Growing dwellings

The explorative design of a dwelling supporting biodiversity

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This research has two main purposes: (1) to show the quality of dominant nature, above man and (2) to demonstrate the investigation of biodiversity in a city environment both by designing a prototype of a dwelling.

The city environment, in this case, is Amsterdam; the dwelling is designed in the Jordaan. The location is chosen because this neighborhood has a low amount of biodiversity and inhabitants have difficult access to surroundings with a high amount of biodiversity. Ecology, a dynamic interaction between environmental factors, organisms, geography, and abiotic factors, is part of the integration of biodiversity in architecture. These subjects change the architecture of the prototype. Abiotic factors such as wind, sun, temperature, can affect the growth of the organism, but also influence the living conditions. The ecological flow and ecological management make influences on the ecology. Organism arrowing on nutrients and sunlight are the main ingredients to reach the purpose of the research.

The use of a combination between quick growing and slow growing plants, trees, and mycelium in conjunction with an open construction is the concept of the design. This open construction made of not living natural organism stimulates the growth of the quick and slow growing plants, trees, and mycelium by stimulating the geography, for example, the air temperature and the quality of the nutrients in the ground. Whereas the ecological flow during the time secures the growth of the organism during the lifespan of the use of the construction, the ecological management by the human users is low. The growing organism slowly overtakes the human-made architecture, the surrounded city environment.

Keywords: Amsterdam, biodiversity, city environment, dwelling, dynamic interaction, ecology, Jordaan, growing, nature, organism, prototype, sunlight.

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Preface

In this research, I investigated in the possibility to create a dwelling consisting of living nature, continually growing in the lifespan of the dwelling. I wrote this research as a part of the graduation process at the TU Delft for my master degree on Architecture. During the writing process, I designed with the conclusions of the research. The design is a prototype of a dwelling to be built in favor of nature, instead of human.

For the research, I am supervised by Nico Tillie. During my research he helped me a lot with both the structure of the research and the complexity of the biological backgrounds of the project. For the design process, I was supervised by Paulien Bremmer. Thanks to a continuous link between the research and the design process these two are well integrated. I would like to thank Nico and Paulien for the excellent cooperation. In the final months of the process Pierre Jennen guided me on the technical aspects of the design project. I would like to thank him for his help as well.

While researching, I interviewed and visited several people for this study. I would like to thank all of them for the inspiration they gave me. Furthermore Bob, Cathelijne and Lelie Radstake in Dalfsen and Ppauw in Wageningen for their hospitality and Tjeerd Veenhoven, Davine Blauwhoff, Hans Kaljee, Ferdinand Ludwig, Beate Bouwan and Thijd de Zeeuw for sharing their knowledge.

I wish you a lot of pleasure reading this thesis.

Lian Blok

Delft, March 3, 2019

Introduction

Last year I went camping in Delfse Hout closeby the university. It was the night before an important presentation which is mostly the moment that people prefer to have a good rest in their own bed. Camping relaxes me. From childhood onwards, I went camping often; with the girl scouts, my parents and for work purposes. The adventurous aspect of camping arouses my interest; searching for a spot to sleep, being surrounded by plants and animals and its primitive qualities, open space for free interpretation and to think in creative solutions that offer comfort. I began to ask myself why camping relaxes, more then a house does. As I started to dive into solutions between camping and living permanently I found plenty of possibilities such as tiny houses, caravans and yurts. All these possibilities are partly similar to the concept of a dwelling, but more integrated with flora and fauna. However, these possibilities are separate objects in nature that do not bring the plants and animals closer to the living environment than to the outer shell, the skin of a house.

Henry David Thoreau, an American ethical philosopher, wrote in an essay in 1851 called 'Walking':
'Life exists with Wildness.
The most alive is the wildest.
Not yet subdued to man,
its presence refreshed him.'
This same unsubdued wildness I find while camping. Having to work with the given environment and adapting to changing circumstances refreshes me. I find the positive effects of being in nature enormous.

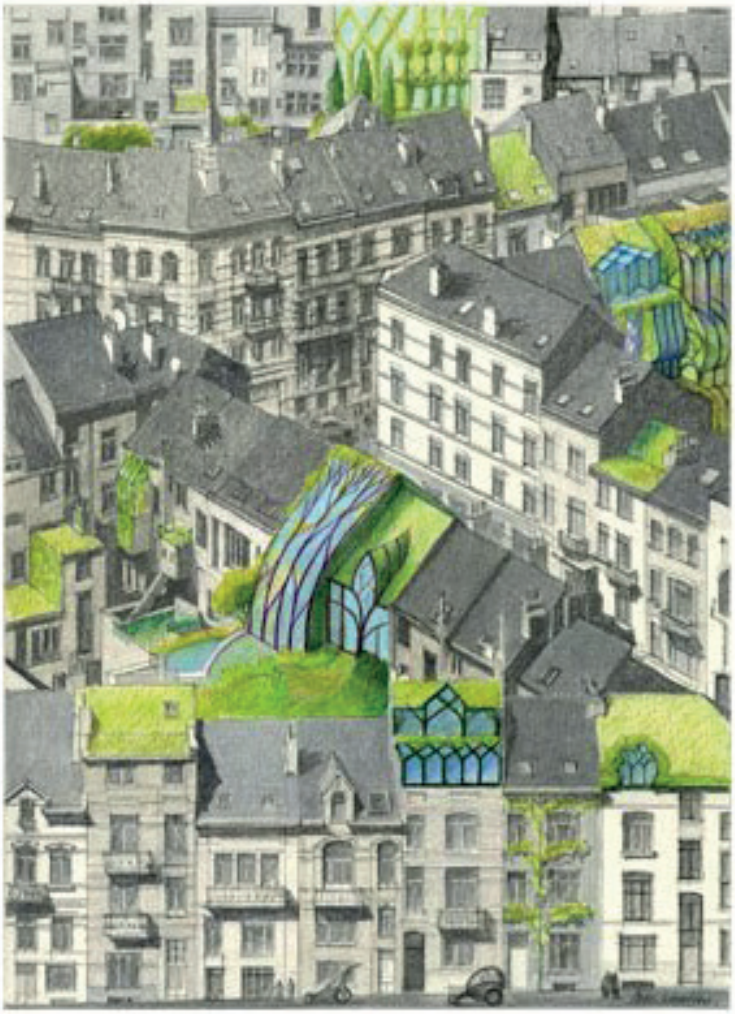
More than half of the population in the world is living in urban area's at the moment (Ritchie & Roser, 2018). This point has already bean reached in 1870 in Western Europe (Schilthuizen, 2018). Focused on the Netherlands, the amount of green area in the center, is decreasing. A study showed in 2016 that in the center of Amsterdam, within the canals, there is 3,6 m2 green per inhabitant. In comparrison to the outer center of Amsterdam, this is 31m2 (Van Zoelen, 2018). 'De gezonde stadsmonitor', an organization that conducts research into sustainability in Amsterdam, claims that the amount of green space has decreased by 1m2 between 2015 and 2016 (De Broekert, 2018). Next to the decreasing amount, Inhabitants from Amsterdam must travel the furthest distance, in comparison to other inhabitants in the Netherlands, to have access to recreative green area. Recreative green area is nature where the access is public (Bezemer et al., 2002). Also this area is decreasing. There is 7,5 ha less parc than the year before, 7 ha less outdoor sports area and 6 ha less open natural dry terrain (Van Zoelen, 2018). Reducing the amount of green does not only lead to unattractive living environments, but also it has also negative effects for human health. Contact with nature can lead to physiological stress reduction. The effects of a walk through nature were investigated in 1991. It turned out that forty minutes of walking in nature showed more effective and cognitive recovery from stress than test subjects who walked through an urban environment during a similar period or relaxed indoors (Hartig e.a., 1991).

Finally, the decreasing of the amount of green also has an impact on the temperature in the city. Research shows that not only the surface temperature can be 10 to 20 degrees Celsius higher than in the center and outside the center of Amsterdam, but also that the temperature differences between day and night are smaller than in the center and outside the center. (Van der Hoeven & Wandl, 2013)

We are currently living in an era in which the Earth's climate and atmosphere will change permanently as a result of human activities: the Anthropocene (Berkers & Van den Bergen, 2014). This exploded area, which Dirk Sijmons called the 'urban landscape', is all planned by human. The wildness, the given environment created not subject to human, relaxes me. I aim to design a prototype of a dwelling where the environment in the dwelling change during the time without the management of human. If more dwellings in the center of Amsterdam transform with the same criteria as the prototype does, there will exist a wilder environment. The project aim is shown in image 0.1, the third picture will be the design for the prototype of a growing dwelling. This environment is not yet subdued to man. The wildness can be expressed with a higher amount of biodiversity; biodiversity is the amount of different organism.

The aim of the research is to explore the integration of living nature with the architecture of a dwelling, where the living nature becomes functional in the dwelling. The outcome must provide a benefit to nature, which is expressed with the amount of biodiversity. The benefit should increase during the lifespan of the dwelling.

This research will answer the key question: How can a dwelling contribute to biodiversity in a low biodiverse context? To prove the increasement of nature, the amount of biodiversity is measured. The first subquestion is: what is the ideal location of the prototype of a growing dwelling? The second subquestion is: which biodiversity can be added with a function in the growing dwelling? The third subquestion is: What are the requirements for a prototype of a growing dwelling? The conclusions of the research are the design brief for the prototype of a growing dwelling.



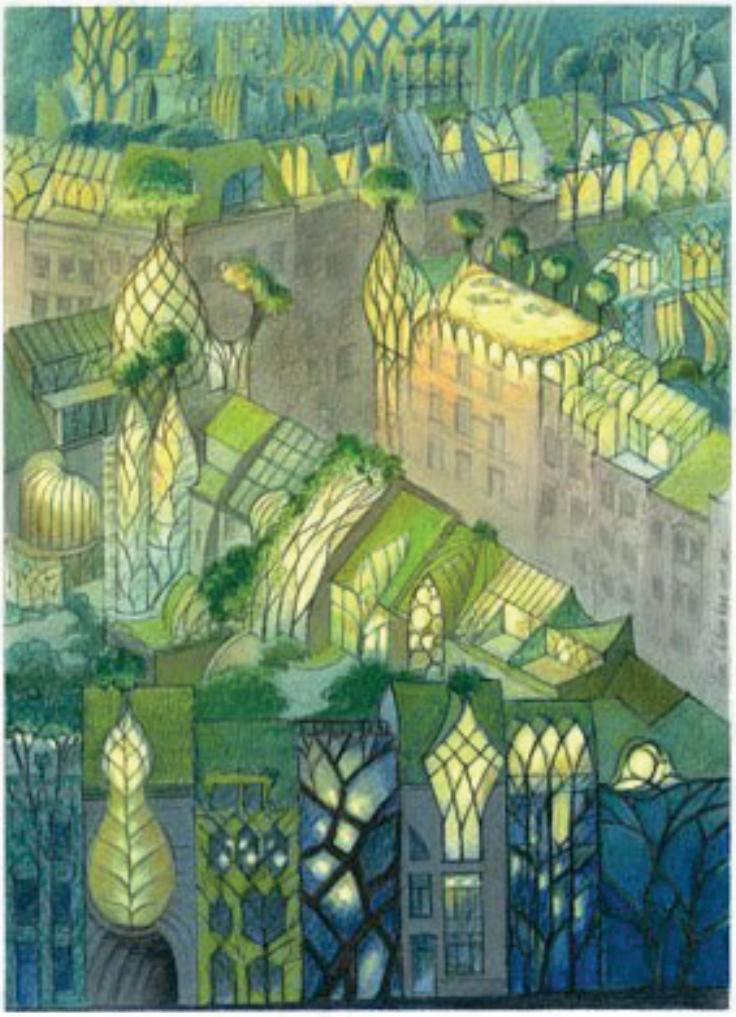


Image 1:
the future of cities by integrate
organism in dwellings
(Schuiten & Labrique, 2009)

Methodology

The main question of the research is: 'How can a dwelling contribute to biodiversity in a low biodiverse context?' The main question divides into three sub-questions. In this paragraph, the chosen methodologies help to answer the subquestions.

1 What is the ideal location of a prototype of a growing dwelling?
This subquestion is the 'where' of the prototype of a growing dwelling. The location of the prototype is essential to show the benefits in the design and the effect on the surrounding. This subquestion uses the data of the municipality of Amsterdam to research the different relationships between different aspects of the biodiversity in Amsterdam.

2 Which biodiversity can have a function in the growing dwelling?
This subquestion is the 'what' of the prototype of a growing dwelling. Interviews with experts have been taken to increase the knowledge on the experimental use of living organism. Literature studies complete the context.

3 What are the requirements for the prototype of a growing dwelling?
This subquestion is the 'how' of the prototype of a growing dwelling. With the help of 12 individuals with, in my opinion, an extreme vision of living close to nature, this subquestion has been analyzed. These 12 individuals live in Dalfsen or Wageningen; both areas in the Netherlands. The observation is based on experiences of the view, the feeling, the smell, and the sound. The focus of the observation is on similarities and differences between their vision on living and usual dwellings in city environments.

The three questions together are the results of the research, which is the design brief of the prototype of a growing dwelling.

Main question :

How can a dwelling contribute to biodiversity in a low biodiverse context?

1 Where

What is the ideal location of a prototype of a growing dwelling? → Location

- data analysis

+

2 What

Which biodiversity can have a function in the growing dwelling? → Practical possibilities

- literature
- interviews

+

3 How

Which biodiversity can have a function in the growing dwelling? → Requirements

- case study based on experience

=

Design brief

1

Ideal location

In this chapter analyze drawings are made to search for a location in Amsterdam to design a prototype of a growing dwelling. A location study shows where a new dwelling in the center helps to expand green area as a start of a transformation in the surrounding into an area with more biodiversity.

Definition growing dwelling: A growing dwelling is a dwelling which consists of living nature, continually growing in the lifespan of the dwelling.

1 Ideal location

1.1 Amsterdam

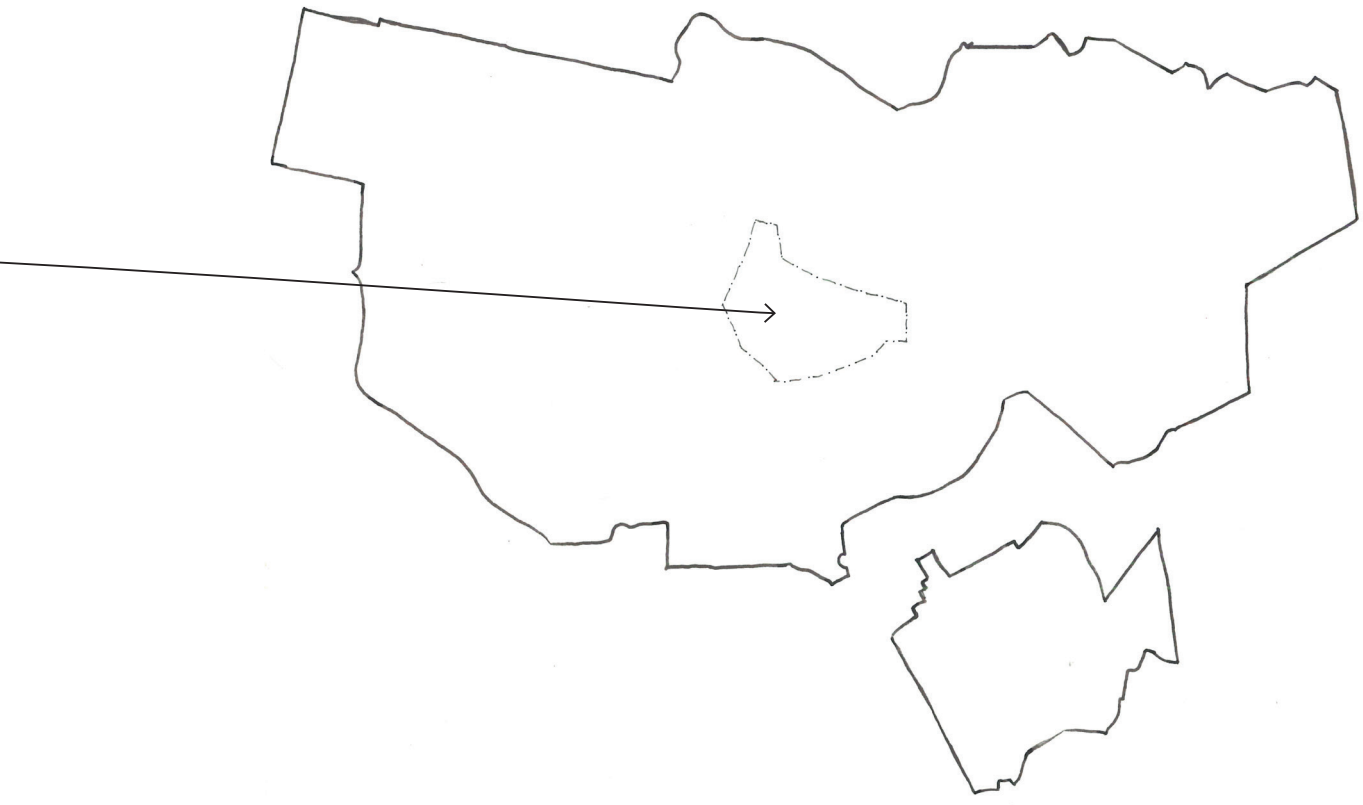
People, homo sapiens, have a dominant role in the ecosystem and the amount of biodiversity in an area (Schilthuizen, 2018). In 2007 there was a crucial milestone in the world. For the first time, more people lived in cities than outside. In Western Europe, this milestone had already reached in 1870. Amsterdam, the largest city in the Netherlands, consists of 821,752 people, this number is still growing. In illustration three the growth of inhabitants and dwellings in Amsterdam is shown in numbers and indicative drawings. In the introduction of the thesis is explained that research shows that residents in Amsterdam have to travel the furthest distance in the Netherlands to have access to public green space.

Illustration 1

Is this not only the distance but also this m2 public green space is decreasing. There exist 7,5 ha less park in Amsterdam than the year before, 7 ha less outdoor sports area and 6 ha less open natural dry terrain (Van Zoelen, 2018).

The ecological vision of Amsterdam (the last version is for the first time in favor of nature instead of human experience) aimed at increasing the chances of survival of nature and animals (Timmermans & Daalder, 2012). Because there is a small budget available by the government, the plans of the government about increasing the biodiversity merge with separate spatial projects, for example, they merge their projects with the provincial state North-Holland, Rijkswaterstaat and Natuurmonumenten (Timmermans & Daalder, 2012). This strategy is not enough, because the amount of green area in the center is decreasing. A study showed in 2016 that the amount of green area per inhabitant of Amsterdam decreased with 1,4 m2. (Van Zoelen, 2018). If homo sapiens change their role in the ecosystem by integrating 'green' architecture in the center, the so-called the quantity 'green area' can increase considerably. In this chapter analyze drawings show the location where the benefits are the biggest with the possibilities of expanding green area by increasing architecture. By this architecture is build in favor of nature.

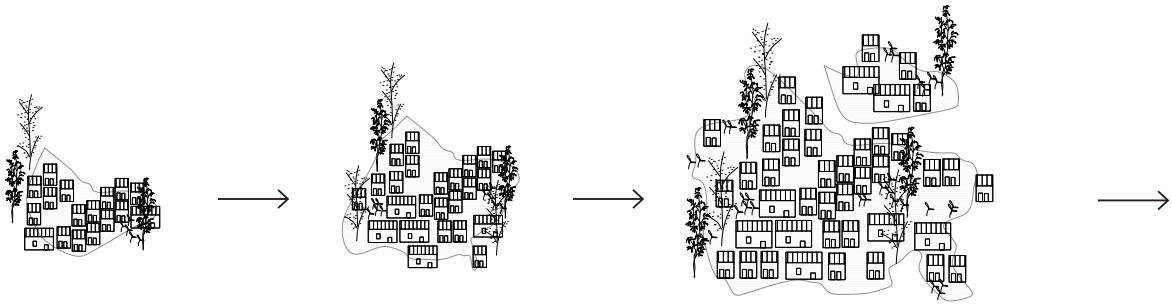
The neighborhood for a prototype of a dwelling existing of nature has to meet the following circumstances:
- Low biodiversity
- Low access to surroundings with high biodiversity



The border of the center of Amsterdam

The border of the municipality of Amsterdam

Illustration 2

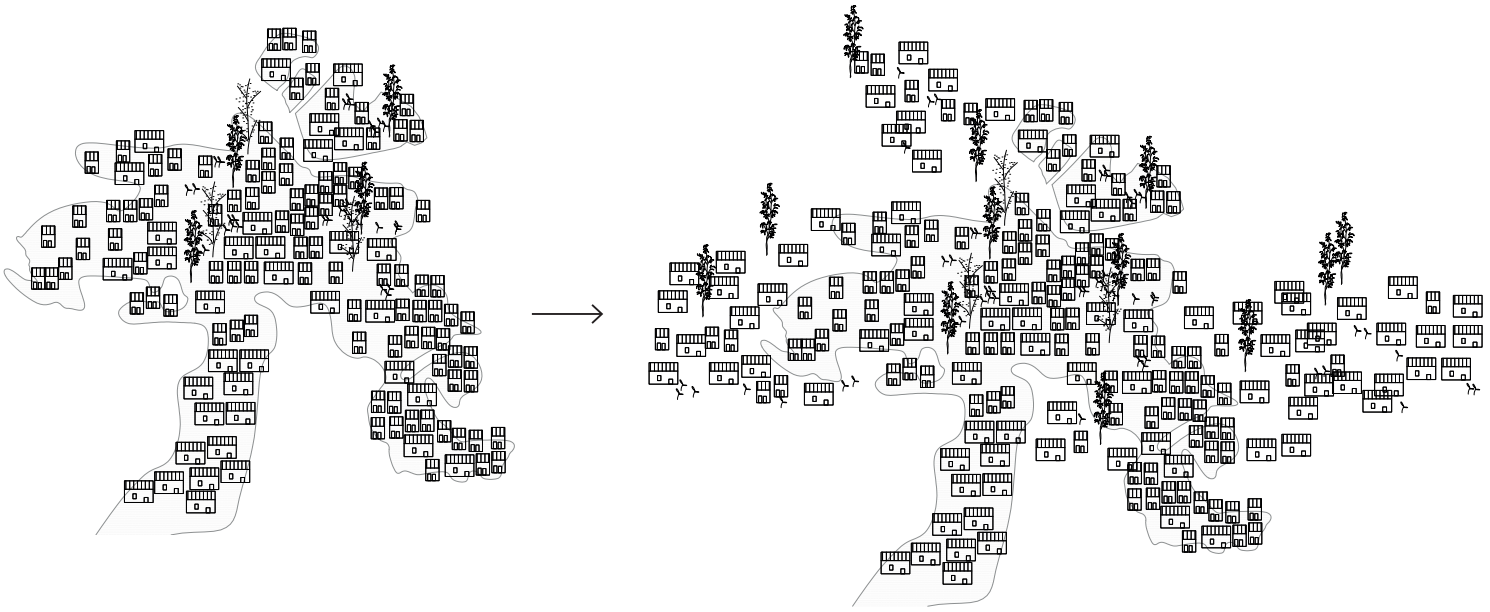


Amsterdam 1850
225.710 inhabitantts
unknown dwellings

Amsterdam 1900
520.602 inhabitants
116.903 dwellings

Amsterdam 1950
835.834 inhabitants
222.823 dwellings

Illustration 3 (Centraal Bureau voor de Statistiek, 2017)

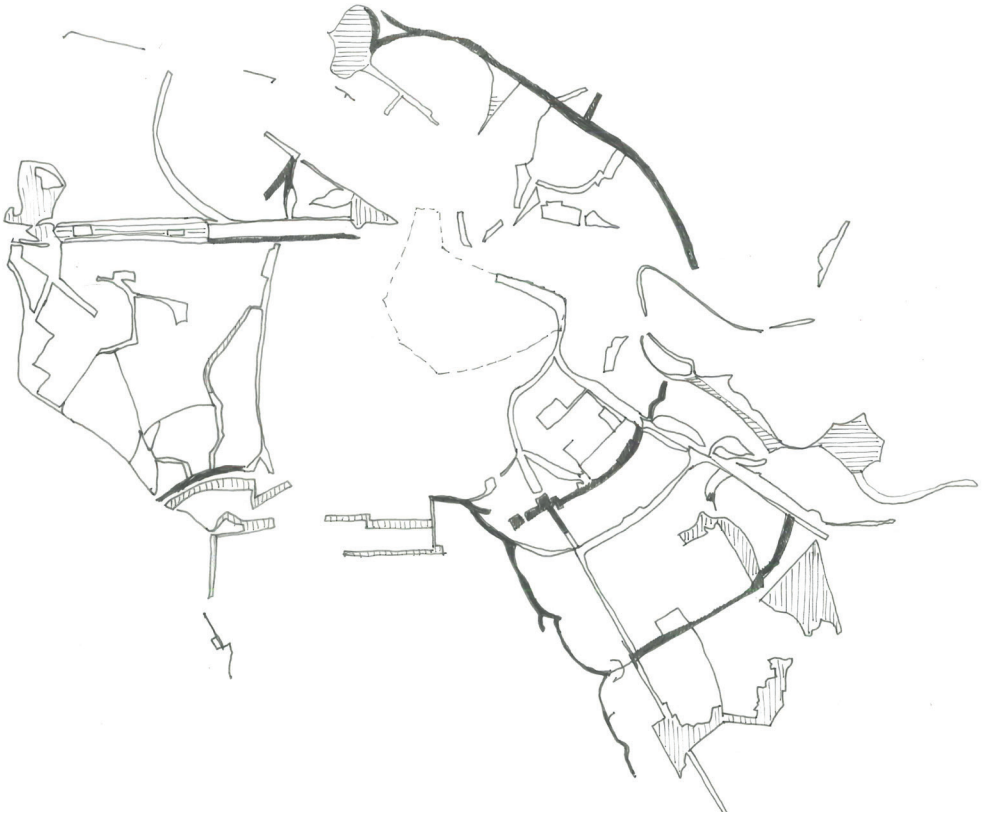


Amsterdam 2000
731.289 inhabitants
369.180 dwellings

Amsterdam 2050
998.248 inhabitants
526.735 dwellings

1.2 Ecological vision of the municipality

Illustration 4 shows the structure of the ecological vision of Amsterdam. This vision explains the focusing area for the government on increasing the chances of survival of flora and fauna. Their plan exists of 170 different connections between the more significant regions where attention. These connections ensure that animals can move from one area to another with different ecological conditions. The living area of flora and fauna is increasing as well as their surviving chances. The government tries to improve these connections before 2040. The municipality works in combination with larger plans from, for example, the provincial state of Noord-Holland, Rijkswaterstaat and Natuurmonumenten. The vision visualizes infrastructure, parks, forests, and rough areas. This given structure is limited to outside the city center.



Infrastructure

Forest/parks

Roughness

The border of the center of Amsterdam

Illustration 4 (Timmermans&Daalder, 2012)

1.3 Protected flora and fauna

In Amsterdam is a list of different species of protected flora and fauna. These species tracked accurately by the municipality of Amsterdam and shown on their site. The size of the dots corresponds to the number of observed species. It can be assumed that if there is high biodiversity, the area has a good ecological condition. The protected animal species require an excellent environmental condition. The number of protected species in an area assume thus the status of the environmental state of an area. The large area without protected biodiversity in the south-west of the map is Schiphol, the largest airport in the Netherlands. Due to air traffic, the environmental state of the area is low. The large area without protected biodiversity in the east is the Ijsselmeer. Most areas with more than 40 species of protected flora and fauna are surrounded by areas where there are 31-40 species of protected flora and fauna. In the center, there is little-protected flora and fauna. In the analyzes on the following pages, a continual link between this drawing and the drawing of the relevant page define possible causes of low or high biodiversity, which is similar as the environmental state of an area.

21-30 protected species

31-40 protected species

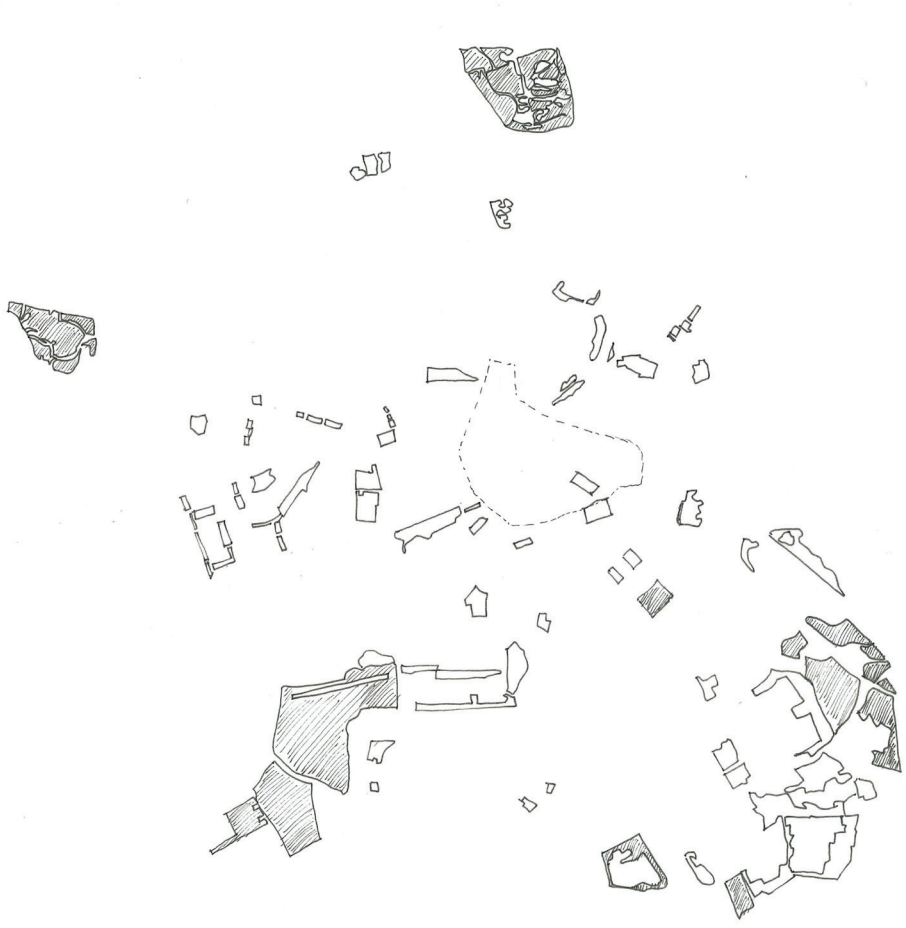
>40 protectes species

The border of the center of Amsterdam

Illustration 5

1.4 Parks and forests

In the center of Amsterdam, the choice for planting species of plants and trees is limited to the circumstances. Some trees do not survive road salt, many environmental changes or need more land than places with many underground pipes. Parks and forests have consistently extremely high biodiversity, more than other areas such as infrastructure and dwelling areas. This can be seen on the card 'protected flora and fauna' on page 21. The toughest trees situated on the most used roads. Specific types of plants and trees situated in parks and forests (attachment 5). Many parks and forests are located outside the center, especially in the south and west of Amsterdam. There are also forests located on every side of the city. Only 'Artis', the oldest zoo from the Netherlands which exist of a high biodiverse area, is located in the center.



Forest

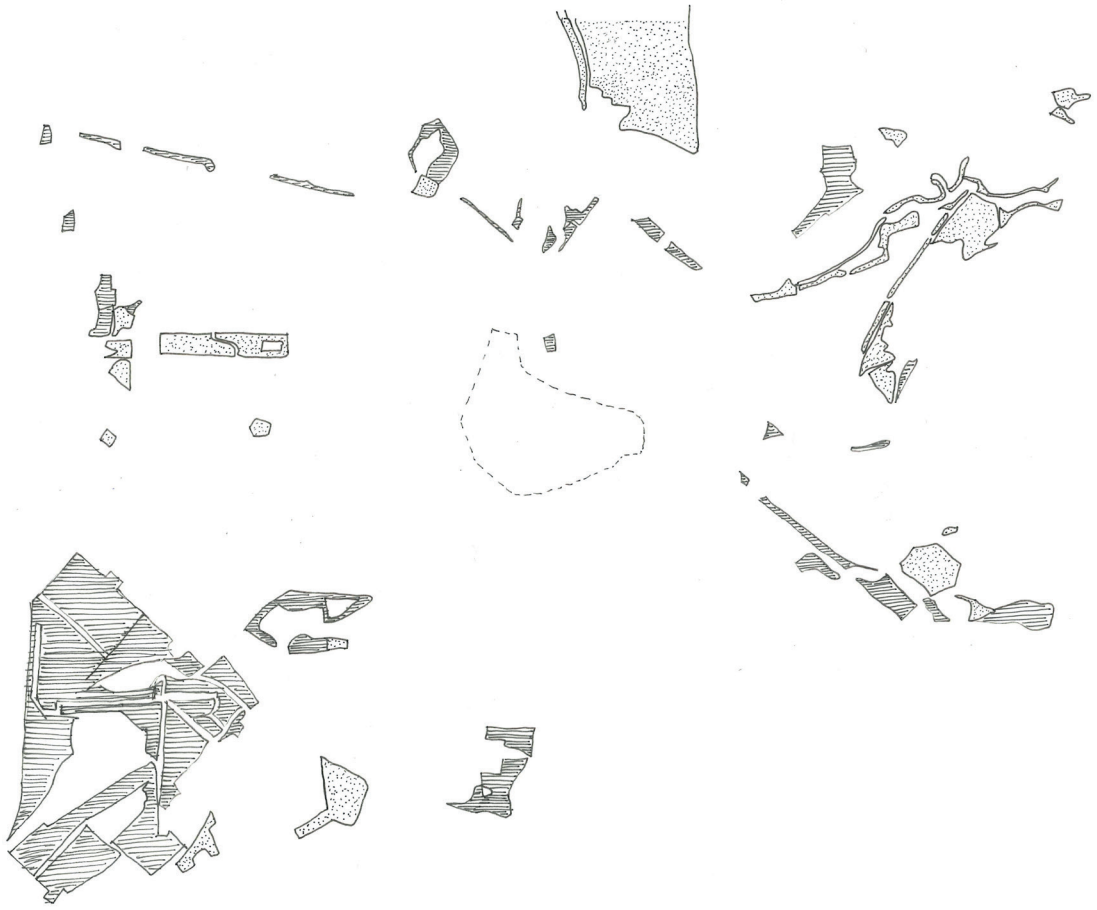
Parks

The border of the center of Amsterdam

Illustration 6

1.5 Roughness

Roughness is an area where there is no management. A rough area often exists with wild-growing plants, usually herbaceous vegetation. The amount of plants results in high biomass. There is roughness with wet and dry ground, which results in different vegetation. The 'protected flora and fauna' card on illustration 5 compares with this card shows that the biodiversity in a rough area is not always very high. The small areas often exist of high biodiversity. The larger areas, the northern wet roughness and the south-west dry roughness has low biodiversity, which suffers too much from other circumstances, as a result of which biodiversity cannot grow. No management is not only the key to high biodiversity, but it does help the growing process.



Dry roughness

Wet roughness

The border of the center of Amsterdam

Illustration 7

1.6 Sport parks

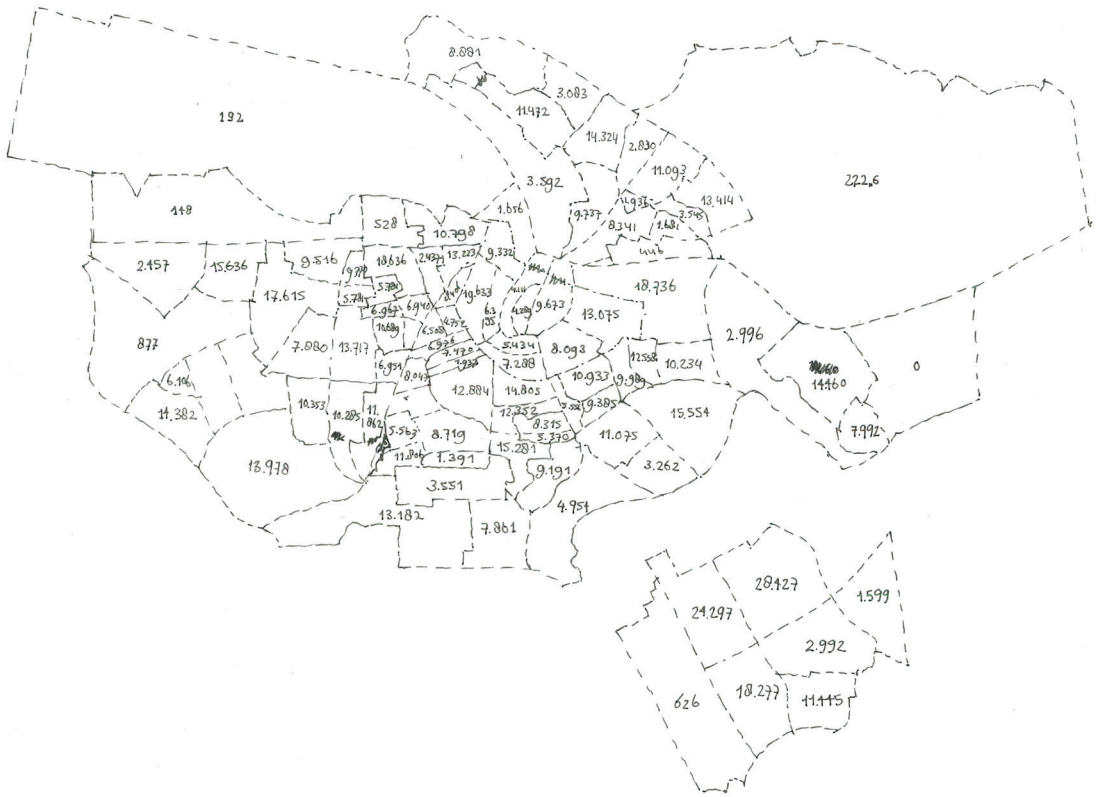
Sports parks, recreative areas to play an outside sport, are not located in the center of Amsterdam, but mostly situated about 2 km away from the border of the center. Even though sports parks officially count as recreational green (Bezemer et al., 2002), these fields often exist of a more significant area of artificial grass, for example, the sports fields at the Boelelaan on the south axis and the sports fields of Sportpark Oost at Amstelveen. The unknown percentage of artificial grass in sport parks results in a question whether sport parks are part of the 'green' areas of Amsterdam.

The border of the center of Amsterdam

Illustration 8

1.7 The number of population density

A total of 848.790 number of inhabitants live in the municipality of Amsterdam (Onderzoek, Informatie en Statistiek, z.d.). The dotted-dashed lines represent the various neighborhoods within the municipality of Amsterdam. The neighborhoods become smaller in the center, but the number of inhabitants per neighborhood does not decrease. There are nine neighborhoods where currently more than 15,000 people live. There is a difference in size per neighborhood. A comparison between the 'protected flora and fauna' map on illustration 5 and this map concludes that there is low biodiversity in the neighborhood with a high number of inhabitants.



The border of the neighborhood

Illustration 9

1.8 Conclusions

The ecological structure defined by the municipality of Amsterdam focuses on the infrastructure, parks and rugged areas. These areas situate around the center of Amsterdam. In this ecological structure, a 'hole' is visible that is not part of the ecological structure. There is a clear overview of the areas where it is little and where a lot of protected species of flora and fauna is present. Parks and forests result in areas with lots of protected flora and fauna. Dense population areas result in areas with a low amount of protected species of flora and fauna. Due to a high amount of human-related objects and activities in the center, for example, the use of land for houses, pipes, and infrastructure or spreading salt in winter, result in a low biodiverse center. Finally, all maps show that little or nothing happens in the center which is linked to biodiversity.

The chosen location, the Jordaan, is located in the city center. The Jordaan is in the center of the 'hole' of the ecological structure of the government. This neighboorhood has less than 20 species of protected flora and fauna. Parks, forests, sports parks, and roughness are not in this district. It is with its 19,633 people (Research, Information and Statistics, z.d.-b) the most populated neighborhood in the city center.

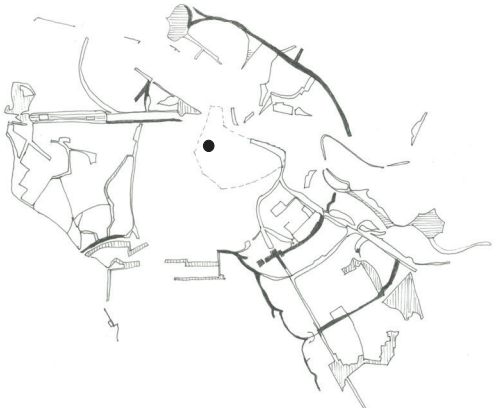
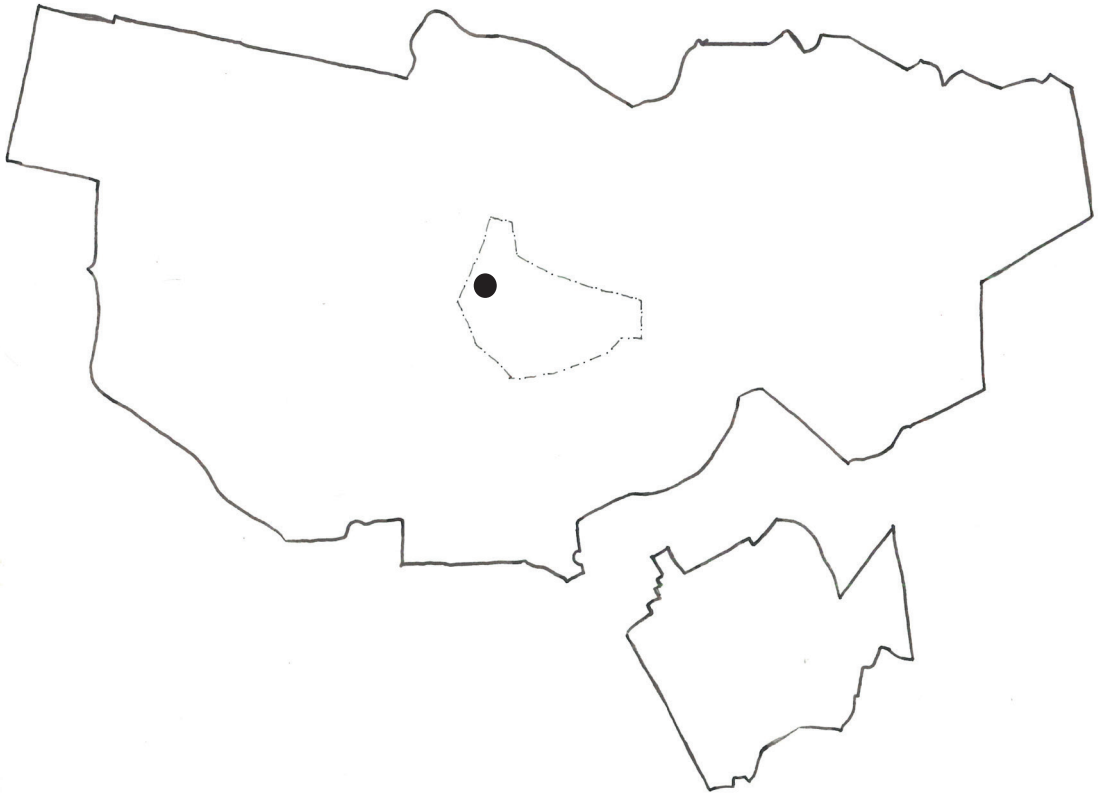


Illustration 4

Illustration 5



The border of the center of Amsterdam

The border of the municipality of Amsterdam

Illustration 10

1.9 Integration of conclusion in prototype

In the Jordaan, the main location is situated for the design of the prototype of a dwelling. The different requirements for the main plot of the prototype are:

- A street that is often used, so that the prototype is often noticed by passengers and functions as an inspiration for others.
- A standard plot between two conventional houses, to emphasize the contrast between the newly designed dwelling and a conventional dwelling.
- Many possible locations in the vicinity to show the impact of multiple dwellings in the neighborhood.
- Minimum width of 5 meters, to be able to build with trees.

The main location: Hazenstraat 60, Amsterdam

The chosen location is in the so-called tenth street of the Jordaan, with catering facilities, galleries, clothing stores, a hairdresser and sports facilities. This 4.4m x 12.6m plot is located between two typical Amsterdam buildings that border the public Hazenstraat at the front and at the back a semi-public traffic space for inhabitants to enter the collective garden.

To show the impact of building architecture to increase biodiversity on a bigger scale, more potential locations in the surrounding are searched. These locations do not meet all similar requirements as the main plot, but do fit into the building line of the environment and do not deviate from the existing urban structure. Already three possible locations are in the Elandstraat and one in the Konijnenstraat, which are situated within 500m of the main location.

Main location: hazenstraat 60

Possible locations

Jordaan

The border of the center of Amsterdam

Illustration 11

2

Functional biodiversity

2.2 Living building material

At the moment there are already several bio-based building materials, for example sustainably produced wood, cork from the cork tree or finishing varnish from potato starch. Bio-based building materials that are presented can no longer grow when it acts as a building material, this is dead material. To create a growing dwelling, materials made of living organisms are needed. This chapter shows the possibilities of living building materials.

2.3 Influences on the organism

Organisms are part of an ecology. To understand the influences on organisms, the system of ecology and its relation to architecture is described.

Definition 'biodiversity': biodiversity is the amount of different organism in a particular habitat, a measurement of the variety of the ecology.

2 Functional biodiversity

Biodiversity can be split up in 'bio' which means life and 'diversity' which means variety. 'Biodiversity' is a number to count of different species living organism on earth or in a specific area. Because of biodiversity, there is clean drinking water, fertile soil and a stable climate. ("Wat is biodiversiteit en waarom is het belangrijk? | Biodiversiteit.NL", n.d.). At the moment, biodiversity is decreasing. In history this happened more often, because of climate- and sea-level changes, meteorite impacts of volcanic eruptions. The volcano Krakatau, for example, erupted on August 26 and 27, 1883, and ejected about 20 cubic kilometres to almost 40 km high (Scientific American, 2002). The amount of soot came into the atmosphere; the sunlight could not reach the earth for years which influenced the biodiversity in the area of the vulcano. At this moment, the reason for climate change is the combination of human activity and the high amount of population in the world. Human affect habitats by forest logging, infrastructure, fishing or trade in dangerous species. Next to that, human travel with native species which endanger other indigenous species in for them foreign areas. Also, the use of energy by a human does not have positive effects on the biodiversity. The French philosopher Michel Serres state that human became a geological force (Ten Bos, 2017). We are living in the so-called Anthropocene, a term for the era in which the earth's climate and atmosphere are affected by human activity. (Berkers & Van den Bergen, 2014). To design dwellings with living organisms, human contributes by living on the increase of biodiversity.

The high amount of population demands for a lot of dwellings. To build dwellings for human, made to increase biodiversity, the building materials are or organism or influencing organism. In subchapter 2.1, building materials from organism are discussed. In subschaper 2.2, building materials which have an influence on organism are discussed. When dwellings and their surrounding have a positive effect on biodiversity, human becomes a positive geological force and biodiversity will increase.

> image 2:
an environment with high
biodiversity in Taipei
(Mass, n.d.)


鴻勝鐘錶
CHIMEI

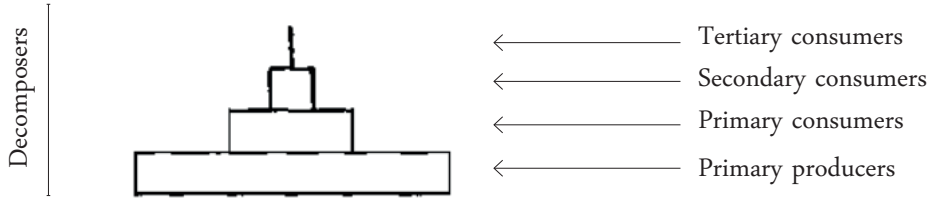
2.1 Living building materials

It is important for the increasement of biodiversity with the design of a growing dwelling that the material is alive at the time it is applied and will keep on growing during the lifespan of the growing dwelling. To use living building material, different organisms are searched out.

Organisms are individual living elements that can grow, maintain themselves, respond to their external environment and regulate themselves regardless of the changing external environment (Biology online dictionary, 2017). The classification of organisms are based on the difference in the cells of the organisms ("Het ordenen van organismen; het dierenrijk", 2010). Organisms are separated by the presence of the cell nucleus, green granules and cell wall. They can be seperated in four categories:

- bacteria — no cell nucleus, no leaf green granules, with cell wall
- fungus — with cell nucleus, no leaf green granules, with cell wall
- plants — with cell nucleus, with leaf green granules, with cell wall
- animals — with cell nucleus, no leaf green pellets, no cell wall

The cell nucleus is the central part of an organism where the DNA is stored which organisms use for gene expression to grow and reproduce (Biology-Online Dictionary, n.d. a). The force of the sun is collected and processed in leaf green granules. Leaf green granules create photosynthesis. (Wikipedia, 2018a). The cell wall is the wall that is formed around a membrane of a cell. The cell wall absorbs physical forces and thus protects itself against the intruders. Also, it provides counter pressure when the cell swells up due to water absorption (Wikipedia, 2018b). Next to the different categories of organism, there is a pyramid of organisms: the ecological pyramid. The ecological pyramid shows the feeding pattern of organism in different ecologies. The illustration below show the relation between organisms with the ecological pyramid. Decomposers, such as fungus and bacteria, can break down organisms which is very important in the biological cyclus. Primary producers can convert light by photosynthesis in organic molecules. A primary consumer is an animal that feeds himself by eating plants, secondary consumers eat primary consumers ("Ecological Pyramid", 2017). In this research has only been looking at decomposers and primary producers.



2.1.1 bacteria

Bacteria are microscopic single-cell organisms which reproduce by cleavage or by forming traces and can live anywhere; in the soil, in heat sources, in waste, in seawater, in earth crust and even in the bodies of other organisms (Biology-Online Dictionary, n.d. b). The ecosystem is strongly depended of the activity of bacteria. Carbon, nitrogen and sulfur is completed by the activity of bacteria. For example, without carbondioxide, photosynthesis becomes unavailable for plants. Bacteria decomposite organisms, this is their most important role ("Life History and Ecology of Bacteria", n.d.). Bacterias are not stif, it is necessary to merge the bacteria with other organisms to use as a building material.

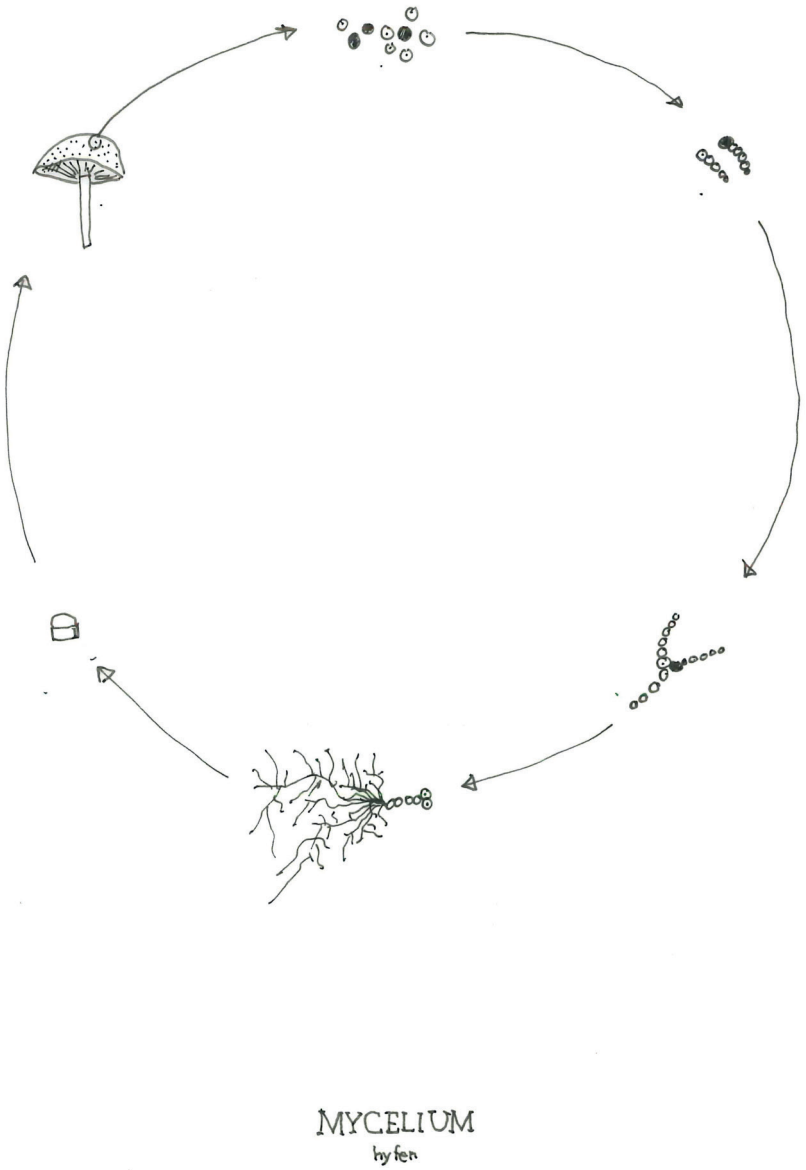
Henk Jonkers, a researcher at the technical university in Delft, invented self-healing concrete through the application of bacteria. He was inspired by the easy to imagine automatic system of a human body. 'When you break your leg, it eventually knits itself back together. Osteoblast cells produce minerals that create the structure of new bone, turning fragments back into a whole." As a charactericstic for human, more organisms can maintain themself except bacteria, they need nutrients. He embeds concrete with bacteria (the Bacillus Pseudofirmus or the Sporosacina Pasteurii) and calcium lactate. When air and moisture are added, the calcium lactate becomes calcite, an ingredient of limestone. The bacteria can survive 200 years in the stone, which is longer than the common lifespan of a building. When buildings are made of concrete in combination to bacteria and calcium lactate, water and moisture are naturally add when the building start to crack. When the bacteria growth to limestone, the crack is automatically repaired.

Bacteria who demand a specific ecology, a wet ecology, are algae; a collective name for 3000 different micro-organisms. Algae are weightless, which makes them completely different from plants. They also branch out differently from trees and have no trunk. Because algae do not have to pump nutrients up to overcome gravity, all branches are relatively thin. Algae needs less stiffness than a tree, by this they contain less lignin. No fertile soil is needed to grow algae, only a small amount of sediment layer. This sediment layer can be on a rock or in the water. Algae can grow under controlled conditions. If the number of light decreases, some algae will die. If the number of light increases, the algae will grow faster (attachment 3). Currently, there is a lot of experimenting with algae and it is still very much in its infancy. Roscoff Culture Collection, located in the French Bretagne, is currently one of the largest innovative research centers that research many algae species for several potential practices. This potential is not only focused on the food industry, pharmacy, and cosmetics, but also on the biomass that can be interesting in the construction industry (Ministerie van Landbouw, Natuur en Voedselkwaliteit, 2016). For example; Biomass which is created by the combination of algae, sunlight, CO_2 and the correct nutrients, can be converted into biogas, which can be stored with the right technical equipment to provide a space for its energy needs (Redactie Bouwwereld, 2012).

2.1.2 fungus

Fungi exist of thin wires under the ground that supply nutrients. Fungi are officially no roots because it does not have fruiting bodies, the flowers of the fungus which spread the spores to propagate. Mycelium, the vegetative part of funghi, lives underground in symbiosis with the roots of plants. Mycelium does not have leaf-green granules and therefore can not trigger photosynthesis, which they need to make glucose. Because of the large network where they need to make easily water with, mycelium exchange water for glucose with the roots of plants and become a symbiosis.

The mycelium is a fast-growing wire with a glue-like structure. The glue-like structure makes it easy to merge with different fibers to become a strong material. An example of fibers is cocoa peel, beech sawdust, miscanthus, bran or hemp. At this moment there is often experimented with dead mycelium. Sterilized mycelium helps to count out unwanted bacteria. Unwanted bacteria does not bind or are unhealthy for the human environment. Mycelium in combination with fibers is produced in a mold to grow in a controlled manner. This mold is a vacuum-extracting material. The final result can be compared with the strength of polystyrene foam, 0.1 mpa. Organizations such as Centre of Expertise Biobased Economy are experimenting to improve the strength of the material by changing the composition of fibers. If the mycelium is not killed correctly, it will start growing again (attachment 4). Mycelium as a stiff material function as isolating panels, bricks or when the threads are 3D printed in an object. An already build example is the mycelium tower, designed by David Benjamin in New York, in image 4.2 is grown in 5 days in molts of bricks by Ecovative (Inhabit, 2014). Image 4.3 shows the use of living mycelium. The image shows the 3D printed chair of mycelium wires by Erik Klarenbeek in collaboration with the University of Wageningen. The growth of the mycelium gives the structure strength (Fairs, 2016).



> Illustration 12:
cyclus of mycelium

2.1.3 plants

Plants are the easiest organisms to observe with the eye in contemporary life. All primary consumers eat plants, including human. To attract other organisms in the dwellings, plants are essential in the design. Plants are more often associated with architecture then bacteria or funghi. The house 'Casa de Vidro' by architect Lina Bo Bardi from 1951 is known for the relationship between the spaces in the house and the integrated relationship with the architecture. She designs spaces that allow the growing of nature and to observe it from the inside of the spaces. The building is lifted, the ground floor is situated outside. The stairs to the entrance which connects the ground floor and the first floor are outside. The living space extends into the dining room and workspace and is located on the first floor. Due to the height of the functions and the many glasses used, the resident looks out on the treetops. (Apers & De Architect, 2016). In the same year architect Niemeyer designed his family house 'Das Canoas House' in a suburb of Rio de Janeiro. He designed the house between the already existing natural environment, where he pretends not to touch nature. Instead of touching, he uses nature to make the living room with shade and curtains redundant (WikiArquitectura, n.d).

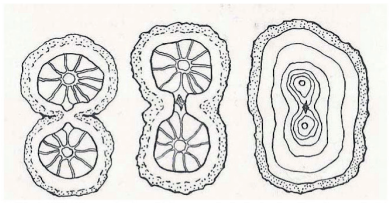
In addition to the non-constructive architectural function of plants, such as shade and ventilation, they can also be used pragmatically for the construction. There are several techniques to build with strong plants. A wooden perennial plant with a single stem or trunk, which grow to a considerable height is a tree. ("tree | Definition of a tree in English by Oxford Dictionaries", n.d.).

Arthur Wiechula, a German landscape engineer, has written several techniques to build with trees which he calls "Arbortecture". The techniques to design buildings are waterproof, cheap and durable. By inoculating trees, two pieces of living plant tissue are joined together and fused together. Arthur Wiechula calls this a "natural building method" (Wiechula, 2012). According to him, it is not about building buildings, but about growing wood in the right forms, creating closed structures that can act as solid walls, doors or windows. The inoculation of immobile roots is regularly done underground, restoring their own imperfections. The natural process of inoculating trees is called inosculation. First, the bark tissues melt together, then the bodies of the wood develop and melt together. Finally, there is continuous growth (Ludwig, 2014). This can be seen in figure 12. There are hundreds of types of transplants. The approximate graft is the easiest since no parts are cut, it can be performed at any time of the year. A graft is created by making a wound in a branch and then melting it on another branch (Reames, 2005). The types of trees that are best suited for inosculation are robust trees where wounds heal quickly and with a thin bark that is poor in fibres (Ludwig, 2014).

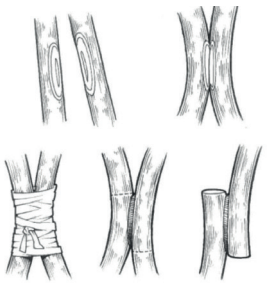
Because trees grow in the longitudinal direction and can melt together by inoculation, it is possible to use trees as a structure in a building. As the trees only grow longitudinally, the main geometry will not change during the growing process. In Figure 12 examples of potential structures are shown, drawn by Arthur Wiechula.

Options to use trees as a structure are:
- planting a young tree, growing into the structure over time.
- use trees at a certain height that are already the correct form and size you need
- Transplant during the process

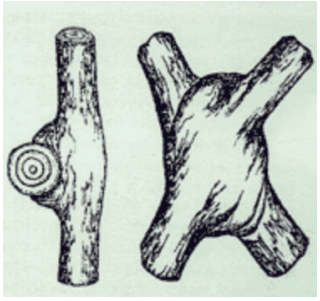
The growing structure is from fast-growing trees or sustainable trees, but for each tree, the growth principles are similar. New parts of the tree grow continuously on the longitudinal sides, the existing parts, such as the branches, only grow in thickness. Figure 12 shows a connection between wood and stainless steel. The focus of this image is the grow in thickness. Trunks and branches not only bear their own weight in nature but also snow and wind loads. They transport water from the roots to the leaves through their own bodies to the places where it is most needed. By moving nutrients where gravity is overcome, the thickness increase if necessary. The branches growth adaptively, which generate a constructive function for the architectural structure. It retains the strength of the surrounding element and transfers these forces through the trunk to the ground. The total surface area of biomass that survives at a location is limited because a tree grows on the basis of photosynthesis. For example, the amount of wood that normally stands in a mature forest is around 0.04 m^3 per m^2. This amount is the maximum amount of construction material for the building, which requires a considerably lightweight structure. In addition to competing between trees, they can work together with the exchange of tasks. Roots can inoculate, as explained earlier, therefore they use the same root network so that they can exchange nutrients among themselves. By exchanging nutrients, a tree no longer has to take on all functions, but they can spread functions. Because of this possible collaboration, the loss of parts of the tree can be compensated and new parts can be generated at the same place or somewhere else in the fused tree. By planting trees in the ground and, after some time by transplanting to generate new trees on it, the trees can indicate each nutrient from the ground, and photosynthesis of an even higher plane can take place. The trees together form an automated system over time, making the entire structure of the tree stronger. (Ludwig, 2014)(Attachment 5)

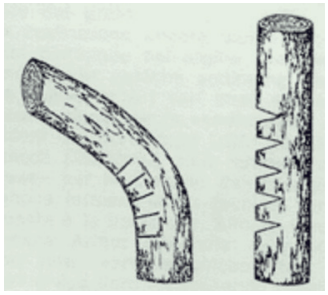


4.1. The natural grafting process between two young stems.



4.2. Approach graft. When a cut is made the branches are joined together securely and eventually become one.





> Illustration 13:
above: the process of inosculation
under left: grafting
right: tongue inosculation
(Wiechula, 1995)

Architect Ferdinand Ludwig has experimented and realized several buildings with this building technique, one of them is shown in image 8.

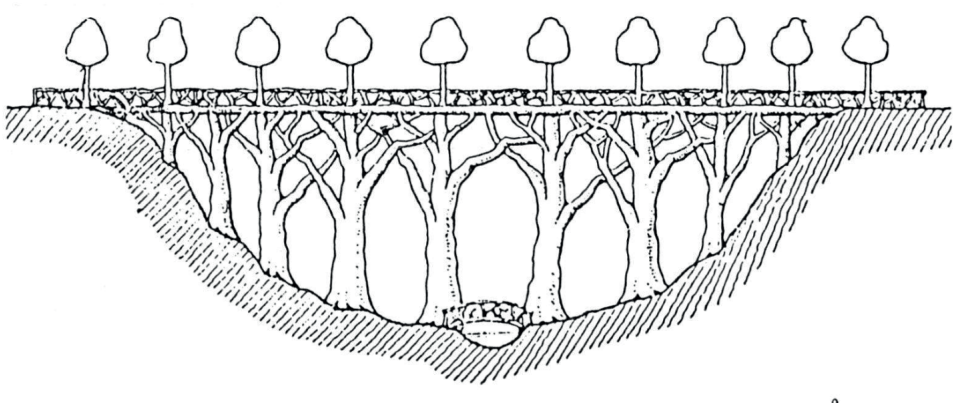
The biggest advantage in the center of a city is the amount of ground to grow the roots of the tree. Each tree needs about 5m by 5m by 1m deep to ground its roots. Taken Amsterdam as an example, the peat package of 3 to 5 meters thick ensures that not every tree gets a chance to grow. The groundwater level in Amsterdam is in most places at 80 cm or shallower, whereas roots of trees do not grow under the groundwater level. This, in combination with the cables of telephones, sewer pipes and sky water wells, ensures that there is not much room for roots to grow. If the tree does not get enough space, it stops growing. As a result, many trees in Amsterdam are only a few meters high. If the area of the tree is too small, the adjacent suspension layer under the vowels can be replaced by tree soil. This allows the roots to expand further to the street and still has enough room to grow. The more space there is for the roots, the older the tree becomes. A tree in the city often 70 to 100 years but I can be up to 500 years old. Because the ecological conditions are better in parks and forests, more different species are planted. There is also less management in this areas of parks and forests (attachment 5).

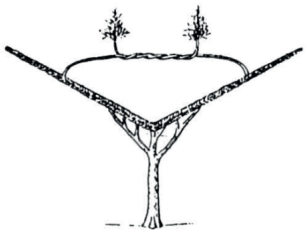
In tropical environment is found the Fiscus Elastica Tree. This Tree has aerial roots, which are pulled by human into a desired shape. In this tropical environment they often guide the roots across the river, to grow overtimes with inoculation, the already earlier technique Arthur Wiechula mentioned, where the branches or roots of two trees grow together. This bridge is originally build of living organisms, because all other material should decompose over the years. The amount of time depending on when the bridge is functional to use, depends on local factors such as the health of the tree and what level of community is involved while the roots are growing. Frequently bamboo, palm trunks or steel wire function as scaffolding and help to speed up time to the functional use of the bridge (Rogers, 2018). Image 9 shows an example. Unfortunately, trees with aerial roots does not grow in the Dutch climate.

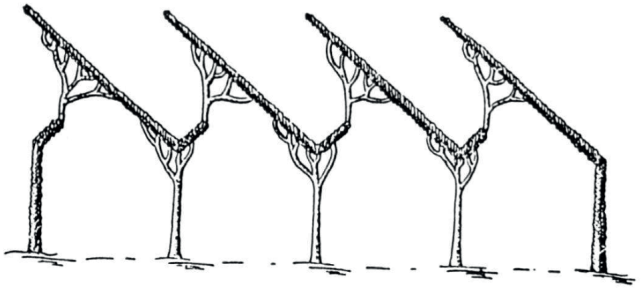
One type of grass, bamboo, can be used for construction purposes. Bamboo is flexible to use, has good technical conditions and provides beautiful light. Bamboo is durable because of its quick growth in 4 to 6 years for construction purposes. The compressive strength and tensile strength of bamboo vary in the lifespan of the bamboo, this mainly due to the amount of moisture present in the bamboo. The average compressive strength is 40-80 n / mm2, which is twice to four times higher than the compressive strength of most wood types. The average tensile strength is 160 n / mm2, which is three to four times higher than the tensile strength of most wood species. Because of the sustainable and strong quality of bamboo, it has already been built a lot. For example, bamboo is used for scaffolding, see image 7.3. Also living bamboo is used, for example in a theatre in China, built by DnA architects in 2015, this is shown in image 7.5. Bamboo is also used for foundation purposes, an example is shown in picture 7.6.

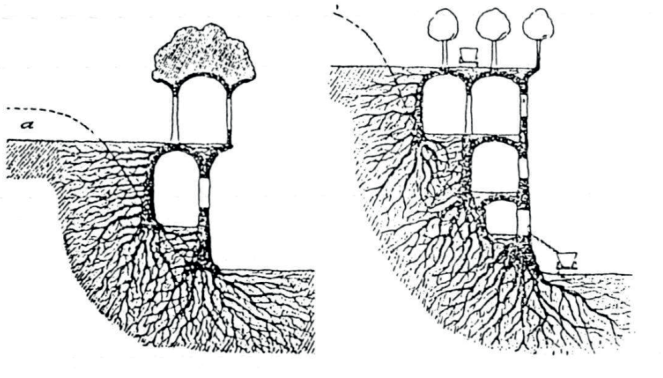
If Bamboo is used cut to guarantee the quality, cut it in preferably dry seasons because of the lower amount of starch and insects in the soil. There are several ways to treat bamboo sustainable, for example in water, natural salts, free mite and lime powder (Galjaard, Hornung, & Vellema, 2017).

> illustraion 14:
(Wiechula, 1995)
constructions of trees









> Image 3:
mycelium pressed in a tile
(Blok, 2018)

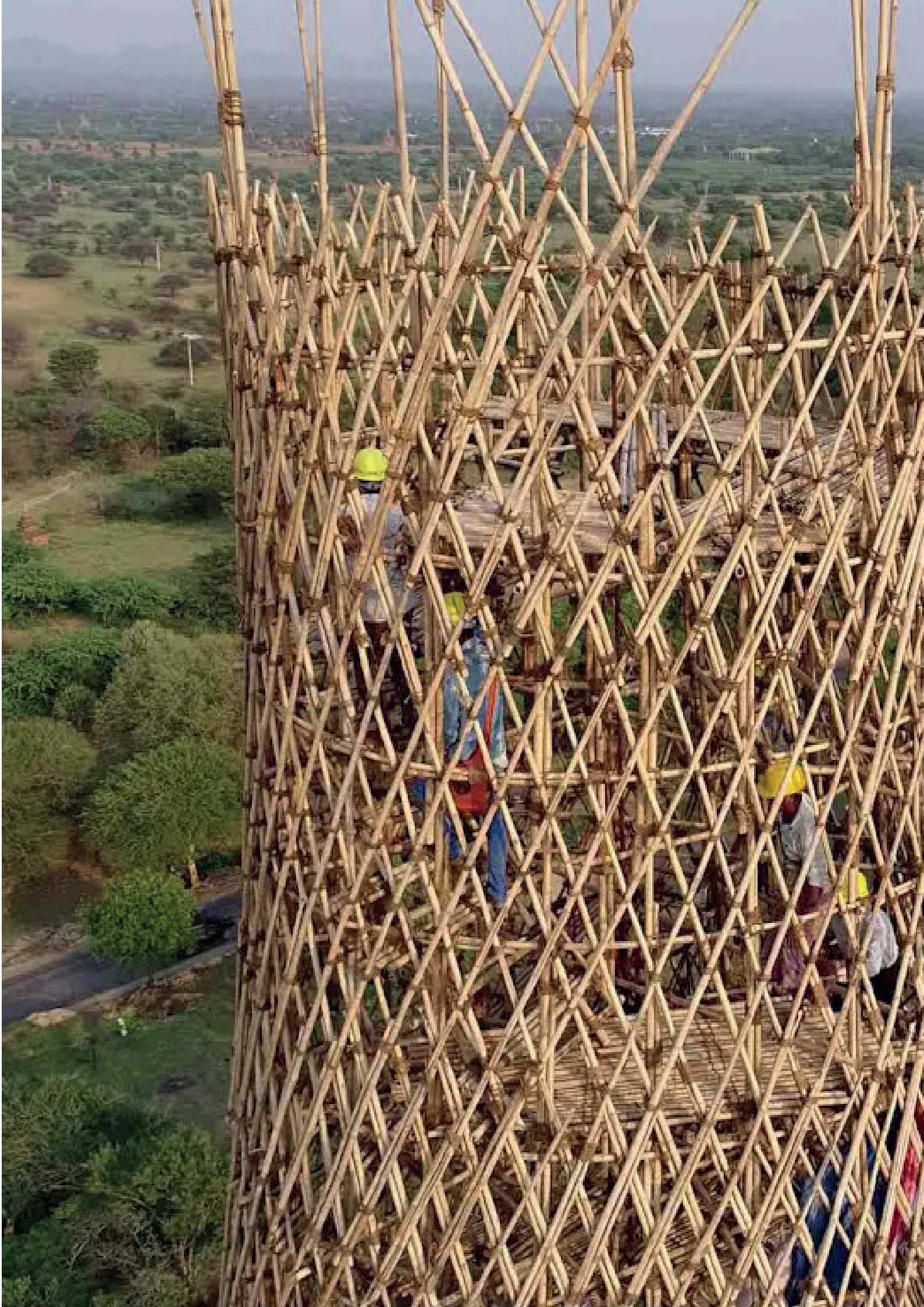
> Image 4: mushroomtower grown in 5 days (Bonnefin, n.d.)

> Image 5: 3d printed mycelium chair (Fairs, 2016)

> image 6, 7:
uncultivated space to
grow organism during the
lifespan of the building
(Phaidon, n.d.)
("De Architect", n.d.)

> image 8,9:
building fitting in the already existing nature, using nature for shade, ventilation and privacy
("Clássicos da Arquitetura: Casa das Canoas / Oscar Niemeyer", n.d.)

> image 10:
bamboo scaffolding
("Occhio ai ponteggi,
sono pericolosi", 2013)



> image 11:
building with living
bamboo ("Bamboo Theat-
re / DnA", 2018)




Image 12: growing construction from spring 2005 till autumn 2010 (Ludwig, 2014)

Image : living root bridge

2.1.4 Conclusions

Decomposers, such as bacteria and fungi, and primary producers, mainly plants, are the most essential organisms in an ecology. Bacteria are not stiff themselves and need to be combined with other organisms to function as a building material. Algae, growing only in a wet environment, can be used to convert into biogas. Also from the threads extracting out of algae, non-constructive elements are possible to 3d print. Especially the vegetative part of the fungi, mycelium, is a functional building material because of its sticky texture. Mycelium in combination with fibers is stiff, highly isolated and acoustic. As a living building material, it can help plants in dry periods to exchange water for glucose. Mycelium wires can 3D print in any form. Plants can be used non-constructive, for shade and curtains redundant, and constructive, as the technical structure. By inoculation trees, waterproof, cheap and durable structures exist.

Options to use trees as a structure are:
- planting a young tree, growing into the structure over time.
- use trees at a certain height that are already the correct form and size you need
- Transplant during the process

The trees together form an automated system over time, making the entire structure of the tree stronger by inoculating and above and under the ground.

As the knowledge of the use of dead organisms as building material is larger as of the use of living organisms as building material, the knowledge of dead organisms as building material can support the practise of building with living organisms.

2.2 Influences on organism

Organisms are part of an ecology, defined by the Oxford Dictionary as: "The branch of biology that deals with the relations of organisms and other physical environments." (Oxford Dictionary, n.d.-a). Ecology is, therefore, a dynamic interaction between environmental factors; organisms, geography and a-biotic factors. Geography is the study of physical features of the earth and its atmosphere (Oxford Dictionary, n.d.-b). Geography is split up in physical and social geography, whereas physical geography is focused on the form of the landscape, social geography is focused on especially the inhabited part of the earth's surface. Abiotic factors are external environmental factors that have no biological origin; they can be grouped in climate (precipitation, humidity, temperature, day length, light intensity, wind strength and wind direction), soil (soil type, groundwater level, acidity, parent rock, relief), water (salinity, concentration of dissolved mineral substances, concentration of organic substances, water depth, turbidity, transparency, wave height, current). When abiotic factors change in the environment, for example, due to a flood or climate change, the organisms will survive with the properties that are resistant to this change (Wikipedia, 2018).

The ecological factors, which are described in the previous alinea, are influenced by two aspectst: the flow and the ecosystem management. The ecological flow is a result of the reaction between abiotic factors; for example leaves falling from the tree, birds that defecate, rain and wind that influence nutrients. This ecological flow influences the living comfort for all organisms. Finally, ecosystem management has an important role in the growing process of the organism. The ecosystem management is behaviour by an organism on physical elements to improve the ecological system. For example, Amsterdamse Bos is a human-made forest in the south-west of Amsterdam. A third of this forest is managed in nature-friendly management for fifteen years. Nature-friendly means the growth of nature is the most crucial aspect, humans only control the ecology of the walking paths. When a tree falls by a storm which is not on the walking path, they leave the trunk on the soil. The results were evident within a few years and biodiversity increased rapidly. There came more birds, more variety of insects and more species of small mammals.

In illustration 15 the definition 'ecology' is explained visually.

Illustration 15:
explanation of the
ecological conditions
(Mollison, 1988)

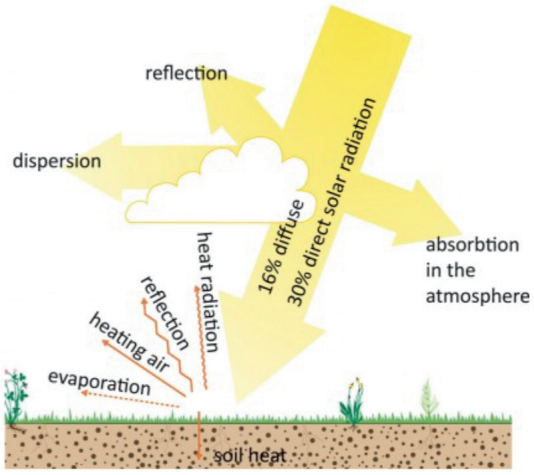
ECOLOGY
the interaction between these environmental factors

ECOLOGICAL FLOW results of the interaction between the abiotic factors
ECOSYSTEM MANAGEMENT behaviour by an organism on physical elements

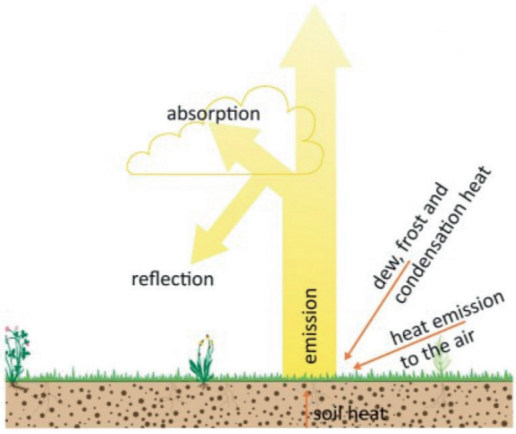
ORGANISM	GEOGRAPHY	ABIOTICS
- bacteria	- physical geography	- climate
- fungus	- social geography	- soil
- plants		- water
- animals		

2.2.1 Geography

Geography is the study of the soil and of the distribution of life on the soil, including human life and the effects of human activity (geography, etc.). Figure x explains the relationship between the geographic surface and the environment.



Instraling balans op een 's zomerse dag [BRON]



Nachtelijke uitstraling balans [BRON]

Illustration 16

The influences of human actions on the surface of the soil are demonstrable, partly due to materials and objects built by human. As the city size increase due to the increase of population, according to researcher T.R.Oke, the heat island effect increase as well (Oke, 1973). A heat island is an area in the city that is up to 10 degrees Celsius warmer compared to an outside area, this is 7-9 degrees Celsius in Amsterdam on hot days and is one of the strongest heat islands in Europe. According to the measurements between Waterland, an area located on the municipal boundary, and the centre of Amsterdam, the surface temperature during the day can differ 10 to 20 degrees Celsius and at night 7 to 9 degrees Celsius. When the surface of the soil increase, heat radiation, evaporation and the temperature of the aire increase. All aspects influence the organism by the supply of nutrients and by their living conditions.

The soil surface is mostly heated by paving, concrete, stone, asphalt and sprayed sand to cover the soil and displace the greenery. Cooling, or decreasing the temperature of the soil surface, is caused by shadow, a sky view, vegetation, the increase in the percentage of surface water, the decrease in the percentage of traffic surface and the choice of material for the facades of buildings. The exact amount of cooling and heating of the geographic surface in temperature is written in table x. (Van der Hoeven & Wandl, 2013)

indicator ruimtege-bruik	minimum/maximumwaarde	gemiddelde verandering oppervlaktetemperatuur
Schaduw	0 - 600	-3.6°C
Sky-view	0 - 1.0	-3.0°C
Albedo	0 - 0.5	8.2°C
Vegetatie (NDVI)	0 - 1.0	-5.3°C
Oppervlaktewater	0 - 100%	3.3°C
Verharding	0 - 100	11.6°C
Verkeersoppervlak	0 - 100%	-1.0°C
Gebouwschil	0 - 120.000	2.0°C

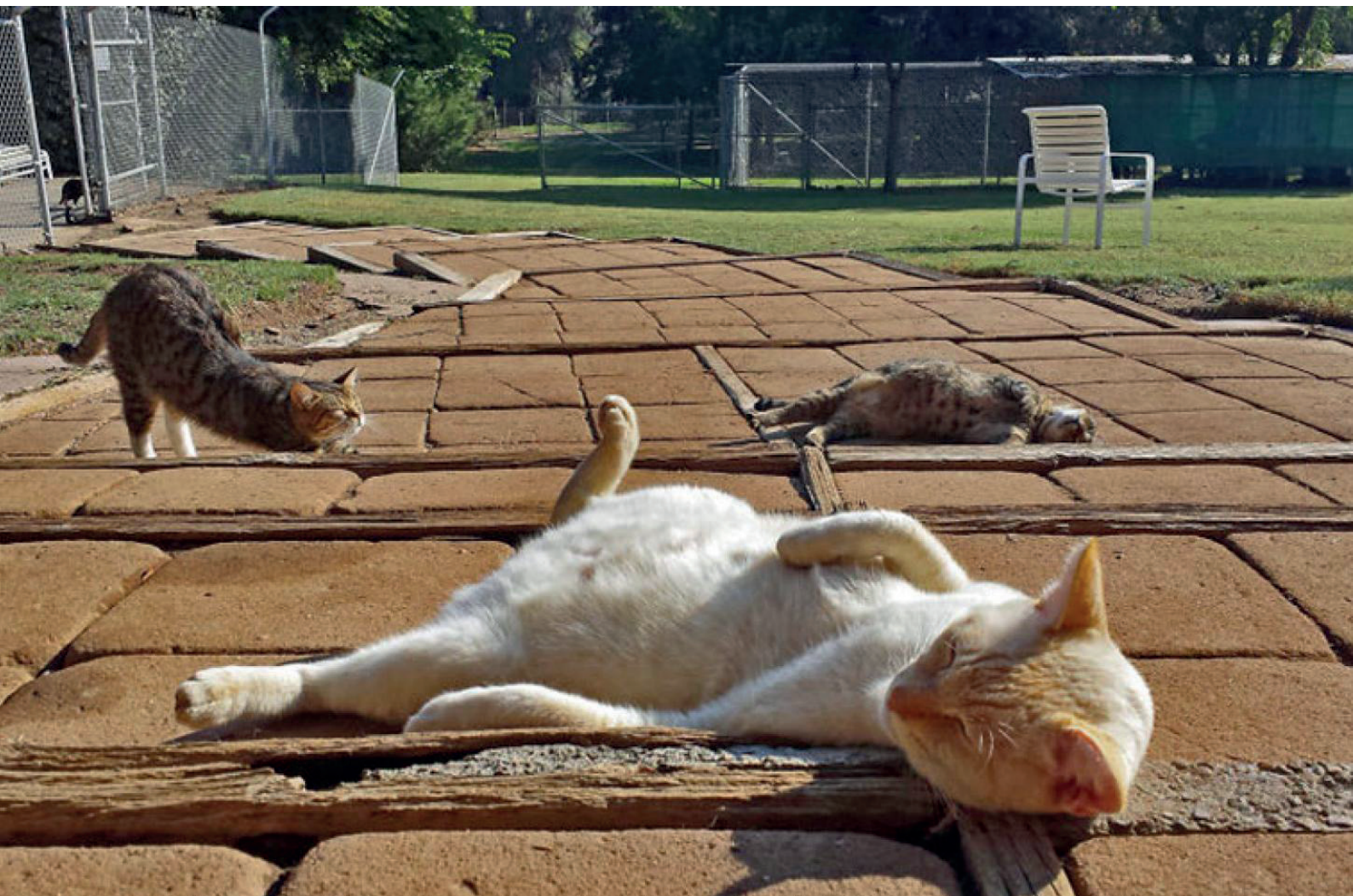
2.2.2 A-biotic factors

A-biotic factors are non-living elements that influence organisms such as temperature, light intensity, duration of exposure, amount of water, composition of the air, wind and soil conditions. For a primary producer, an organism that lives on photosynthesis, every factor has a minimum value, an optimum value and a maximum value. Abiotic factors influence the conditions of living areas for primary consumers, herbivorous organisms. Architecture, designed living spaces, can stimulate abiotic factors and where necessary protect primary consumers against unwanted abiotic factors.

Atelier Bow-Wow, an architecture firm based in Tokyo, introduced the word 'Behavioriology'. Behaviorology is architecture where the building responses to abiotic elements and relates to the city and their surrounding (CCAchannel, 2013). In afbeelding 11, 12 en 13 zijn voorbeelden weergegeven als een reactie van a-biotische factoren op zowel primary producers, primary consumers als objecten.

> image 14:
tree behaviorology
("Carpinus Betulus,
Cesare Leonardi", 1962)

> image 15
Catching Some Rays



> image 16:
house behaviorology
("House behaviorology",
n.d.)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2.2.3 conclusions

Ecology is a dynamic interaction between organisms, geography and abiotic factors. All aspects are influenced by the ecological flow and the ecosystem managment.

Geography is important for the living environment of organisms. Architecture can play an essential role in the use and protection of geography. There is a clear agreement between densely populated areas and an increase in air temperature. The air temperature is influenced by the soil surface. By designing the minimum with materials such as paving, concrete, stone, asphalt and sprayed sand, the soil surface temperature will remain as low as possible. Shadow, air supply, vegetation, the tin release of the amount of surface water and the decrease of traffic surface will cause a temperature decrease of the soil surface. The decrease of the soil surface is in favour of the air temperature, the supply of nutrients for organisms that depend on it and for the living conditions for all organisms that live on the soil surface.

Architecture can be designed to stimulate abiotic factors in favour of the growth of primary producers and promote accommodation for primary consumers. It can also protect primary producers against unwanted abiotic factors.

3

Requirements

To follow my intuitions of the requirements of the prototype of a dwelling, instead of using the construction standard, I interviewed twelve individuals who have a different vision of living with nature instead of usual dwellings. These twelve individuals live or in Dalfsen or in Wageningen. I reside for two nights by this people. By experiencing, all senses are observed; to see, feel, smell and listen. The main focus was on the similarities and differences between their dwelling and usual dwellings. These similarities are the base of a prototype of a growing dwelling. The differences are the additions which improve the living comfort.

3.1 Case study 1

In case study 1 the experience in a family house in Dalfsen is observed and concluded.

3.2 Case study 2

In case study 2 the experience in a community in Wageningen is observed and concluded.

3.1 Case study 1

In a forest in Dalfsen, inhabitants converted about 15-holiday houses into permanent houses. Several families, with or without children stay in these houses. Some of them have an extra house that they use for the cold winter months. The house where I stayed for two nights was a permanent house in both summer and winter conditions.

The entrance towards the forest locates on a quiet road. In the woods, height differences are used to make a distinction between the traffic area and the plots whereas the traffic area is higher than the plots. Because of the swampy area in the woods and the low location of the houses, the houses have a thick natural foundation which is higher build than the ground level.

The house where I stayed over, the red dot in illustration 17, consists of two separate low-floor buildings with interior spaces. In one building are the bedrooms, the kitchen and the dining room. In the other building are the toilet, bathroom and yoga room. Finally, a cabin was built on a tree stump which is the nursery. Outside is a large garden with a fireplace. Around the fireplace are stumps that are used as a chair. This spot is also used when no fire is on. Depending on the weather conditions, the area outside is used more than the living room. They use the elements such as sun, wind, and temperature to depend on their most efficient and comfortable daily routine.

(attachment 1)

> Illustration 17:
situation drawing of
location in Dalfsen

SITUATION

Bob, Catheljne en Lelie Radstake

1:1250
20 m

N

Observations

The building on an old tree trunk is a child room. For one night, I made my bed in this room. Because of the small height between the floor and the ceiling of the treehouse, it felt like climbing in a hole while going to bed. The hexagonal circle, with reclining horizontal walls, created a practical and pleasant space, which felt open on every side. The small child room in relation to the view of the woods made me feel small and impressed by the environment.

Conclusions

- A view of nature provides peace and well-being of the environment and its seasons.

Illustration 18: main building

Observations

The illustrated area is a living space, located outside. The furniture, arranged on a flat surface between different trees, makes it a living space. The trees create several spots in the living room with shadow and direct sunlight. The living room does not have borders as a wall or a floor. The size of the space looks infinitely large.

Conclusions

- The furniture defines the function of the area.
- As the furniture is movable, users have the best natural circumstances in their living space.

Illustration 19: living room in the woods

Observations

Below is a fragment of a bicycle wheel wrapped in branches. The bicycle wheel ensures that the branches do not grow at this location. Because no branches grow around this place, a window is created, making it possible to look from one side of the wall to the other side of the wall.

Conclusions

- Non-organic material tells indirect to nature how they should grow.

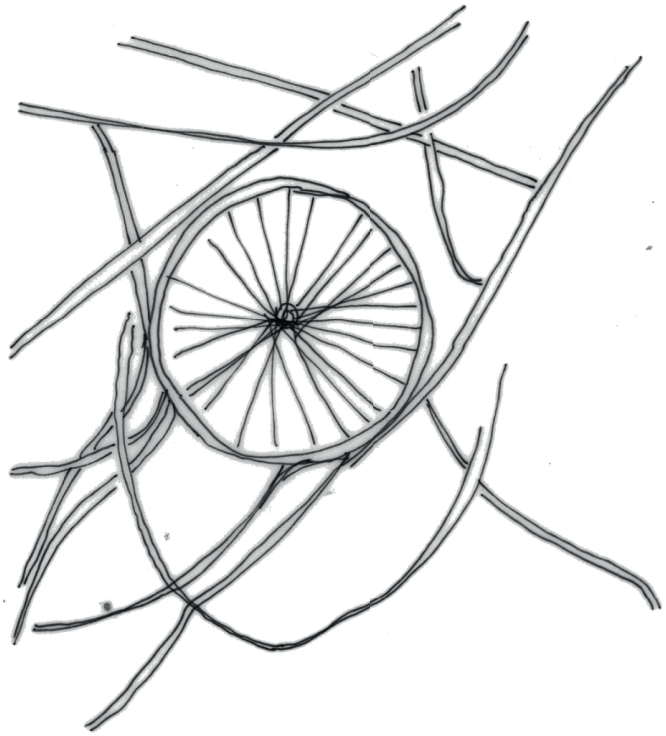


Illustration 20: wheel in branches of trees

Observations

The toilet and the bathroom are in the same building, in the same area. Below the separating wall is drawn between the toilet and the shower. The wall consists of branches filled with clay. The branches ensure the feeling that inside and outside are similar. The back wall of the shower is bricked.

Conclusions

- Materials which are growing in nature and used inside give the feeling of being outside.
- A shower does not need a closed off area.
- Walls without a door provide a private atmosphere.

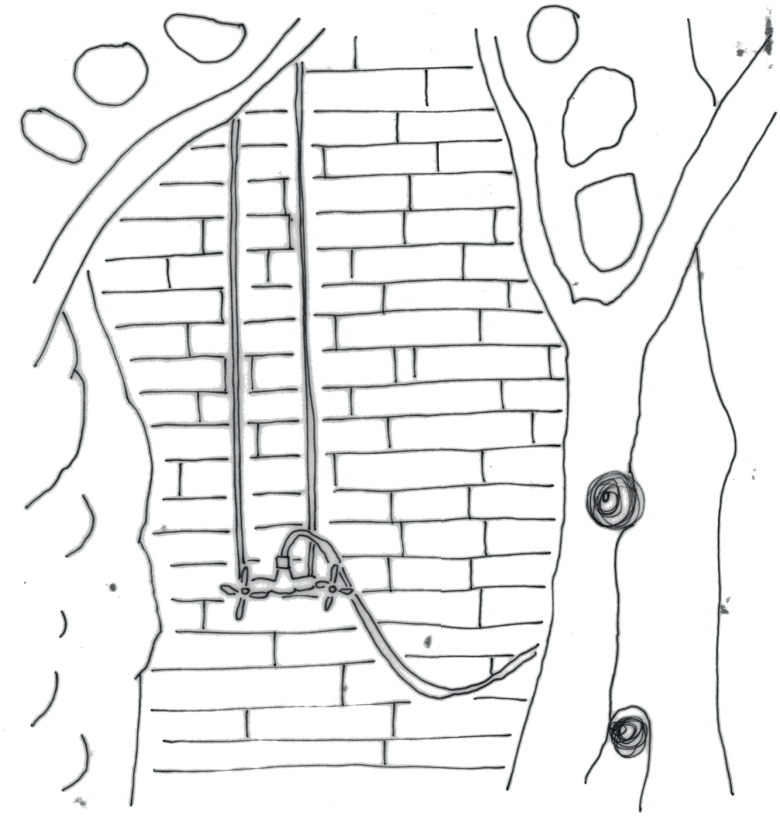


Illustration 21: bathroom

3.2 Case study 2

The so-called 'Ppauw' community live with about fifteen individuals, tolerated by the municipality, in the middle of the forest in Wageningen. The residential area in the forest has been fenced to avoid unwanted visitors. The demarcated living area in the forest has one common closed off inside area, and several separate sleeping spaces secluded in the woods. This living area serves as a dwelling for these fifteen individuals throughout the year.

Illustration 22 shows the situation drawing of the location. The red dots are closed of buildings, variating from caravan, tent, tiny house or living room. The entrance of 'Ppauw' is on a road with a gap of trees that runs through the forest. Close to the entrance are the living room, the kitchen, and the toilet. There are no showers. The circulation area is outside and has additional functions; living, playing, running, grow food.

Because there are many common areas, there is mutual contact between the individuals. The private sleeping quarters are all sheltered in the forest, with possible access to places where the sun can shine through the trees. The sleeping quarters are often closed off from nature; there is a lot of nature around the sleeping area.

(attachment 2)

> Illustration 22:
situation drawing of
location in Wageningen

SITUATION

20m

N

2.1

Observations

23

Illustration 18 shows the collective buildings of the community; an inside living room, a garage box, and a building on wheels with luxury showers as a work in progress. The buildings are with their backside towards the forest, with their front side to the gap of trees in the woods. The gap of trees allows the sun to shine on the buildings. The buildings consist of many windows so that even when it is colder, it can absorb a lot of heat from the sun. If the weather conditions are pleasant, there is enough space outside. The living room exists of a kitchen, dinner table, a library, a chill corner, and several musical instruments. All individuals used this room very often.

Conclusions

- The sun does not come through the woods if the forest is too dense.
- A combination of inner and outer space combines the possibility to adapt to weather conditions.

Illustration 23: collective area

Observations

On illustration 24 is the sleeping spot of a couple depicted. This sleeping building, a yurt, is made of cotton. The space around the sleeping spot, filled with planted plants, unplanted plants, and trees, is in the circulation area. The individual living space, the outdoor area around the yurt, is endless. Sun can shine directly in the living room because it is not entirely sheltered. The sun invited the individuals to use the open collective circulation area to use as a living room, with or without furniture.

Conclusions

- The weather plays a significant role in the use of the living area.
- The sleeping area is less flexible as other functions.

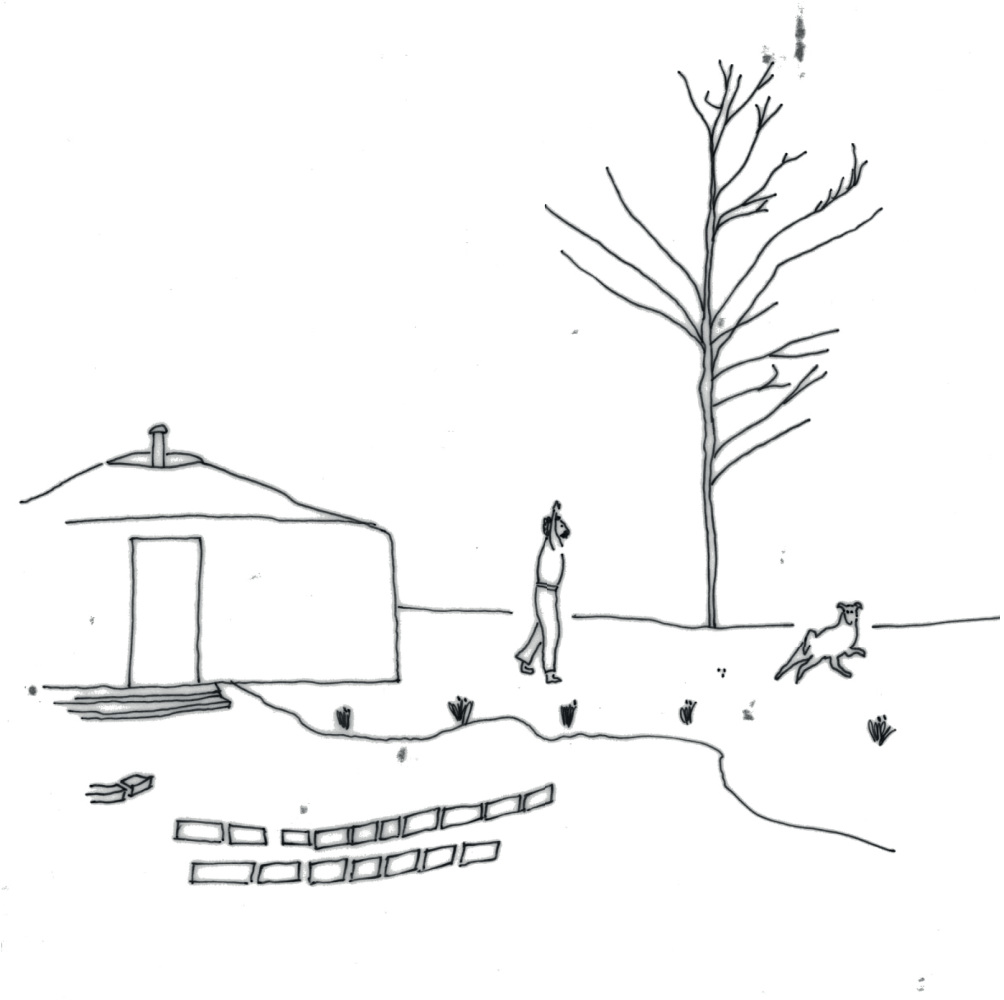


Illustration 24: sleeping, living and circulation area combined

Observations

The tipi below is a guest room. The tipi is set up on a hill hidden between the trees, with the construction of poles and walls of sails. The top of the tipi cannot be closed off, because the combined poles are in conflict with the sail. Not only rain falls through, but also at night there is a lot of oxygen. The sail can also not be completely closed at the ground level. At night there are many animals around the tipi, for example, boar and deer. The animals feel very unsafe. In front of the tipi, there is space to wash. Because the tipi is standing on a hill while washing, you can look over the hill. While looking at the natural context of 'Ppauw', you start to think about the setting of your day. The view is an excellent start at the beginning of the day.

Conclusions

- Closed off areas protect against unwanted animals during the night during the sleeping process.
- The view of a context can be seen as a reflection on your daily situation.

Illustration 25: guest house

Observations

The treehouse below is also a guest room, located at a height of about 10 meters in a tree next to a walking path. You can only go to the tree house if it is still light, otherwise, the traffic route becomes very dangerous. Because it is just a bedroom, toileting at night is not an option. The dependency on the light creates a keen awareness of the natural surrounding. The walking path, adjacent to the tree house, provides social control. Passing persons can help if possible in difficult situations.

Conclusions

- The location of a dwelling close to an open route provides social control.
- A forest does not let a lot of light through.

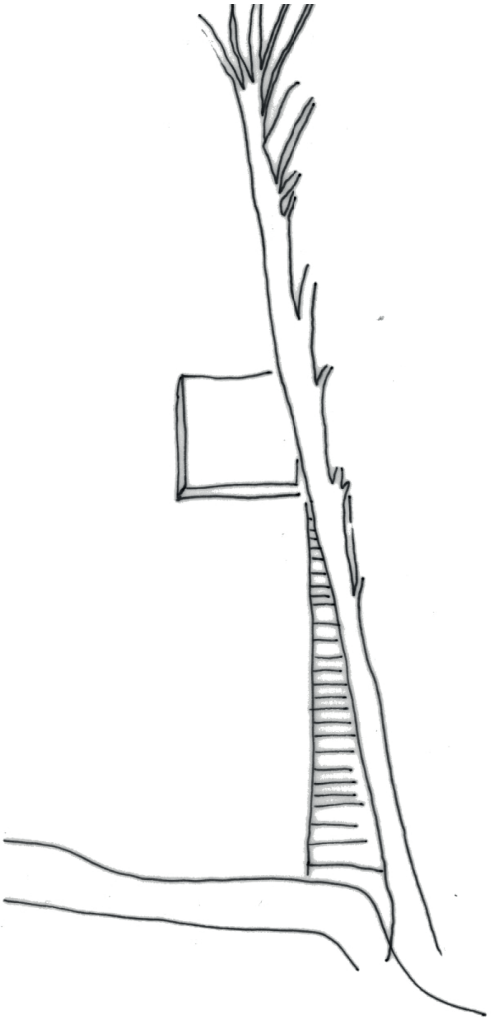
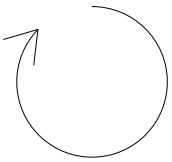


Illustration 26: tree house

3.3 Conclusions

To bond the conclusions written in subchapter 3.1 and 3.2, 5 additions are set-up as the assumptions of the prototype of the design of the growing dwelling. These assumptions have to be followed for all aspects of the building.

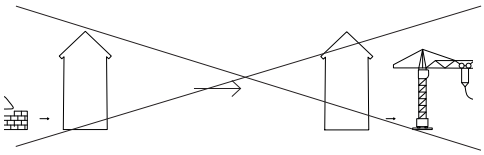


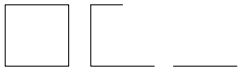
1 biological life cycle

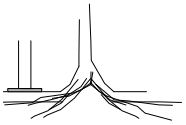
All parts of the building which are not living must preferably decompose naturally when they lose their function for primary consumers.

2 primary producers are more important than primary consumers

Primary producers are needed, as they are the building material, to implement a dwelling for primary consumers. By this, primary consumers have to adapt to primary producers.







3 the amount of organisms grow during the lifespan of the dwelling

The amount of organisms grow during the lifespan of the dwelling. Whereas a traditional building is built and finished behore using, the growth of this building takes care of the functional use of the dwelling.

4 primary consumers adapt while external conditions change

As the growth of primary producers and decomposers is the most important aspect of the dwelling, primary consumers have to adapt to this proces. The dwelling, for example, must be intented for changing weather conditions by having the possibility as a primary consumer (human, bird, etc.) to move between spaces with different circumstances. For human, this are open, half open and closed area. Open areas allow human to extremely integrate with the surrounded nature. Closed areas protect human for nature and wild animals.

5 geography is protected and improved

The geography, filled with the foundation of the dwelling, exist of living organisms or react positively on living organisms in the surrounding.

4 Conclusion

This research analyses unsubdued wildness integrating with daily used architecture, created by human. With the results of this research, a dwelling is designed where people have to adapt to changing circumstances. The wildness increase during the lifespan of the building, without the management of human and, is expressed by the amount of biodiversity, which is the amount of different organism. To find the answer to design a dwelling contributing to biodiversity, the key question of this research is: 'How can a dwelling contribute to biodiversity in a low biodiverse context?'

People, the majority living in cities since 2007, have a dominant role in the amount of biodiversity. By this, Amsterdam, the largest city of the Netherlands, has been analyzed. The ideal location of the prototype of a growing dwelling has to have low biodiversity and low access to surrounding with high biodiversity. All public areas with high biodiversities, such as parks and rugged areas, are located outside the centre of the city. Dense areas with a high population have the lowest biodiversity, due to humanrelated objects and activities, such as the use of land for houses, infrastructure and spreading salt in the winter. The chosen plot for the prototype is situated in the Jordaan. This neighbourhood is the most populated, without any public green areas located.

Organisms can be separated into four categories: bacteria, fungus, plants and animals. Bacteria, fungi and plants are the most important organism of an ecosystem. Bacteria and fungi, decompose dead material into living material and exchange nutrients with other organisms to keep them alive. They are both not stiff themselves but especially the vegetative part of the fungi in combination with fibres have the potential to function as an isolated and acoustic non-constructive material. Plants grow on photosynthesis and are the nutrients for animals, provide shade and curtain redundantly and are also possible to use a constructive structure. Constructions made of plants are waterproof, cheap and durable. There are three options to use trees, strong plants exist of wood, as a structure: planting a young tree and growing them into the structure over time, use trees at a certain height that are already the correct form and size you need or transplanting trees during the growing process. Trees together, after inoculating above and under the ground, form an automated system over time, making the entire structure of the tree structure.

All organisms are part of an ecology, which is a dynamic interaction between organism, geography and abiotic factors. Ecology can be influenced over time by the ecological flow and ecological management Architecture has an essential influence on geography and abiotic factors. By designing as little as possible with paving, concrete, stone, asphalt and spaced sand, the soil surface temperature will remain as low as possible. By designing with shade, lots of air supply, vegetation, the increase in the amount of surface water and the decrease in the traffic surface, a temperature decrease will be achieved. Due to the decrease

in temperature, the soil can respond well to environmental factors. Architecture can stimulate abiotic factors in favour of the growth of bacteria, fungi and plants and promote accommodation for animals.

To follow my intuitions of the requirements of the prototype of a dwelling by experiencing nonconservative dwellings, five additions are set-up as the assumptions to increase biodiversity by dwellings. First, all parts of the building which are not living must preferably decompose naturally when they lose their function for primary consumers. Second, primary producers such as plants and trees are needed, as they are the building material, to implement a dwelling for primary consumers, such as people and birds. By this, primary consumers are less important have to adapt to primary producers. Then, the number of organisms grow during the lifespan of the dwelling. Whereas a traditional building is built and finished before using, the growth of this building takes care of the functional use of the dwelling. As the growth of primary producers and decomposers is the most important aspect of the dwelling, primary consumers have to adapt to this process. The dwelling, for example, must be intended for changing weather conditions by having the possibility as a primary consumer (human, bird, etc.) to move between spaces with different circumstances. For humans, there is an open, half open and closed area. Open areas allow human to extremely integrate with the surrounded nature. Closed areas protect human for nature and wild animals. Finally, the geography, filled with the foundation of the dwelling, exist of living organisms or react positively on living organisms in the surrounding.

With this research, based on analyses, literature, interviews and experiences, there can be concluded that a dwelling, located in the centre of a city with a high populated neighbourhood, can contribute by using bacteria, fungi and plants as building materials. Next to that, by designing the soil temperature can decrease to influence the building materials positively. Also, abiotic factors such as wind, sun or rain can navigate to increase the grow of organisms and to protect organism to these factors if wanted.

5 Discussion

For this research, analyzes, literature and experiments have been used to analyze the architecture and to mediate between these possibilities and the environment. The analyzes are based on data from the municipality of Amsterdam and the used literature is written in various reports and books. Results in researches with the same expectations will be similar. The assumptions, based on experiences, will vary.

This research shows that the biodiversity in the old centre is low due to the dense population of houses. A relationship between houses and low biodiversity, known from research, is the interior of the plot for a building and infrastructure. Designing with building materials consisting of living organisms such as bacteria, fungi and plants will increase the biodiversity of a building. To design with shade, a lot of air supply, vegetation, the increase in the amount of surface water and the decrease in the traffic surface, the soil temperature will ensure that these activities make a positive contribution to biodiversity.

The result is a step-by-step approach or capabilities to show and change the negative human impact on biodiversity to a positive impact. By understanding the impact of conventional techniques of building dwellings and give possibilities for options with similar climate conditions, I want to show that there are many opportunities to generate a positive impact.

Current research is a combination of various existing literature with a unique focus on a specific component to increase biodiversity. Knowledge of specialists in the field of mycelium, the diversity of trees in the city centres and the inoculation of trees has been combined to make a prototype of the applications of these possibilities come together. Based on this research, building engineers and architects can be inspired and generate more biodiverse architecture.

This research provides a grasp of the general biological influences on architecture and the integration of organisms as building materials in dwellings, where both biological aspects are very complex and newly built homes are a small part of architecture. Different types of bacteria, fungi of plants, the impact of the ecological flow of ecological management on biodiversity and the short duration of everyday building processes may change the focus of the result.

The advice on a possible follow-up to this study is therefore to conduct a deeper investigation into types of organisms and into influences on organisms and to use contemporary techniques such as robotics that can have an impact both in the construction process and during the growth of the dwelling, to be further investigated.

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Images

Image 1: the future of cities by integrate organism in dwellings
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Image 3: an environment with high biodiversity in Tapei
Mass, A. (n.d.). City Jungle in Tapei. Retrieved May 24 2018, from https://www.flickr.com/photos/rejss/24074904711/in/photostream/

Image 4: reaction from a human on light intensity
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Image 5: 3d printed mycelium chair
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Image 6: mycelium pressed in a tile
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Image 7: mushroomtower grown in 5 days
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Image 8: uncultivated space to grow organism during the lifespan of the building
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Image 9: building fitting in the already existing nature, using nature for shade, ventilation and privacy
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Image 10: uncultivated space to grow organism during the lifespan of the building
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Image 11: growing construction from spring 2005 till autumn 2010
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Image 12: bamboo scaffolding
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Image 13: building with living bamboo
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Image 14: living root bridge

Bandyopadhyay, S. (2016, February). Top view from Living Root Bridge in Mawlynnong. Retrieved November 19, 2018, from htt

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Image 15: Cat catch some sun

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california-700-cats/?utm_source=google&utm_medium=organic&utm_campaign=organic

Image 16: House behaviorology

[Photograph]. (n.d.). Retrieved March 20, 2019, from https://www.gjf.cz/archiv/

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Annex

- attachment 1 : Interview Dalfsen
- attachment 2 : Interview Wageningen
- attachment 3 : Interview Tjeerd Veenhoven
- attachment 4 : Interview Davine Blauwhoff
- attachment 5 : Interview Hans Kaljee

Attachment 1 : Interview Dalfsen

Stay-over at Lelie, Cathelijne en Bob Radstake (resume, Dutch)

18 tot 20 maart 2018 heb ik geslapen bij de familie Radstake; een gezin dat woont in het bos in Dalfsen. Vakantiehuizen zijn omgebouwd tot woningen, er wordt als een community geleefd in het bos. Als visie wil dit gezin, als visionaire leidend binnen de community, plekken die geen functie hebben gebruiken om biodivers te wonen of plekken die al een functie hebben uitbreiden met de functie wonen. Door op een plek te wonen willen ze, heb ik het gevoel, door ecologisch management een positieve invloed uiten op de natuur. Op dit moment bouwt de familie een woning om de woning. De woning waar ze nu in wonen, wordt als tijdelijke woning beschouwd die in principe kan worden afgebroken als de woning eromheen af is gegroeid. Door plantenbakken te stapelen en te vullen met grond en bomen, groeien op verschillende hoogtes bomen. Deze bomen, veel hazelaars, worden aan elkaar gesmolten zodat de wand uiteindelijk dicht groeit. Er is voor hazelaars gekozen omdat deze relatief snel groeien en weinig licht nodig hebben. De hazelaar is afgewogen met wilgen, maar die hebben een te open structuur. Een andere man die in de community woont, Bouwie, bouwt zijn huis met pallets gevuld met hennepbeton; dat bestaat uit hennepsnippers, hydraulische kalk en water. In de pallets plant hij kastanjes. Door de sterke relatie en de afhankelijkheid van en met de natuur in deze woning ervaar je veel van de natuur, bijvoorbeeld wanneer de zon schijnt of wanneer het regent. De zon schijnt veel en de vogels zingen, wat me anders niet was opgemerkt. Door de afhankelijkheid van de natuur is de kennis van de natuur groot; zo weten de bewoners precies dat de eikenbomen in het bos iets later hun bladeren los laten als de andere bomen, waar de plek van de zonnepanelen afhankelijk is door veel licht te kunnen vangen. ‘S avonds zijn er geen plekken waar de lampen aankunnen. Hierdoor ben je sterk afhankelijk van de natuur en leef je met de tijd die de zon je geeft. Als er toch behoefte is aan sociaal contact ‘s avonds, wordt de haardkachel aangestoken. Dit zorgt voor warme ontmoetingen waar iedereen dicht bij elkaar staat. Ook ben je je bewust van de volle maan, die als een zaklamp de open verkeersruimte verlicht. Als je na een lange tijd buiten ineens naar binnen gaat, begin je van jezelf te gloeien. Iets wat je zelden ervaart als je veel binnen bent. Er is een sterke relatie tussen de straat en de kavels gecreëerd door open zichtlijnen en grote hoogteverschillen. Als je het toegangspad van het huis bewandelt, kun je goed zien of er iemand aanwezig is in het huis van de familie Radstake, waardoor er een paar keer per dag mensen langskomen voor sociaal contact. Deze mensen komen bij het haardvuur bij elkaar, ook als het vuur niet aanstaat. Er is veel interesse voor hun plan, waar ze deels zelf werk van maken. Ze hebben veel contact met de gemeente, fotografen, investeerders, naast het uiten van hun mening zijn ze vooral ook praktisch gericht op zoek naar oplossingen om hun eigen droom te verwezenlijken. Door te zoeken naar een gat in de in heel hoge mate regelgeving van Nederland zoeken ze een manier om dichter met de natuur te leven in tegenstelling tot een conventionele manier van wonen, en dat is nog niet zo makkelijk. Ook heb ik kennis leren maken met André, een man die volledig buiten het Nederlandse systeem valt. Hij heeft me veel geleerd over manier van leven in Nederland zonder een onderdeel te zijn van het systeem.

> image
Cathelijne geeft de hazelaars water (“Ceton”, 2018)

kinderkamer/ voorgevel

gebouw in aanbouw

voorgevel vanaf de binnenkant

achtergevel

wand tussen toilet en badkamer

gevel van Bouwie met kastanjes

extra woonkamer

ander huis gebouwt door Bob

Attachment 2 : Interview Wageningen

Stay-over at PPauw (resume, Dutch)

15 tot 17 april heb ik geslapen bij de community Ppauw, bestaand uit 11 mensen. Er wonen twee kinderen, geen hele oude mensen en de gemiddelde leeftijd is tegen de 30 jaar. Verspreid in het bos in Wageningen, waar ze wonen, heeft iedereen zijn eigen slaapkamer. Rondom de slaapkamers is veel ruimte. De toilet, badkamer, woonkamer en eetkamer word gedeeld. Stroom wordt zelf opgewekt, groente wordt zelf gekweekt en kippen lopen rond om de bewoners van eieren te voorzien. Vooral de tussenruimte speelt een belangrijke rol in de voelbare vrijheid die de bewoners uitstralen, een ruimte voor open invulling.

Door los te staan van technologie en zo veel mogelijk lowtech op te lossen, proberen ze het denken zelf in te vullen in plaats van dit over te laten aan een machine. Sommigen die hier wonen vinden dat technologie de kloof tussen mensen vergroot, door de sterke afhankelijkheid van techniek. De geur van het bos en van natuurlijke materialen zoals tentdoek en de zuurstof die in het bos en in de natuurlijke materialen vrij komt, de sociale omgang tussen bewoners, die gevoelsmatig ontstaat door de menselijke afhankelijkheid, zorgt voor een aangenaam gevoel.

gemeenschappelijke ruimten

gezamelijke woonkamer en entree

gezamelijke keuken/eetkamer

relatie tussen keuken/eetkamer/entree

boomhut, slaapplaats voor bezoek

tipi, slaapplaats voor bezoek

slaapplaats van een bewoner

slaapplaats van een bewoner

Attachment 3 : Interview Tjeerd Veenhoven

Studio Veenhoven on 17th of September 2018 (resume, Dutch)

Algen groeien in een natte ecologie. Tjeerd werkt met de algen die specifiek in water groeien, niet in een sediment hiervan. Iets wat algen bijzonder maakt, is dat ze gewichtloos groeien. Dit is een groot verschil tussen algen en bomen, de groei en de vertakking verschilt hierdoor. Algen hebben niet een stam en zijn relatief dunner dan bomen omdat ze zwaartekracht niet hoeven te overwinnen om voedingsstoffen rond te pompen. Lignine en cellulose zijn kortgezegd de vulling van een boom, waar alle voedingsstoffen en sappen doorheen stromen en die de boom stijf maakt. Algen hebben weinig lignine door de gewichtloze groei en zijn hierdoor ook niet stijf. In sommige algen zit veel cellulose, die voor een houtachtige structuur zorgt. Sommige algen hebben maar 10% cellulose. Het is dus belangrijk goed te specificeren welke algen je nodig hebt. Omdat algen geen vruchtbare grond nodig hebben om op gekweekt te worden, zijn ze duurzamer dan bomen. CO2 en zonlicht zorgen voor de groei van algen. Hierdoor is CO2 geen afvalproduct maar een grondstof. Door de hoeveelheid lichttoevoer te verminderen of te vermeerderen, wordt het groeiproces vertraagd en versnelt. Sporen blijven rondzweven, waardoor een spoor zich kan verplaatsen en op een andere plek weer kan groeien. Door te variëren met licht, kunnen algen onderdeel worden van wanden. De wand zal meer zonlicht vangen in de zomer, waardoor de wand groener is door de grotere hoeveelheid algengroei. In de winter zullen er veel algen afsterven en zal de wand doorzichtiger worden. Normaal zakken dode algen in de zee naar de bodem en wordt het sediment. Als dit in de wand naar de bodem zakt, zullen de dode algen wel geoogst of weggenomen moeten worden, het verwijderen van de dode algen is alleen nodig als het een storend effect heeft op de transparantie van de wand.

Tjeerd gebruikt de dode algen nog voordat ze gecomposteerd zijn en haalt ze uit de cyclus in zo goed mogelijke groei. Hierdoor zijn de cellulosen not niet afgebroken en is het materiaal nog niet gaan rotten. De cellulosen extraheert hij om wollen draad te maken. Voor hem is het grootste obstakel contaminatie, hij wil met een soort werken waardoor hij eenzelfde soort wol in grote hoeveelheid kan maken. Voorbeelden die hij noemt zijn Roscoff en Spitsbergen. In Roscoff is het getijdengebied goed. In Spitsbergen is er alleen maar 3 maanden per jaar zonlicht, waardoor de algen in een groeispurt komen en stappen overslaan in het groeiproces. Het is zichtbaar dat als de omgeving veranderd, de alg zich aanpast aan de omgeving. Als laatste voorbeeld geeft hij de Golden Jellyfish, om het nut van de algen in het ecosysteem te benadrukken. De Golden Jellyfish is een kwal die leeft in aan afgesloten stuk van de zee als gevolg van een aardbeving. Doordat het watergebied is afgesloten van de zee zijn nutriënten niet oneindig. Na vele vermenigvuldigingen waren in verloop van tijd de nutriënten op. Als oplossing zijn de kwallen een symbiose aangegaan met de algen, waardoor ze kunnen leven op alleen maar CO2 en zonlicht. Hun tentakels werden overbodig, dus hun lichaam is aangepast aan de nieuwe manier van voedingsstoffen en eenmaal per dag zwemmen ze naar boven om zonlicht te vangen.

Attachment 4 : Interview Davine Blauwhoff

The Center of Expertise Biobased Economy on 18th of May 2018 and 26th of October 2018 (resume, Dutch)

De bouwindustrie is conservatief, waardoor The Center of Expertise vooral experimenteert op kleine schaal. Ze werken alleen met dode mycelium maar hebben de ambitie om te gaan werken met levende mycelium. Dit gesprek is voornamelijk gericht op de mogelijkheden die mycelium biedt met de kennis die het centrum heeft over dode mycelium.

Mycelium, dunne draden van 0,01 mm, worden normaliter samengegroeid met vezels en 'doodgemaakt' waarna vervolgens de eigenschappen vastgesteld kunnen worden van het product. In principe kun je mycelium niet dood maken, waardoor het vervolgens weer zal gaan groeien. Het risico is dat mycelium geïnfecteerd kan raken door andere bacteriën en schimmels van buitenaf, dit kan schadelijk zijn voor de menselijke gezondheid. Een mogelijkheid is om regelmatig te 'slechte' schimmels te filteren, dit kan bijvoorbeeld met uv-licht maar dat is niet een duurzame oplossing. Een mogelijkheid is om mycelium niet dood of levend toe te passen maar in slaaptoestand, je droogt mycelium dan aan de lucht. Als er water aan de slapende mycelium wordt toegevoegd, zal het weer gaan groeien. Droog is mycelium sterker dan levend, als het nat is, fungeert het als een soort spons. Droge mycelium kun je vergelijken met piepschuim, 0.1 mpa, het is dus niet constructief. Het heeft nog de potentie, door de dichtheid aan te passen, om sterker te worden. Door bijvoorbeeld mycelium onder hoge druk en hitte te persen krijg je een soort mdf plaat, de sterkte is dan veel hoger. In principe absorbeert en dempt mycelium geluid en heeft het een isolerende functie.

Als slapende mycelium aan elkaar is gegroeid kun je wortels toevoegen, schimmels en wortels gaan namelijk ook goed samen in de groen. Een vraagteken is echter wel hoe lang mycelium voldoende nutriënten vindt als het niet met het maaiveld verbonden is. De nutriënten voor schimmels zijn water, aarde en mineralen, maar kunnen ook voldoen aan alleen vezels en compost. Planten hebben een ander voedingsschema. Wel kunnen de schimmels en planten een symbiose aangaan, zo hebben schimmels een groter netwerk waardoor ze makkelijker aan water komen. Het water ruilen de schimmels met de planten voor glucose dat kun je alleen aanmaken met fotosynthese. Een ander groot risico van slapende of levende mycelium toepassen is dat je niet weet hoe het zich gedraagt gedurende de tijd.

Attachment 5 : Hans Kaljee

Tree Consulent of Government of Amsterdam on 19th of September 2018, (resume, Dutch)

Bij de afdeling duurzaamheid, gemeente Amsterdam, wordt veel aandacht besteed aan het planten en behouden van bomen. De komende jaren is er 15 miljoen euro beschikbaar voor het aanplanten van 'groen' in de stad, verspreid over de 33 buurten in Amsterdam. Onder 'groen' valt onder andere gevelgroen, openbaar groen en achtertuinen. Iedere inwoner in Amsterdam kan tot 50.000 euro subsidie aanvragen om bomen te planten, als de stam dikker is als 20cm. Voor bomen in de tuin geldt dit tot 5.000 euro. Deze subsidie loopt geen storm omdat het planten van bomen in een dichtbezette stad ingewikkeld is. Naast het toevoegen van 'groen' zijn er ook opgaven over duurzaamheid, klimaat, regenwater en natuurinclusief bouwen.

In Amsterdam staan 15.000 verschillende soorten bomen. Alle bomen die geplaatst worden moeten bestand zijn tegen het Nederlandse klimaat, vriezen en extreme hitte. In de hoofdstructuur zijn bomen geplaatst die gemiddeld het meeste kunnen verdragen; graafwerkzaamheden, ophoging, grondwater en strooizout. Tot deze bomen worden gerekend: de iep, de plataan, de arcasia, de esdoorn, de populier en de wilg. De wilg is minder interessant omdat het veel takken laat vallen en dat kost veel onderhoud. Daarnaast heb je nevenstraten en structuren, waar minder veranderingen in de omgeving plaatsvinden. Tot slot kunnen in de parken alle soorten bomen staan. Iedere boom heeft ook weer verschillende soorten. In de iepen alleen al zijn dan wel weer 60 verschillende soorten in Amsterdam. Die kun je kopen van smal, breed, haaks, etc. Geel blad, bont blad, hangende takken, opgaande takken, iets langzamer groeiend, hard groeiend. Ook binnen de iepen heb je een soort top 10 van iepen die we het meeste kopen.

Klimaatverandering speelt een belangrijk aspect bij het plaatsen van de juiste bomen. Door de hardere wind en de extremere temperaturen wordt rekening gehouden met bomen die bestand zijn tegen 30 graden vorst in combinatie met een natte omgeving. Door de grond kun je Nederland als hoofdindeling in tweeën verdelen, waar in het oosten vooral eiken zijn gepland en in het westen vooral iepen zijn gepland. In het westen van Nederland bestaat de grond namelijk uit moeras, in Amsterdam is dit veengrond geworden van 3-5 meter dik. Veengrond zakt elke dag, waardoor elke 20 jaar de stad moet worden opgehoogd met 10 tot 20cm. Het Vondelpark is bijvoorbeeld 1,5m lager aangelegd dan dat het hedendaags is. Door ondergrond moeten kabels en leidingen doordat er veel woningen en verkeer in de stad is. Er zijn nu niet alleen rioolstelsels maar ook hemelwaterriolen sinds jaren 30/40. Sinds de jaren 60 lopen ook telefoons met kabels en leidingen door de grond. Tot slot lopen ook de stroomvoorzieningen door de grond. De wortels van bomen en planten groeien niet onder de grondwaterstand, in Amsterdam ligt de grondwaterstand op gemiddeld ongeveer 80cm. 1 boom heeft ongeveer 5m x 5m x 1m nodig om zijn wortels te aarden. Er is dus kortom weinig plek voor het wortelstelsel van bomen en planten. Natuurlijk is het mogelijk om te bouwen op daken, echter zit je dan met de toevoer van watersystemen

en nutriënten en dat is niet altijd mogelijk. In het westen van Nederland zijn van de geplante bomen 70% iep, waar in heel Nederland 70% van de iepen die geplant is dezelfde soort is. In de jaren 20 kwam de Iepenziekte, de eerste zieke iep is gesignaleerd in 1918, die geïntroduceerd is in Azië. Hierdoor zijn miljoenen iepen verdwenen. Sinds 1936 is er gesignaleerd dat dit komt door een bepaalde schimmel.

Tot de jaren 90 plantte de gemeente Amsterdam bomen, waarbij rekening werd gehouden met 2mx2m x1m. Met de grondwaterpeil die zo hoog ligt, stopt de boom dan na 5 jaar met groeien, waardoor het een soort potplant in de straat wordt. In de jaren 80 is er veel onderzoek gedaan naar verbetering. In deze onderzoeksperiode is een substraat bedacht, 'bomenzand', die bestand is voor onder tegels of andere verharding in het straatprofiel, waar de wortels van bomen en planten in kunnen groeien. De gemiddelde stadsboom wordt 30 jaar. Sommige bomen in de stad zijn 150 jaar, maar dat zijn echt zeldzame bomen. Aan de grachten staan vooral jonge bomen. Door bijvoorbeeld het vernieuwen van kademuren, het veranderen van functies en het ophogen van ruimten worden bomen vaak gekapt binnen 25 jaar. Als het streven is om een boom groot en oud te laten worden, is een goede hoeveelheid aan grond belangrijk. Buiten de stad kunnen iepen tot 500 jaar worden.

Een boom hoef je niet te beheren, behalve als die geplant is in de kwekerij en verplaatst wordt naar de juiste plaats. De boom heeft 20% van de wortels meegekregen van de kwekerij, 80% van de wortels, het meest actieve gedeelte, blijft achter. De boom moet als die eenmaal is verplaatst 2 jaar geholpen worden om door die stress situatie heen komen. De eerste twee jaar moet hij water krijgen en hoeft hij niet te veel te verdampen. De afgelopen zomer zijn er daardoor ook veel jonge bomen doodgegaan. Als de boom eenmaal staat en hij heeft zijn wortelstelsel herstelt, en hij heeft voldoende groeiruimte tot zijn beschikking, dan is beheer overbodig. Zeker met de veengrond is er altijd water in de grond, daarnaast is er altijd condensvorming, en ook snoeien in alleen nodig als de takken in de weg hangen. De enige reden dat bomen in het straatprofiel aan de onderste kant van takken wordt ontzien is een praktische reden.

Attachment 6 : Ferdinand Ludwig

Architect, professor at TU Munchen on 11th of January 2018 (resume)

Ferdinand Ludwig studied architecture in Stuttard, started in 2000, and stumbled over the topic 'building with trees' by examples. Fascinated by the idea but scared by the contradiction with nowadays traditional outdated buildings it seems an impossible vision to build with trees. It especially seems impossible to integrate buildings with trees with conventional daily needs. With a mix of research and practical tests, he set up a foundation of knowledge about living architecture in many years, including a PhD.

The first practical example he tried to build with a colleague was a footbridge, started in 2005, in a non-urban surrounding with simple techniques. By the practical working method, they learned from the many mistakes in terms of botanical technical details. The footbridge was standing on the willow from the first moment, this is one of the benefits of this very simple approach, which was a big advantage. Disadvantages in this project were the designed joints that did not work, the diagonals that were shaded which ensure that the willows die, it was too flexible and positioned in the middle point of the wind. Ferdinand wants to integrate living architecture preferably in an urban area, with different species. His PhD was focused on the question: what are the design rules if you integrate trees in a design? The time aspect in designing change over time and is unplannable,. The expectations of the growth of a tree have to do with the direction of growth, the density in the environment and if they are combined with more trees. After his PhD, his focus shifted. In the beginning, his interest in living architecture was focused on the structural aspect of designing and shifted to the ecological aspects to support the climate. Not only the structure became important but more interesting is to fuse conventional buildings and trees. For him, it is important that there is not only focus on the inside, or to save energy, but also to improve the surrounding. The baubotanik details are some options to improve nature by building. In 2017 Ferdinand and his colleagues reanalyzed and reconstruct the footbridge by their new knowledge. They cut the existing trees and let them regrowth, it became a process of constant regeneration. On top of the footbridge, there is still the old structure. The bridge bears his forces by cutting on a contemporary construction, which will be removed after 5 years.

Ferdinand and his colleagues prefer to design in collaboration with nature with high contrast between man-made objects and nature-made processes, by this they preferably always use steel as an added material. By having a clear difference between steel and the tree, the architecture does not become unclear and easy to read.

In all buildings, they do not build a foundation, even in a public building they build. Often foundations are made of concrete, but that will cover the space used for the roots of the trees. They do change the soil type in projects situated in urban dense area's, to support the closely planted trees in the growth of the root system by the need of their nutrients.

There are three strategies;
- planting a young tree, growing into the structure over time.
- use trees at a certain height that are already the correct form and size you need
- no process in the making of the building in the structure

Some design principles are the timeline, how it regrowth, how the water transport, how leaves work, how wood works, how the tree die, how the tree is shaded. Trees become less flexible over time, younger trees are more flexible, older ones are not. There are two important aspects of designing with growing trees; the growth in length and the growth in width. Every trunk stretch the first 20-50cm, after that, it is only growing in branches. If you place something on top, it is not shifting. Horizontal elements depending on the branches or stamps never move upwards, they only go down if the branch or stamp die. In all projects, they have the process of growth and the process of decay. Sometimes, the process of decay already starts after one year. Ferdinand draws lines for the process of growth, with dotted lines to suggest the possible decay process. Every tree can be cut and regrowth, by this the project is a continuous process. Finally, every part of the project is replaceable.

Robots have potentials to help the growing buildings. Ferdinand and his colleagues analyse the traditional techniques of growing trees and try to improve baubotanik purposes by implementing robots. They have made projects where they use robots for baubotanik fabrication, they now analyze the integration of robots in the management part of the growing architecture.

Ferdinand's inspirations are Frei Otto, Edouard Francois and Gilles Clément. His next plans are focused on several events. They are mainly diving into the possibilities of living root bridges in urban spaces in collaboration with several parties in China by analyzing and following workshops in India.