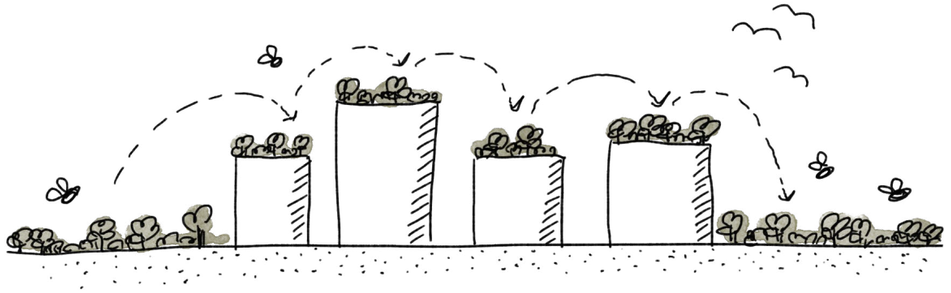
The biggest threat to biodiversity today is the rapid urbanization all over the world. Biodiversity is decreasing on a global scale, and the natural habitats for animals are being replaced by concrete, buildings and simple grass lawns. The animals are in some cases trapped in small patches in the city, where colonies are unable to move and thereby risk inbreeding within a colony. Many species are depending on a large variation and structures of plants, bushes, stones and water environments connected to each other through green corridors. Man-made nature such as lawns or well trimmed bushes do not provide these needs and is therefore an inadequate way of keeping the values of nature within the city (Latty, 2016).



What is biodiversity?

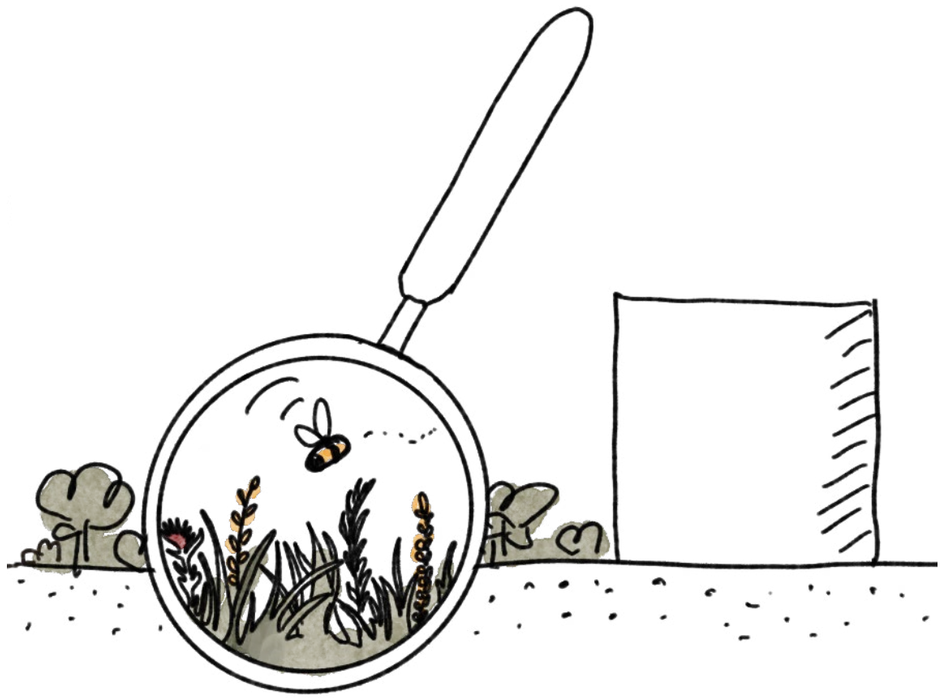
Biodiversity is the term used to describe all the living things on our planet, such as animals, plants, bacteria and fungi. The number of species estimated to live on earth is around 8,7 million, but only around 1,2 have been identified and named by humans. The majority of them are insects. (National Geographic, 2021). How biodiversity is measured can generally be divided into three different categories; Species diversity, genetic diversity and ecological diversity. The most relevant kind of biodiversity on green roofs is species diversity, which describes the total amount of different species within an area (Latty, 2016).





Biodiversity and green roofs

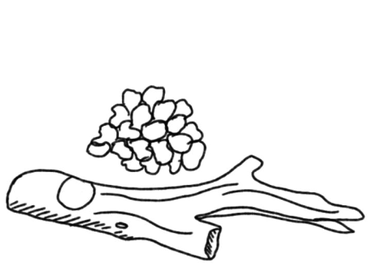
One of the most important aspects of increasing biodiversity in the city is to add more environments for the animals to live in. In the urbanized environment with little space left for nature, the rooftops hold a great potential. Even though green roofs have been built for thousands of years it is during the last couple of decades they have been constructed in a technical advanced way, where one of the purposes is to promote ecosystem services. The research that has been made on the subject is therefore limited, but studies show that green roofs together with other green infrastructure have a positive impact on biodiversity in the city. The biodiversity also increases with the number of green roofs and actions for green infrastructure that exists in the area. It is however important to remember that it is not possible to mimic the conditions on the ground onto a green roof. The environment is harsh and vertebrates without the ability to fly are not able to reach the roof. Why there needs to be several different actions to increase the biodiversity in a city and not just green roofs as the only solution. It is also important to work with plants and a biotope that benefits the species that lives or could live in the area by for example choosing a biotope present in the nearby area (Latty, 2016).



Biodiversity

Animal species

The number of vertebrates that can use the green roof is limited, but birds and bats are animals that could benefit from the roof. The main need except for food and water for birds is spaces to nest and raise their young. Research has been made on the subject that showed that birds used the roofs as nesting spots but their chicks had issues surviving due to the harsh climate. There is always a risk in providing everything a specific species requires on a rooftop, and the discovery that the specific animal species resides on the roof is not proof of success. The roof could also act as an ecological trap, where the animals choose the roof before a more suitable environment and then have trouble surviving (Latty, 2016). Focusing on increasing biodiversity in birds could also be problematic on public rooftops since many bird species get aggressive and attack humans while nesting (Lundberg, 2014). It is easier to create environments for invertebrates on green roofs. They are smaller and thereby require less space to accommodate all the needs on a single roof, there are also more studies made on invertebrates and the number of different species to target is bigger (Latty, 2016).



Studies on invertebrates on green roofs in Sweden

There have been a few studies that have monitored species visiting green roofs in Sweden. Lundberg (2014) made a study in her master thesis where she found 12 different invertebrates on green roofs in Stockholm. During an evaluation of the Vinova project BiodiverCity, Haaland (2017) investigated how butterflies and bumblebees used the green spaces within the project where a few of the spots were green roofs. A year later Haaland (2018) made a study within the same project where she used time lapse cameras on green roofs to see what species visited the roofs. (See appendix 1.1)

In the study with time lapse cameras by Haaland (2017) the cameras were directed towards different plant species, where e.g. phedimus had a large number of visits by Red-tailed bumblebees and blueweed had many visits from large earth bumblebees and hoverflies. Malmö stad (2015) also monitored visits by insects on Augustenborg botanical roof garden and found many visits on blueweed, english lavender, yellow chamomiles and oregano plants. (See full list in appendix 1.2). Both studies looked into roofs with a thinner substrate depth.

Ways to increase biodiversity

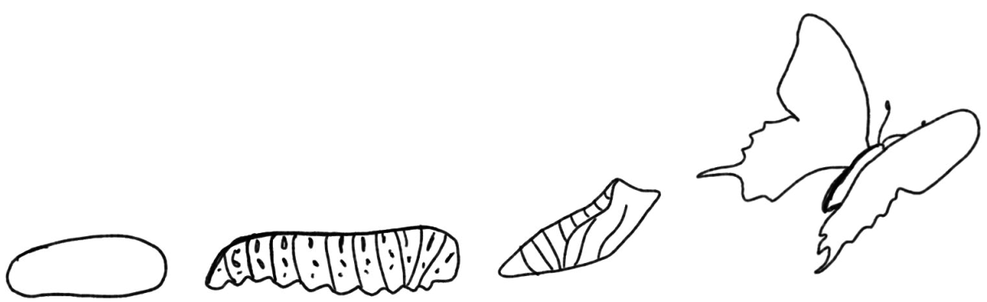
There are many actions that can be made to increase the biodiversity in vertebrates on a green roof. One important factor is to use a large number of plant species and flowering plants that have different flowering seasons. It is also important to provide water and shelter. Shelter can be provided by adding natural elements such as dead wood and rocks in different sizes and piles of sand (Pettersson Skog et al., 2017). Another common way to provide shelter for insects is by adding man made insect hotels. Studies however shows that the hotels in some cases have been taken over by invasive species and that the biodiversity of more sensitive species could decrease (Latty, 2016).

Wild bees

There are two types of bees, the social bees which are living in a society and the solitary bee which lives without a society amd without producing any honey. Bees are important pollinators but many species are endangered and risk to die out completely. Flowers are very important for the bees, together with a lot of other animals. There are however a few species that are very beneficial and can be grown of green roofs, such as Väddklint (Centaurea scabiosa), Blåklocka (Campanula rotundifolia), Blåmunkar (Jasione montana), Sommarfibbla (Leontodon hispidus), Gråfibbla (Hieracium pilosella), and Åkervädd (Knautia arvensis). The tree Sälg (Salix caprea) is crucial for the queen bumble bee in the spring when she has woken up from her long winter sleep.
Many of the wild bees lay their nest in the ground and in sand piles. The sand piles need to be at least 50 cm deep for the bees to build their nests. Dead wood with premade holes are also good spots for some species to lay their eggs in (Länsstyrelsen, 2019). Even though many flowers are beneficial for wild bees some species have a host plant that they are depending on to survive.

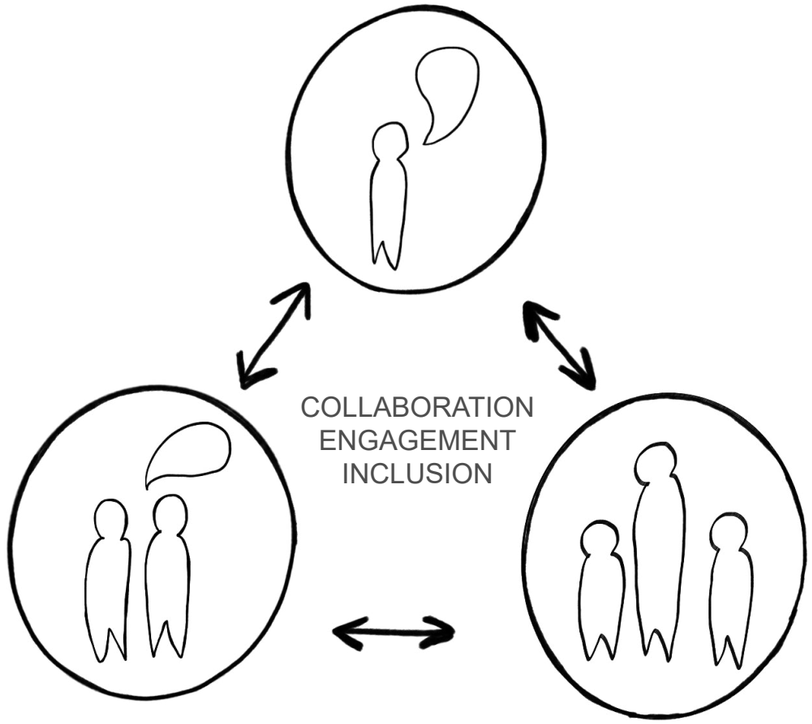
Butterflies

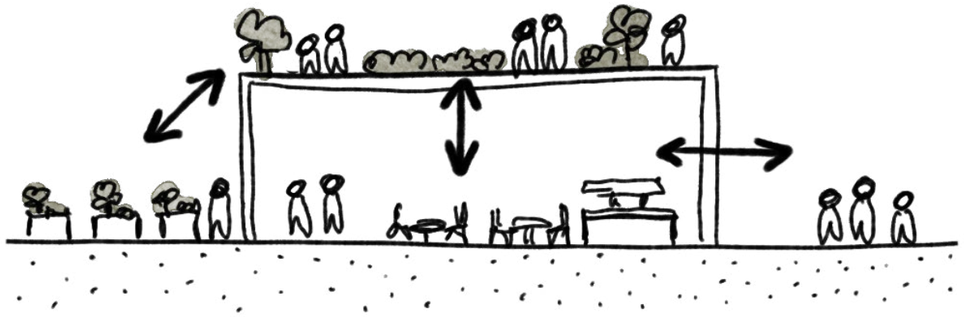
The number of red listed butterflies is increasing because of the decreased flowering landscapes that they require to survive. Generally butterflies act as a good indicator on the value of biodiversity of an area, many species of butterflies give an indication of richness in other vertebrates. The life of a butterfly can be divided into four different stages, from egg to caterpillar, pupa and then butterfly. Even though some species can fly long distances to find a source of food, they are depending on a high variation of plants since their need for different plant species are changing during their lifetime. Some of the host plants for the caterpillars and eggs are for example käringtand (Lotus corniculatus), Getväppling (Anthyllis vulneraria) and Brännässla (Urtica dioica). Even though the grown up butterflies can get nectar from most flowers some are more beneficial than others. A few of them are Ängsvädd (Succisa pratensis), Åkervädd (Knautia arvensis), Kungsmynta (Oregano), Väddklint (Centaurea scabiosa), Rödklint (Centaurea jacea) and Sälg (Salix caprea). Some grown up butterfly species are in hibernation during the winter and need protection from the cold and harsh environment. The shelter can be provided on a green roof by adding piles of rocks, dead wood or by building a butterfly hotel (Göteborgs stad, 2014).



Urban farming

With the majority of the population living in cities the challenges of providing locally produced and sustainable food is increasing. The farm areas are located further away in the countryside when the size of the city is expanding. One way to meet present and future needs to grow food within the city is by using the rooftops as additional farm land (Wilkinson et al., 2016). There are several different approaches to farming on rooftops depending on the desired outcome and target group. The purpose of the farm could for example be to grow larger amounts of food, where an urban farmer is mostly involved and responsible for the crops. This type of farming is often not accessible by the public. Another approach is to create a place for community farming, where for example local groups of volunteers could be involved in the farming together with a professional farmer. The amount of food produced is less, but the farming can instead strengthen the community and act as a place for learning about nature and food production for the public (Caputo et al., 2017).





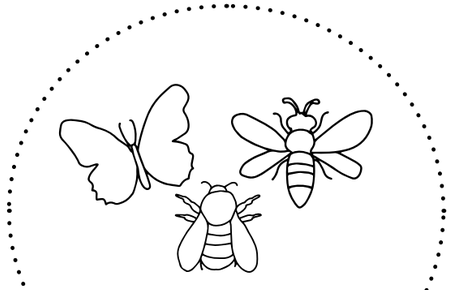
Another possibility in involving the public in urban farming is to increase the knowledge of farming and encourage people to start growing food in their homes. The demands for spaces to grow food locally in the community might increase when the knowledge is shared and wider among the community. Understanding where food comes from and growing food with a shorter supply chain can also help decrease the food waste and the carbon footprint. (Wilkinson et al., 2016). A rooftop farm also holds the potential of acting as a strong connection to the surrounding area and strengthening the activities within and outside of the building.

There are several different techniques that can be used to farm on a rooftop depending on the local conditions on the site and the conditions of the building. Free standing cultivation boxes could for example be used as a low cost alternative on buildings with a lower load bearing capacity. It is possible to move the boxes when the harvesting season is over, and the loads on the building are thereby lower during the winter season. It is also possible to grow directly in the substrate on the roof and thereby create a bigger space for farming. This requires a more technical advanced solution, but is contributing to the ecosystem services and the building qualities in the same way as a conventional green roof. A greenhouse could be installed on the roof to grow vegetables that are more sensitive to the harsh climate on the roof.

3.

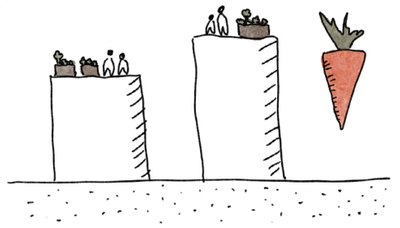
PROJECT STRATEGIES

Project actions

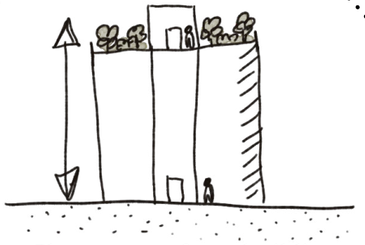


Focus on bees and butterflies

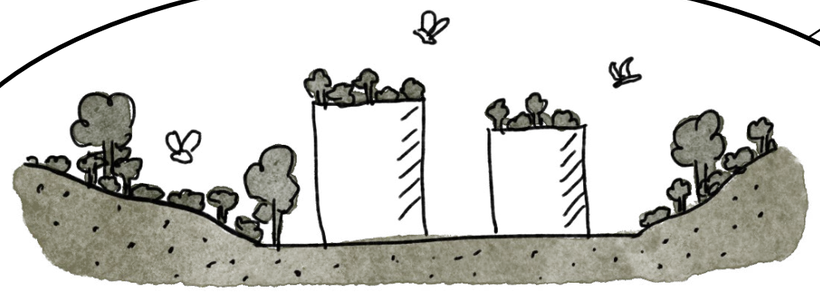
Natural elements as protection



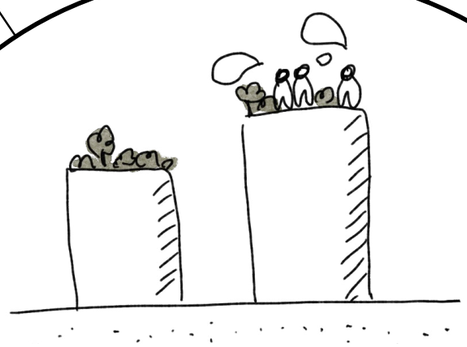
Public urban farming



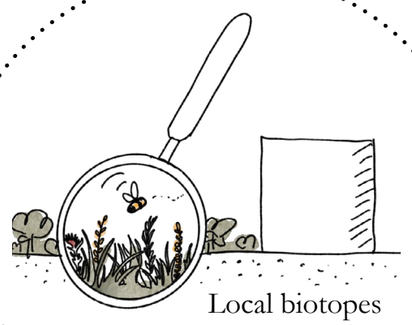
Clear access from building and ground



Actions for biodiversity

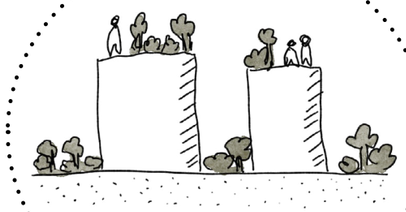


Social human actions

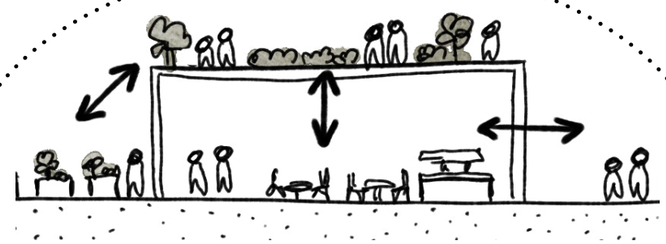


Local biotopes

Biodiversity in plants



Recreational space

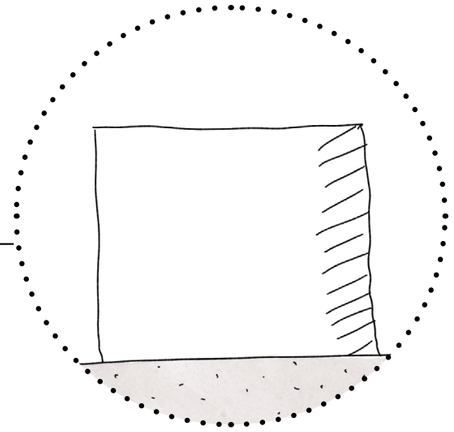


Connection between building activites and surrounding area

Project scales

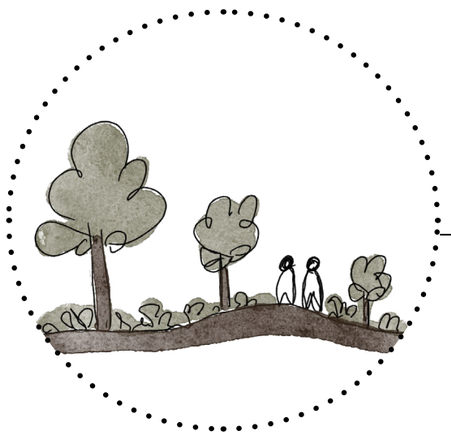
City scale

Green corridoors and relevant species and biotopes.



Building scale

Building activites and flow of people.



Human scale

Design details in usage of the building and rood.

Insect scale

Habitats and needs during the life cycle of insects.

4.

SITE ANALYSIS

Project site

Site context in Gothenburg

The project site is located in Västra Frölunda, in the western part of Gothenburg. The project building is the culture house called Frölunda Kulturhus. Frölunda Kulturhus was built in 1977 and is located in the south of the forest Ruddalen, which is a large recreational area with a variation in nature and species. There are wet areas with ponds as well as a rocky area. The wood is mixed with pine, oak, birch and aspen trees (Göteborgs stad, 2021). In the south of the building is the shopping mall Frölunda Torg.

The buidling is located in a highly urbanized area but with some connection to nature and green pathways that stretches over the west parts of Gothenburg.

Biodiversity in Gothenburg

The Biodiversity in Gothenburg is, as in most of the cities in the world, decreasing in a rapid speed. Gothenburg city has therefore developed an action program with the goal of protecting endangered species (Miljöförvaltningen, 2017). The species in the protection program are mostly insects, plants, birds, bats and water living animals such as fishes and amphibians. Gothenburg is also responsible for protecting biotopes that can be found in different parts in and outside of Gothenburg,

Välen

South of the project site is the nature reserve area "Välen". Välen is an important place in Gothenburg both because of the high biodiversity and the presence of many red listed species (Artportalen, 2021), but also because of the recreational values for people visiting the area. The main biotopes found are dry meadows, agricultural landscape, marine landscape and deciduous forests (Länsstyrelsen, 2021).

Project site

Project focused species

Seven different species have been selected as the project focus. The small scabious mining bee (Andrena marginata), the Silver spotted skipper (Hesperia comma) and the Small blue (Cupido minimus) are red listed species that have been chosen because they have been observed in Gothenburg during the last ten years (Artportalen, 2021). The small scabious mining bee (Andrena marginata) is also one of the species that Gothenburg is responsible for protecting from extinction (Miljöförvaltningen, 2017). The Common brimstone, the peacock butterfly, the large earth bumblebee and the Red tailed bumblebee are common species that have been observed on green roofs in previous studies (Haaland, 2018). Even though many species have specific host plants they need to survive, and the plant choices can be very specific, the same plants are often host plants or beneficial for other vertebrates as well. By focusing on one specific species many others will therefore be included. The red listed species have been selected based on a number of parameters. Except for being red listed they have also been observed in relevant places in Gothenburg and some of the required plant species or landscape can be fulfilled on the green roof on the project site.

Scabious mining bee
Guldsandbi
(Andrena marginata)

The scabious mining bee is a solitary bee that builds their home in piles of sand. Their host plants are Ängsvädd (Succisa pratensis) and in some cases Åkervädd (Knautia arvensis). These flowers are very important for most pollinary species, and therefore very beneficial for biodiversity. A large amount of the flowers are however needed to provide the pollination needed for the bees (Larsson, 2006).

Silver spotted skipper
Silversmygare
(Hesperia comma)

The silver spotted skipper is a red listed butterfly that has been spotted and reported in Välen three times during 2020. The caterpillar has a few host grass plants such as Rödsvingel and Fårsvingel. The full grown butterfly can collect nectar and pollen from several flowers, such as Åkervädd (Knautia arvensis) and flowers from the Centaurea and circum genuses (Artportalen, 2021).

Small blue
Mindre blåvinge
(Cupido minimus)

The Small blue is depending on the host plant Getväppling (Anthyllis vulneraria) to survive, but has also been reported to use käringtand, Lotus corniculatus as a host plant. Getväppling is decreasing and thereby the small blue, due to the loss of areas of dry meadows. Even though host plants are crucial for the survival of the butterfly, it can also gather nectar and pollen from other flowers aswell. (Artportalen, 2021).

Common brimstone
Citronfjäril
(Gonepteryx rhamni)

The Common brimstone is depending on the host plant Brakved (Frangula alnus) in which it lays eggs. It is one of the butterflies species in Sweden which lives longest and is in hibernation during the butterfly stage. It is therefore dependent on spring plants such as Sälg (Salix caprea) and Tusilago (Tussilago farfara) when they start to fly in spring (Artportalen, 2021).

Peacock butterfly
Påfågelöga
(Inachis io)

The host plant for the Peacock butterfly is, as well as many other butterfly species in Sweden, the Stinging nettle (Urtica dioica), but as the common brimstone it flies early in spring and is therefore also dependent on early spring plants. As most butterflies in Sweden it gathers nectar and pollen from red and blue flowers during summer (Artportalen, 2021).

Red tailed bumblebee
(Bombus lapidarius)

Large earth bumblebee
(Bombus terrestris)

There are about 40 species of bumblebees in Sweden, and most of them have similar needs. They like to build their nests in the ground or in pre made holes in dead wood. They gather pollen and nectar from all sorts of flowers depending on the length of their tongues. The Large earth bumblebee has a very short tongue and is therefore a specialist of clovers (Jordbruksverket 2021).

200 m

500 mm
deep sand

Scabious mining bee
Guldsandbi
(Andrena marginata)

P

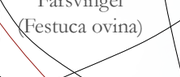
N

Åkervädd
(Knautia arvensis)

Ängsvädd
(Succisa pratensis)

Blåklint
(Centaurea cyanus)

Fårsvingel
(Festuca ovina)



Rödsvingel
(Festuca rubra)

Silver spotted skipper
Silversmygare
(Hesperia comma)

Common brimstone
Citronfjäril
(Gonepteryx rhamni)

Tussilago
(Tussilago farfara)

Rödklöver
(Trifolium pratense)

Slåtterfibbla
(Hypochaeris maculata)

Rödklint
(Centaurea jacea)

Getväppling
(Anthyllis vulneraria)

Small blue
Mindre blåvinge
(Cupido minimus)

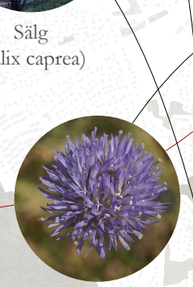
Found in a few
places around
Gothenburg

Peacock butterfly
Påfågelöga
(Inachis io)

Kärringtand
(Lotus corniculatus)

P & N

Sälg
(Salix caprea)



Blåmunkar
(Jasione montana)

Väddklint
(Centaurea scabiosa)

Brakved
(Rhamnus frangula)
Found in Ruddalen

Brännässla
(Urtica dioica)

Blåklocka
(Campanula rotundifolia)

Found in Välen

Vitklöver
(Trifolium repens)

Gråfibbla
(Hieracium pilosella)

Ljung
(Calluna vulgaris)

Lingon
(Vaccinium vitis-idaea)

P & N

Blåbär
(Vaccinium myrtillus)

Fetbladsläktet
(Phedimus)

Flockfibbla
(Hieracium
canadense)

P & N

Large earth bumblebee
(Bombus terrestris)

Found in
Botanical garden

Blåeld
(Echium vulgare)

Sommarfibbla
(Leontodon hispidus)

Red tailed bumblebee
(Bombus lapidarius)

Found in Välen

Project site

Intersection of urban and nature

Frölunda Kulturhus is an interesting building in many aspects, and one of them is the way it is located. The nature in the North and the open areas in the east are abruptly cut off by a concrete square and the asphalt and concrete area of Frölunda Torg and the highway in the south. The building lies in the intersection of the two variating environments, where the landscape is sculpting the look of the building. It is a three storey high but the roof is always close to the ground due to the terrain.

In the east of the building is the area called “Positivparken”. It consists of a mixture between open grassy lawns and deciduous trees. It is unclear what the exact species of deciduous trees there are, but the ones counted as deciduous are Elm, Ash, Beech, European or common hornbeam, Oak, Sweet Cherry, Linden and Maple trees. The forest has an important role in terms of biodiversity, since many species are depending on the deciduous forest to survive. The biodiversity value is greater when the forest and the trees are old, and it is therefore important to keep old trees in the urban environment (Skogsstyrelsen, 2020). The pine forest in Ruddalen also has an important role for many different species, where some butterflies for example have the Pine tree as their host plant.

Impermeable, urbanized areas

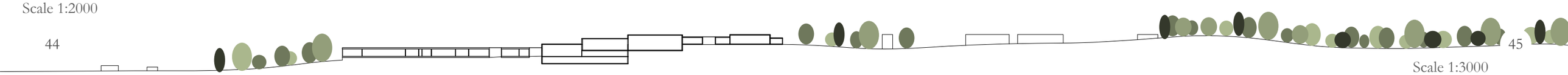
Open grassy areas with Deciduous forest

Pine forest and Deciduous forest

Positivparken

Frölunda Torg

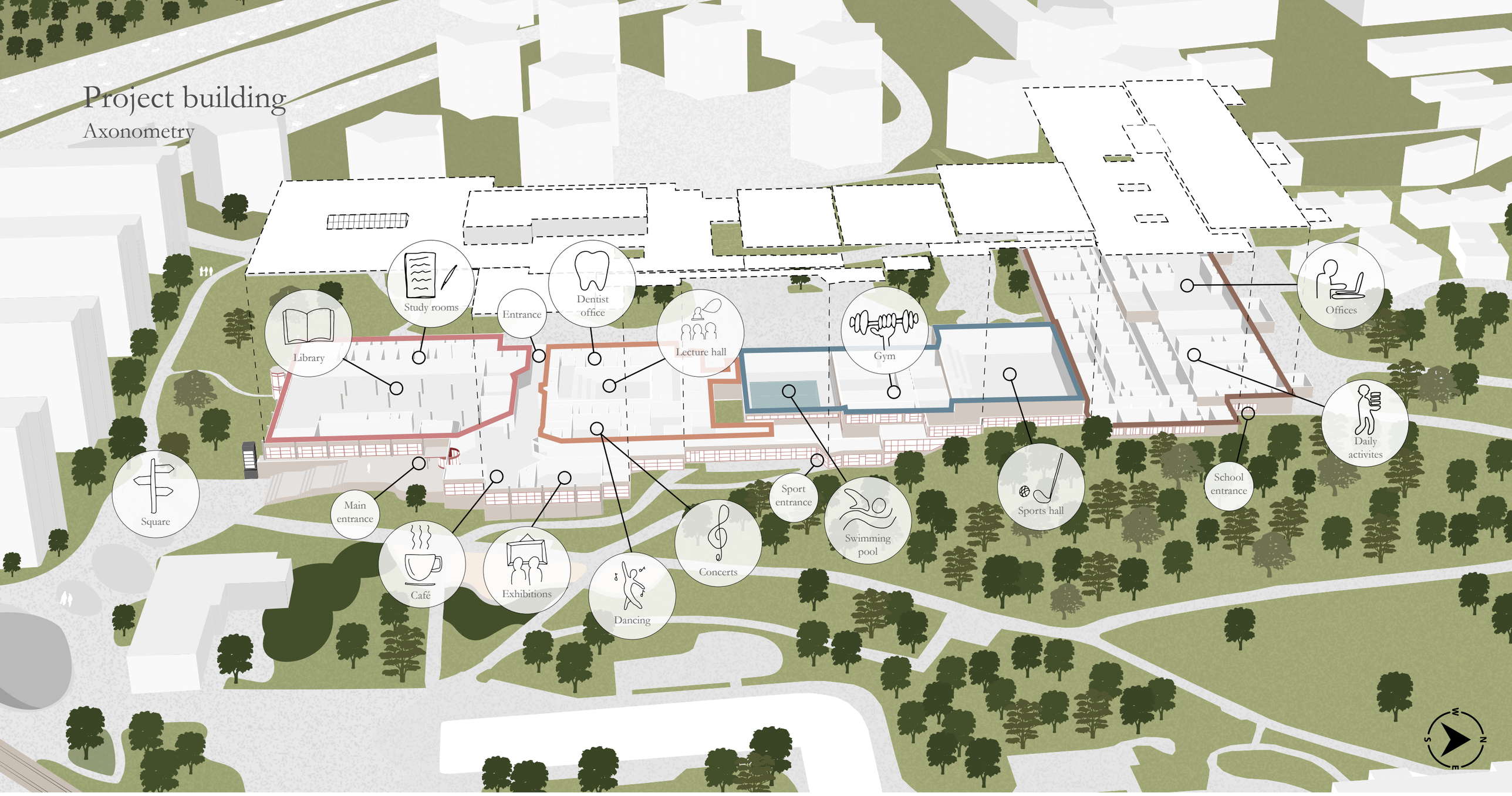
Scale 1:2000



Scale 1:3000

Project building

Axonometry



Frölunda Kulturhus

Frölunda Kulturhus was built in 1977 and is a large three storey building. There is an indoor street along the eastern side of the building. The idea of corridor along the windows is that it should be easy to navigate and find the different functions and blocks. Next to the building is the large park called "Positivparken" with playgrounds, and large open areas.

CULTURE BLOCK

The culture block consists of a library with study rooms and an exhibition room. The library is hosting many different events, such as study help and readings.

GATHERING BLOCK

The gathering block has different rooms for meetings and gatherings and a large two floor lecture hall. The rooms are used for activities such as dancing and music performances.

SPORT BLOCK

The sport block is located within three floors of the building with a bath house, a gym and a sports hall. The entrance to the sport block is located to the east of the building.

OLD SCHOOL BLOCK

The school "Frölunda Gymnasiet" used to be located within the school block. The old facilities are still there, but is now accommodating offices and a place for people with function variations to perform daily activities.

Project building
Flow of people

Frölunda Kulturhus is a very special and important building that contributes to the community both on a local and city scale. It hosts many different events for a large variation of target groups. In the culture and gathering blocks of the building there are several activities every week. Most of them are related to culture, for example evenings with dancing and concerts, both in the café and in the lecture halls. The sport block is also inviting to the public with many different activities, such as swimming classes and games in indoors sports like handball and floorball. The activities are however a bit hidden from the outside due to the main indoor street and the positioning of the blocks behind the light and open street. There are also issues with the connections within the building. The main entrance with a reception, café and a large flow of people seems to be very disconnected from the activities in the old sports block that only accommodates private activities such as offices and daily activities for people with function variations. The green roof therefore holds a great potential of making the activities inside the building and on the roof more visible to the public. It can also connect the people and activities within the building on the roof, and connect people with nature.

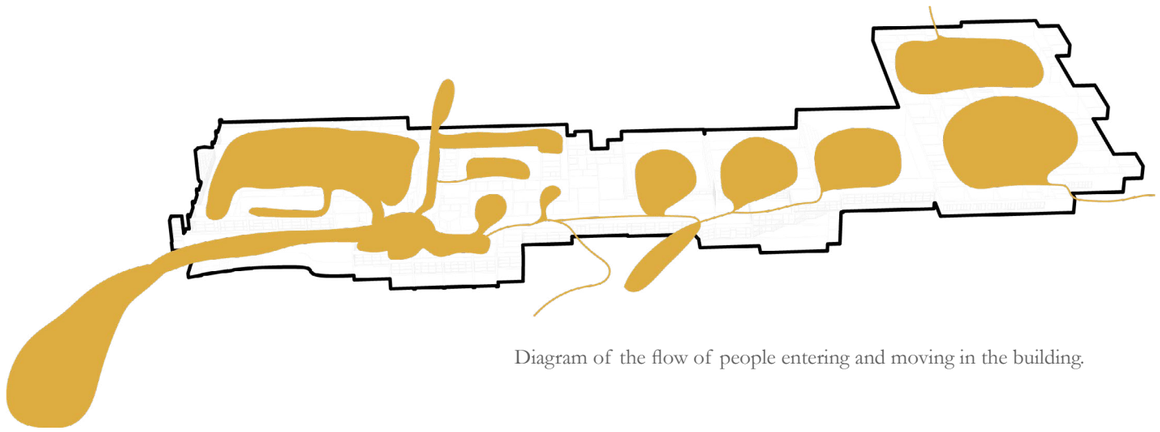


Diagram of the flow of people entering and moving in the building.

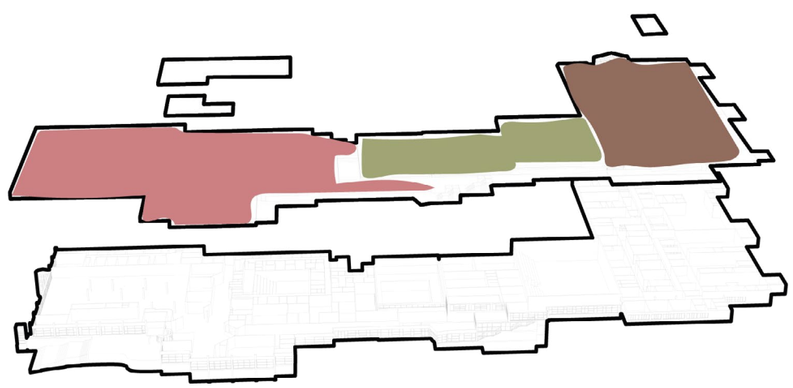
5.

DESIGN PROPOSAL

Butterfly meadows
Entrance from lecture hall
Butterfly pavilion
Elevator from the ground
Solitary bee meadows
Greenhouse classroom
Farming
Entrance from old school block
Daily activites
Fruit guilds
Outdoor serving
Herb greenhouse
Workshop room
Butterfly meadows
Main roof street
Staircases and elevators
Bumblebee meadows
Elevator from the ground
Spiral staircase

Overall structure

The main concept of the project is to increase biodiversity in vertebrates, with a focus on butterflies and bees, and to increase and encourage learning from nature and farming. The roof has been divided into three different areas, with butterflies in the south of the building, a focus on wild bees and bumblebees over the sports block and public urban farming in the north of the building. The butterfly meadows and the public farming is accessible to people, while the meadows for the bees are only accessible for insects. There are five entrances to the roof, both from the ground and from inside the building. The main entrance to the roof is located on top of the main entrance of the building where the roof can be reached by a spiral staircase. There is also an entrance from the second floor of the large lecture hall and from the old school block. It is possible to reach the roof directly from the ground through two elevators, where one is located from the parking area in the west of the building and the other can be accessed next to the main entrance of the school block.



Added flows

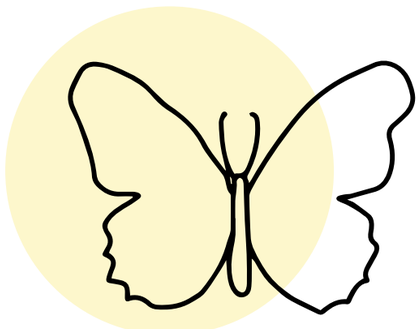
The roof square is placed right above the building entrance and connected with a spiral staircase. Since most of the people who enter the building do so from the main entrance there is already a natural meeting point around the staircase. The largest flow of people on the roof will most likely be in the entrance room, in the pavilion and in the outdoor serving of the café. The roof street is located on top of the main indoor street and connects the butterfly area with the public urban farming with both stairs and elevators. The three public entrances to the roof are the spiral staircase and the two elevators from the ground. The entrance from the lecture hall and the old school block are more private, and more likely to be used by the people using the facilities in the building.

Exsisting flows

Added flows

Rooftop landscapes

Species and needs

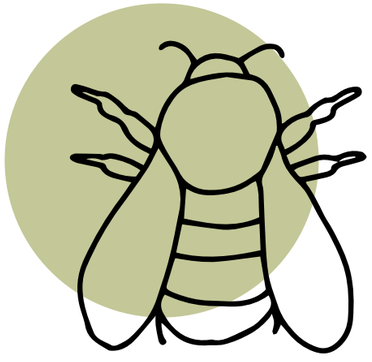


Butterfly meadows

Since different butterfly species requires specific host plants to lay their eggs in and for the caterpillars to eat from, it is impossible to cover all relevant species on one single roof. The butterfly meadows therefor puts focus on the Silver spotted skipper, the small blue, the common brimstone and the peacock butterfly. To benefit more species of butterflies, there are also some general host plants on the meadow that can cover many different species. The meadow with a focus on the fully developed butterfly is more general with a focus on red and blue flowers for nectar and pollen. Since the butterflies lays their eggs on the host plants their need for natural elements such as piles of rocks, dead wood and piles of wood are more relevant to their hybernation during winter.

Solitary bee meadows

The main focus on the wild bee meadows is to promote solitary bees, and especially the Small Scabious mining bee. Many solitary bees are depending on specific host plants to gather pollen from, but can collect nectar from other flower families as energy for flying. Many of the solitary species are mining bees, which means that they dig out their nest in earth or sand and lay their eggs in tunnels and branches in the ground. Some of the wild bees also create their nest in elements such as bamboo sticks and dead wood.



Bumblebee meadows

The needs of the bumblebees are often more general and similar between the different species. The flowers needed are depending on the lenght of their tounge, where the bumblebbes with short tounges are visiting flowers with short corollas. The white clovers (Trifolium repens) is an example of an important flower with a short corolla. Bumblebees wake up early in the spring and fly for a long time during autumn, and is therefor depending on a large variations of flowers during the season. They prefer to create their colonies in dark and warm places.

Rooftop landscapes

Areas and vegetation

Butterfly meadow

- Focus on red and blue nectar and pollen flowers for butterflies

Natural elements:
Piles of rocks, dead wood, piles of wood

Butterfly meadow

- Focus on host plants for the eggs and catterpillars of butterflies.

Solitary bee meadow

- Dry, sandy meadow with flowers for solitary bees.

Natural elements:
Areas with open substrate, bamboo, piles of sand, dead wood.

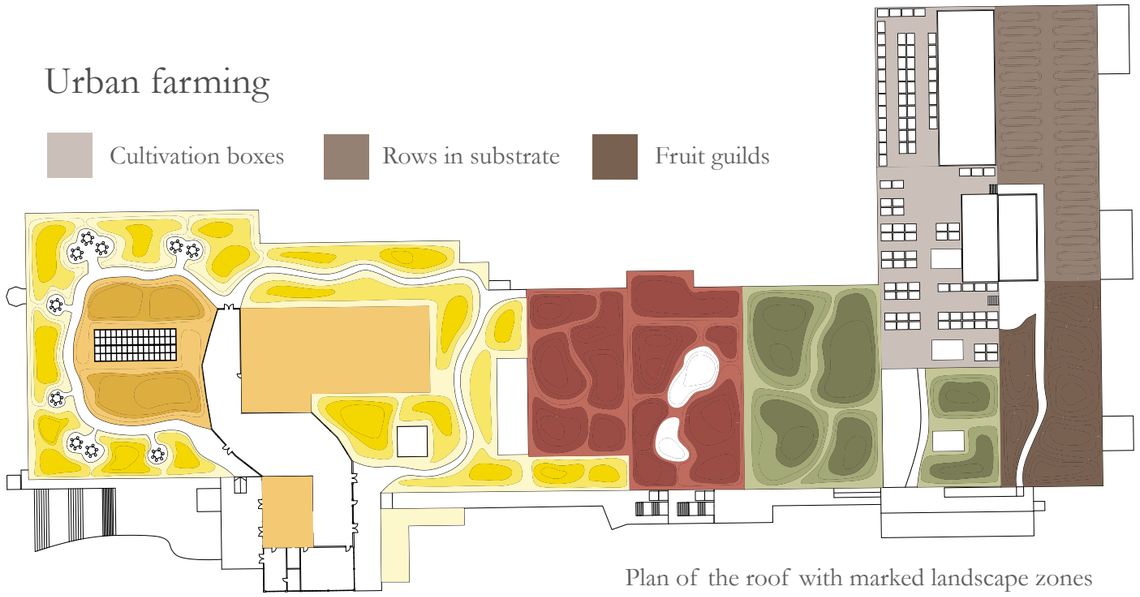
Bumblebee meadow

Nectar and pollen flowers for bumblebees.

Natural elements:
Areas with open substrate, bamboo, up-side down pots, dead wood

Urban farming

Cultivation boxes | Rows in substrate | Fruit guilds

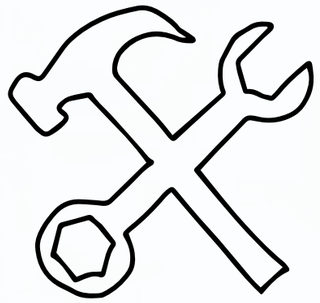


Plan of the roof with marked landscape zones

Butterfly focus

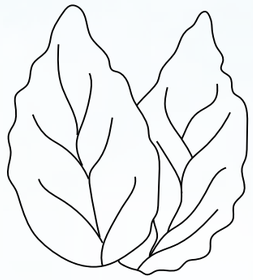
Section and plan

The entrance room is an added building on the roof which consists of the entrance hall with the spiral staircase, a greenhouse with a workshop room and a herb greenhouse. The butterfly pavilion is connecting the new building with the existing floor with the lecture hall and a fan room. An entrance has been added to the lecture hall to make the roof more accessible from within the building, and to connect the activities in the gathering hall with the roof. The lecture hall could for example be used as a meeting point for school classes visiting the butterfly pavilion and participating in workshops. The addition of the building is connected to the focus on knowledge and learning, where for example the activities in the library could be extended to the roof and vice versa.



The Workshop

The workshop room can be used both as a classroom to perform workshops related to the exhibition pavilion and insects, for example building an insect hotel or creating models of butterflies, but also for other activities in the building and on the roof.

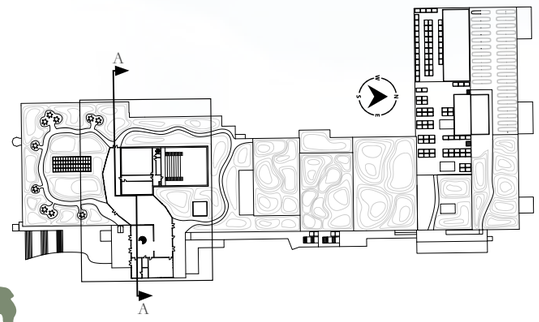


Herb greenhouse

The small greenhouse is a place for the café in the building to grow herbs in a sustainable and easy way. The main urban farming is located in the north of the building, but the small greenhouse could also be used to harvest the fully grown plants from the public urban farming for the staff in the café in a more efficient way during working hours. A tomato plant grown in the main greenhouse in the public urban farming area could for example be moved to the small greenhouse when the tomatoes are ready to be harvested.

Butterfly pavilion

The shape of the butterfly pavilion is inspired by the life cycle of a butterfly, with the closed and warm shape of the egg transforming into the caterpillar, pupa and the butterfly that rises and flies away. The pavilion is an exhibition hall with information, art and interactive activities related to butterflies. The main target group are families with children and groups of school children. There are also areas in the pavilion with exhibitions of crafts made by the visiting children in the workshop room.



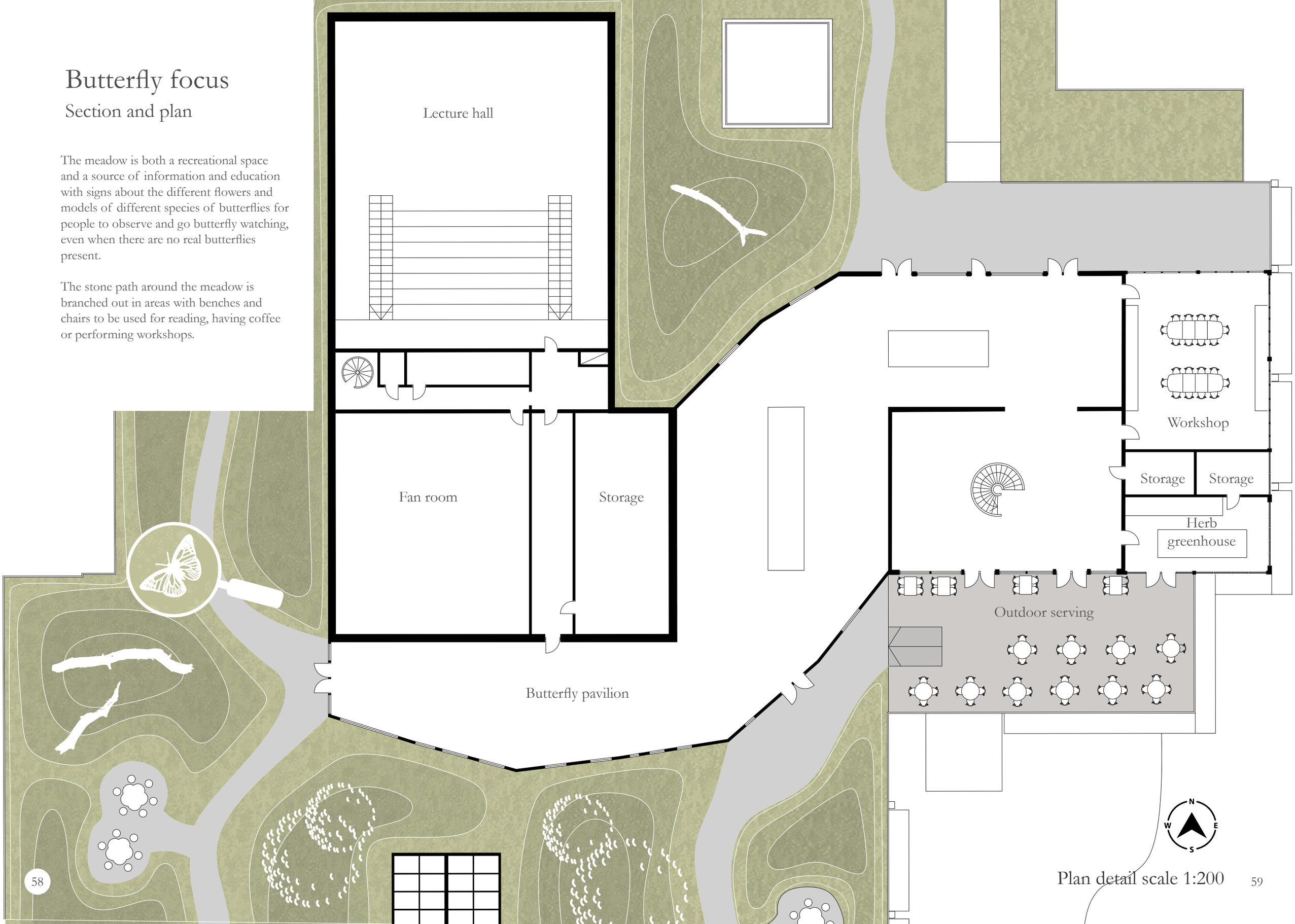
Section A-A Scale 1:200

Butterfly focus

Section and plan

The meadow is both a recreational space and a source of information and education with signs about the different flowers and models of different species of butterflies for people to observe and go butterfly watching, even when there are no real butterflies present.

The stone path around the meadow is branched out in areas with benches and chairs to be used for reading, having coffee or performing workshops.



Plan detail scale 1:200

Wild bee meadows

Timeline

The bumblebee queens wake up in early spring when the Sälg tree starts to bloom. She is tired and dissoriented, flying close to the ground in search of a place to start her colony (Jordbruksverket 2015).

When the queen has found her new home, which is usually pre made holes in the ground, abandoned bird nests or man made homes like upside down terracota pots on the ground, she lays the eggs of the first workers.

When the first workers are hatched the queen stays in the nest while the workers collect pollen for the colony. (Naturskyddsföreningen, 2021).

Flowers like Vitklöver (Trifolium repens) are important for the short tounged bumblebees.

When the colony is large enough the queen chooses a few eggs that will get more food and attention from the colony. These bees will be the new queens. The queen also lay unfertilized eggs that developes into males (Naturskyddsföreningen, 2021).

The scabious mining bee (Andrena marginata) developes into the stage Imago from larvea and starts flying.

The mating season begins, where the male s and the new queens leave their nest to find a partner. When the new queens are fertilized they finds a place to hybernate during winter. The male bees die after the mating season.

The worker bees and the queen dies in the autumn when the new queens and males has left the nest.

The female bee finds a sunny and protected area with sand and digs tunnels with branches for her eggs.

The bee collects pollen from Ängsvädd and creates ca. 20 lumps in the branches in the tunnel. She lays one egg on each lump and closes the branches. The larva eats the pollen and turns into a pupa that lives in the ground during winter.

The male bumblebees starts to fly and gets ready for the mating season.

The male only flies in the beginning of the season and his only function is to fertilize the female.

March · April · May · June · July · August · September

Sälg (Salix Caprea)

Lavendel (Lavendula)

Styvmorsviol (Viola tricolor)

Blåbär (Vaccinium myrtillus)

Brudbröd (Filipendula Vulgaris)

Lingon (Vaccinium vitis-idaea)

Vitklöver (Trifolium repens) and Sandnejlika (Dianthus arenarius)

Prästkrage (Leucanthemum vulgare)

Blåeld (Echium vulgare)

Käringtand (Lotus corniculatus), Gul fetknopp (Sedum Acre), Gulmåra (Galium verum)

Åkervädd (Knautia arvensis)

Rödklöver (Trifolium Pratense)

Getväppling (Anthylis vulneraria) and Gräfibbla (Hieracium pilosella)

Blåmunkar (Jasione montana)

Färgkulla (Cota tinctoria)

Bläklint (Centaurea cyanus)

Rödklint (Centaurea jacea) and Väddklint (Centaurea Scabiosa)

Backtimjan (Thymus serpyllum), Kungsmynta (Organum Vulgare) and Ljung (Calluna vulgaris)

Stor blåklocka (Campanula persicifolia)

Sommarfibbla (Leontodon hispidus)

Liten blåklocka (Campanula rotundifolia)

Flockfibbla (Hieracium canadense) and Gulsporre (Linaria Vulgaris)

Ängsvädd (Succisa pratensis)

Kärleksört (Hylotelephium telephium) blooms until november

The Sälg tree located in the butterfly meadows is an important source of pollen in spring for many species.

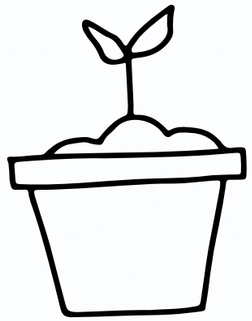
For a small population of Scabious mining bee to survive approximately 200 flowers of Ängsvädd i required.

The wild bee meadows are planned to fulfill the needs during the entire life cycle of the bumblebees and the scabious mining bee with both preferred flowers and possible nesting areas both for their nest and for their hibernation in winter. The life of the Large earth bumblebee, the red tailed bumblebee and the Scacious mining bee all lasts over one season, where the bumblebees wake up in early spring and die in the autumn and the Scabious mining bee only flies in the end of the season. The bumblebee queens however go into hibernation as full grown bees in the imago stage already fertilized, while the scabious mining bee is hibernating as larvae. Even though these two types of bees fly at the same time during late summer, they mostly require different kinds of flowers and the risk of competition for pollen access is lower between the bumblebees and solitary bees than between the two bumblebee species that have the same needs.

Public urban farming

Perspective

The public urban farming area has a focus on knowledge and learning about urban food production. There are four types of farming which are farming in substrate, in greenhouses, in cultivation boxes and with fruit guilds, which is a way of co-planting around a fruit tree with plants with different functions that together creates a mini ecosystem. There are several different ways of farming on the roof because the different methods are most optimal for specific crops. Crops like tomatoes and cucumbers prefer the hot climate in the green house while kale and radishes can grow in a colder climate in the substrate. The cultivation boxes offer a more controlled farming, where for example every school in the surrounding area or people interested in farming could have a number of boxes to take care of during a season. The people in the daily activities could have farming on the roof as a daily activity, where they could be responsible for the crops and sell locally produced food to nearby restaurants and cafés. They could also be involved in helping the visiting children with their crops, or work with vegetables and herbs for the café inside the building.

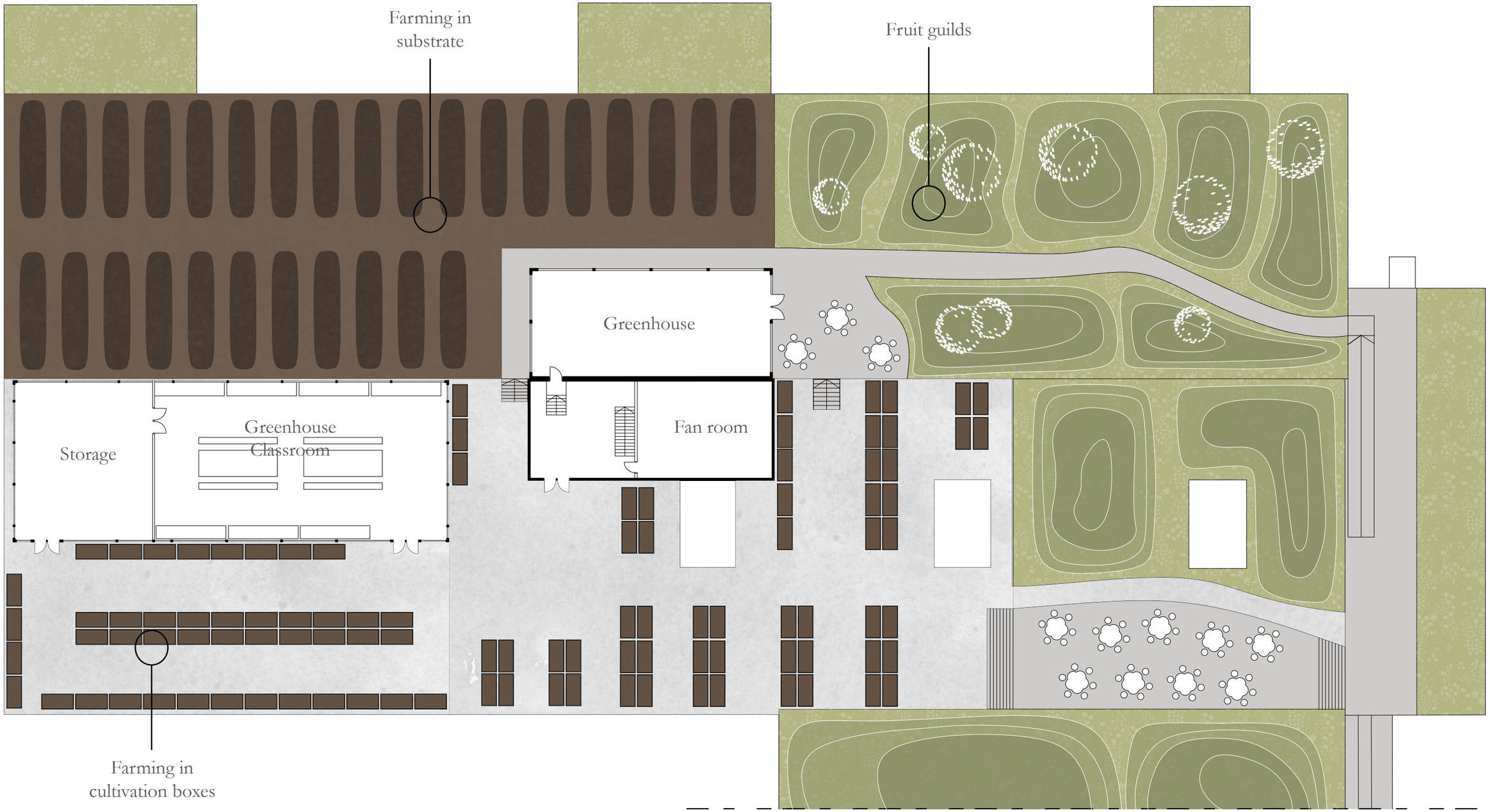


Greenhouse classroom

The greenhouse classroom is a place for school children to come and learn about farming and nature and practice planting with a professional. It could also act as a place for hosting evening courses in urban farming, or as a workshop place where people could come and bring their own plants to change pots and soil or trade plant parts with each other. Teaching about local food production in the city and how to grow crops on a small scale could help people to get a better understanding of where the food comes from, and how important it is to reduce the transportation and waste.

Public urban farming

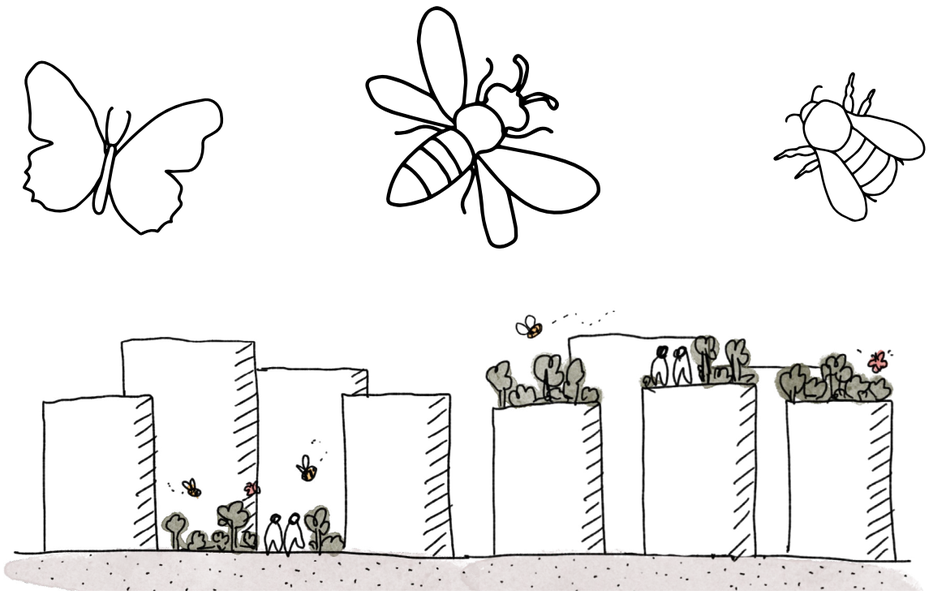
Plan



Plan scale 1:300

6.

REFLECTIONS



This project has taught me what great potential a green roof can have and how we need to plan and build with biodiversity as a factor. It is easy to believe that adding vegetation will increase biodiversity automatically, and forget that different species have different needs in terms of food and protection. A lot can be done on existing rooftops, but there are many species that are unable to access a roof and the actions to increase biodiversity therefore need to be present on the ground as well. This can be done by e.g. replacing grassy lawns with flowering meadows and by keeping dead wood and other natural elements in the urban environment. In this project I have focused on divided areas with focuses on wild bees and butterflies, but another approach would be to work with mixed ecological systems and investigate how those systems interact with each other.

There are also factors in the project that would be interesting to work more with, such as more detailed information about the green roof structure and how the green roof can affect the energy consumption within the building.

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Appendix 1.1

	Scientific name	Swedish name	English name
Lundberg (2014)			
	Apis	Honungsbi	Honeybee
	Gonepteryx rhamni	Citronfjäril	Common Brimstone
	Formica rufa	Röd skogsmyra	Red wood ant
	Syrphidae	Blomfluga	Hower fly/ flower fly
	Bombus lucorum coll.	Jordhumla	Large Earth bumblebee
	Bombus lapidarius	Stenhumla	Red-tailed bumblebee
	Musca domestica	Husfluga	Housefly
	Psyllobora vigintiduopunctata	Tjugotvåprickig nyckelpiga	22 spot ladybird
	Coccinella septempunctata	Sjuprickig nyckelpiga	7 spot ladybird
	Odonata	Trollslända	Dragonfly
Haaland (2017)			
	Aglais io	Påfågelöga	European peacock
	Bombus vestalis	Sydsnyltshumla	Vestal cuckoo bumblebee
	Bombus lapidarius	Stenhumla	Red-tailed bumblebee
	Bombus lucorum coll.	Jordhumla	Large Earth bumblebee
	Bombus norvegicus	Hussnyltshumla	Cuckoo bumblebee
Haaland (2018)			
	Bombus lapidarius	Stenhumlor	Red-tailed bumblebee
	Bombus lucorum coll.	Jordhumlor	Large Earth bumblebee
	Bombus hypnorum	Hushumla	Tree bumblebee
	Pieridae	Vitvingar	Pieridae
	Aglais io	Påfågelöga	European peacock
	Syrphidae	Blomfluga	Hower fly/ flower fly

Appendix 1.2

	Scientific name	Swedish name	Comments
Haaland (2018)			
	Phedimus	Fetbladssläktet	Many Red-tailed bumblebees
	Origanum vulgare	Kungsmynta	
	Echium vulgare L.	Blåeld	Many Large earth bees and hoverflies
	Lavandula angustifolia	Lavendel	
	Sedum album	Vit fetknopp	
	Trifolium arvense	Harklöver	
Malmö stad (2015)			
	Echium vulgare L.	Blåeld	
	Lavandula angustifolia	Lavendel	
	Anthemis tinctoria	Färgkulla	
	Origanum vulgare	Kungsmynta	
	Veronica spicata	Axveronika	
	Trifolium pratense	Rödklöver	
	Trifolium repens	Vitklöver	
	Achillea millefolium	Rölleka	
	Phedimus spurius	Kaukasiskt fetblad	
	Lotus corniculatus	Käringtand	
	Sedum album	Vit fetknopp	
	Vicia cracca	Kråkvicker	
	Lythrum salicaria L.	Fackelblomster	
	Centaurea jacea L.	Rödklint	
	Sedum acre L.	Gul fetknopp	
	Geranium	Nävor	
	Myosotis scorpioides	Äkta förgätmigej	
	Linaria repens	Strimsporre	
	Verbascum nigrum L.	Mörkt kungsljus	
	Calendula officinalis L.	Ringblomma