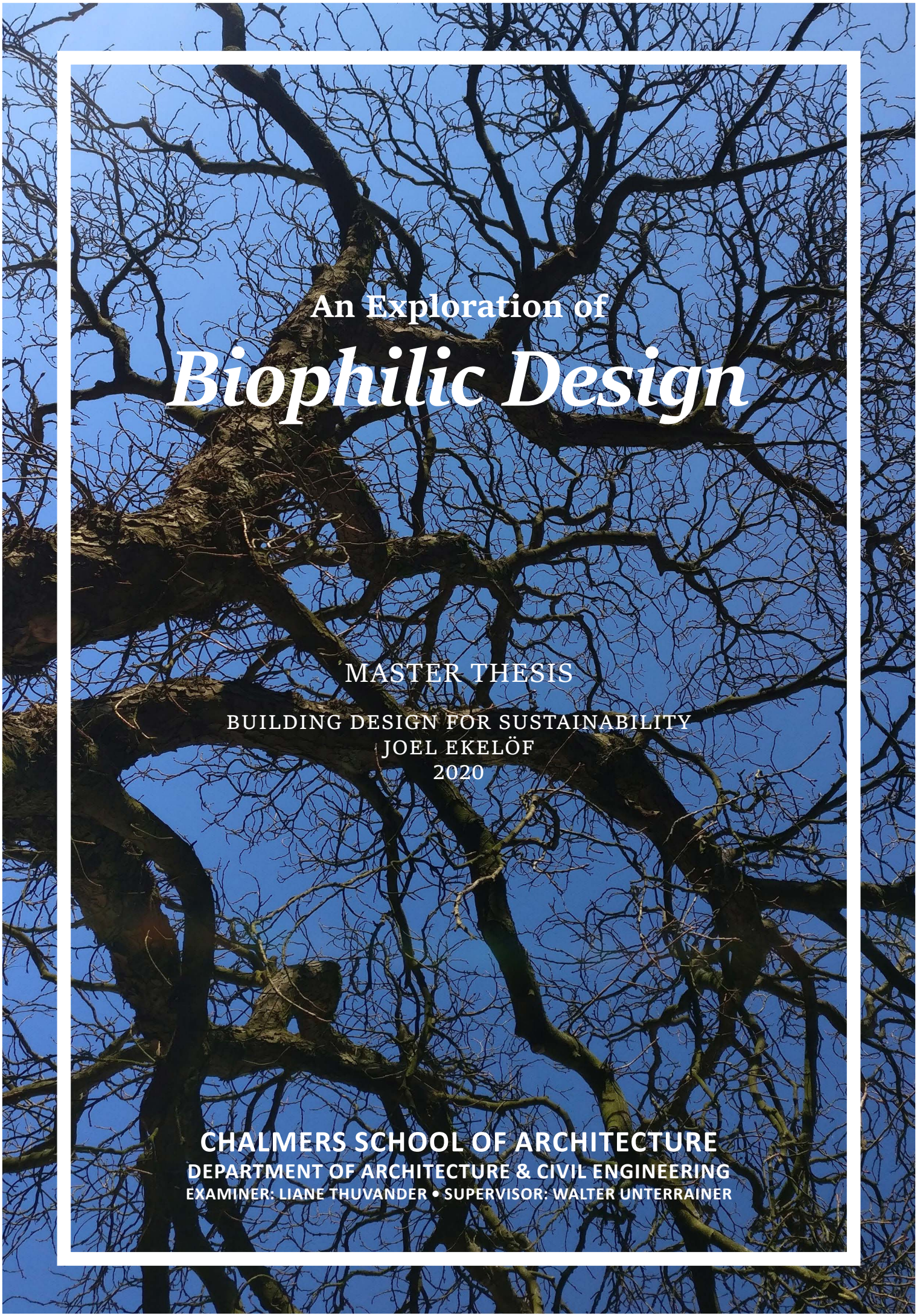

An Exploration of

Biophilic Design

MASTER THESIS

BUILDING DESIGN FOR SUSTAINABILITY

JOEL EKELÖF

2020

CHALMERS SCHOOL OF ARCHITECTURE

DEPARTMENT OF ARCHITECTURE & CIVIL ENGINEERING

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ABSTRACT

The purpose of this thesis has been to do an exploration within the field of Biophilic Design to get a deeper understanding of how and when nature can be used within design to support health.

More specifically, to better understand different properties of nature and nature-like environments and when those could be used to support wellbeing, in the sense of improved restoration, performance, and preference, within the context of residential architecture, in a dense urban setting.
This is important because if we as architects want to take more responsibility for the spaces we design, we also need to address and improve our knowledge of how those spaces may affect our health and wellbeing.

This thesis is targeted toward architecture students with a new interest in nature's relation to health, and as such the thesis also focuses on showcasing and presenting a clear and interesting overview of the subject with examples of how to work with it.

The exploration in itself has been an open-end process and is presented in three parts; one theoretical, one analytical, and one practical.

The theoretical part uses the report "14 Patterns of Biophilic Design" as the main reference, as it systematically presents how nature can be understood in different ways, it also provides existing health research on each matter. In this part summaries and illustrations are presented as a way to improve the overview of the topic and the research.

The analytical part uses the findings from the first part to identify natural aspects in a dense urban setting and uses a city block within the neighborhood of Masthugget in Gothenburg as a site. In this part descriptions and comparisons are made to better understand the nature-like qualities of the place, or the lack of, and its relation to the site's history and future plans.

The practical part uses the findings from the first and second part and applies it to an existing development plan for the site, to understand what design interventions should be prioritized and what adaptation could be made to improve the condition of the residents. In this part, a roof garden is presented as an effective design intervention that suits the site but still is general enough to be applied in other similar contexts.

In the conclusion, the implications of biophilic design are discussed together with findings and limitations of the exploration, and suggestions are presented for what future research could investigate further.

Keywords: exploration, biophilic design, nature, wellbeing, residential architecture, dense urban setting, courtyards, rooftop

There are only trunks, branches and twigs on the front page

CHALMERS

UNIVERSITY OF TECHNOLOGY

AN EXPLORATION OF

BIOPHILIC DESIGN

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DEPARTMENT OF ARCHITECTURE & CIVIL ENGINEERING

MASTERS PROGRAMME

OF ARCHITECTURE & PLANNING BEYOND SUSTAINABILITY

STUDIO: BUILDING DESIGN FOR SUSTAINABILITY

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2011-2013

THESIS MOTIVATION

Why I care for this thesis
As a becoming architect, I strive to have a good sense of design and broad knowledge in many fields. I also hope to be able to work closely with customers and clients with projects where sustainability and health are taken for granted.

By sustainability, I mean climate-friendly materials and energy-efficient solutions, to "nudge" a more sustainable lifestyle, and to include biodiversity.

By health, I mean knowing research in evidence-based design and environmental psychology. Understanding how design affects our decisions and habits. Also, avoid toxins and the risk of accidents.

To me, no building is neutral in its design, but good design is when a building gives more to its place than it takes. Hence the importance of sustainability and health.

Joel Ekelöf

Me, myself and I

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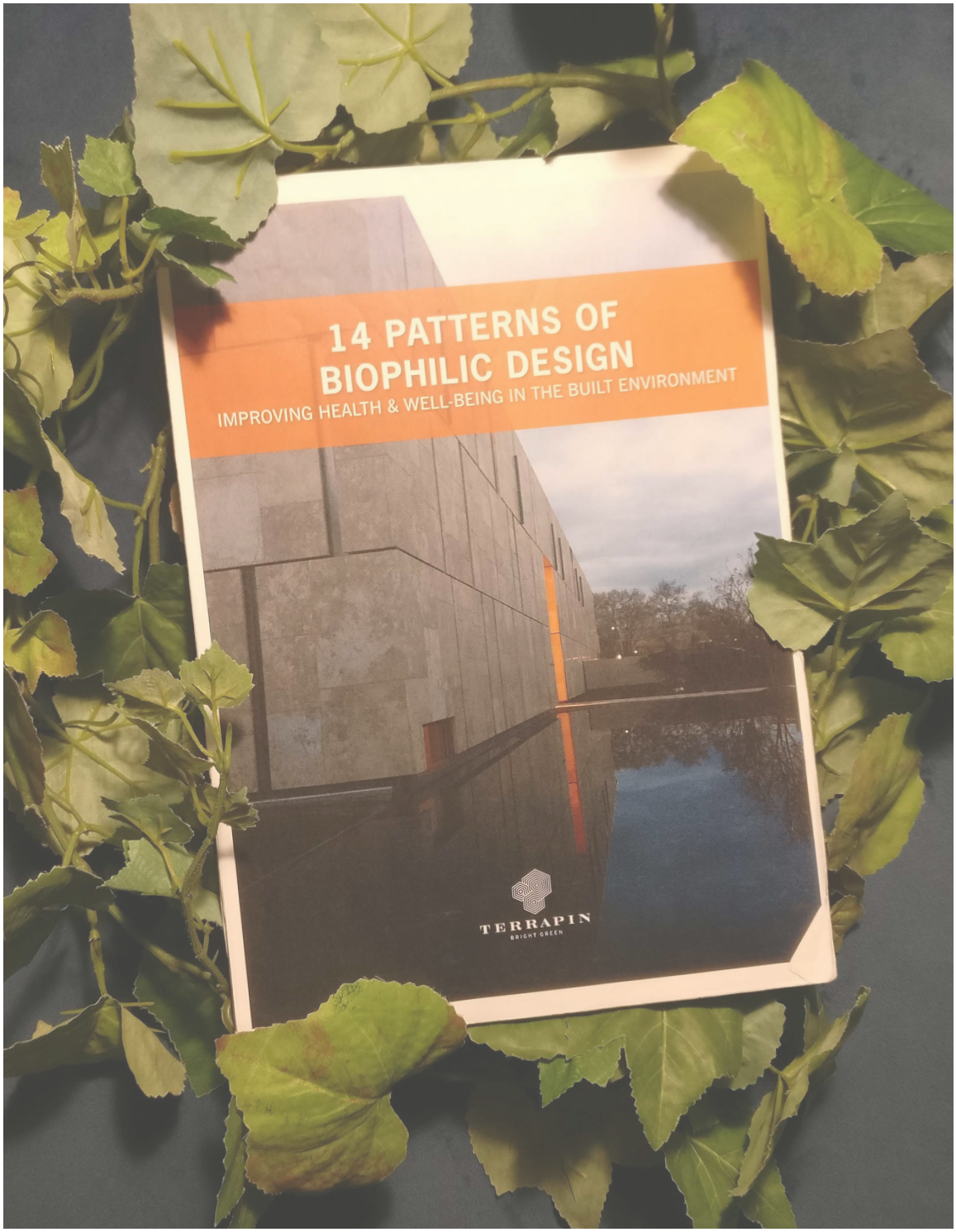


The main reference for this thesis

1 INTRODUCTION
READING INSTRUCTION

This booklet is divided into 7 chapters in 3 parts. First, a part that introduces the exploration, then a part with three chapters about the exploration, and finally a part that ends the exploration together with references and the process.

INTRODUTION
The first chapter presents the structure and context for this thesis along with the background, goal, and the thesis question. It also specifies the exploration itself and its delimitations.

BIOPHILIC DESIGN
The second chapter presents the exploration of the theory of biophilic design, it introduces the health aspects, the three main approaches, and the 14 patterns that are used throughout the thesis.

BLOCK BARKEN
The third chapter presents the exploration of analyzing a site through a biophilic lens and how to use the 14 patterns to understand and identify the nature-like qualities of the place.

ROOF GARDEN
The fourth chapter presents the exploration of applying a biophilic design perspective to one of the residential buildings in the proposed development plan.

DISC & CONCL
The fifth chapter concludes the exploration by answering the thesis question and presents a reflection about the project.

REFERENCES

APPENDIX
Includes the process and parts of the exploration that has been left out.

1.1 BACKGROUND
DESIGN, NATURE & WELLBEING

Biophilia
The background of this exploration is my curiosity for *biophilia,* meaning *"the love of life and living systems",* coined by Erich Fromm in his book *The Heart of Man* (Fromm, 1964) and later popularized by Edward W. Wilson in his book *Biophilia* (Wilson, 1984).
I wanted to explore the possibility that space itself can bring out the best of us, our potentials, by supporting our wellbeing in everyday life.

Out of our depth
As Hanzi Freinacht argues in his book *The Listening Society* (Freinacht, 2017), it is necessary to address a deeper layer of welfare with our everyday wellbeing, as our new society demands more of us than ever before. We need more psychological and social functional people to keep up with the ever-increasing complexity of our society that we ourself have created. Freinacht put it "*We are out of our depth"* (Freinacht, 2017, Location No. 2072).

An indoor species
According to Klepeis, N. E. et. al. (2001) we are becoming an indoor species, as Americans spend on average 87% of their time indoors and it is not too far to conclude that it is probably more or less the same for us here in Sweden. If this stays true we rather need to address how those spaces affect.

Rediscover the intuitive obvious
Since Roger Ulrich's famous study *"View Through a Window May Influence Recovery from Surgery"* (Ulrich, 1984), there has been ever-growing research interest in *Evidence-Based Design* and how nature and nature-like environments have the potential to affect our physical and mental health positively. The empirical evidence, especially from the last decade, shows that when exposed to nature we collaborate better, care for, and show more compassion for each other and are generally more productive. We also become more creative, feel better, and get higher self-esteem, just to name a few benefits (Beatley, 2016).

To shape the everyday lives of others
The problem I want to address is the one of wellbeing and how design in the context of our homes can support our everyday life, in the sense of stress reduction, increasing cognitive performance, and general preferences. This also includes improved relations and connection toward nature. This is important because we as architects need to address and improve our knowledge of how the surrounding nature and the spaces we design affect our health and wellbeing.

The point is that there is a wealth of research into how our environment affects us in ways that could have a major impact on everyday life. As such it's our responsibility as architects to have general knowledge about those findings.

1.2 AIM, GOAL & QUESTION
SHOWCASE & EXAMINE

The starting point of my thesis has been to increase my design knowledge about nature and align it with existing research from environmental psychology, the discourse of healthcare architecture, and the benefits of nature.

Aim
To systematically explore the concept of Biophilic Design to understand its application and possible impact on residential architecture within a dense urban setting. A further, more personal aim is to increase my design knowledge within architecture by connecting to the research behind the wellbeing of nature and Biophilic Design and be able to argue critically about its application.

Goal
To showcase an exploration of biophilic design to make it easier for others to delve into its theory and the health research behind it, the language that it provides to describe nature, its application in design, and what to prioritize.
The thesis has been an open-end process from the start with no specific defined end goal more than the exploration itself. As the thesis started to evolve and unfold itself it became clear that a defined goal would be necessary to wrap up and finish this project. As such the following end goals were defined:

I want to contribute to the discussion of biophilic design with my visualizations & simplification of the theory, showcasing an example of the suggested health aspect, speculating about its impact on residential architecture and how it could be applied within a dense urban setting.

Thesis Question
How can biophilic design be used as a framework, to support wellbeing, in the context of a residential building, within a dense urban setting?

How can biophilic design be used as a framework,
to support wellbeing,
in the context of a residential building,
within a dense urban setting?

1.3 METHOD & THESIS STRUCTURE
AN EXPLORATION IN 3 PARTS

Post-design structure of an open-end process
My approach for this thesis has been to explore biophilic design systematically to deepen my understanding of how natural environments could be used in an architectural context. This also includes examining the existing research that suggests that natural environments have a potential improvement to health and wellbeing. The exploration in itself has been an open-end process and evolved throughout the work with this thesis and what I present here is a post-design structure that describes it better.

The exploration can best be described in three parts.

Biophilic design ***Part 1: To learn the theory through summaries and illustrations***
Block Barken ***Part 2: To analyze a site through descriptions and comparisons***
Roof Garden ***Part 3: To apply practice by prioritizing and adapting***

BIOPHILIC DESIGN
Part 1: To learn the theory through summaries and illustrations
The first part of the exploration focuses on theory and to understand the basics of biophilic design by reading the report *"14 patterns of biophilic design"* by Browning, et al. (2014). As the report lists 14 aspects, what they describe as patterns, under 3 approaches, the goal has been to understand their relations with each other and how they can be used and combined. This is mainly done through summaries & illustrations.

Result of part 1 exploration
- A summary of the main theory and the report
- Comment about some updated research since 2014
- A diagram to use as a tool to visualize all the aspects/patterns properties and their relation to each other
- Summary and description of the proposed health benefits
- Description and summary of the 3 approaches with generalized strategies for each of them
- Summary and illustration of each aspect/pattern and naming all their strategies.
- (Also, a ton of sketches was made to understand the aspects/patterns better, see *"Process"*)

BLOCK BARKEN
Part 2: To analyze a site through descriptions and comparisons
The second part of the exploration focuses on a chosen site and to understand its context by analyzing its presence through the lens of biophilic design. As the report presents a clear structure for how nature can be described, the goal has been to understand the nature-like qualities of the place, or the lack of, and its relation to the site's history and future plans. This is mainly done through documentation and comparison.

Result of part 2 exploration
- A summary of the sites history, heritage, and development
- A site plan that describes the building's age and usage
- Two maps describing the surrounding city
- A summary and description of the place today and its critical characteristics
- Photos from site visits with descriptions that analyze the nature-like qualities of the place.
- A summary and description of the future development plans proposed by the city
- Illustrations of the proposed development plans
- (Also, a 1:200 model of the site which did not come into use, see *"Process"*)

ROOF GARDEN
Part 3: To apply practice by prioritizing and adapting
The third part of the exploration focuses on the design and to understand how biophilic design could be used in practice by applying a biophilic design extension/interventions to the existing future development plan. As all the aspects/patterns the report presents are not equally effective or usable, the goal has been to understand which ones should be prioritized in what context and how they could be combined and adapted to the site in a general manner. This is mainly done through designing and illustrations.

Result of part 3 exploration
- A summary of biophilic findings at the site
- Sun analysis of the proposed development plan
- Thought process map that connects the site, the theory, and the design
- Description of the proposed intervention concepts
- A visualization example of the roof garden
- Plan 1:100 describing an example of the roof garden
- Plan 1:200 illustrating different aspects and strategies
- (Also a lot of other, less focused, design ideas applied to the site, see *"Process"*)

1.4 DELIMITATION
WHAT IS AND IS NOT BEYOND THIS THESIS

Sustainable development
Within the subject of sustainable development, this thesis focuses on the more psychological and behavioral aspects, rather than the more common focus on reducing emissions, lowering impact, and care for resources of a system. For example the systems within the building industry.

Biophilic Design
Within the topic of biophilic design, I use the report *"14 Pattern of Biophilic Design"* by Browning, et al. (2014) as my main reference. The report is from 2014 and, as of now, six years old. Since then there has been more research published about the topic, but as for this thesis, I will not focus on those more than a short comment. Also, as this report is commonly referenced, it is fitting to examine it deeper. The most critical aspect of Biophilic Design that this thesis does not focus on is the aspect of collaboration and community engagement.

Health
The main reference for this thesis mainly focuses on the health aspect of biophilic design in the sense of supporting learning, stress restoration, and general preference. Thus this thesis focuses on those as well and does not focus on other aspects of health such as exercise, social interaction, toxic materials, air pollution, reducing risks of accidents, and so on. This thesis is also no research in itself and there is no goal to evaluate the design intervention, more than a short reflection, the design within this thesis should only be seen as speculative and doesn't suggest an immediate and certain health response.

The site
For the exploration, I have chosen to work with a courtyard in Masthugget, as it is one of Gothenburg's most dense and diverse neighborhoods. The courtyard is within the block "Barken" which 2018 received a new detailed development plan with several new building proposals (Göteborgs Stadsbyggnadskontor, 2018). The site has been examined in several master thesis before, but none has worked with the existing development detail plan. As the development plan proposes even more densification to the block I believe is worth exploring. I will further investigate what they propose and add a biophilic perspective on top of it, rather than deconstructing, criticizing, and reconstructing the proposal itself.

The design
With the design intervention, the aim is to explore the width, depth, and potential of biophilic design, rather than producing an optimal and finished building structure, as such the design part of this thesis is not the main goal itself. The design also focuses on the context of residential architecture and how biophilic design could improve everyday life for those residents. The perspective of passing citizens and pedestrians has not been prioritized.
The development plan that is used has several building volumes which are included in the site analysis, but not developed further in the design phase. Instead, there is a zoom in on one of the buildings, to work with it in such a way that one can imagine the design being applied to the other buildings as well.

The exploration
Within the exploration, I have made sketches to understand the different aspects of biophilic design better and I have also collected a diverse range of images that I early on used as inspiration. As I, later on, focused on local qualities present at the site as my main inspiration, I have not included any deeper exploration of other existing examples outside the area, like the ones presented in the collection of inspirations. But for those who are interested, you can find the collection of inspiration here: https://pin.it/1dZNwMM

Target group
This thesis is aimed toward other students with a focus on fellow architecture students that have picked up an interest in nature, health, and design. The goal is to present a clear overview and example of important aspects of biophilic design that should be prioritized. The language used in this thesis assumes that the reader has some familiarity with commonly used architecture terms and also familiar with how the design process in architecture education is structured.

On the shoulders of the giant tree of knowledge within urban architecture, nature, and health

14 PATTERNS OF BIOPHILIC DESIGN

1. Visual Connection With Nature

2. Non-Visual Connection With Nature

3. Non-Rhytmic Sensory Stimuli

4. Thermal & Airflow Variability

5. Presence of Water

6. Dynamic & Diffuse Light

7. Connection With Natural Systems

8. Biomorphic Forms & Patterns

9. Material Connection With Nature

10. Complexity & Order

11. Prospect

12. Refuge

13. Mystery

14. Risk/Peril

2 BIOPHILIC DESIGN
INTRODUCTION TO THEORY EXPLORATION

To understand the subject of biophilic design concerning health and wellbeing this chapter explores the report "14 Patterns of Biophilic Design", by Browning, et al. (2014), which is a commonly used reference within the topic. As the report presents the aspects/patterns systematically, so do I, by summarizing and illustrating them and their properties.

2.1 BIOPHILIA
"AN INHERENT LOVE FOR PLACE & NATURE"

Biophilic Design – the idea that, in the same way, that we humans need to exercise, eat well and simulate our brain to stay healthy, even if we don't have the urge to do it, we need to be surrounded by nature and a healthy ecosystem.
In practice, it's the existing knowledge within the field of Environmental Psychology on how natural environments, and the lack of, affect our health, wellbeing, performance, and motivation. That natural environment is perceived to be more restorative than urban environments has been confirmed many times and could be seen as a given, as it already is within environmental psychology, regardless of it being wild/urban or real/simulated (Menardo, et al., 2019, p. 11-15).

Biophilic "Patterns"
Within this exploration, my main reference is the report *"14 Patterns of Biophilic Design",* Developed by Terrapin Bright Green (Browning, et al., 2014), which is a sustainability consulting firm, committed to creating a healthier world. The report presents a great structure for exploring identified patterns within the existing research of the field. They present tools for understanding design opportunities, put them in context, and explain their suggested benefits and the amount of evidence behind them. Browning, et al. (2014) describe that they used the term "pattern" for several reasons, but mainly to uphold a similar language by other writers such as Christopher Alexander with his book A Pattern Language (Alexander, et al., 1977), and the tradition of patterns books used by designers and architects throughout the ages. A pattern is in a way a solution that takes different shapes every time you use it.

Outdated research - Health & Biodiversity
To work with biodiversity to increase the general health effects of nature is one strategy that Browning, et al. (2014) promote a lot, based on a study by Fuller Irvine, et al. (2007). But later studies have shown that there is no consistent relationship between human well-being and actual species richness and that people, in general, have a poor ability to perceive an accurate estimation of the amount of species richness (Dallimer, et al., 2012, p. 53). Even more recent studies have shown that there is some evidence, but not yet enough to declare what role biodiversity could have within mental health/well-being (Marselle, et al., 2018).
As a distinction, this thesis mention several times the benefits of supporting biodiversity and a multisensory and rich natural experience. In these cases, it focuses on the information richness in space and how the unpredictable behavior of birds and insects adds to that, not the quality of species richness or the diversity itself.

The three Biophilic categories
All the patterns are each a small part of a biophilic experience and they all share properties. Browning, et al. (2014) group them into three categories; "Nature in space", "Nature analogues" or "Nature of space".

Nature in Space is the biggest and most diverse category with a multitude of health responses. All the patterns, P1-P7, share the properties of being a direct experience of a living natural environment. As contact with plants, animals, wind, and sunlight. The strongest experience of Nature in space is achieved through a meaningful interaction (Browning, et al., 2014, p.9).

P1. Visual Connection With Nature
P2. Non-Visual Connection With Nature
P3. Non-Rhytmic Sensory Stimuli
P4. Thermal & Airflow Variability
P5. Presence of Water
P6. Dynamic & Diffuse Light
P7. Connection with Natural Systems

Natural Analogies is a smaller category useful for spaces where it's complicated to achieve real nature. The patterns, P8-P10 share the properties of being indirect experiences of non-living natural environments. As geometries, shapes, sequences, and patterns. The strongest experience is achieved by providing an information-rich environment in an organized and sometimes evolving manner (Browning, et al, 2014., p.10).

P8. Biomorphic Forms & Patterns
P9. Material Connection with Nature
P10. Complexity & Order

Nature of the Space is a large scale category useful for space configuration. The patterns, P11-P14 share the properties of being indirect experiences of exploring natural environments. As the atmosphere of a place and the feeling of trust, curiosity, excitement, safety, and fear. The strongest experience is achieved through deliberate and engaging spatial configuration combined with the other two categories (Browning, et al., 2014, p.10).

P11. Prospect
P12. Refuge
P13. Mystery
P14. Risk/Peril

2.2 BIOPHILIC DESIGN DIAGRAM

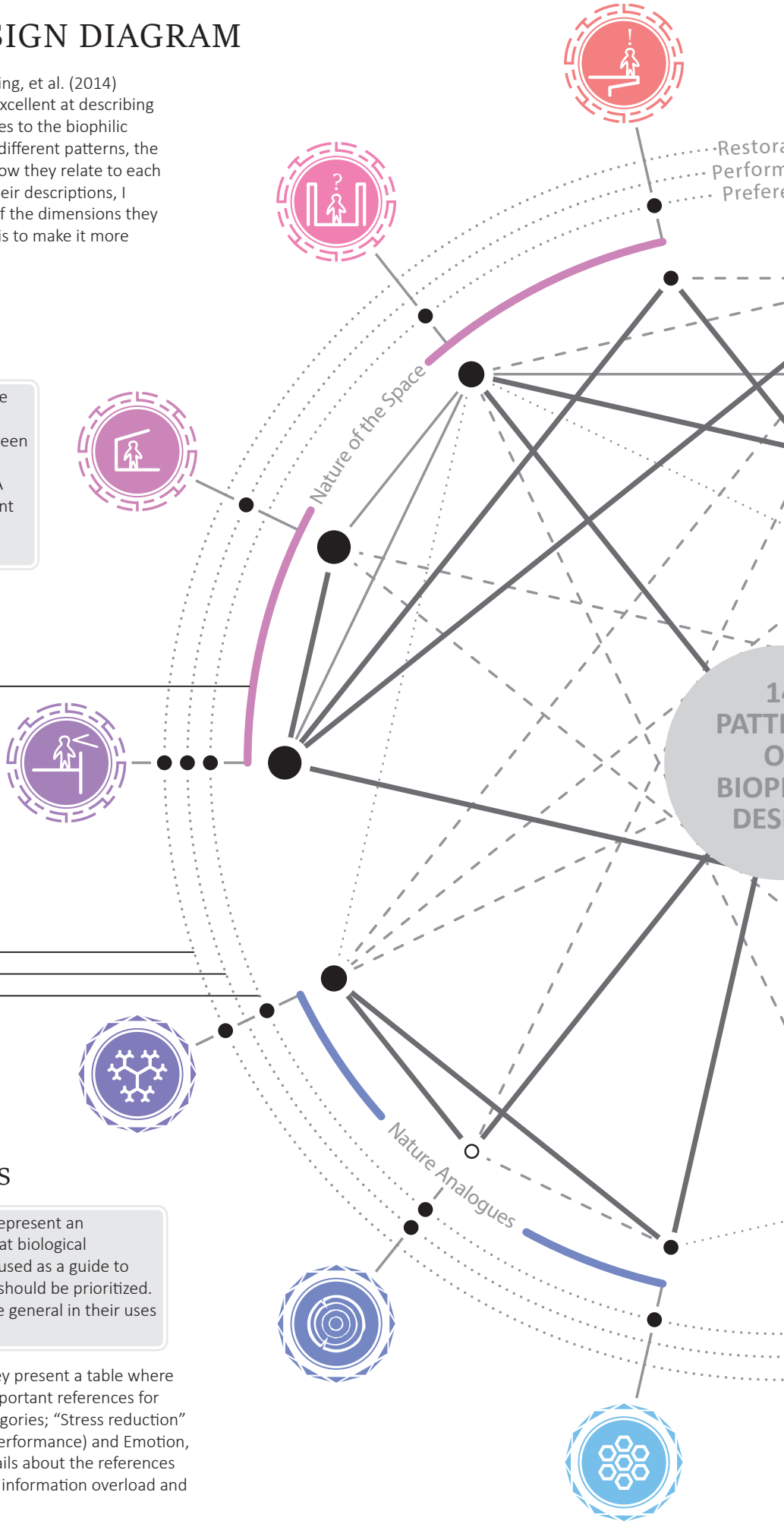
The main reference for this thesis, Browning, et al. (2014) report "14 pattern of biophilic design" is excellent at describing all the interdisciplinary research that relates to the biophilic design before 2014. They describe all the different patterns, the amount of evidence, their function, and how they relate to each other. To get a better visual overview of their descriptions, I made this diagram to showcases several of the dimensions they add to the discussion, where my addition is to make it more clear and visible.

BIOPHILIC CATEGORIES & APPROACHES

The colored lines in the inner border of the diagram represent the three categories of Biophilic Design and the relationship between nature and design. It can be used as an overview to understand similar patterns. A takeaway is that there exist several different approaches toward working with Biophilic Design.

In Browning, et al. (2014, p.9-10) report, each pattern is put in one of three categories; Nature in Space, Nature Analogues, or Nature of Space.

- *Nature in Space*
- *Nature Analogues*
- *Nature of Space*

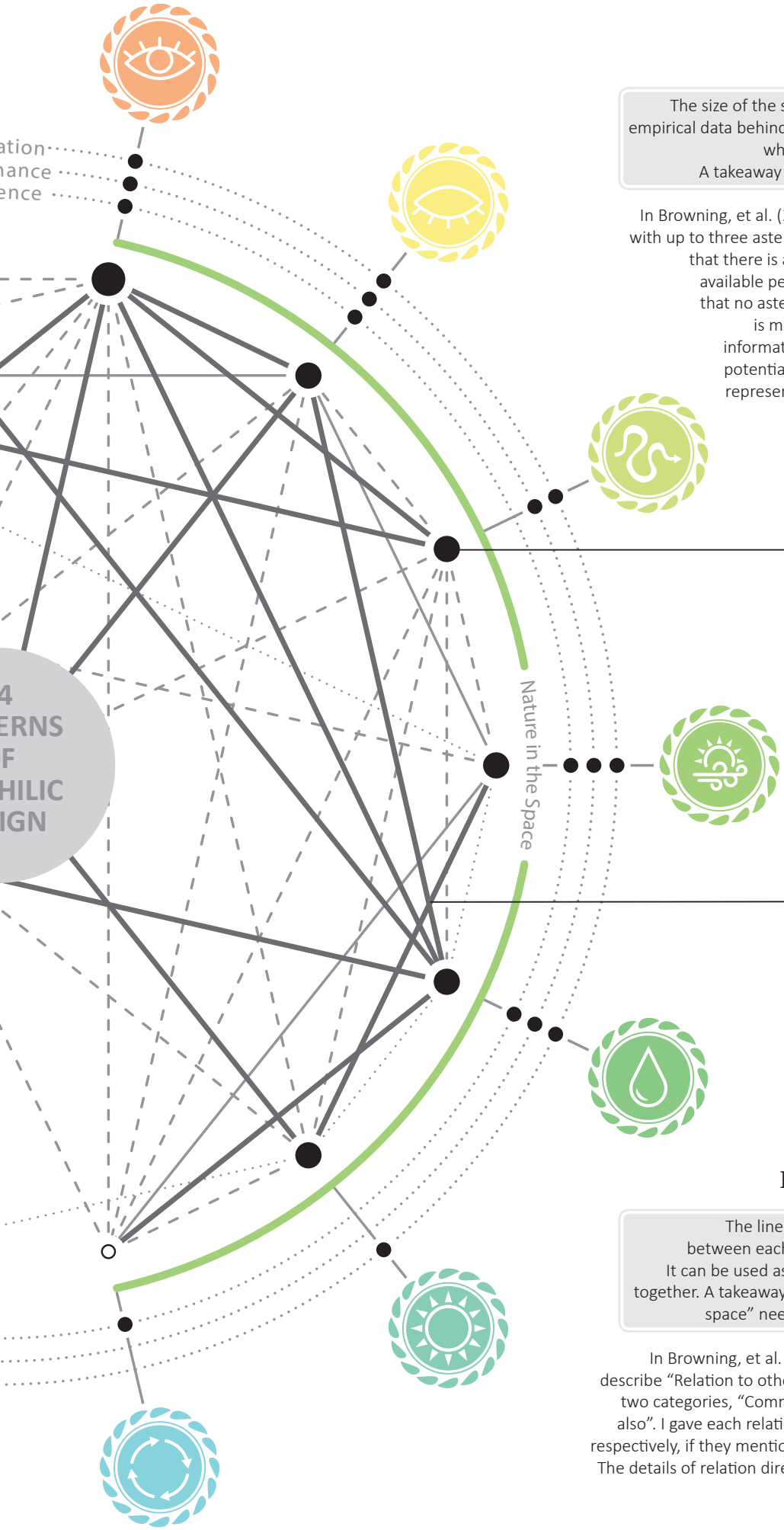


- *Restoration*
- *Performance*
- *Preferrence*

WELLBEING & BIOLOGICAL RESPONSES

The three black dots in the outer border represent an overview of the pattern's function and what biological responses the pattern supports. It can be used as a guide to understanding in which context a pattern should be prioritized. A takeaway is that some patterns are more general in their uses while others are more specific.

In Browning, et al. (2014, p.12) report, they present a table where they give an overview of only the most important references for each pattern, which they put in three categories; "Stress reduction" (Restoration), "Cognitive performance" (Performance) and Emotion, mood & preference (Preference). The details about the references are lost in this diagram, but it reduces the information overload and provides a more simplified overview.



EVIDENCE & RESEARCH

The size of the single black dots represents the amount of empirical data behind the pattern. It can be used to understand which pattern has the most potential impact. A takeaway is that all patterns aren't equally effective.

In Browning, et al. (2014, p.12) report, each pattern is marked with up to three asterisks (***), which reflect, as they describe, that there is a robust amount of quantity and quality of available peer-reviewed evidence. They continue with that no asterisks indicate that the amount of research is minimal (prior 2014), but that the anecdotal information is compelling enough to include it as a potential pattern. In this diagram, the asterisks are represented as three different dot sizes and a grey dot for no asterisks.

Amount of Empirical Data *Anecdotal data*

Strong relation

Weak relation

RELATIONS & OVERLAPS

The lines represent the strength of the connection between each pattern and how they can work together. It can be used as a guide to finding patterns that work well together. A takeaway is that "Nature analogies'' and "Nature of space" need "Nature in space" to work well together.

In Browning, et al. (2014, p.21) report, for each pattern, they describe "Relation to other patterns", where they have more or less two categories, "Common overlaps" along with "and sometimes also". I gave each relation, as "Refuge — Prospect", 1 or 2 points, respectively, if they mention each other with a maximum of 4 points. The details of relation direction are lost in this diagram, but it brings with it a clear overview.

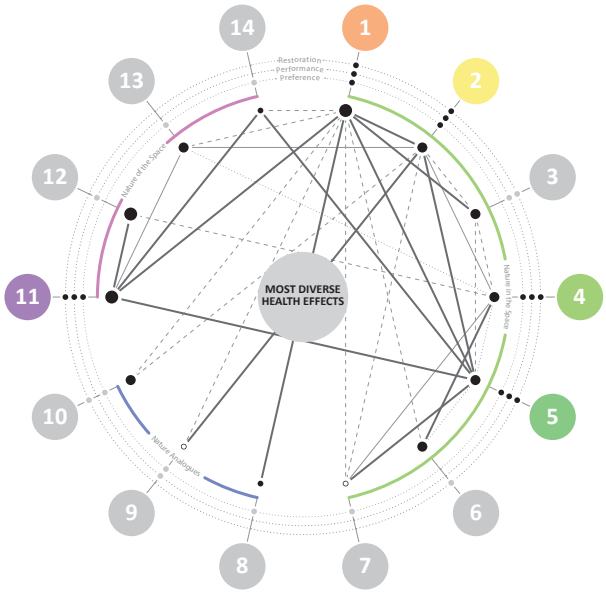
2.3 HEALTH & WELLBEING

Browning, et al. (2014, p.11) describe that much of the evidence for biophilic design can be linked into three overarching mind-body systems with varying amounts of research and verification that have been explored in laboratories or field studies that try to explain how our environment affects our the health and well-being. The three mind-body systems are of course somewhat overlapping.

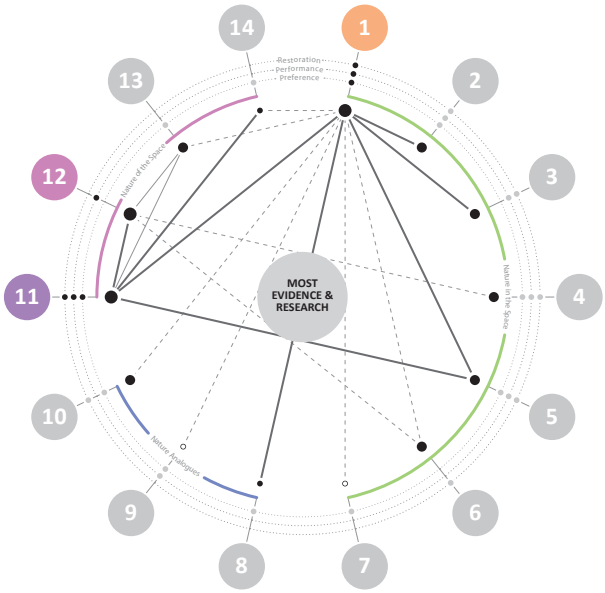
Browning, et al. (2014, p.11) describe the three overarching mind-body systems as cognitive, psychological, and physiological. They also describe them as Stress reduction, Cognitive performance, and Emotion, mood & preference, within this thesis I call it **Restorative**, **Performance**, and **Preference**.

BIOPHILIC PATTERN HEALTH EXPECTATION

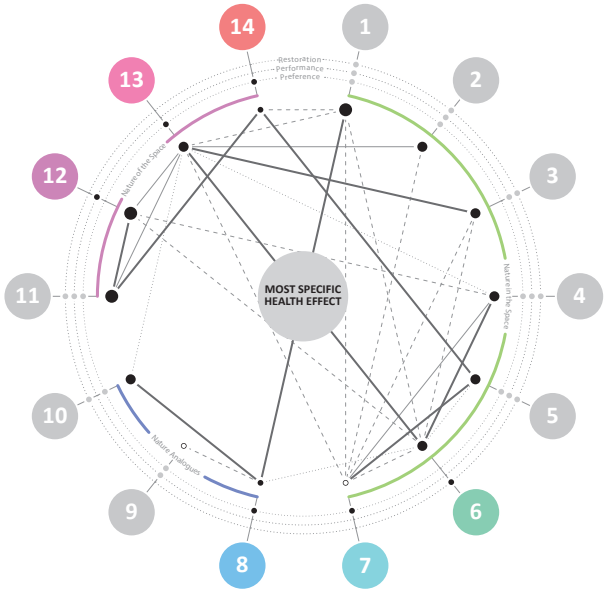
Most diverse health effects



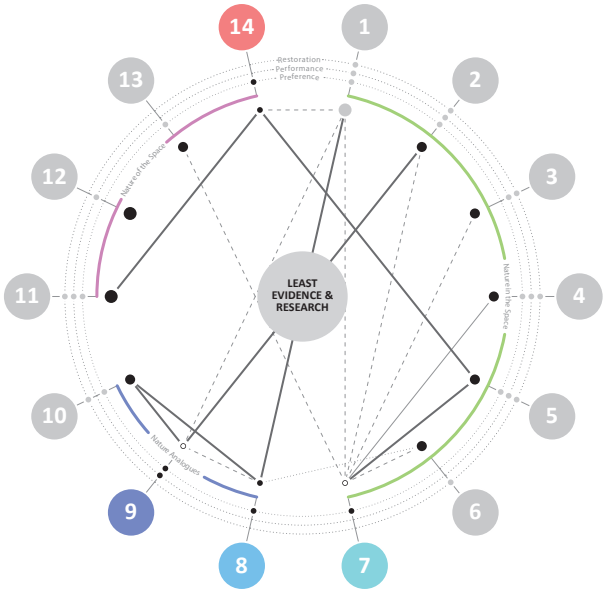
Most evidence & research



Most specific health effect



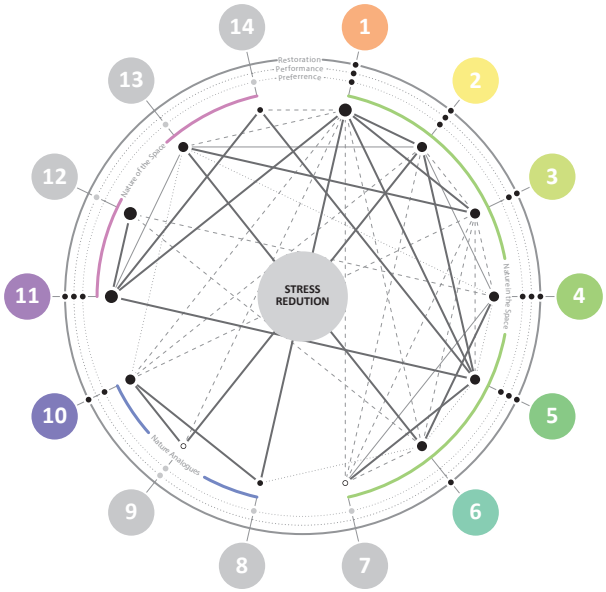
Least evidence & research



MIND-BODY SYSTEMS & BIOLOGICAL RESPONSES

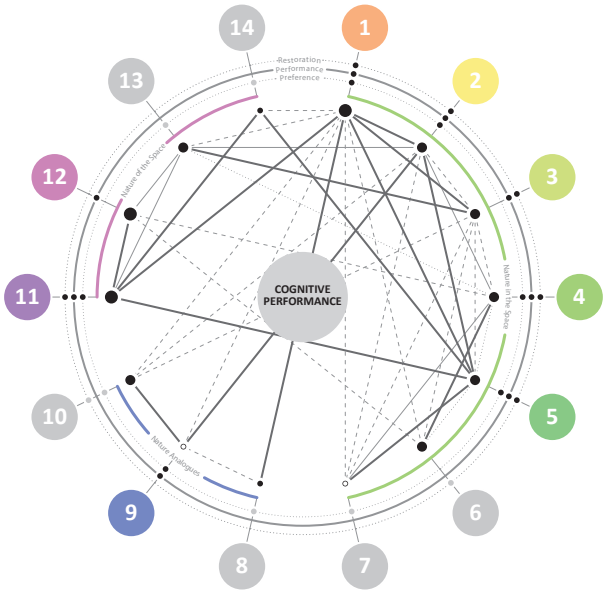
Restorative
The aural, musculoskeletal, respiratory, circadian system and overall physical comfort relate to physiological responses (Browning, et al., 2014, p.11). Physiological responses from natural environments including relaxation of muscles, as well as lowering diastolic blood pressure and stress hormone levels in the bloodstream (Browning, et al., 2014, p.11). Browning, et al. (2014, p.11) also add that short time stress can be beneficial for regulating physiological health.

Summarized, our body has an easier time to relax from stress when exposed to natural environments.



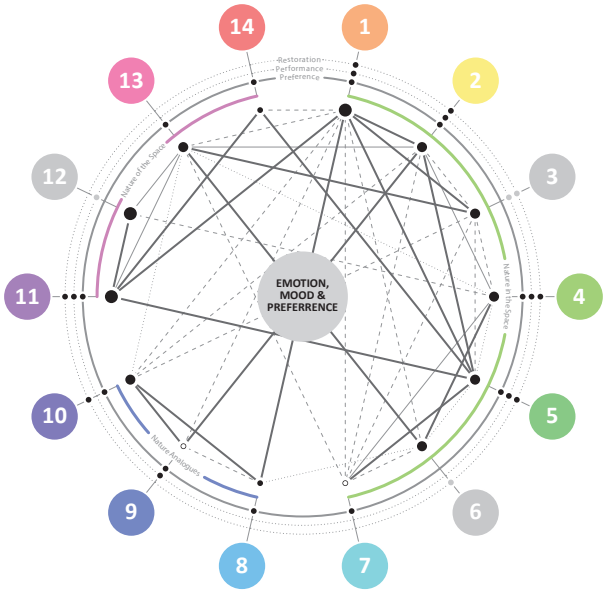
Performance
Mental agility and memory, and our ability to think, learn, and output either logically or creatively relates to cognitive performance (Browning, et al., 2014, p.11). Many mental tasks, from driving on a busy road, calculating or reading require direct attention, which is very energy-intensive, and over time gets depleted and results in mental fatigue (Browning, et al., 2014, p.11). Browning, et al. (2014, p.11) continue with that strong or routine connection with nature can provide an opportunity for mental restoration, during which time our higher cognitive functions can take a break. Hence our capacity for focused tasks is also prolonged and improved.

Summarized, our ability to maintain focus and attention at difficult tasks, such as reading or general problem solving, is improved through a strong or routine connection with nature which helps our mind to rest.



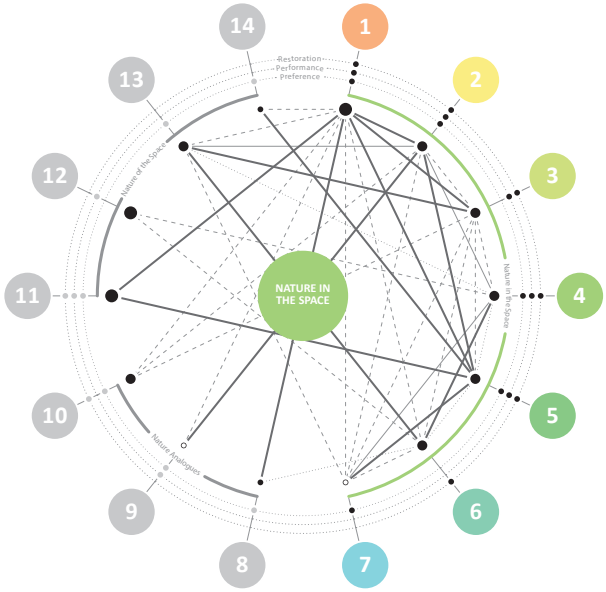
Preference
Adaptability, alertness, attention, concentration, and emotion and mood relate to psychological responses which can be heavily impacted by culture and norms and both can be learned and inherited (Browning, et al., 2014, p.11). Even so, Browning, et al. (2014, p.11) describe that experience of natural environments provides great emotional restoration and stress management compared with urban environments with limited characteristics of nature.

Summarized, the experience of natural environments helps with restoration from disturbances in emotions and mood, more than urban environments.



2.4 NATURE IN THE SPACE
BIOPHILIC CATEGORY I

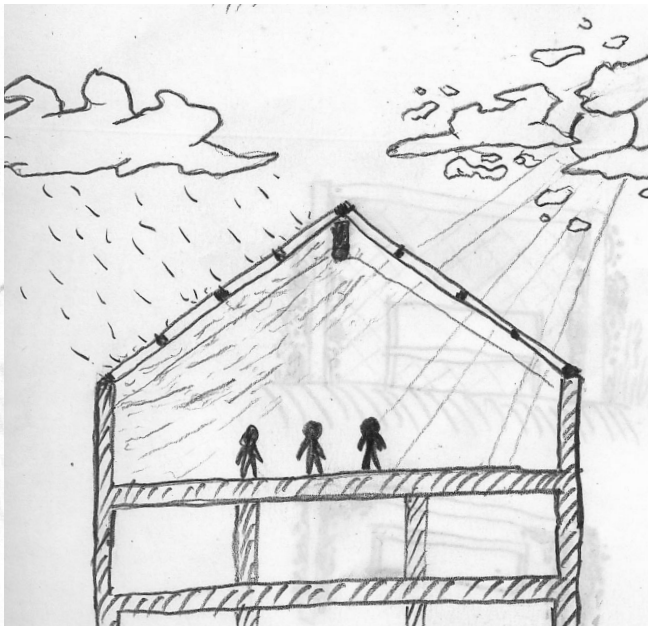
Living Breathing Nature
Nature In The Space is the biggest and most diverse category of Biophilic Patterns with a lot of research behind it. All the patterns in this category aim to work with living or changing properties of natural environments that we experience with our five senses. As the visual experience is the most researched one, it is a pattern on its own and the first one. The experience of our other senses is collected as the second pattern and the following patterns are more about the timeframe and cycle of different experiences as wind, water, and sunlight. The last pattern is the least researched one, but still interesting with a focus on engagement and sense of place.



Generalized strategies - Connect & create living systems
As mentioned, all the patterns in this approach connect somehow to living and dynamic systems and together they enhance the experience of nature and blur the line between inside and outside.

- **Add Greenery** Adding plants and making greenery more visible is the simplest strategy and combined with artificial nature (see Natural Analogues) it can be integrated everywhere. A more advanced option is to choose local plants or more dynamic and multi-sensory vegetation like herbs and seasonal greenery.
- **Support Biodiversity** Supporting pollinators, birds, and the local ecosystem with food, shelter, and water is a general strategy that makes a space more wild and dynamic.
- **Inside out Spaces** To open up a building toward the outside may be the most common way to integrate natural qualities, with windows, balconies or less common interventions as oriel windows or natural ventilation. This creates easily accessible spaces that are more dynamic and closely connected with the outside.
- **Gardener** To provide accessible gardening is a strategy that includes all the 7 patterns and also promotes meaningful engagement with nature processes itself.

Birds doing things



Three residents experiencing changing weather

PATTERNS OF NATURE IN THE SPACE

1: Visual Connection with Nature
This is one of the patterns with the strongest evidence and most research behind it and could also be the most obvious one, to experience nature by seeing it with your eyes.
Green walls and landscape paintings are two different ways to work with it.

2: Non-Visual Connection With Nature
In addition to the visual experience of nature, there is a lot of research focused on our other senses; sound – auditory, smell – olfactory, touch – haptic, taste – gustatory.
Combined with the visual connection it can provide a richer experience of nature.

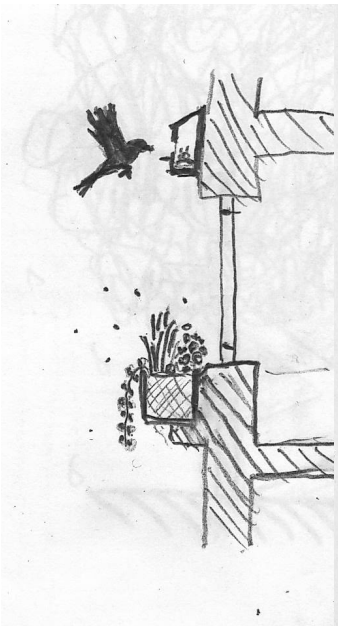
3: Non-Rhythmic Sensory Stimuli
Most things in natural environments occur in cycles but at unpredictable and random intervals. Compared to repetitive and predictable distractions as a pending clock, non-rhythmic distraction, increases attention and interest over time (Browning, et al. 2014. p.29).

4: Thermal & Airflow Variability
This pattern aims to bring in the sense of weather from natural environments and give the individual more flexibility over their comfort and provide a better sense of control.

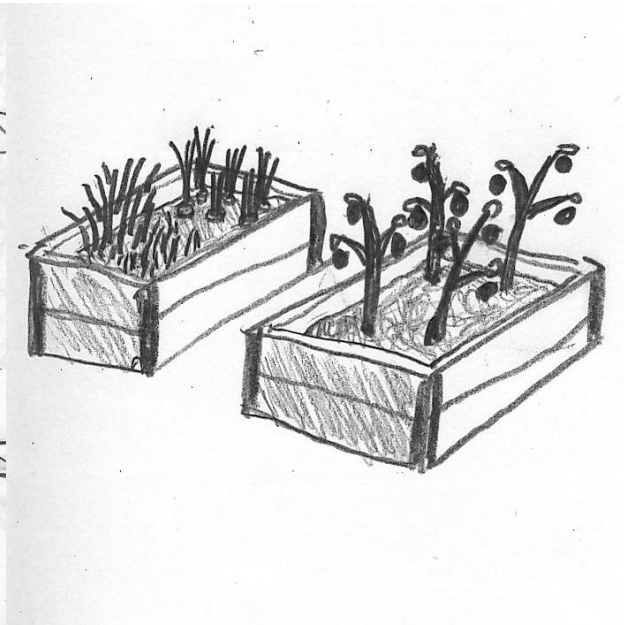
5: Presence of Water
This pattern is to work with water, either to provide visibility over existing bodies of water or to create smaller ponds or fountains. Rain is also a resource that could be used. An interesting aspect that Browning, et al. (2014) brings out is that the benefits of an urban scene with water elements are suggested to be more or less similar to a nature scene without water.

6: Dynamic & Diffuse Light
This pattern aims to promote the usage of daylight and to simulate natural changing light conditions.

7: Connection with Natural Systems
There is limited scientific documentation on this pattern, but according to Browning, et al. (2014, p. 36), it's suspected to enhance positive health benefits. This pattern is in a way a representation of the core of Biophilia, to bring us closer and make us more aware of the ecosystems and processes we are a part of.



A bird coming home outside a window with a flower box



Two cultivation boxes

A roof and wall with greenery and pollinators

VISUAL CONNECTION WITH NATURE

Nature in The Space, Pattern 1

Health & Wellbeing

Amount of Evidence +3

Research background within visual preference and responses to views to nature.

Biological Responses Stress reduction, Cognitive performance, Emotion, mood & preference

Reducing stress, attention fatigue, sadness, anger, and aggression

Improving concentration, recovery rates, mental engagement/attentiveness, attitude, overall happiness, prolonged interest.

Design Strategies

Objective To provide an environment that can help people to shift focus to relax the eyes muscles and temper cognitive fatigue.

Prioritize real nature over simulated nature; and simulated nature over no nature.

Exercise Placement Enable exercise opportunities close to nature.

Visual Connection Design to support a visual connection that can be experienced for at least 5-20 min/day.

Maintain View Design spatial layouts and furnishings to uphold desired view lines, even if you sit down

Limited Space Add small interventions of nature where space is limited.

Challenging Spaces Design simulated nature within spaces that can't easily incorporate real nature.

References

(Browning, et al., 2014, p. 24-25)

NON-VISUAL CONNECTION WITH NATURE

Nature in The Space, Pattern 2

Health & Wellbeing

Amount of Evidence +2

Research background within non-visual sensory interaction and impact on cognitive performance perceived mental health and tranquility

Biological Responses Stress reduction, Cognitive performance, Emotion, mood & preference

Reducing cognitive fatigue, stress hormones, blood pressure

Improving mental restoration, perceived energy & motivation, memory, the healing process, immune functions, relaxation.

Design Strategies

Objective To provide an environment that use one or several senses to engage the individual to help with stress reduction and improving perceived physical and mental health.

Lifelike Prioritize nature sound over urban sound

Easy Accessible Design that is easily accessible from multiple locations and allows daily engagement for 5-20 min/day

Combine Functions Integrate with other aspects of the design program

Multi-sensory A single intervention that can be experienced in multiple ways can enhance the impacts

Visual experience Design for visual & non-visual connection to be experienced simultaneously to maximize potential positive health responses

References

(Browning, et al., 2014, p. 26-27)

NON-RHYTMIC SENSORY STIMULI

Nature in The Space, Pattern 3

Health & Wellbeing

Amount of Evidence +2

Research background from research on people's view behavior and quantified behavior measurements on attention and exploration.

Biological Responses Stress reduction, Cognitive performance

Reducing eye fatigue, mental fatigue

Improving physiological restoration, attention, focus

Design Strategies

Objective To provide natural stimuli as positive distractions that grabs one's attention and help individuals to replenish their capacity to focus.

All Year Around Design multiple interventions that can overlap with all seasons

Stochastic Moment Different from P1 and P2 is the focus on ephemeral (short-lived) and stochastic (random) qualities

Combine Functions Can almost always be combined with any landscape and horticultural plan. For instance pollinators

Peripheral View A Intervention within the peripheral view is more effective

Limited Space Add small interventions of nature where space is limited.

Lifelike Natural movements are more positive than mechanical motions

Planning An intervention that leverages simulation of (rather than naturally occurring) natural stimuli will likely necessitate early collaboration with the mechanical engineer or facilities team.

References

(Browning, et al., 2014, p. 28-29)

THERMAL & AIRFLOW VARIABILITY

Nature in The Space, Pattern 4

Health & Wellbeing

Amount of Evidence +2

Research background from research on natural ventilation in offices, spatial pleasure "allesthesia" (nature in motion), and a growing discontent on conventional approaches on thermal design.

Biological Responses Stress reduction, Cognitive performance, Emotion, mood & preference

Reducing Boredom, passivity

Improving Perceived pleasure & comfort, concentration, performance, short term memory, sense of control

Design Strategies

Objective To provide an environment that allows users to experience the sensory elements of thermal & airflow variabilities. Also to provide the users the possibility to control their environment or have access to different conditions within a space.

Diversity To distribute variability over space and time, incorporate airflow and thermal conditions into; materials, daylighting, mechanical ventilation & fenestration (window arrangement)

Reduce Energy Bridge with sustainable design with interventions that reduce energy cost/demand and widen perceived comfort

Engagement Design in features that allow users to control or change their environment. This will allow for a greater range of acceptable temperatures with +/- 2° from conventional parameters.

Planning Coordination of design strategies among a project team (e.g., architect, lighting designer, and MEP engineers) as early as the schematic design process will be particularly important for achieving design intent.

References

(Browning, et al., 2014, p. 30-31)

PRESENCE OF WATER

Nature in The Space, Pattern 5

Health & Wellbeing

Amount of Evidence +2

Research background within research on visual preferences and emotional responses to environments containing water elements.

Biological Responses Stress reduction, Cognitive performance, Emotion, mood & preference

Reducing Stress, heart rate, blood pressure

Improving Feelings of tranquility, concentration, memory restoration, perception/psychological/physiological responsiveness, landscape preference, self-esteem and mood, prolonged interest

Design Strategies

Objective To utilize water and its multisensory attributes to enhance the experience of a space that promotes, enhanced mood, and restoration.

Multi-Sensory Prioritize a multi-sensory experience to maximize beneficial outcomes

Lifelike Prioritize naturally fluctuating movement over predictable movement or stagnancy

Low Intensity Avoid having high volume & high turbulence water to close

Reduce Energy Keep in mind that a lot of features can be water & energy-intensive. Minimize losses.

Maintenance Keep water clean and unpolluted to maximize beneficial outcomes

References

(Browning, et al., 2014, p. 32-33)

DYNAMIC & DIFFUSE LIGHT

Nature in The Space, Pattern 6

Health & Wellbeing

Amount of Evidence +2

Research background within research on how daylight affects productivity, illuminance fluctuation, visual comfort, human factors and perception of light, and the impact of lighting on the circadian system functioning.

Biological Responses Stress reduction

Reducing Dental decay

Improving Productivity, performance, positive moods, circadian system functioning, sleep quality

Design Strategies

Objective To provide the user with lightning options that provides comfort and support attention, and to help maintain circadian system functioning.

Reduce Glare Dynamic light conditions can help the transition between indoor and outdoor spaces

Low Intensity Drastic dynamic lighting conditions may not be appropriate for spaces where directed attention activities are performed

Maintain Daylight Circadian lightning will be especially important in spaces the people occupy for extended periods.

References

(Browning, et al., 2014, p. 34-35)

CONNECTION WITH NATURAL SYSTEMS

Nature in The Space, Pattern 7

Health & Wellbeing

Amount of Evidence n/a

Biological Responses Emotion, mood & preference

Improving natural stewardship, ecosystem awareness.

Design Strategies

Objective to heighten the awareness of natural properties within an ecosystem and with that improve environmental stewardship of that ecosystem.

Weather Awareness Integrate design that responds to rain events

Local Awareness Low-cost strategy is to provide visual access to existing natural systems

Material Awareness Incorporate responsive design tactics, as materials that change form or color depending on use or the environment

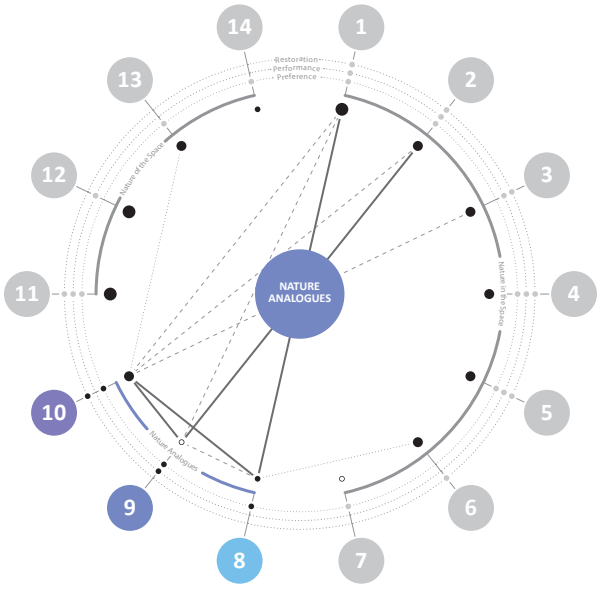
Engagement Design interactive opportunities for children, patients, and the elderly.

References

(Browning, et al., 2014, p. 36-37)

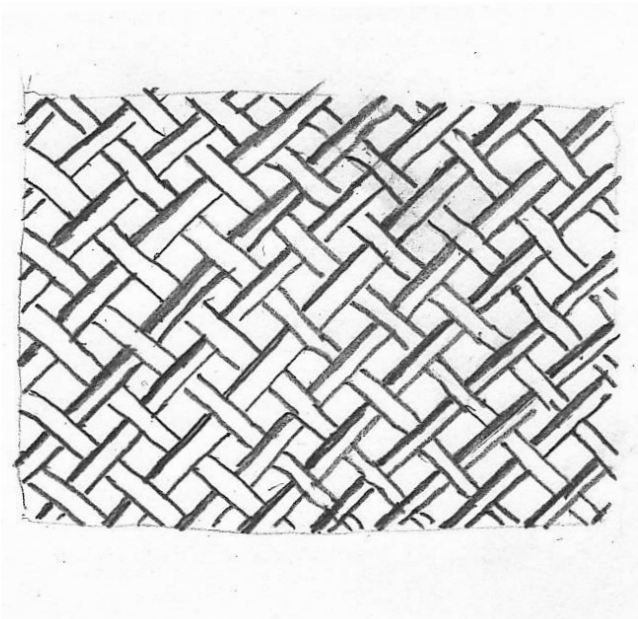
2.5 NATURE ANALOGUES
BIOPHILIC CATEGORY II

The Shape of Living Systems
This approach to Biophilic Design is in a sense a subcategory of the first pattern *Visual Connection to nature*, as it expands on the subject of artificial nature and how we humans have a strong preference toward organic shapes and natural patterns. All the patterns in this approach aim to create interesting and coherent spaces that are both visual and tactically stimulating. The first pattern focuses on the shape of the structure and the second pattern on the surface layers. The third pattern is about the arrangement and composition of scales and sizes.

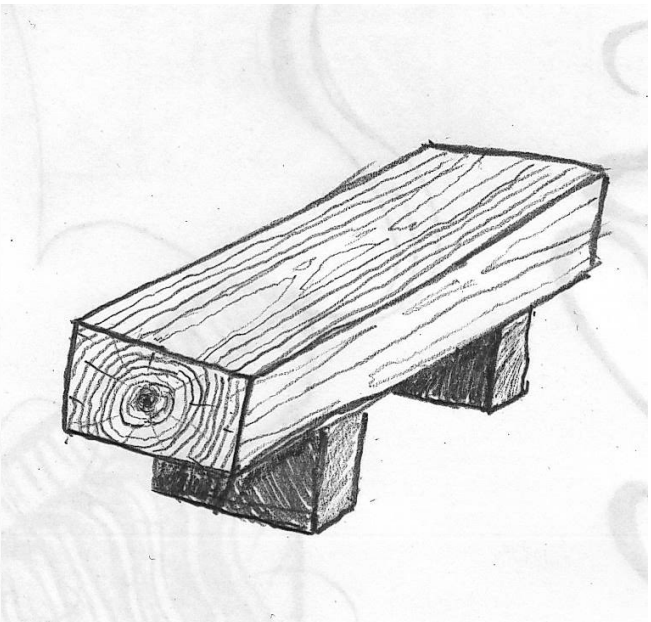


Generalized strategies - Fill in the Blanks
Of all the three approaches that Browning et. al. (2014) present, this is the one with the least amount of research behind it. Still, its wide application is its biggest strength and the patterns can be used to understand general preferences among the population and how to make a design more coherent or interesting.

- **Artificial nature.** A recording, a photo, or other realistic simulations of nature can be used as a strategy to incorporate nature in cases where real nature is not an available option. In similarity to the strategies of Nature in The Space, this can be more or less multi-sensory or engaging, but in comparison, this experience is only artificial.
- **Nature artwork.** Adding murals, sculptures, paintings or any other decorative element that is inspired by nature is a diverse strategy to incorporate this approach coherently and playfully.
- **Biomimicry.** To mimic structural solutions that can be found in nature is a more advanced strategy to incorporate natural properties in a more large-scale and grand fashion.
- **Local Heritage.** To integrate patterns, shapes, and materials from local resources and traditions is a strategy which connects to the place's history and provides possibilities for more community engagement.



Woven overlapping structure



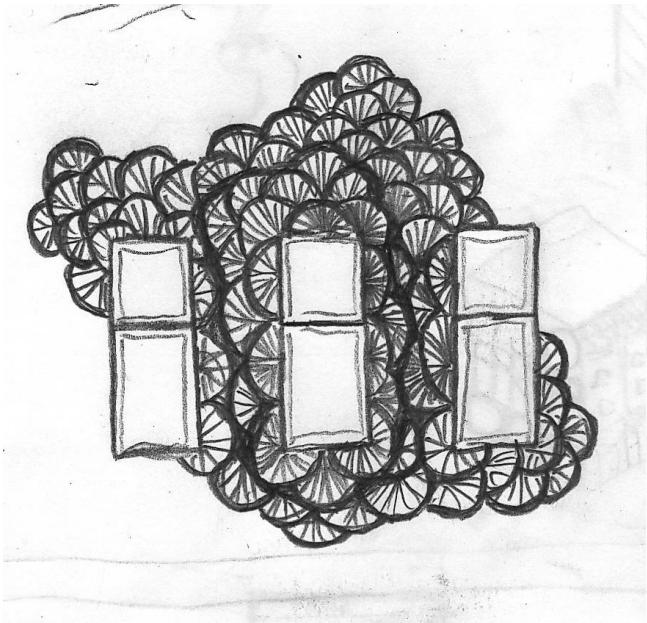
Bench made of a tree trunk

PATTERNS OF NATURE ANALOGUES

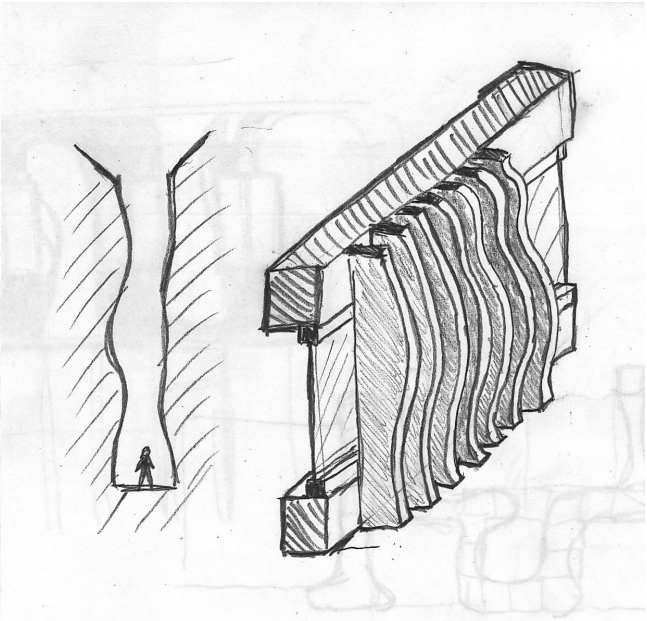
8: Biomorphic Forms & Patterns
According to Browning, et al. (2014, p 38-39), this pattern aims to recreate patterns, forms, arrangements, and compositions that can be found in nature. It has been documented that we have a preference for organic and biomorphic forms and patterns, however, more research is needed to answer why.

9: Material Connection with Nature
There is a limited amount of science on natural material's effect on health and wellbeing, but according to Browning, et al. (2014, p. 40) research is beginning to shed more light on the topic. I didn't have time to investigate this further, but I would suggest that there probably is much more recent research on this topic

10: Complexity & Order
This pattern focuses on the fractal qualities that can be found in nature as a way to make a space information-rich and interesting, but still not overwhelming. Fractals are forms or geometries that repeat themself in different scales. Like a branch from a tree that looks like a miniature of the tree itself.



Organic mural painting



Organic facade

BIOMORPHIC FORMS & PATTERNS

Nature Analogues, Pattern 8

Health & Wellbeing

Amount of Evidence +1

Research background within view preferences and its effect on stress and concentration.

Biological Responses Emotion, mood & preference

Reducing stress

Improving preference, concentration

Design Strategies

Objective To provide representational design elements that allow the user to make connections to nature. The intent is to use it in a way that creates a more visually preferred environment.

Decorative Use as a cosmetic decorative component of a larger design.

Combine Functions Integrate with the structure or functional design.

Diversity Apply on 2 or 3 planes or dimensions (floor plane, wall, furniture, windows, soffits) for greater diversity and frequency of exposure.

Low Intensity Avoid overuse of form and patterns that may lead to visual toxicity.

Lifelike Use patterns and ratios that are common in nature, as the Fibonacci sequence (0, 1, 1, 2, 3, 5, 8, 13, 21...), ratio (1:1618), and angle (137.5°). Another common angle is also 120°.

Planning More comprehensive interventions will be more cost-effective when they are introduced early in the design process.

References

(Browning, et al., 2014, p. 38-39)

MATERIAL CONNECTION WITH NATURE

Nature Analogues, Pattern 9

Health & Wellbeing

Amount of Evidence n/a

Research background within research on physiological responses on exposure to different amounts of natural materials and natural color palettes, especially green, and its effect on cognitive performance.

Biological Responses Cognitive performance, Emotion, mood & preference

Reducing blood pressure

Improving comfort, creativity

Design Strategies

Objective To explore the characteristics and optimize the quantities of natural materials to promote cognitive or physiological responses. It can be used both decorative or functional, but as most materials are almost always heavily altered, it should always be seen as analogous for its "natural" state.

Prioritize Quantities of a natural material and color should be specified based on the intended function of the space (restore/stimulate).

Diversity A degree of variability of materials and applications is recommended over high ratios of any one material or color.

Lifelike Real materials are preferred over synthetic variations because human receptors can tell the difference between real and synthetic, so minimally processed materials from real nature are preferred whenever possible.

Maintain Creativity Incorporate instances of the color green may enhance creativity.

References

(Browning, et al., 2014, p. 40-41)

COMPLEXITY & ORDER

Nature Analogues, Pattern 10

Health & Wellbeing

Amount of Evidence +2

Research background within research on fractal geometries in nature and those from art and architecture.

Biological Responses Stress reduction, Emotion, mood & preference

Reducing stress, nausea

Improving preference

Design Strategies

Objective to provide symmetries and fractal geometries in a coherent structure to create a visually pleasing environment to promote cognitive or psychological responses. Fractal geometries can also be used at any scale.

Prioritize Use artwork, material selection, architectural expressions, landscapes, and master planning schemes that reveal fractal geometries and hierarchies.

Rule of Three Fractal structures with iterations of three will be more impactful than a design limited to two iterations.

Algorithm Generated If a fractal design is generated with an algorithm, consider using a mid-range dimensional ratio (broadly speaking D=1.3-1.75).

Middle Intensity Avoid overuse or extended exposure to high-fractal dimensions, as it can have the opposite effect. Also avoid under-utilization of fractals, as it can result in complete predictability and disinterest.

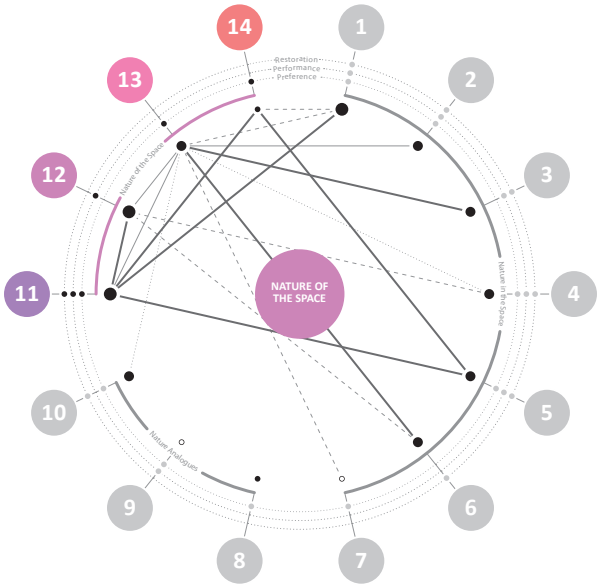
Skyline A new building or landscape design should take into account its impact on the fractal qualities of the existing urban skyline.

References

(Browning, et al., 2014, p. 42-43)

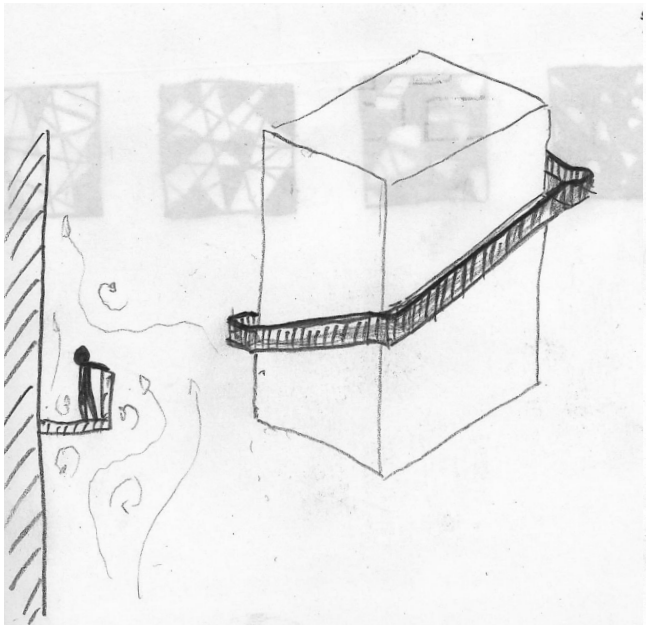
2.6 NATURE OF THE SPACE
BIOPHILIC CATEGORY III

The Shape of Human Nature
Rather than nature itself, this approach focuses on different spaces that can be found in nature that have benefited our survival as a human species. All the patterns in this approach focus on the atmosphere and the layout of a space. The first two patterns focus on withdrawal, protection, and to survey your surroundings. They go together a lot and are two of the patterns with the most research behind it. The third pattern focuses on exploration, movement, and curiosity. The last pattern focuses on perceived danger and excitement.



Generalized strategies - Space in Space
This is the biggest scale approach and as it focuses on spatial configuration a lot of space may be necessary. It can still be used on a smaller scale but its own, this approach may have the most familiar and common strategies to work with. As it focuses on a spatial configuration, a lot of great architecture design has these qualities per default. In this case biophilic design is not something revolutionary, but more a rediscovering of the intuitive obvious that we haven't been able to explain or measure before.

- **Sidetracks.** A general strategy is to provide spaces outside of the main flow of activities as it provides more possibilities to explore or to rest. A shelter view from one space into another also provides a safe space where you can focus better and spend a longer amout of time.
- **Height.** Working with elevated spaces, big windows, high ceilings or balconies provides endless possibilities to integrate all the patterns.
- **Playfulness.** Playgrounds, watchtowers, stepping stones, outdoor gyms, or other activities are good opportunities to incorporate this approach as a break from another context.
- **Integrated.** On its own, this approach may not be enough to provide a biophilic experience and it should be combined with the other approaches to enhance each other.



Someone walking along an external staircase

Someone reading under a tree in the fall

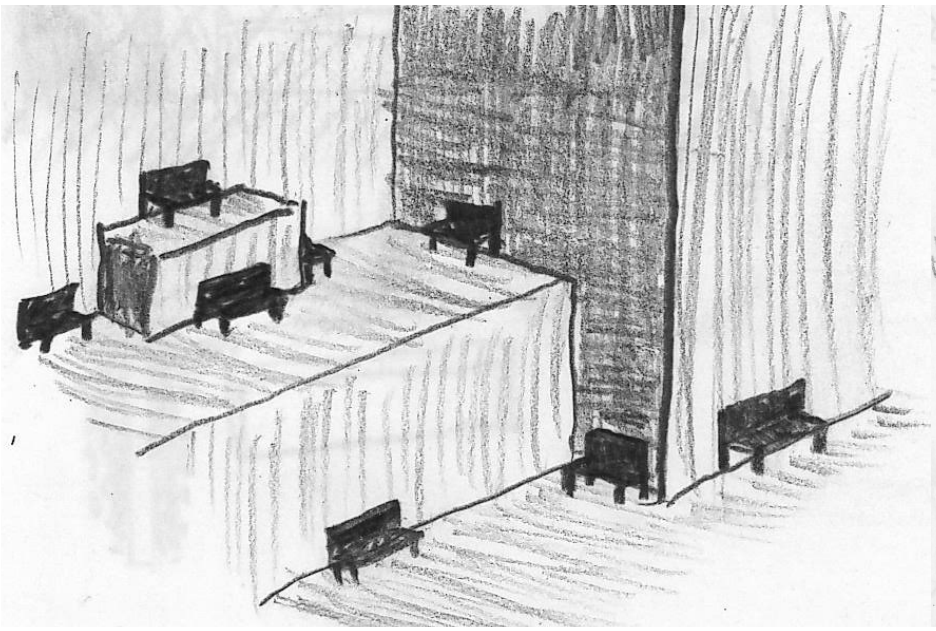
PATTERNS OF NATURE OF THE SPACE

11: Prospect
This pattern focuses on providing views over a distance and the pattern is one of those with the most evidence behind it. It's closely connected with the Savanna Hypothesis, that we humans have a strong predisposed preference for savanna-like scenes and environments (Browning, et al., 2014, p.44).

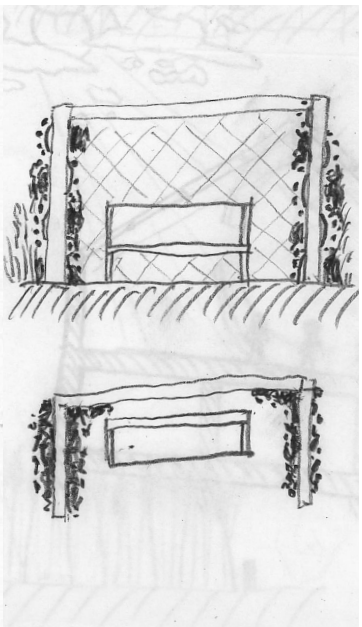
12: Refuge
This pattern focuses on providing spaces for withdrawal, a shelter, or protection within a bigger space, outside the main flow of activities. It has a strong connection to the pattern of Prospect and both strengthen each other tremendously. It is one of the patterns with the most research behind it.

13: Mystery
This pattern focuses on curiosity and the basic spatial need to understand and explore. Compared with the other "Nature of the space" patterns, this one focuses more on movement.

14: Risk/Peril
This pattern aims to combine perceived risk with trusted safeguards to trigger positive arousal and curiosity.



A variety of seats with different conditions



A sheltered bench with greenery

PROSPECT

Nature of The Space, Pattern 11

Health & Wellbeing

Amount of Evidence +3

Research background within research on visual preference and spatial habitat responses, as well as cultural anthropology, evolutionary psychology, and architectural analysis.

Biological Responses Stress reduction, Cognitive performance, Emotion, mood & preference

Reducing stress, boredom, irritation, fatigue, perceived vulnerability

Improving comfort, preference, perceived safety

Design Strategies

Objective "to provide users with a condition suitable for visually surveying and contemplating the surrounding environment for both opportunity and hazard" (p. 44).

Orientation work with the orientation of buildings, workspaces, windows, or sightlines to optimize visual access and the experience.

View Quality Designing with or around an existing or planned savanna-like ecosystem, a body of water, and evidence of human activity or habitation will help the information-richness of the prospect view. Refer to *Visual Connection With Nature* to optimize the prospect experience with a quality view.

Depth of Field Provide a focal length of ≥ 6 meters and preferably 30 meters.

Remove Barriers When a space has sufficient depth, remove visual barriers to enhance the experience. Spatial barriers with a height of ≈105 cm will still allow seated occupants to view across space.

Glazed Stairwell Locating a glazed stairwell next to the facade can form a dual Prospect condition.

Elevated Spaces When high ceilings are present, interior spaces elevated 30-45 cm will enhance the experience.

Prospect - Refuge Often the view quality and the balance between Prospect and Refuge will be more important than the size or frequency of the experience.

References

(Browning, et al., 2014, p. 44-45)

REFUGE

Nature of The Space, Pattern 12

Health & Wellbeing

Amount of Evidence +3

Research background within research on visual preference and spatial habitat responses (Browning, et al., 2014, p.46).

Biological Responses Cognitive performance

Reducing blood pressure, heart rate, stress, irritation, fatigue, perceived vulnerability

Improving restoration, concentration, attention, perceived safety

Design Strategies

Objective To provide an easily accessible space for protection and to limit visibility into the protected space. Generally, as with Prospect, there are endless ways to design for good Refuge.

Indoor Refuge space indoors is usually characterized by lowered ceiling conditions. In a space with standard ceiling height, a lowered of 45-60 cm is suggested.

Outdoor For outdoor or indoor spaces with particularly high ceilings above >4,5 m. A bigger difference is necessary, as a freestanding structure or a tree.

Diversity When designing for a larger population, there is a need to have a diversity of refuge spaces.

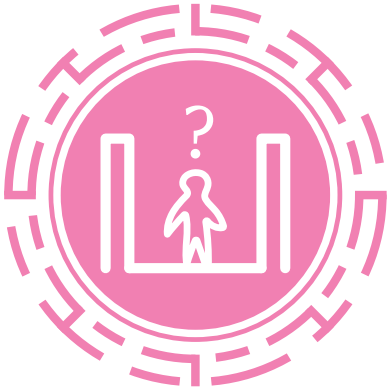
Light Difference Light levers in Refuge spaces should differ from adjacent spaces and user lighting controls will broaden functionality as a refuge space.

Rule of Three To have protection on three sides is optimal, with a priority on the back and above.

Prospect - Refuge It's more effective to balance the experience between Refuge and Prospect rather than maximizing both.

References

(Browning, et al., 2014, p. 46-47)



MYSTERY

Nature of The Space, Pattern 13

Health & Wellbeing

Amount of Evidence +2

Research background within research on visual preference, perceived danger, and responses to anticipatory situations (Browning, et al., 2014, p.48).

Biological Responses Emotion, mood & preference

Improving preference, curiosity, interest

Design Strategies

Objective "to provide a functional environment that encourages exploration in a manner that supports stress reduction and cognitive restoration." (p. 46).

Curves Curving edges that slowly reveal are more effective than sharp corners in drawing people through space.

Shadows Dramatic shade and shadows can enhance the mystery experience

Depth of Field A depth of field between ≥ 6 to ≥ 30 meters is more preferred.

Walking Speed The speed at which users are passing through space will influence both the size of the aperture and the size of the subject; faster typically means bigger.

Maintenance Organically evolved mystery conditions, as low maintenance gardens or winding paths, that change over time should be monitored. Since those changes could enhance the experience, but also evolves into a surprise condition

Prolonged Interest It can be a bigger challenge to sustain a sense of mystery in spaces that people routinely visit, but can somewhat be prolonged with anview into spaces with changing activities.

Low Intensity A quality experience should avoid triggering fear responses, as with close up surprises and obscured views with a shallow depth of field.

References

(Browning, et al., 2014, p. 48-49)

RISK/PERIL

Nature of The Space, Pattern 14

Health & Wellbeing

Amount of Evidence +1

Research background For adults short doses of dopamine are associated with several positive health responses and for children, these experiences play a role in the development of risk assessment (Browning, et al., 2014, p.50).

Biological Responses Emotion, mood & preference

Improving motivation, memory, problem solving, fight-or-flight responses

Design Strategies

Objective "is to arouse attention and curiosity, and refresh memory and problem-solving skills." (p. 50). The design experience can vary from the extreme, as great heights to the more moderate as getting your feet wet.

Priority Risk/Peril design interventions are usually quite deliberate and as such not be appropriate for all user groups or places.

Planning Design strategies that rely on spatial conditions will be easier to implement when incorporated as early as concept design and schematic phases of the design process.

Safety The element of safety must protect the user from harm while still permitting the experience of risk.

Fears Risk can be generated by a learned or biophobic response triggered by a near and present danger.

References

(Browning, et al., 2014, p. 50-51)

3 BLOCK BARKEN
INTRODUCTION TO SITE EXPLORATION

To understand the usage of Biophilic Design it's beneficial to try it out and explore it in practice. In this chapter, I analyze an urban setting to identify the patterns that were described earlier. The choice of this site is due to its urban density and general lack of nature. Still, it's liked by many, has a rich cultural heritage, and is very much alive. The block this thesis focuses on also recently received a new detailed development plan.

3.1 HISTORY
A SHORT STORY ABOUT BOATS, TRADE AND SAILORS

A patchwork of buildings
The area called Masthugget today began as a small trading harbor with a focus on wood and boatbuilding, the name derives from the manufacture of masts, ("Mast-chopped"). As it was located in the suburbs of Gothenburg the businesses did not have to adapt to the city regulations or the opening hours of the gates, which allowed more free development (Lissvall, etal., 2012, p. 5).

During the 1700s the area around Järntorget and Masthugget had several squares and open spaces that became more defined as the city expanded and the grid system we can see today was established in 1866. Most buildings were built during 80 years between 1850-1930, mainly in stone with stores on the ground floor and residential above with a building height of 3 to 6 floors. The courtyard and area surrounding the buildings were commonly used for workshops, farms, and material storage. Due to small plot sizes and a slow development with changing ideals during the expansion period, a great variety of building styles can be found in the area today (Lissvall, et al., 2012, p. 5).

In 1948 a new city plan was developed for the area with separated functions between trade in the north and residential in the south. As a result, the north blocks got merged into bigger properties and more coherent buildings with overbuilt courtyards. In the south, some of the buildings within the courtyards got torn down. A park was planned for block Barken but it was never built and instead resulted in reduced building rights for the block (Lissvall, et al., 2012, p. 6).

The Long Life Along the Long Streets
According to Lissvall, et al, (2012, p. 9), Gothenburg as a city can be understood through four different epochs.
The Fortress Town – The Trade Town – The Industrial City – The Knowledge & Event City (today)
The Långgatorna and Masthugget area represents a core piece of the trade and industrial era. As mentioned the harbor has been important for the development of the area as the streets have provided everything needed for all the sailors, traders, and workers passing by. Even when the bourgeois with their stone buildings moved in, the diversity and variety of people in the area were the same. Later on, Järntorget became a meeting point for the worker's movement (Lissvall, et al., 2012, p. 9).

Figure 1
Siteplan of Block Barken illustrating the mixture of building and usage that Lissvall, et al, (2012, p.24-26) provides, 1:1200 (m) Tree

Note: Background map: GSD-Property Maps Real property classificaion © Lantmäteriet, GSD-Property Maps Built-up areas © Lantmäteriet (2020). Retrieved from: https://geodata.chalmers.se/. Adapted with permission.

1:1200

Figure 2
Typology of Gothenburg and the area around Masthugget, 1:10000 (m)

Note: Adapted from GSD-Property Maps Hydrography © Lantmäteriet, GSD-Property Maps Transport network © Lantmäteriet, GSD-Property Land data © Lantmäteriet, GSD-Property Maps Built-up areas © Lantmäteriet, GSD-Elevationdata, grid 2+ © Lantmäteriet, Background map: GSD-Orthophoto, 0,25m color © Lantmäteriet (2020). Retrieved from: https://geodata.chalmers.se/. Adapted with permission.

0 50 100 200 300 400 500 1000
(m) 1:10000

3.2 PRESENT
TO WANDER AROUND BLOCK BARKEN

Today the streets of Långgatortna are some of the most attractive neighborhoods of the city with high cultural capital. The atmosphere in the area is quite harsh and rough with pubs and porn stores, which keep exclusive brands away. Still, it is very friendly and open-minded. With relatively low rent and small properties, the area is a hub for new small businesses to grow and network. Together with a lot of grassroots culture and movements, it is an area where culture itself is produced (Lissvall, et al., 2012, p. 10).

Critical Characteristics
Within the report *Långgatorna i Masthugget* by Lissvall et al. (2012) they present eight critical points about important characteristics with Långgatorna and block Barken, which should be regarded for future development.

- *The roof landscape*
- *The wide variety in typology and style*
- *Mixed usage*
- *The remaining workshop buildings and the wood fence*
- *The former police station*
- *The lines of sight*
- *The greenery*
- *The contrast*

Very simplified I think they could be described as a **juxtaposition**.
A Juxtaposition of; spatiality, volumes, styles, materials, usage, people, etc

Biophilic analysis
On the coming pages, there is an analysis of the site from a biophilic pattern perspective and what different nature and nature-like properties exist on the site today. As shown in the last chapter there are 14 aspects/ patterns divided into 3 overarching categories/approaches to how natural environments could be described, for this analysis, the 14 patterns are used. The goal of the analysis has been to understand better how to identify the patterns in an urban context and how the patterns can help with describing the experience of a place.

Y Y-Photo location Tree

Figure 3
Siteplan of Block Barken and the Market Hall, 1:1200 (m)

Note: Background map: GSD-Property Maps Real property classificaion © Lantmäteriet, GSD-Property Maps Built-up areas © Lantmäteriet (2020). Retrieved from: https://geodata.chalmers.se/. Adapted with permission.

Figure 4
Neighborhood of Masthugget, 1:6000 (m)

Note: Background map: GSD-Orthophoto, 0,25m color © Lantmäteriet (2018). Retrieved from: https://geodata.chalmers.se/. Adapted with permission.

Church Square / Tramstop Playground

0 50 100 200 300 400 500
(m) 1:6000

TREDJE LÅNGGATAN

Inviting Entrance
As the streets of Långgatorna are inclined 10° from west to east, the streets are quite shaded. The height differences within Barken allow for sunlight to reach the north street which creates an inviting opening for further exploration. As important is the great chestnut tree that hangs out over the street which provides a view of greenery along the entire street and a promise for more.

(See photo P for more greenery)

Sightlines & roof landscape
When you approach closer the tree takes up more of your field of view. The light and the tree suggest that there is an opening behind the old police station, instead, you meet a closed gate and a brick wall. The roof landscape within the block barken opens up behind the tree together with empty firewalls and old square chimneys. The Oscar Fredriks Church also became visible in the background as a new guideline to follow.

Chestnut tree
The big chestnut tree next to the old police station provides the most visible greenery within the block and acts as a local landmark. The closer you get the richer the experience.
It provides a sense of seasons with rich greenery during summer and a fractal and organic quality during winter. The space under the tree provides shelter from rain and sun with a dynamic shadow play. The tree also provides shelter and food for other animals.

FJÄRDE LÅNGGATAN

Hidden backdoor
The south street of the block is not so eventful. However, there is an open alley, which is rare for the neighborhood. When you pass through the 5m wide alley, you enter the southeast half of Barkens courtyard, which mostly consists of parking spaces and a fenced garden with a tree. The old police station and the Chestnut tree are visible toward the north. The tree provides similar qualities as the chestnut tree but is not as interesting. The courtyard provides a shelter from the street, but due to short sightlines and a single narrow entrance, you feel more cornered than safe.

Graffiti & patina
As visible on the future development plan (page 36) two buildings will be demolished. At the present, these two buildings are also the only ones covered in Graffiti. Graffiti has a lot of biomorphic qualities and within Masthugget it is somewhat integrated, as behind the Market place (photo V). In this case, it is a case of vandalization and rather presents a sense of decay and redundancy.

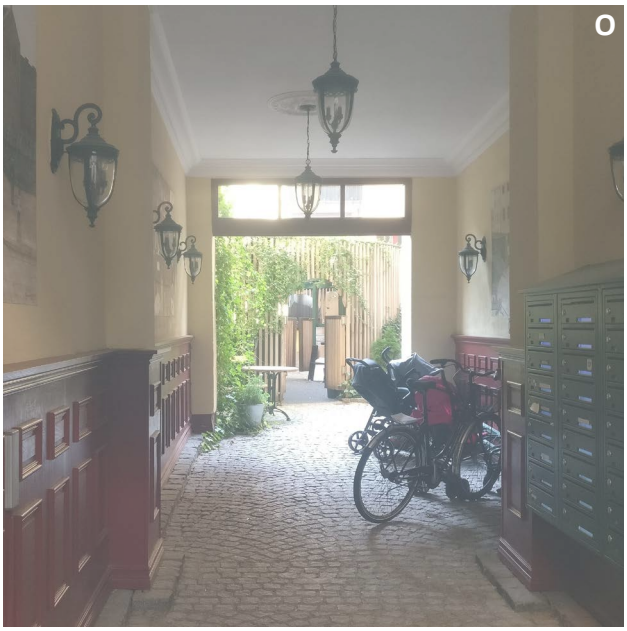
OUTSIDE BLOCK

Bricks, colors & patterns
The area has a heritage of stone buildings with facades out of stone, bricks, and plaster, reflecting a variety of styles with different qualities of Natural Analogues. Bricks are especially common and used with different roughness, colors, and patterns. For example, Oscar Fredrik Church's more elaborated brick patterns or how light on a curved corner allows a homogeneous brick wall to highlight its structural pattern.

INSIDE BLOCK

Courtyards
Most of the old courtyards on the site are small and usually in the shade, due to the dense urban environment. Even so, some of them managed to find space for greenery and be cozy and personal. Small balconies are common and the facades are very minimal compared with the ones facing the street. The light colors of the facade and the reflective windows allow some diffuse light and sun patches to reach further down. Still, it's very shaded. The stairwells are usually pushed into the courtyard occupying a lot of space, but also creating a more organic spatiality.

Thresholds & Passages
To enter the stairwells you usually need to pass through a gate, a passage, and sometimes also the courtyard. The passage works as great weather protection which together with the light differences creates a clear threshold between inside/outside the block and indoors/outdoors the building.



URBAN LANDSCAPE

Landmarks
The dense urban setting of the block provides a rich experience of different local landmarks around every corner. With Masthugget church to the west, Oscar Fredriks Church to the south, and Stena Lines Terminal to the North. At the site, The old police station is a central piece of heritage from the national romantic style. However, since the building is not so inviting in comparison with the market hall on the other side of the street, it is somewhat hidden even when it is right in front of one's eyes.

Balconies
In the neighborhood, balconies are commonly used within the courtyards and on corner properties of the block. They are quite small and there isn't much greenery to observe, still, they provide an elevated and protected outdoor experience for each apartment. The older building's balconies are usually smaller and hanging out with more organic and decorative railings. The newer building's balconies are usually bigger and more integrated into the building's facade or roof.

POCKET PARK

Green oasis
Behind the Market Hall, there is a passage through the block. With several tall trees, bushes, and a colorful green wall the short path is surprisingly vibrant. There are several wood benches along the path and a small half-covered seating group in the largest sunspot next to graffiti with a nature motif. Together with the surrounding market hall, restaurants, and elevated residential balconies, the place feels sheltered but still lively.

3.3 FUTURE
DENSIFICATION OF BLOCK BARKEN

New Detailed Development Plan
As for today, the city planning office has proposed a new detailed development plan for block barken that will allow for about 80 new apartments and 700 m^2 premises together with a new passage through the block and an adjacent square (Göteborgs Stadsbyggnadskontor, 2018, p 3.).

A focus in the development plan for the block has been to take care of the characteristics of the neighborhood and they have provided the following guidelines for how to approach a development project (Göteborgs Stadsbyggnadskontor, 2018, p 6.).

- *The diversity of buildings and activities is a key characteristic of the area's identity*
- *The slow development of the neighborhood should be regarded and continued.*
- *Businesses on the ground floor are important to get a vibrant urban life.*
- *Different kinds and sizes of residential should be regarded*
- *Narrow building plots and a big focus on the public environment is important*

One clear change they made to the site is to add a passage through with a small square next to the chestnut tree, similar to the passage and pocket park behind the Market hall. They also demolish the old workshop buildings at the site together with a part of the Old Police Station. All the new buildings are joined together except for one, which is also the tallest and all roofs have specified slopes to fit in with the roof landscape of the area.

Lack of Nature
One aspect that I think the detailed development plan lack is to incorporate the old park, (see 3.1 History) that was once envisioned better as there is already a lack of nature at the site. The elevated courtyard provides some, but it is also not much to be shared between buildings, and the new square and passage have no plans to incorporate much more natural, compared with the pocket park that has a dozen trees. They do admit in the detailed development plan that they do not succeed in contributing to the city's environmental goal *God bebyggd miljö (Good Built Environment)* of providing enough green area to the citizens (Göteborgs Stadsbyggnadskontor, 2018, p.49).

Section A:A

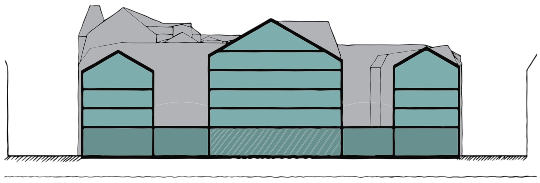
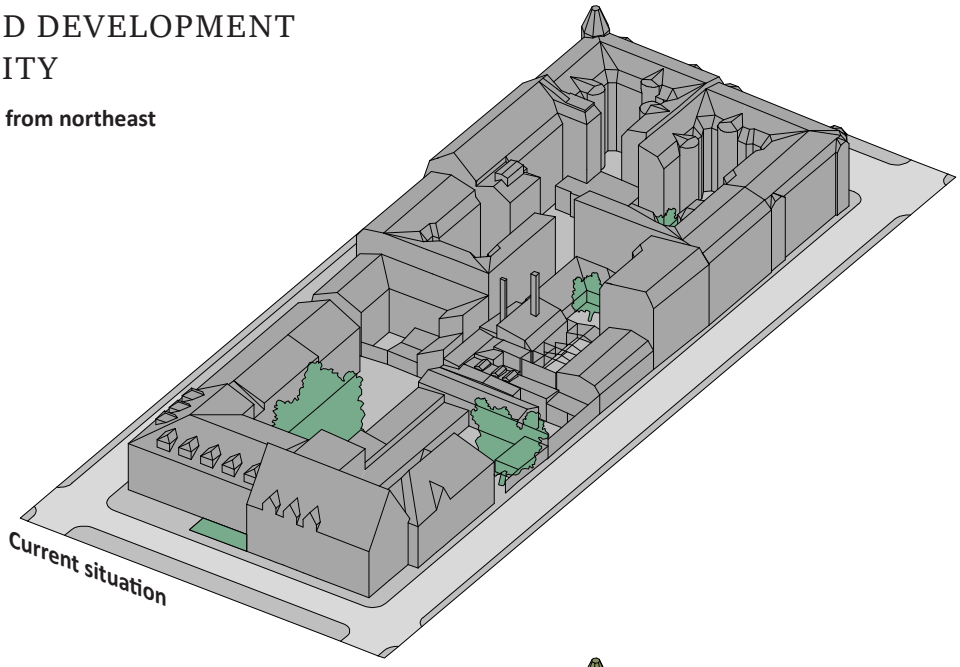


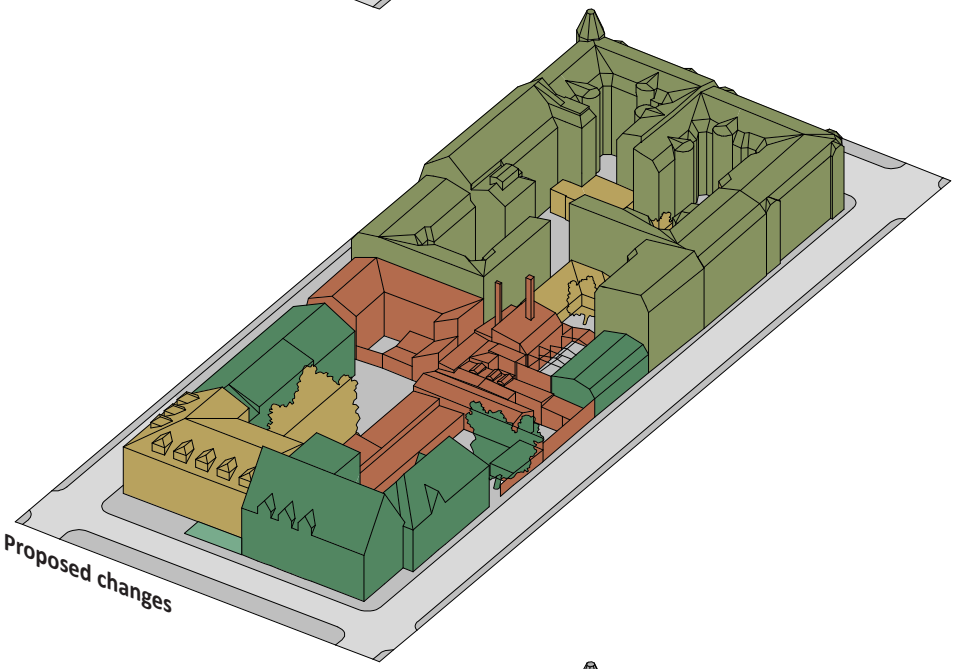
Figure 5
Siteplan and section of Block Barken with the new detailed development plan, 1:1200 (m)

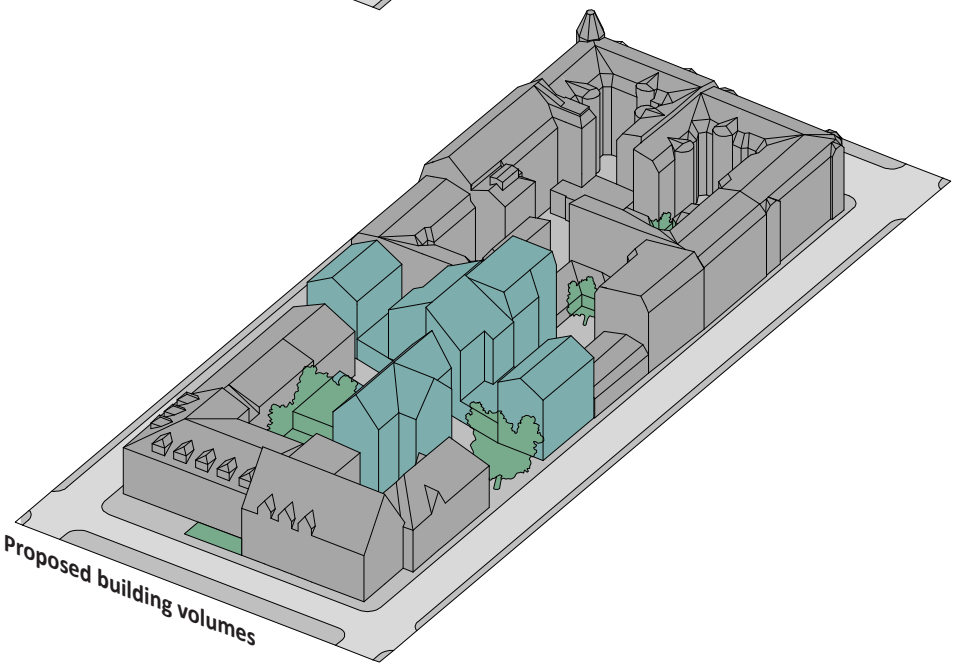
Note: Background map: GSD-Property Maps Real property classificaion © Lantmäteriet, GSD-Property Maps Built-up areas © Lantmäteriet (2020). Retrieved from: https://geodata.chalmers.se/. Adapted with permission.

PROPOSED DEVELOPMENT BY THE CITY

Axometric view from northeast







To be demolished | No statement | Should not be demolished | High cultural heritage value | New buildings

4 ROOF GARDEN
INTRODUCTION TO DESIGN EXPLORATION

The last part of the exploration focuses on the design part of biophilic design and how it could be used in practice by applying an extension/interventions to the existing future development plan and how things should be prioritized in a specific context.

4.1 BIOPHILIC EVALUATION
ANALYSIS OF BLOCK BARKEN

Outdoor experience
A strong biophilic experience is commonly connected with a strong outdoor experience, as quite visible in the site analysis, with the balconies, courtyards, the chestnut tree, and the pocket park. At the proposed development plan they work with elevated courtyards as a way to provide the residents with an improved outdoor experience. Even so, there is a question if it's good enough.

Sun analysis
A simplified standardized tool that can be used to understand the potential quality of an outdoor experience of a space, is to measure how much sunlight there is on the site. Especially in cold climates, as in Sweden, sunlight provides a lot of biophilic qualities.
The sixth pattern "Dynamic & diffuse light", which mainly focuses on work environments, provides some general guidelines for working with sunlight, as Reduce Glare, Low Intensity, and Maintain daylight, even so, it doesn't provide any tools to work with. Instead, I used the report Solkart by Boverket (1991), which provides a rule of thumb for sunshine in a Swedish context:

> *"At least 5 hours of sun from 9:00 to 17:00 at the spring and autumn equinox in the home and the immediate surroundings play areas and seating."*- (Boverket, 1991, p.17)

It is quite a simplified and old standard compared to the advanced sun analysis tools that are available today, still, it is a clear guideline to work with to get a sense of potential challenges and problems. Within the work of this thesis, it is accurate enough. When analyzing the proposed development plan for the site, it is quite clear that there is a lack of direct sunlight for the entire proposal. For some of the buildings, it is okay but none of the elevated courtyards provide any really good spaces. Even during the best-case scenario, the day of the summer solstice, it is limited.

Roof Landscape
For a dense urban setting, this is not so surprising as the courtyards usually are located at the ground floor within the block, shaded and sheltered by the buildings themself. On the contrary, the roof landscapes are blazing with sunlight. As mentioned in the last chapter, the diverse and colorful roof landscape is one of the strongest characteristics at the site today and is a clear aspect that has been worked within the new development plan. However, it is more worthwhile to work with the rooftops from the heritage aspect of mixed usages and greenery. From a biophilic perspective, it provides a wide array of natural and outdoor qualities, especially in the aspect of prospect and refuge. **So what if we apply a biophilic approach to the roofs?**

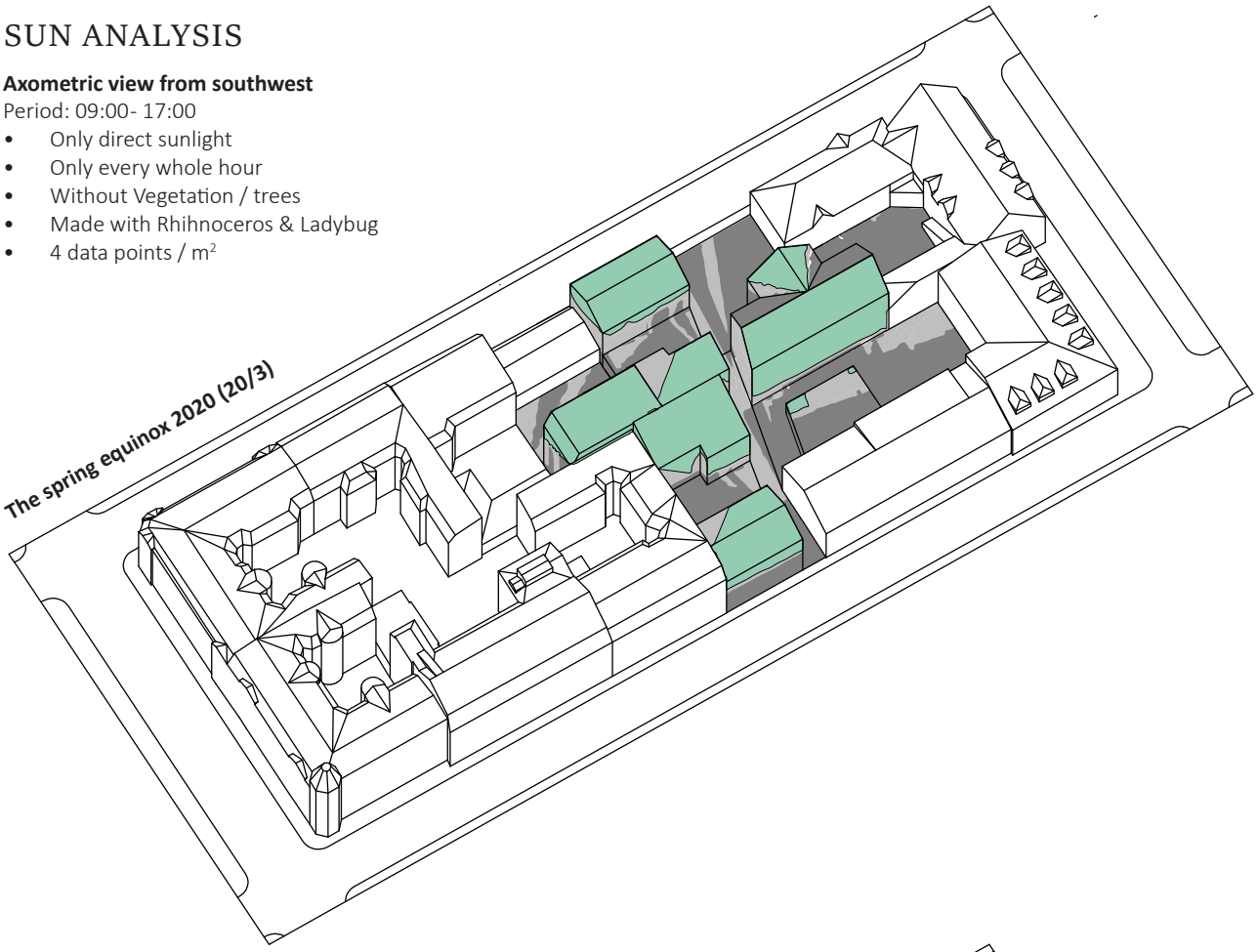
Figure 6 *Sunanalysis of of Block Barken, 1:1200 (m)*

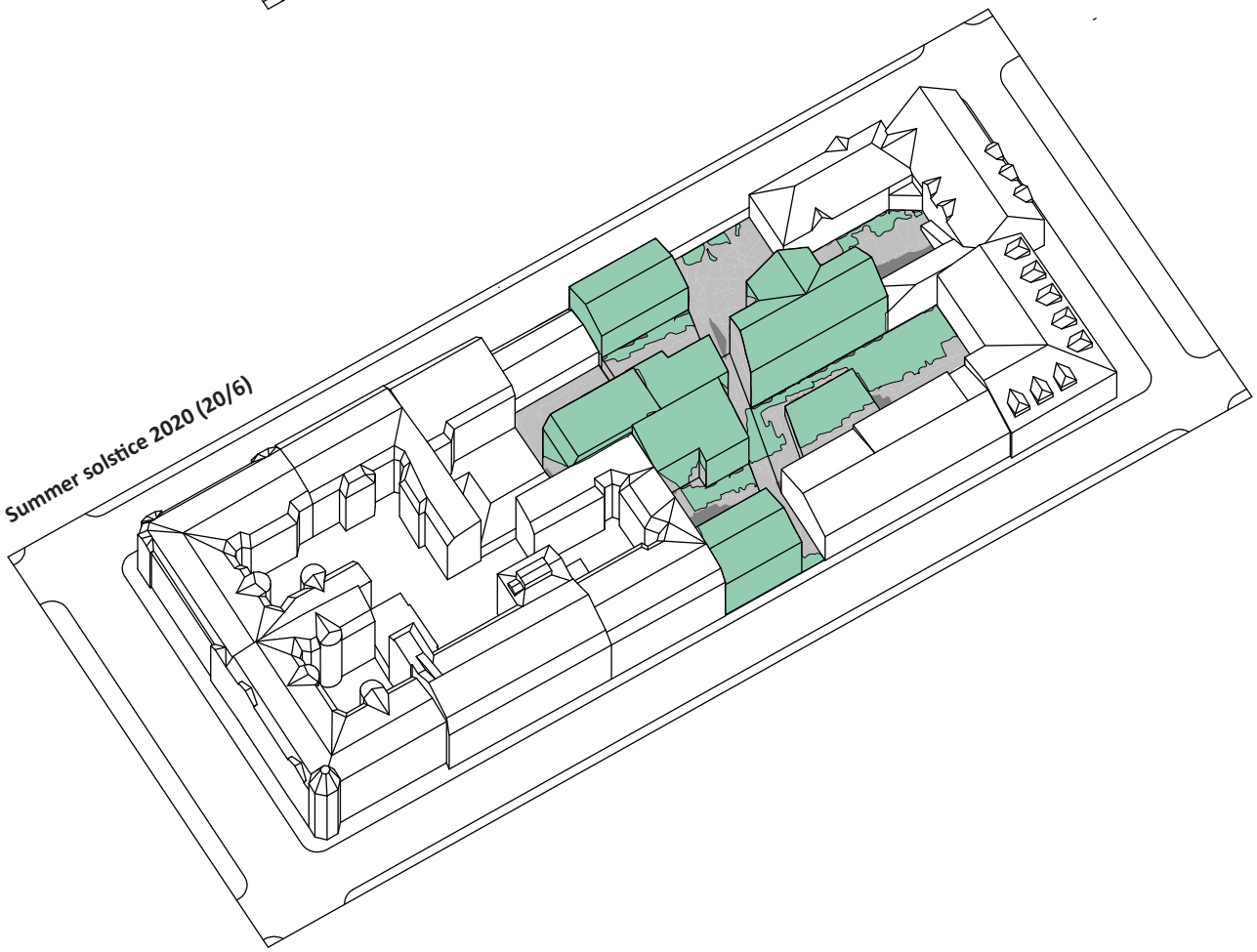
Note: Background map: GSD-Property Maps Real property classificaion © Lantmäteriet, GSD-Property Maps Built-up areas © Lantmäteriet (2020). Retrieved from: https://geodata.chalmers.se/. Adapted with permission.

SUN ANALYSIS

Axometric view from southwest
Period: 09:00- 17:00

- Only direct sunlight
- Only every whole hour
- Without Vegetation / trees
- Made with Rhihnoceros & Ladybug
- 4 data points / m^2





More than 5 hours direct sunlight
Less than 5 hours direct sunlight
0 hours direct sunlight

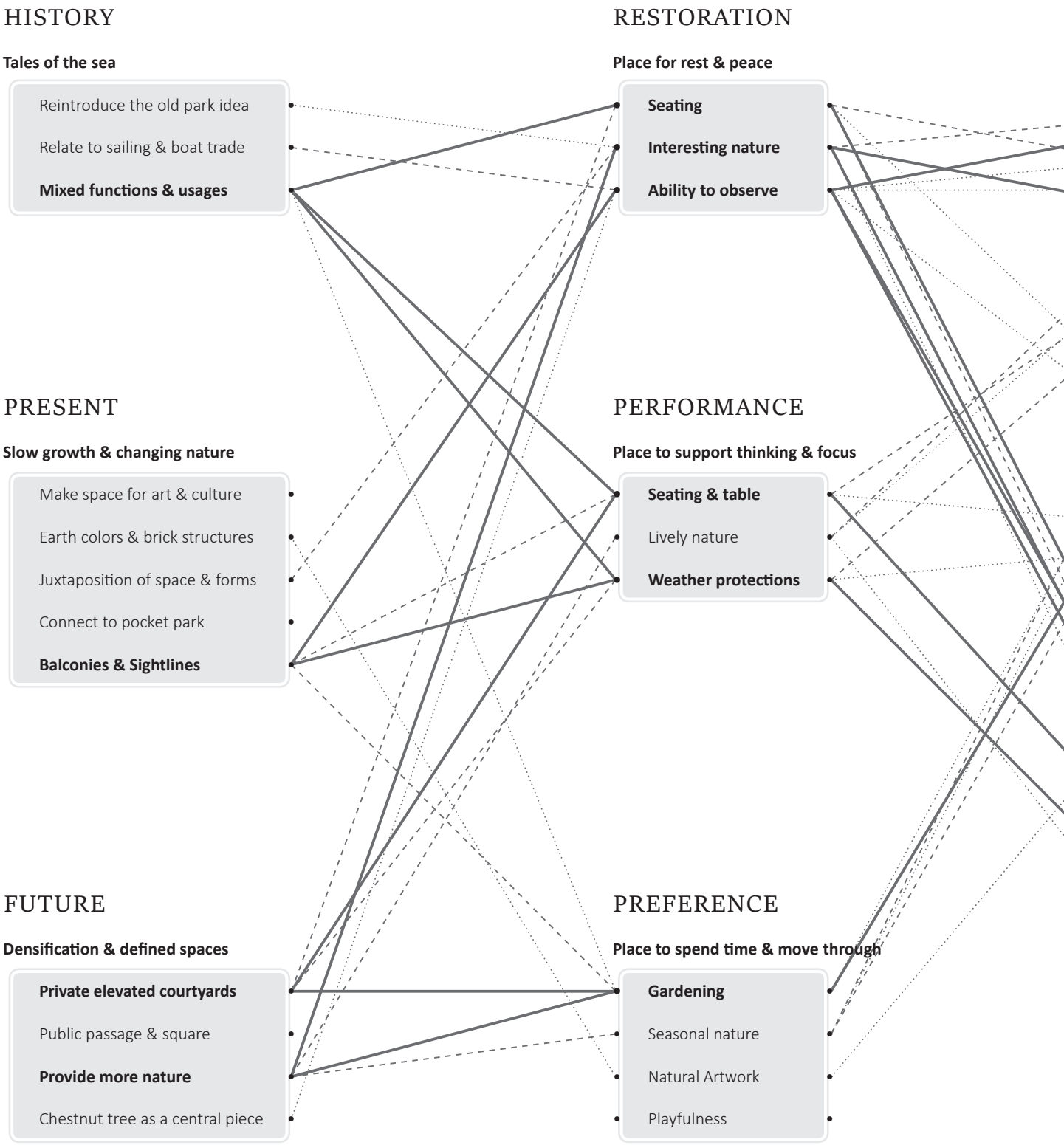
4.2 THOUGHT PROCESS

CONTEXT OF BLOCK BARKEN

Block barken and Masthugget is a very interesting place with a lot of heritage and diversity to work with. There is a general lack of nature, which, however, also enhances the experience of the little that exists. Also, the slow and diverse development of the neighborhood provides some nature-like properties.
Below is a summary of characteristics I found the most interesting from a biophilic perspective, and which ones I prioritized to develop further and focus on, in connection with the roof Landscape.

DESIRED HEALTH RESPONSES

To integrate the health aspect of biophilic design is a tricky business, as it is not as easy to replicate into a new context, in this case, residential architecture, and expect the same outcomes that can be found from research done in schools, hospitals, offices, etc. Even so, I summarized some aspects below that I think are general enough to be replicated and provide some desired outcomes, but of course with no certainty.



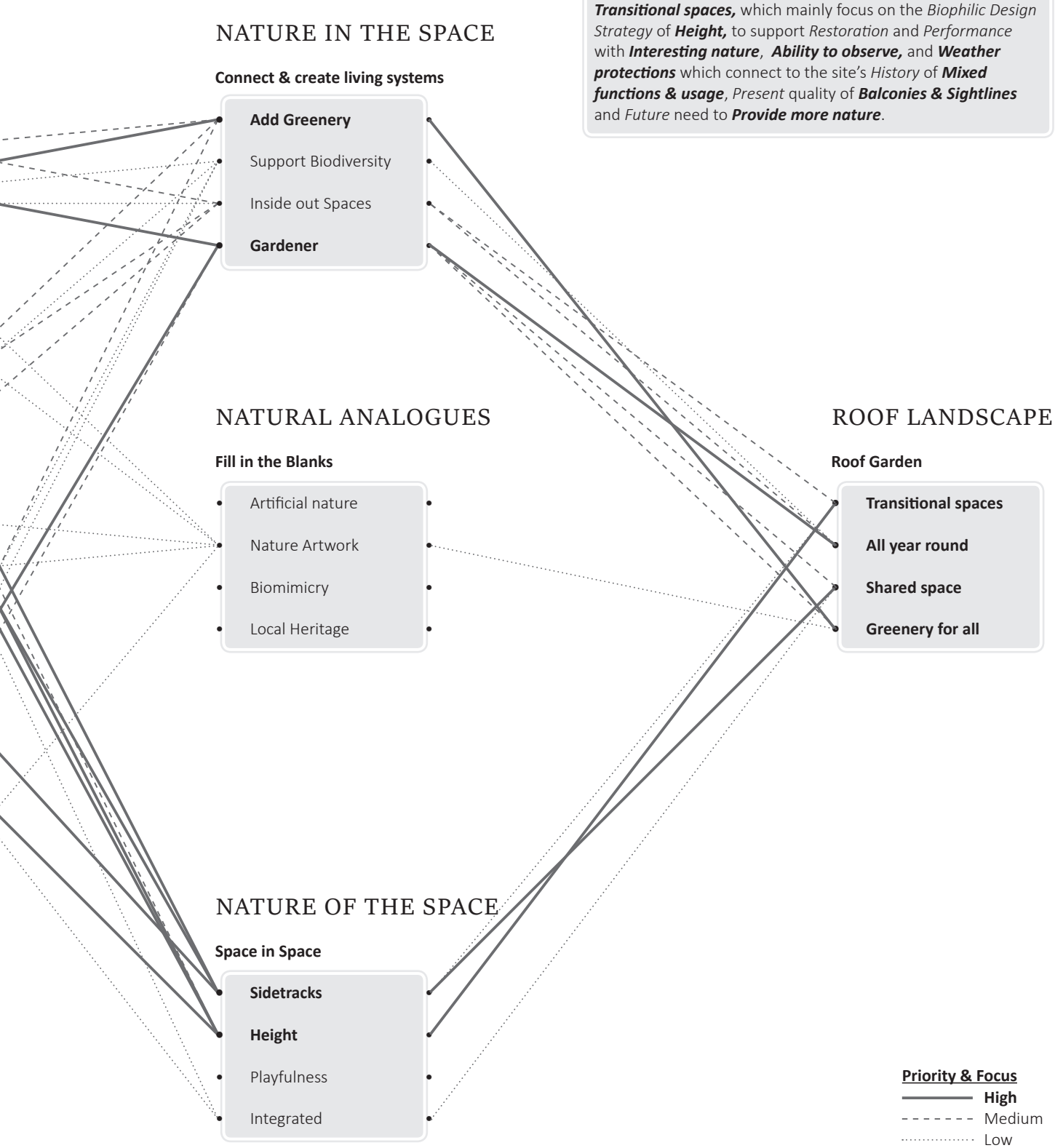
BIOPHILIC DESIGN STRATEGIES

These strategies are detailed in the "Biophilic Design" chapter. In the context of the roof landscape, some strategies connect much better with the aspect of heritage and health and not all of them are as useful or effective to work within.
To improve the probability of positive health responses, the focus has been on strategies that relate to, Visual Connection with nature (P1) and Prospect – Refuge (P11 & P12), the patterns with the most research. As such, Natural Analogues has not been prioritized.

BIOPHILIC APPLICATION

Working with the roof landscape provides many possibilities and below is a list of concepts that I have worked with that connects with the rest of the exploration and they are more detailed on the next spread.
Here the thought process behind the concept can be followed back to how it connects to the context of the site through a biophilic design perspective.

Thought process example:
With the *Roof Garden* I have worked with the concept of ***Transitional spaces,*** which mainly focus on the *Biophilic Design Strategy* of ***Height,*** to support *Restoration* and *Performance* with ***Interesting nature***, ***Ability to observe,*** and ***Weather protections*** which connect to the site's *History* of ***Mixed functions & usage***, *Present* quality of ***Balconies & Sightlines*** and *Future* need to ***Provide more nature***.



4.3 ROOF GARDEN CONCEPTS
BIOPHILIC DESIGN

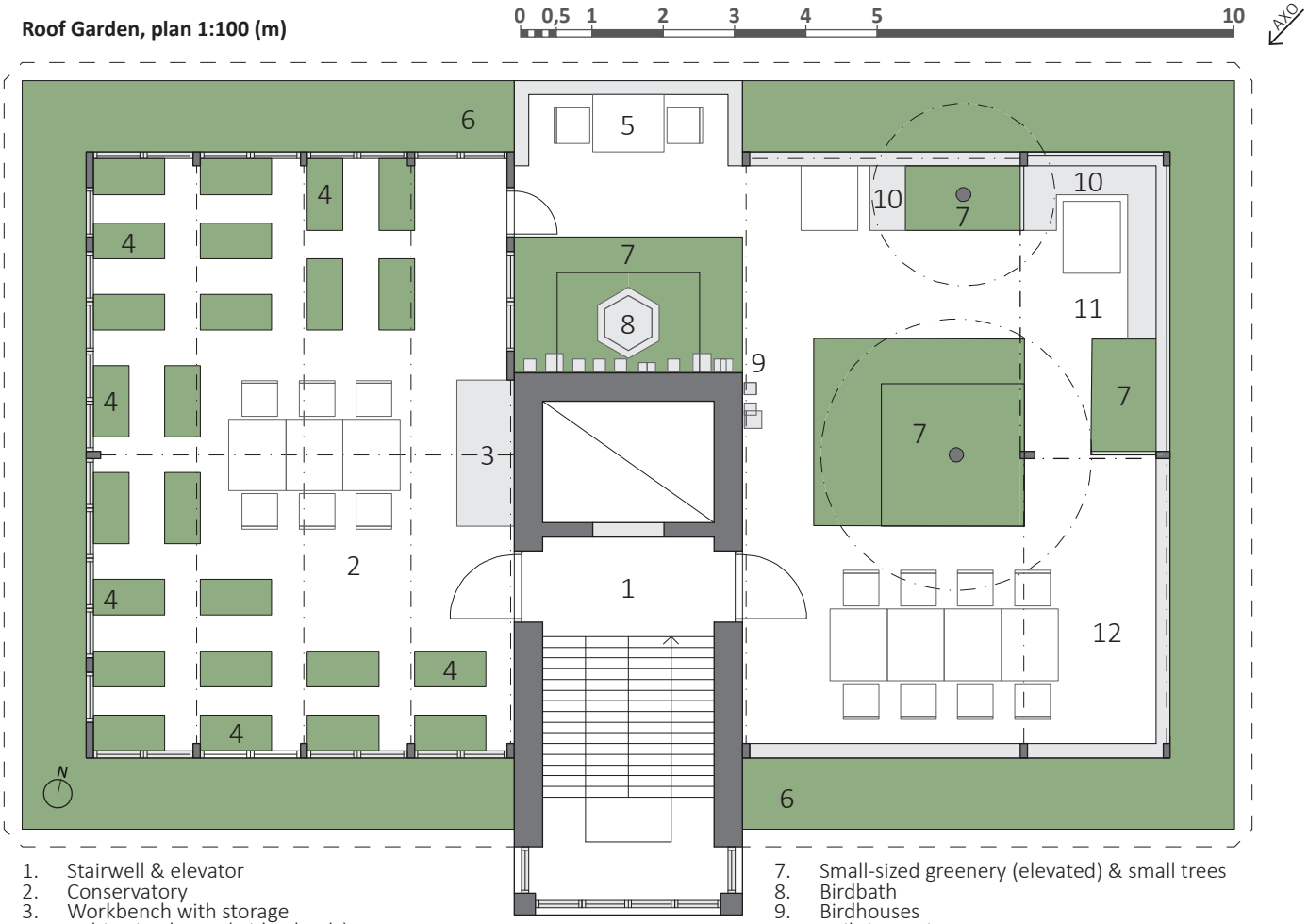
Transitional spaces
This concept focuses on the middle between space, in this case, of indoor and outdoor experience. The idea is to bring in the outdoors and make it more accessible with several spaces, sidetracks, and seating that provides different amounts of protection and shelter. As with the greenery that, like a hedge that always surrounds you, even if you are outside you are still somewhat sheltered from the surrounding.
The height and elevation of the roof garden provide a strong experience of being transitional with the surrounding through a prospect – refuge experience. The Inside out experience of the conservatory with the cultivation boxes also enhances the experience of providing visible greenery all the year-round.

All year round
This concept focuses on providing a wider and richer natural and outdoor experience by enhancing the seasons and providing accessible gardening. The idea is to integrate the different seasons and weather throughout the year. So even if it is hot, cold, rain, sun, or snow, there is a space to be.
The big conservatory provides an interesting inside out space, with a glass roof that enhances the experience of snowy or rainy days. Also smaller things such as the birdbath and birdhouses, that support biodiversity, make the seasons richer. The Cultivation boxes provide an engaging, rich, multisensory, and, most importantly, accessible experience of nature for the residents of each apartment.

Shared space
This concept focuses on providing a richer experience of nature by centralizing it into a shared space that all the residents can use. The idea is that instead of focusing on each apartment, where interference is quite limited, due to the residents' own right to choose, a shared space can provide something more extraordinary than a single apartment cannot provide.
The rooftop provides such a strong biophilic experience that it should not be reserved for only one household. By sharing it, it provides additional space for gardening, relaxing, working, and socializing. Like tables and chairs, the cultivation boxes can be moved, so the conservatory and open terrace can be used for bigger events or parties throughout the year.

Greenery for all
This concept focuses on accessible greenery by providing a more diverse nature experience with strategic placement and elevation of greenery, to make it more visible and engaging. The idea is to always be surrounded by greenery and have ever-changing nature qualities in your sight of view.
To start with the roof garden needs to be accessible and flexible in its usage. Cultivation boxes, gardening, and supporting biodiversity with birdbaths and birdhouses also bring in more randomness and life to the experience. Surrounding the entire roof garden with greenery makes it ever-present within it, which also makes greenery more visible to surrounding buildings and pedestrians.

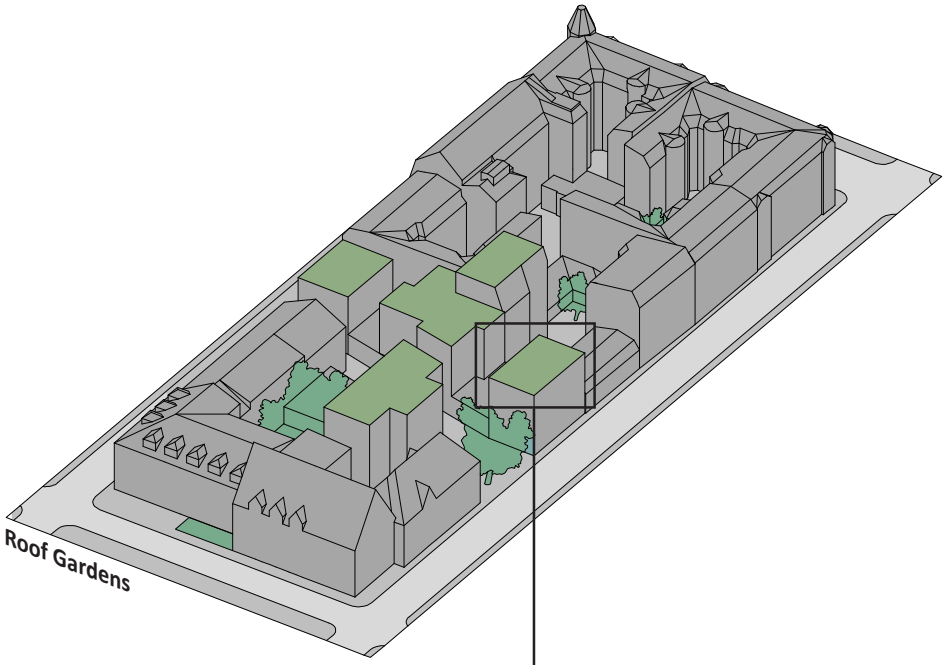
Roof Garden, plan 1:100 (m)



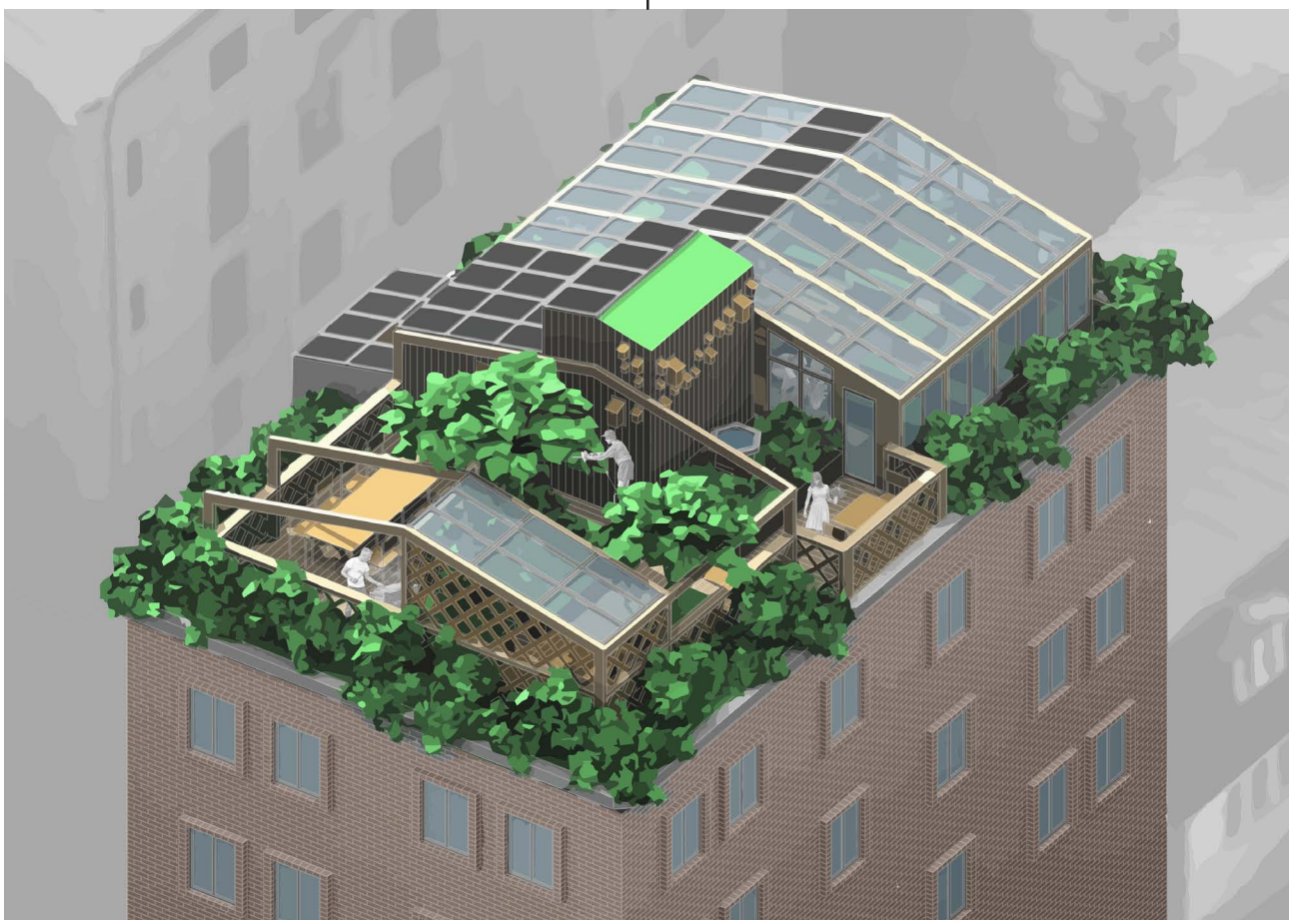
1. Stairwell & elevator
2. Conservatory
3. Workbench with storage
4. Cultivation boxes (with wheels)
5. Lookout point
6. Medium-sized greenery (wild)
7. Small-sized greenery (elevated) & small trees
8. Birdbath
9. Birdhouses
10. Built-in seating
11. Weather protection
12. Open terrace

ROOF GARDENS APPLIED TO THE DEVELOPMENT PLAN

Axometric view from northeast

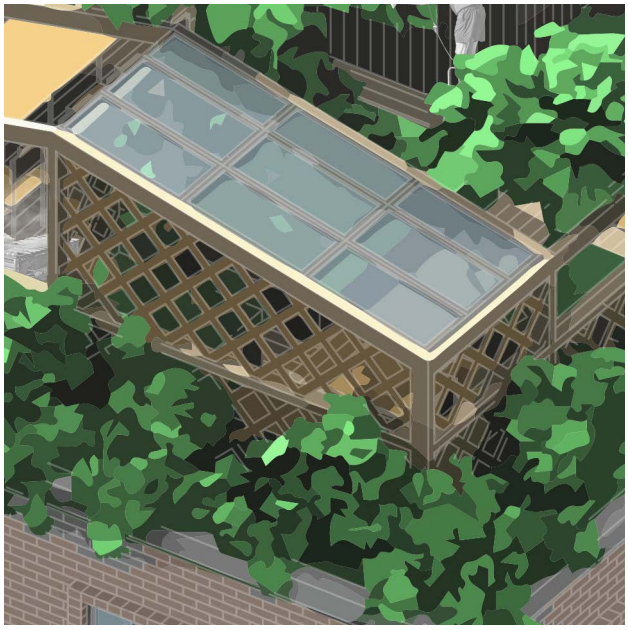


Visualization of Roof Garden

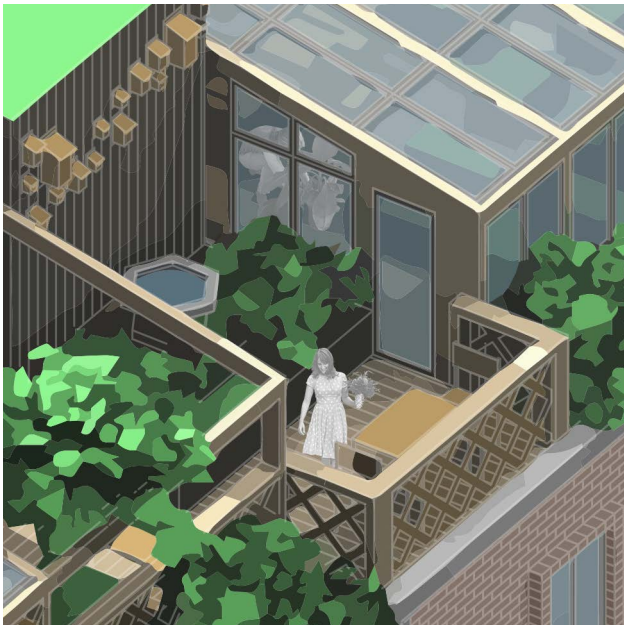


ROOF GARDEN CONCEPTS

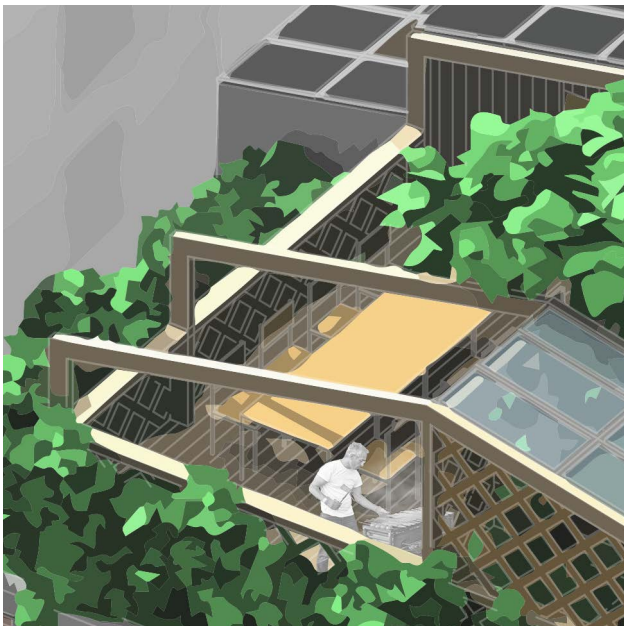
Transitional spaces



All year round

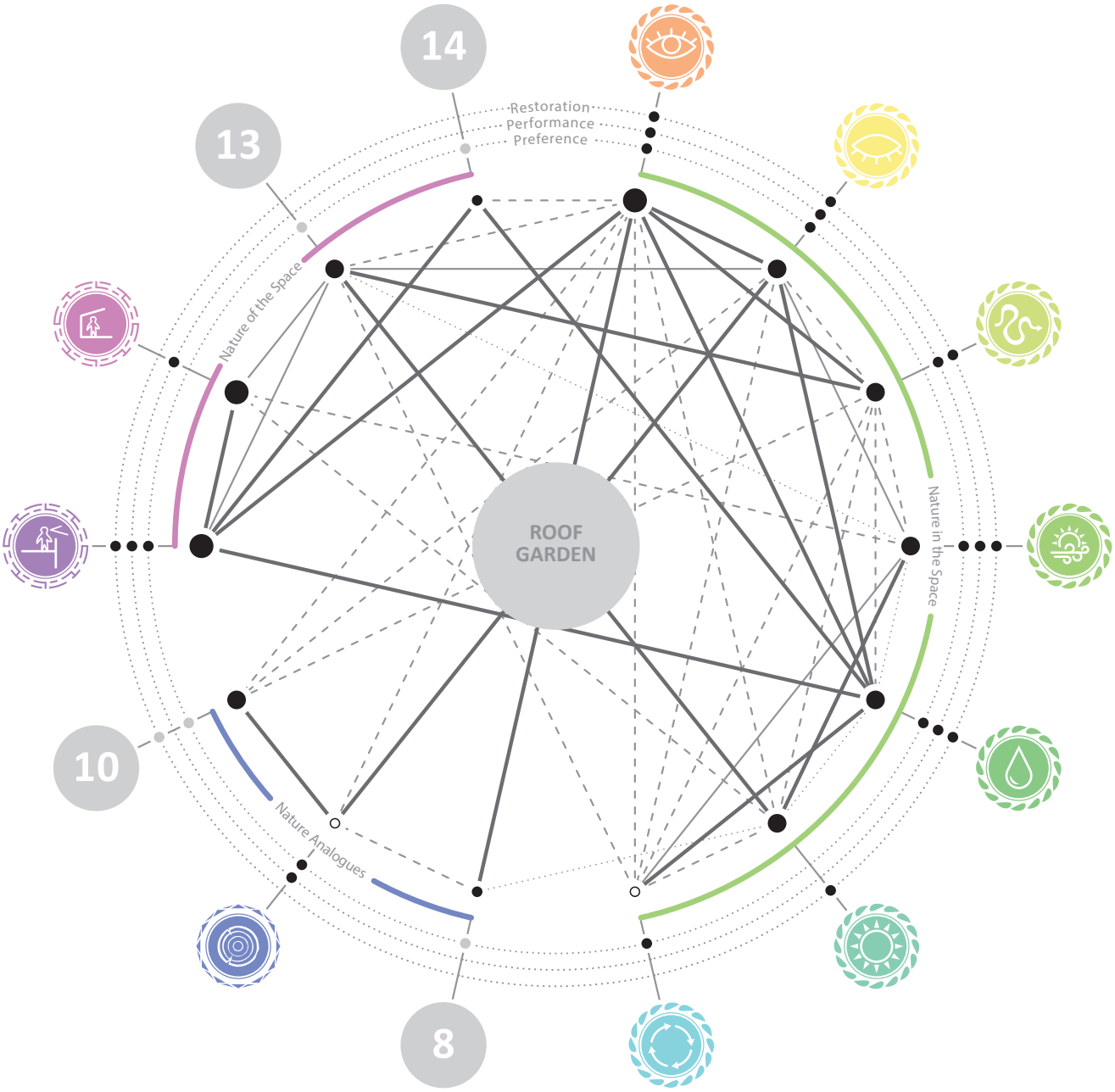


Greenery for all



Shared space

10 PATTERNS OF ROOF GARDEN DESIGN

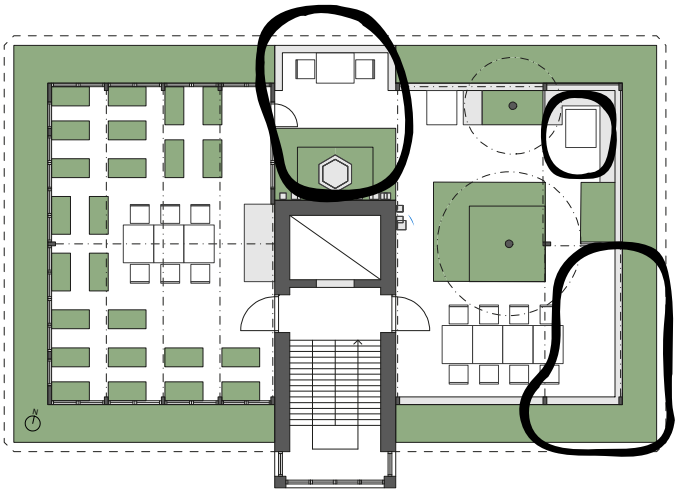


4.4 FORM & FUNCTIONS 1:200

EXPECTED HEALTH RESPONSES

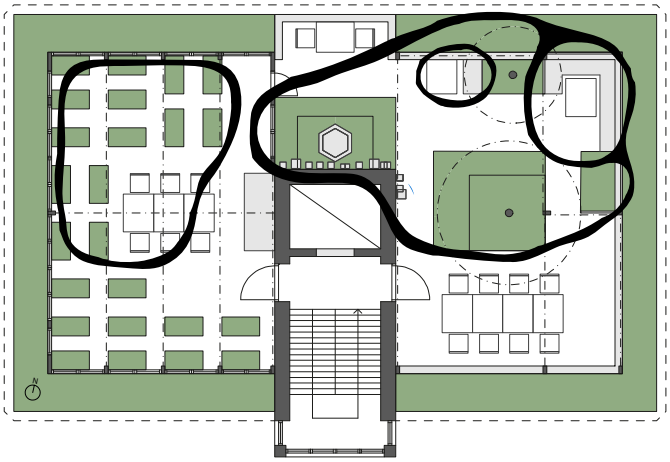
Restorative

According to Browning, et al. (2014, p.12), space, where you can prospect and observe your surroundings, is suggested to reduce stress. They also suggest that a view of greenery and a multi-sensory experience of nature reduce blood pressure and lowering the heart rate. As the roof garden provides this sort of experience it is worth speculating that it will have a restorative effect here as well



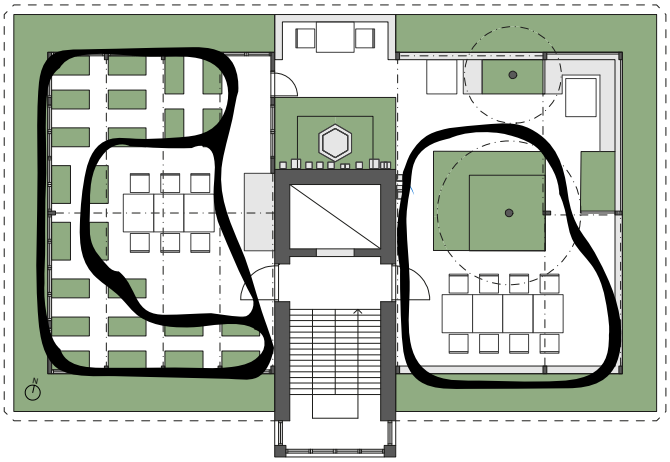
Performance

According to Browning, et al. (2014, p.12), a sheltered space where you can observe your surroundings reduces boredom and improves attention. They also suggest that view of greenery and a multi-sensory experience of nature improve mental engagement and concentration. As the roof garden provides workspaces with these properties and as the conservatory could be refurbished for this purpose, it is worth speculating that the roof garden will support performance and learning positively.



Emotion, mood & preference

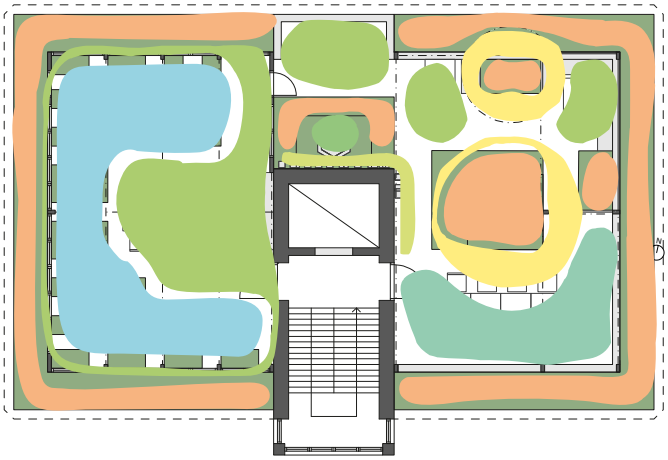
According to Browning, et al. (2014, p.12), space, where you can prospect and observe a surrounding, is suggested to improve overall happiness and comfort and perceived safety. They also suggest that a view of greenery and a multi-sensory experience of nature improve tranquility and overall happiness. As the roof garden provides the possibility for gardening and several spaces for social interaction that are surrounded by these properties, it is worth speculating that the roof garden will be a generally preferred space to hang out, socialize and do free-time activities.



BIOPHILIC DESIGN APPROACHES

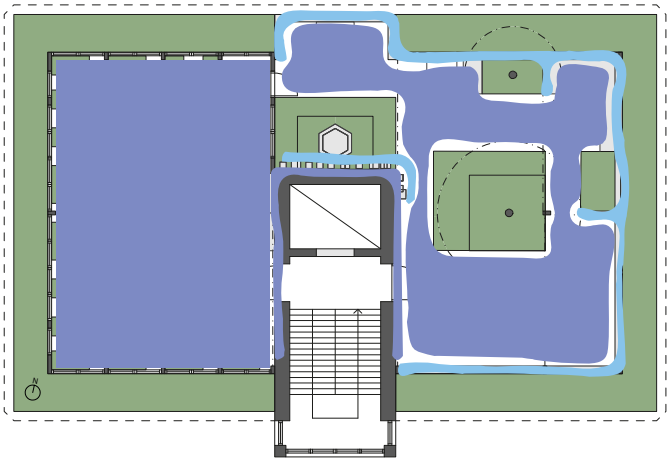
Nature in The Space

The roof garden uses all the patterns in this category. To start with there are strong visual and non-visual experiences of nature wherever you are. The elevation provides an ever-changing experience of the weather and together with the birdlife and gardening, it provides a more lifelike and wild experience. Sunlight presents a thermal and dynamic experience. Finally, the conservatory, gardening, and seasonal greenery provide a closer connection to natural systems and the cycle of seasons.



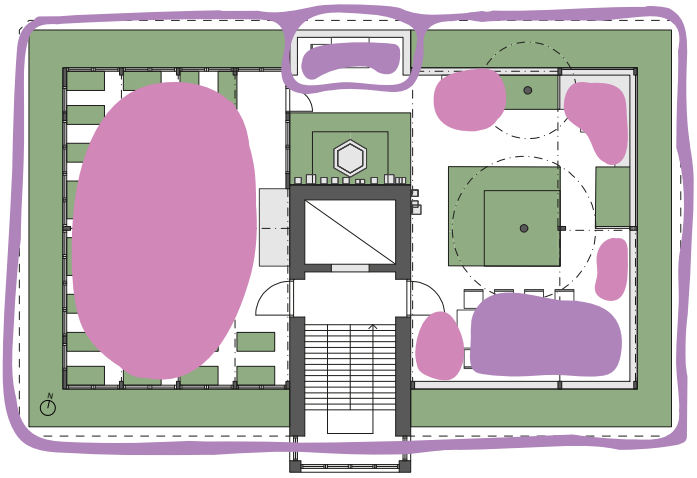
Natural Analogues

The roof garden only uses this category sparsely and mostly in the case of natural material like wood for all the surfaces and the furniture. To an extension, the weaved wooden pattern of the railing and the birdhouse cluster has some biomorphic qualities.



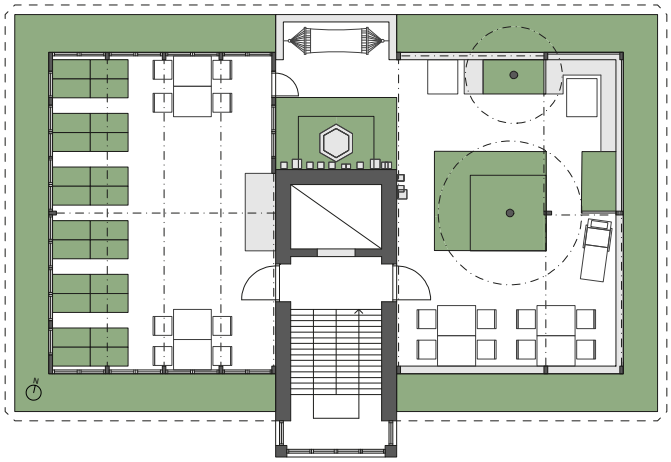
Nature of The Space

The roof garden focuses on the relation of prospect–refuge within this category. As to provide a variety of shelters where you can observe your surrounding. The elevation of the roof garden enhances these experiences, as a shelter from its surroundings and with a great view of the neighborhood with the close by Police Station, and Oscar Fredrik Church and the Masthugget Church as two landmarks

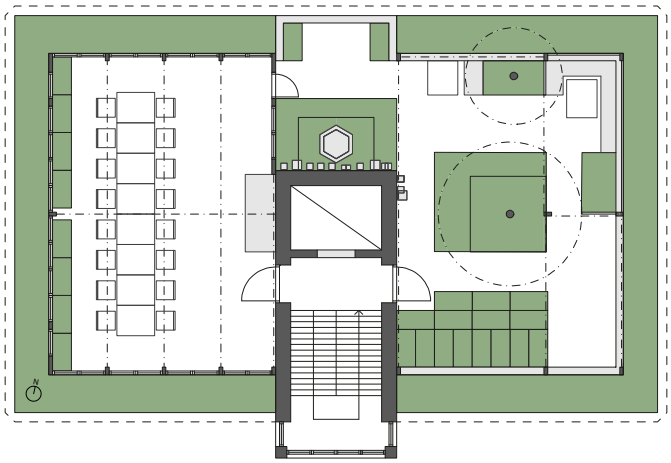


ALTERNATIVE FURNISHING

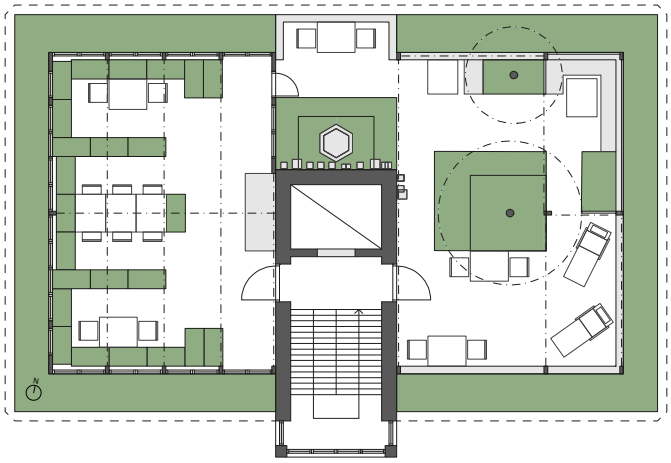
Social distancing



Celebration of a holiday

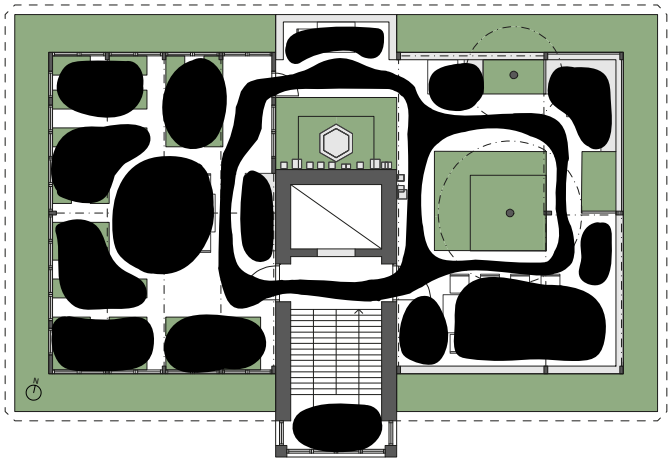


Working from home

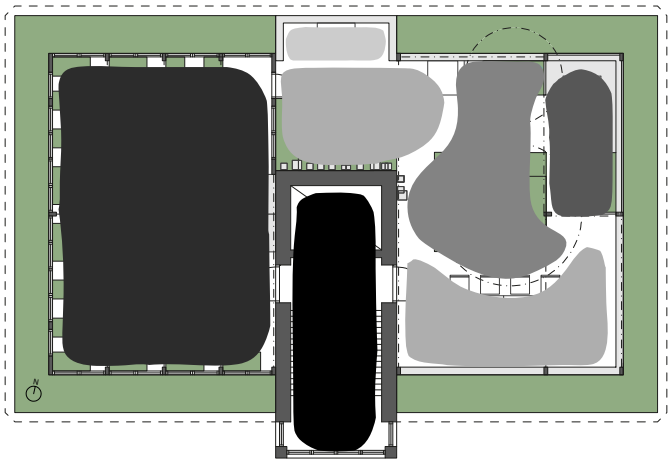


SPATIALITY

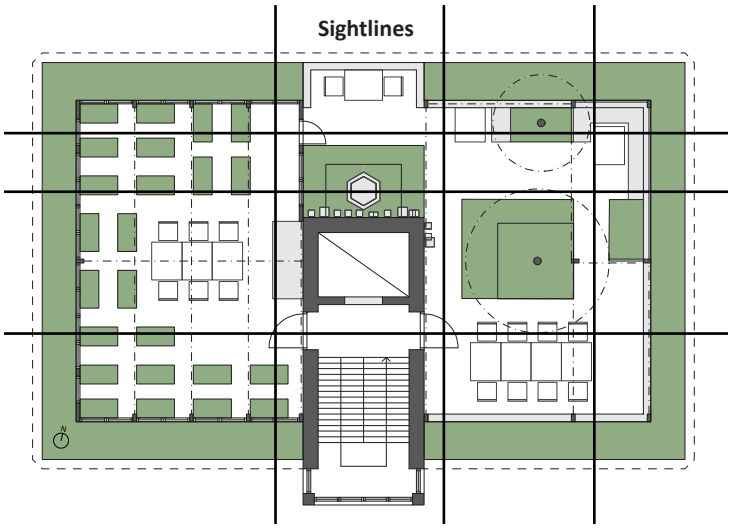
Flow of movement



Indoor / Outdoor



Sightlines



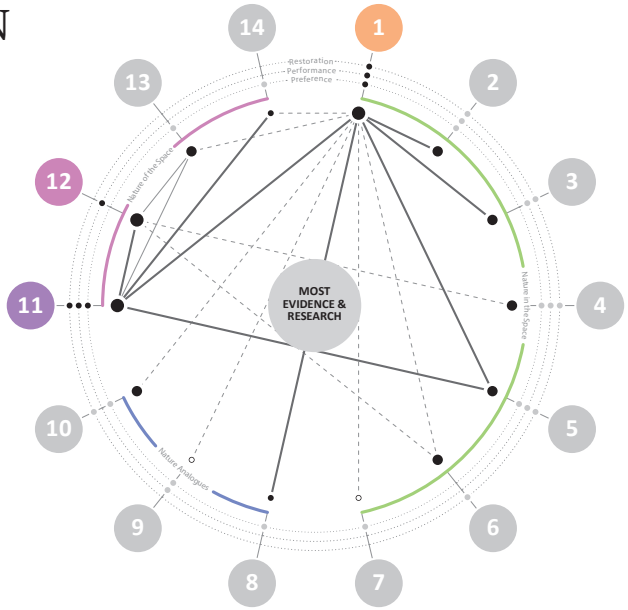
5 DISCUSSION & CONCLUSION
INTRODUCTION

This chapter concludes this work by providing an answer and discussion to the thesis question and my reflections.

5.1 THE THESIS QUESTION
WHAT HAVE I DONE?

"How can biophilic design be used as a framework, to support wellbeing, in the context of a residential building, within a dense urban setting."

Well actually it is four questions in one and as such, it is fitting to answer each of them, how I have worked with them and what this thesis adds to the discussion.



HOW CAN BIOHILIC DESIGN BE USED ...

... AS A FRAMEWORK ...

Communicate our shared experience of nature
Biophilic design can be used as a framework for design by providing a deeper understanding of our shared experience of nature and nature-like environments. With tools, strategies, and categories a more nuanced language is provided that architects and others can use to describe, define, and communicate the shared experience of nature and nature-like environments better.

Visualizations & simplification
This thesis presents a summary of general categories, named strategies, and visualized biophilic theory to make it easier for others to use it as a framework and delve deeper into the subject. A huge amount of time has gone into the layout to provide a compelling structure that could spark curiosity about the subject, with a focus on fellow architecture students. By providing simple concept sketches, site analysis, and design intervention, this thesis hopes to give an example of how biophilic design could be used as a framework for architectural design.

... TO SUPPORT WELLBEING ...

Improved learning, stress reduction & general preference.
Biophilic design is a promising approach to understand and describe nature as it has its roots in research and is steadily evolving based on new findings within the field of research-based design and environmental psychology. As for today, there is a lot of research that shows that nature and nature-like environments can be used to support health and wellbeing, in the sense of improved learning, stress reduction, and general preference.
This knowledge comes from research and field studies conducted in hospitals, schools, offices, and laboratories. The report "14 patterns of Biophilic Design'' by Browning, et al. (2014), has been used as this thesis's main reference, as it's one of the best summaries of contemporary knowledge within the health and wellbeing aspect of biophilic design.

Showcasing an example
An important aspect to understand with this thesis is that it's not research in itself, it's rather an exploration and showcase of the health research the main reference has provided. Biophilic Design is a huge topic from community engagement to nature conservation. The health aspect is somewhere between and it is what this thesis focuses on.
As such this thesis doesn't present Biophilic design in its great wholeness but rather how it can be used to understand existing and potential design intervention's possible impact on wellbeing, and to be clear, in the sense of improved learning, stress reduction, and general preference.
In the case of The Rooftop Garden, the most crucial patterns are "Visual Connection with Nature" together with "Prospect" and "Refuge", as they are the most researched and such the most certain ones to promote/support wellbeing.

... IN THE CONTEXT...
... OF A RESIDENTIAL BUILDING ...

Lack of research
The strength in the argument for biophilic design, I believe, is the research behind it and as such it's also a trick subject to work with if we also aim to keep a research-based approach to our design. As mentioned, most studies from the report this thesis focus on comes from research and field studies conducted in hospitals, schools, offices, and laboratories.
It doesn't provide much information on pure residential architecture and all design applications this thesis presents should therefore be seen as speculations and a translation from one design context to another.
It's still too early to answer what role research-based biophilic design can have on our wellbeing in residential architecture and as such, it is also not possible to evaluate the potential health improvement the suggested design applications could provide.

Speculations
Even so, it's worth speculating about its potential impact and what it could look like if we translate biophilic design aspects from one design context to another.
As with the present 2020 pandemic, it's very clear that our homes also need to be able to function as a second school, office, and hospital. So there is much promising knowledge that could be further integrated from those contexts to the context of our homes.
One difference and challenge with residence and homes is the conflict between public/private and shared/owned spaces, which I would suggest future students investigate more. In this case, the rooftop garden is an example of a shared–private approach to provide a more accessible, versatile nature experience all year round.
Biophilic design can be seen as a very costly approach to improve residential's well-being, and as for now, more research is needed to evaluate to what degree it's effective and worth it. Until then a single high-quality nature experience that can be shared between the residentials may be the most cost-effective and easiest to research and evaluate.

... WITHIN A DENSE URBAN SETTING

The Juxtaposition of overlapping forms & functions
As mentioned, biophilic design can be used to describe and evaluate existing and potential nature and nature-like experiences. This can be applied to a dense urban setting as well and could be used to identify or create a space/experience that supports our wellbeing, to some degree, in the case of learning, working, and resting.
This thesis also focuses on a residential building and the outdoor experience of those residents, rather than passing pedestrians. In the context of this building the aspect of a dense urban setting this thesis focuses on is the general lack of space and the juxtaposition of overlapping forms and functions.
So rather than transforming the entire development plan the city has proposed for the site, the aim has been to overlap and combine it with a biophilic design intervention on top of it, in this case literally, as the roof has been used.
The function of the roof has been transformed from a heritage point of view to a biophilic point of view, to access a richer outdoor experience for the residents, combined with a setting that could be suggested to support wellbeing.

Beyond courtyards
In a dense urban setting, it's a good question if the outdoor and nature experience that courtyards commonly provide is enough. As space is such a limiting factor, and that there is a need to overlap functions, it's hard to provide the amount of sunlight, sightlines, and refuge that is required to create a qualitative outdoor experience all year-round.
Rooftops could be an opportunity to provide more accessible nature for the residents which further could reduce the wear of more public parks shared by all citizens. How far this could be applied and if it's possible or even worth it, to retrofit gardens on top of existing buildings, goes beyond this thesis and I would suggest future students investigate it more.
To possibly use roofs like a garden is not something new and goes back to the ancient Hanging Gardens of Babylon. Outside of a dense urban setting, it may also not be fitting or even worth changing the usage of roofs, as ground floor courtyards are way cheaper and less complex to work with. If a building is already surrounded by forest or greenery you do not need to put greenery on top of it, but when there are only other buildings to be found, toward the sky we should go.

5.2 REFLECTION

LOCAL HERITAGE

Unexpected findings

One thing that I have tried to integrate in the design throughout the work in this thesis is the heritage of the sea.
As the neighborhood of Masthugget has such a strong connection to the sea with the trade, boat industry, and life around it, it would be a shame not to integrate into the design. Early on I explored many ideas, from fountains and bark boat playground to sea themed decorations and ornaments. As I settled my focus on the roof landscape, and the biophilic patterns with the most research behind it, I left those ideas behind because they mainly only related to the biophilic approach of Natural Analogues. But later on, when I were describing the biophilic experiences with the roof garden, I realised that there were some connections to the sea.

It may indeed be a bit far-fetched but you could say that the heritage of sea-dwelling is incorporated, not by aesthetic, culture, or function but by similar experiences. From a biophilic perspective the experience of sailing could of course be described as having properties from all the patterns. However, except from the strong presence of water, ever-change to your sense of balance and real risk of drowning, the roof garden shares a similar strong prospect – refuge, and weather exposed experience. As being sheltered and elevated in a limited space, with a clear observable view of your surroundings, while being exposed to sun, wind and water/rain

Experience heritage

As mentioned, it may be a bit far-fetched to compare the roof garden with being on a boat, but it raises the question of *experience heritage* and what experiences we value, is it possible to translate them to other contexts? and which ones do we want to keep or remove? who decides? As much as I wish to explore this further, this is the end of this thesis and there is no time to explore this much more than the following reflection.

Throughout this thesis, I have explored the many aspects of nature and outdoor experience and their connection to wellbeing. In a way, the theory of biophilic design suggests that we all share a similar experience of natural environments as a heritage from how our species used to live most of our lives outdoors. To what extent is too early to say, as upbringing and culture affect our relation to nature as well. Still, in the context of describing a shared experience, to understand what to prioritize, the language that biophilic design provides may turn out to be a very useful tool to use.

TO EVALUATE HEALTH BENEFITS

Evaluate health responses

Within this thesis, it is not possible to evaluate the proposed health benefits that the roof garden is suggested to improve. However, if we would want to, it would not be impossible.
To collect the data the resident's behavior and health could be monitored voluntarily through activity trackers and heart-rate monitors. Either by sharing data they already collect through different applications on their smartphone, or to distribute wearable monitors to each of them. This could also be expanded by repeated health-check routines or fill-in surveys.
As the garden is not visible from each apartment and optional to use and visit for the residents, it would not be too hard to put half of the resident participants in a control group that does not use the roof garden during a set period. In the same way, there could be a schedule for when and how long the residents could use it.

Limitations of the study size

Of course, the biggest challenge would be the small set of participants in such a study as it is only expected to be around 6 households in the building that has been used as an example in this thesis. Depending on what form of housing it is, there could be more participants over a longer period, but then the long term effect would also be more challenging to measure. As for now, the development plan proposes 80 new apartments for the entire site with mainly tenancies. So if the roof garden were applied to all the new buildings similarly, a somewhat bigger study could be made.

Sculpture on Masthuggstorget depicting carved masts, a way to emphasizes the place's heritage

BIOPHILIC DESIGN & NATURE

More than greenery

This has been an interesting topic to explore throughout the work with this thesis and I will get usage of the in-depth knowledge I gathered for future projects.
When I started this project I had the idea that the education at Chalmers lacked knowledge about working with nature as most of my knowledge of working with plants and greenery came from my own research. In a way, it is not so surprising as the education at Chalmers focuses on building architecture, rather than landscape architecture.
To my surprise the more I learned about the different approaches to biophilic design, especially Nature of Space, the more I realized that the knowledge I gathered at Chalmers was quite useful after all. Not in the term of plants and how they could be used, but about the shape of spaces and the preference for nature-like qualities. An obvious example is the relation of prospect – refuge and its connections to properties such as sightlines, private/public, open/closed, and zoned floor plans. Another common theme is the preference of natural materials, the complex biomorphic and fractal shapes generated with parametric design tools, and the reintroduction of ornament usage.
What I can remember from my studies, there seldomly were any references or discussions about existing studies or research that could support those design decisions. As a reminder, the main reference is from 2014, I started my architectural studies in 2013. Probably people didn't know about them and still, it may, as mentioned before, be too early to do any big claims about the supposed common preference we have toward nature, and it would be naive and not honest to say that I do not have any bias toward working with nature.

Working with Nature

On that topic, the biggest take away from this thesis is to understand the difference between what aspect of nature and nature-like environments there has been solid research on, and what aspects there have only been speculations about. This thesis focuses on the health aspect, but it is just one of many ways to work with biophilic design. As mentioned in the introduction, there are other ways to work as within neighborhood engagement, lower energy consumption, phytoremediation, and nature conservation. Even if the health aspect does not matter, biophilic design and nature still do.

EXPLORATION PROCESS

An open-endless process

The choice to work with this thesis as an exploration has been a double-edged sword, or more like an ivy. The goal was to not have a clear goal and rather find out where the exploration itself led me, in an open end-process. As I pick this subject I know it was complex, but not in the way I imagined. When I started I made myself a clear structure for how I would explore the theory and strategies through sketches and then weave them all together on an urban site in one coherent design.

The thesis grew and as expected it branches away in directions I couldn't predict, the site was more complex than expected, and the amount of research on each pattern differed greatly. It grew into a messy shrub with fragmented parts and too many idea twigs that did not connect.
Unused to work all by myself, and from home, thanks to the pandemic, it was hard and unmotivated, but I kept going. The exploration was an open-end process after all and not every branch can become a trunk, so I trimmed them off, all of them, and refigured the entire project to something similar but yet different from before. I focused more on the researched patterns, gave the site analysis the time it needed, and applied the design in a smaller and more general manner that could easily be translated into other contexts.

Explore unconditionally

Still, I think there is a strength to explore a subject unconditionally in the fashion to learn through experimenting and testing, and I like the motto;

"find that which you are not looking for"

which I learned from an old art & craft teacher before my time at Chalmers. In smaller projects with clear limits, steps, and deadlines, to be open-minded and explore unconditionally can help with getting started, find your own ways of doing things, and discover unexplored areas.

But for this scale of projects, I will probably next time do it in collaboration with someone else, which I think we all should strive for anyway, and maybe not from home, at least not without a roof garden.

Sculpture on one of Masthugget's courtyards depicting a ship, another way to highlight the area's heritage

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*only shown in appendix

FIGURES

All images, photos, plans, and illustrations without a figure in this thesis are made by the author.

Figure 1
Lantmäteriet. (2020). *GSD-Property Maps Real property classificaion* [Geodata], (2020) *GSD-Property Maps Built-up areas* [Geodata]. Geodataportalen.
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Figure 2
Lantmäteriet. (2020) *GSD-Property Maps Hydrography* [Geodata], (2020) *GSD-Property Maps Transport network* [Geodata], (2004) *GSD-Property Land data* [Geodata], (2020) *GSD-Property Maps Built-up areas* [Geodata], (2019) *GSD-Elevationdata, grid 2+* [Geodata], (2020) *GSD-Orthophoto, 0,25m color* [Geodata]. Geodataportalen.
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Figure 3
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Retrieved 17/9 2020 from: https://geodata.chalmers.se/

Figure 5
Lantmäteriet. (2020). *GSD-Property Maps Real property classificaion* [Geodata], (2020) *GSD-Property Maps Built-up areas* [Geodata]. Geodataportalen.
Retrieved 17/9 2020 from: https://geodata.chalmers.se/

Figure 6
Lantmäteriet. (2020). *GSD-Property Maps Real property classificaion* [Geodata], (2020) *GSD-Property Maps Built-up areas* [Geodata]. Geodataportalen.
Retrieved 17/9 2020 from: https://geodata.chalmers.se/

7 APPENDIX
INTRODUCTION

This chapter provides an insight into parts of the process and sketches that have formed the work with this thesis.

7.1 PROCESS - THEORY
THE OLD ORIGINAL EXPLORATION

DESIGN EXPLORATION (OLD)
During the design exploration, before mid critic, I will put between 1 to 4 days on each pattern. Starting with gathering inspiration and knowledge of the pattern. choose tools, then brainstorm and sketch a lot, after that develop one of the sketches, describe it and apply to context. Lastly I will document the process to enable better feedback. After mid critic I aim to synthesize the 14 design explorations into one coherent building.

1. Gather
- Read about the pattern
- Look at references
- Choose tools

2. Brainstorm
- Make a focus list
- Create gestalts / sketches
- Pick out ten, then three
- Describe their attributes

3. Develop
- Choose one
- Make models / perspectives
- Pick out three
- Describe their attributes
- Apply to context

4. Feedback
- Document process
- Talk with Supervisor

PROCESS OF PATTERN PAGE LAYOUT

First iteration

NATURE IN THE SPACE

6. DYNAMIC & DIFFUSE LIGHT

This pattern aims to promote the usage of daylight and to simulate natural changing light conditions. The pattern comes from research on how daylight affects productivity, illuminance fluctuation, visual comfort, human factors and perception of light, and impact of lighting on the circadian system functioning. (Browning et al. 2014. p.34).

Health effects from Dynamic & Diffuse Light, described by Browning et al. (2014, p. 34-35)

REDUCING: Dental decay

IMPROVING: Productivity, sales in stores, performance, positive moods, circadian system functioning, sleep quality

SOME UPDATED RESEARCH

Due to the effort to achieve more cost efficient daylight solutions and thanks to better simulation software, there has been a steady increase of research on "Light Shelves" during recent years (Kontadakis, Tsangrassoulis, Lambros, Stelios, 2017, p. 20). Light shelves provide the possibility to reflect daylight deeper into a building and distribute it more evenly. On the next page spread I explore some of the light shelf designs that Kontadakis et al. (2017) presents.

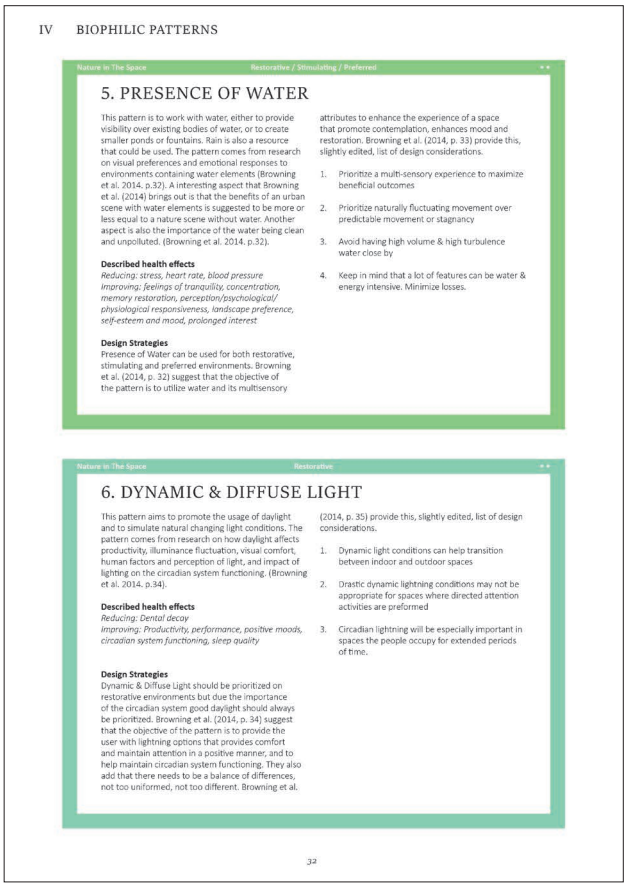
DESIGN STRATEGIES

Dynamic & Diffuse Light should be prioritized on restorative environments but due the importance of the circadian system good daylight should always be prioritized.
Browning et al. (2014, p. 32) suggest that the objective of the pattern is to provide the user with lightning options that provides comfort and maintain attention in a positive manner, and to help maintain circadian system functioning. They also add that there needs to be a balance of differences, not too uniformed, not too different.

Browning et al. (2014, p. 35) provide this, slightly edited, list of design considerations.

1. **Dynamic light conditions can help transition between indoor and outdoor spaces**
2. **Drastic dynamic lightning conditions may not be appropriate for spaces where directed attention activities are preformed**
3. **Circadian lightning will be especially important in spaces the people occupy for extended periods of time.**

Second iteration


IV BIOPHILIC PATTERNS

Nature in The Space — Restorative / Stimulating / Preferred

5. PRESENCE OF WATER

This pattern is to work with water, either to provide visibility over existing bodies of water, or to create smaller ponds or fountains. Rain is also a resource that could be used. The pattern comes from research on visual preferences and emotional responses to environments containing water elements (Browning et al. 2014. p.32). A interesting aspect that Browning et al. (2014) brings out is that the benefits of an urban scene with water elements is suggested to be more or less equal to a nature scene without water. Another aspect is also the importance of the water being clean and unpolluted. (Browning et al. 2014. p.32).

Described health effects
Reducing: stress, heart rate, blood pressure
Improving: feelings of tranquility, concentration, memory restoration, perception/psychological/ physiological responsiveness, landscape preference, self-esteem and mood, prolonged interest

Design Strategies
Presence of Water can be used for both restorative, stimulating and preferred environments. Browning et al. (2014, p. 32) suggest that the objective of the pattern is to utilize water and its multisensory attributes to enhance the experience of a space that promote contemplation, enhances mood and restoration. Browning et al. (2014, p. 33) provide this, slightly edited, list of design considerations.

1. Prioritize a multi-sensory experience to maximize beneficial outcomes
2. Prioritize naturally fluctuating movement over predictable movement or stagnancy
3. Avoid having high volume & high turbulence water close by
4. Keep in mind that a lot of features can be water & energy intensive. Minimize losses.

Nature in The Space — Restorative

6. DYNAMIC & DIFFUSE LIGHT

This pattern aims to promote the usage of daylight and to simulate natural changing light conditions. The pattern comes from research on how daylight affects productivity, illuminance fluctuation, visual comfort, human factors and perception of light, and impact of lighting on the circadian system functioning. (Browning et al. 2014. p.34).

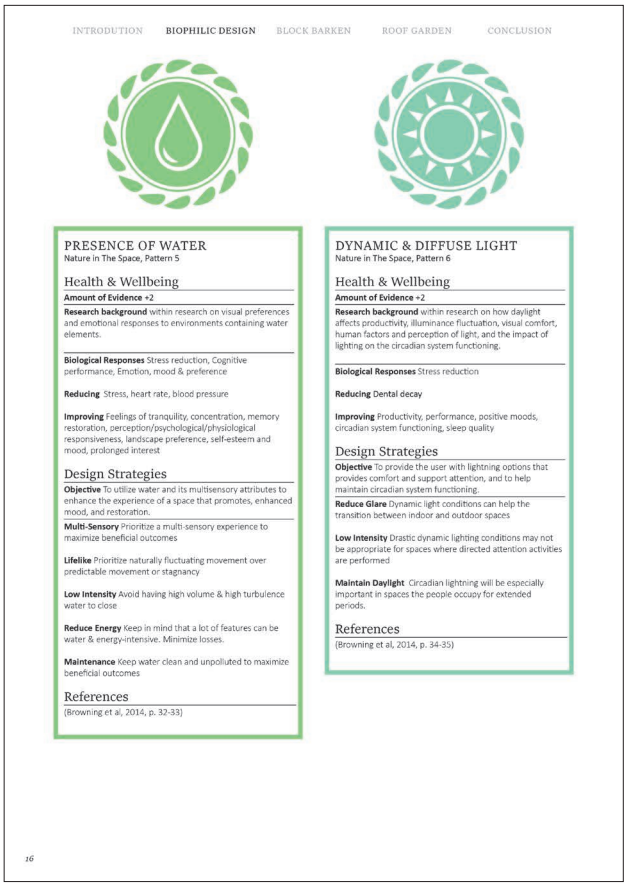
Described health effects
Reducing: Dental decay
Improving: Productivity, performance, positive moods, circadian system functioning, sleep quality

Design Strategies
Dynamic & Diffuse Light should be prioritized on restorative environments but due the importance of the circadian system good daylight should always be prioritized. Browning et al. (2014, p. 34) suggest that the objective of the pattern is to provide the user with lightning options that provides comfort and maintain attention in a positive manner, and to help maintain circadian system functioning. They also add that there needs to be a balance of differences, not too uniformed, not too different. Browning et al. (2014, p. 35) provide this, slightly edited, list of design considerations.

1. Dynamic light conditions can help transition between indoor and outdoor spaces
2. Drastic dynamic lightning conditions may not be appropriate for spaces where directed attention activities are preformed
3. Circadian lightning will be especially important in spaces the people occupy for extended periods of time.

32

Final design


INTRODUTION BIOPHILIC DESIGN BLOCK BARKEN ROOF GARDEN CONCLUSION

PRESENCE OF WATER
Nature in The Space, Pattern 5

Health & Wellbeing
Amount of Evidence +2
Research background within research on visual preferences and emotional responses to environments containing water elements.

Biological Responses Stress reduction, Cognitive performance, Emotion, mood & preference

Reducing Stress, heart rate, blood pressure

Improving Feelings of tranquility, concentration, memory restoration, perception/psychological/physiological responsiveness, landscape preference, self-esteem and mood, prolonged interest

Design Strategies
Objective To utilize water and its multisensory attributes to enhance the experience of a space that promotes, enhanced mood, and restoration.
Multi-Sensory Prioritize a multi-sensory experience to maximize beneficial outcomes

Lifelike Prioritize naturally fluctuating movement over predictable movement or stagnancy

Low Intensity Avoid having high volume & high turbulence water to close

Reduce Energy Keep in mind that a lot of features can be water & energy-intensive. Minimize losses.

Maintenance Keep water clean and unpolluted to maximize beneficial outcomes

References
(Browning et al, 2014, p. 32-33)

DYNAMIC & DIFFUSE LIGHT
Nature in The Space, Pattern 6

Health & Wellbeing
Amount of Evidence +2
Research background within research on how daylight affects productivity, illuminance fluctuation, visual comfort, human factors and perception of light, and the impact of lighting on the circadian system functioning.

Biological Responses Stress reduction

Reducing Dental decay

Improving Productivity, performance, positive moods, circadian system functioning, sleep quality

Design Strategies
Objective To provide the user with lightning options that provides comfort and support attention, and to help maintain circadian system functioning.
Reduce Glare Dynamic light conditions can help the transition between indoor and outdoor spaces

Low Intensity Drastic dynamic lighting conditions may not be appropriate for spaces where directed attention activities are performed

Maintain Daylight Circadian lightning will be especially important in spaces the people occupy for extended periods.

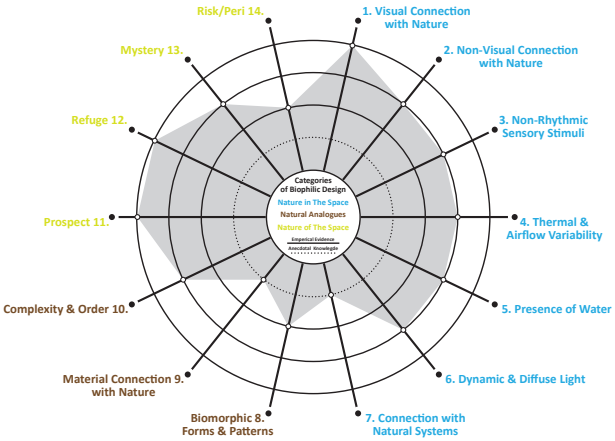
References
(Browning et al, 2014, p. 34-35)

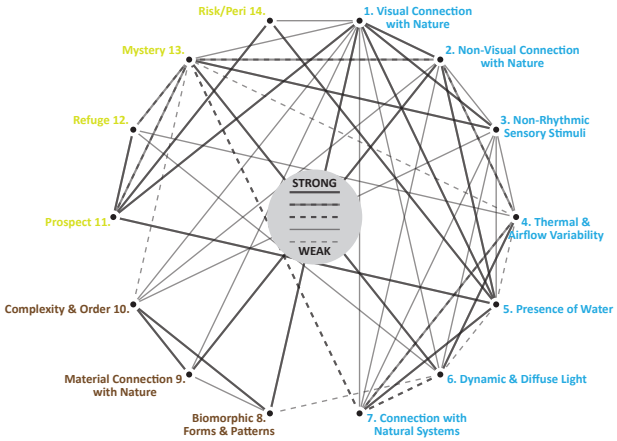
16

PROCESS OF DIAGRAM LAYOUT

First iteration

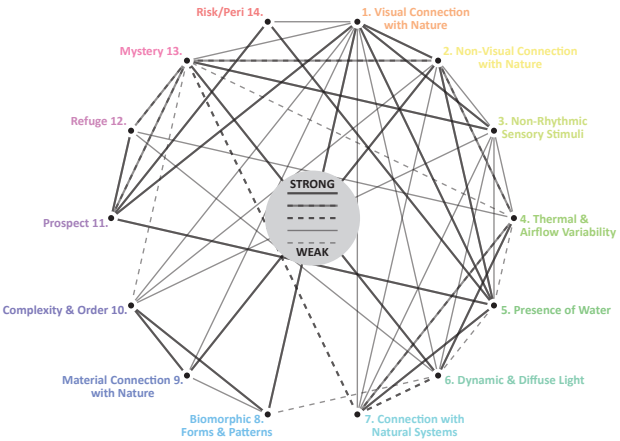
Research and relationships separated





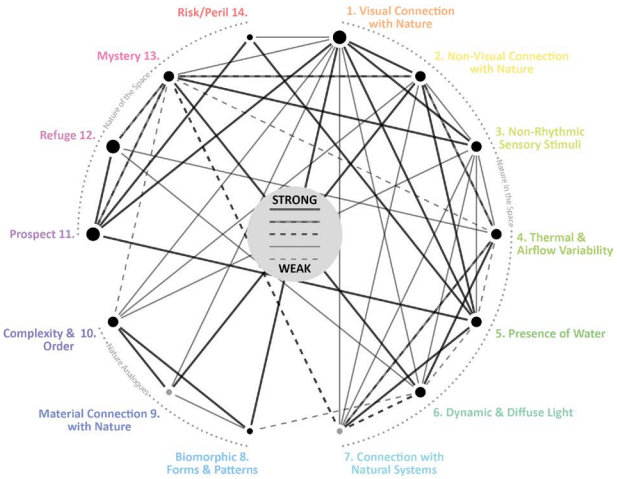
Second iteration

Colorwheel, still separated



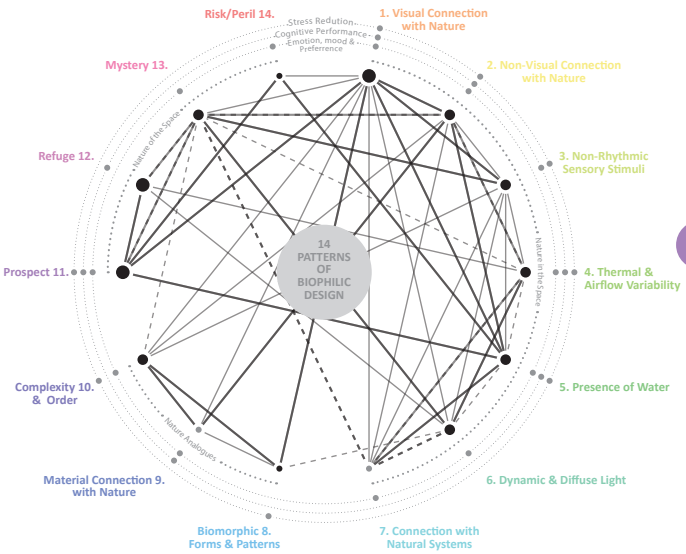
Third iteration

Research, relationships & categories combined



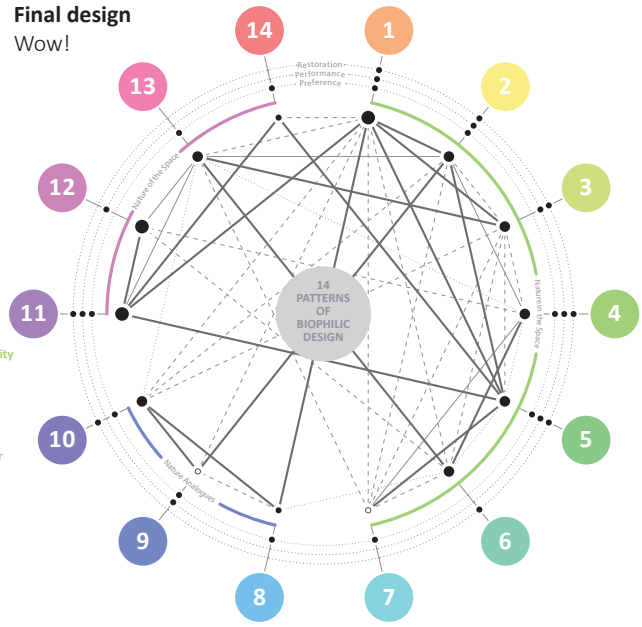
Fourth iteration

Biological Responses added



Final design

Wow!



EXAMPLE OF DEVELOPED SKETCHES [P6]

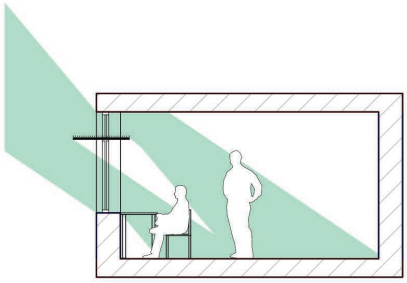
Removed exploration

NATURE IN THE SPACE

GUIDING DAYLIGHT: LIGHT SHELVES

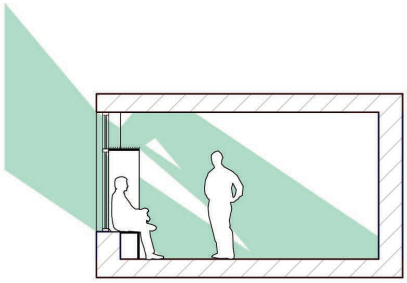
1: WORK SHADING

A light shelf can have many shapes, but this is the most basic. Kontadakis et al. (2017, p. 5-6) suggest that the interior part is as long as the opening above and that the exterior part is no more than 1.5 times the opening. Neither need it to be longer than the distance between the height of the light shelf and the workplane.



2: WALL FURNITURE

In rooms with a height less than 3,9 m and with the latitude of Gothenburg (57.7°), the suggestion height of a light shelf is 1,8 m (Kurtay & Esen, 2017, p. 145-146). Due to it being around eye height, it could be combined with a built-in furniture to feel more integrated and also provide greate space for refuge.



3: STORE ENTRANCE

Another simple aspect to optimize a light shelf is to tilt the exterior part. Kontadakis et al. (2017, p. 11), present a simple equation to find out the slope angle in relation to your latitude. For Gothenburg (57,7°) it's: *40 - (57,7/2) = 11,15°*
Combined with shopping windows the exterior part could be integrated as a sheltered walkway.

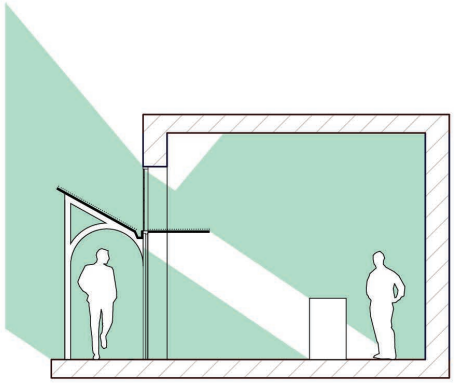


Figure 104-106: Drawings of pattern 6. Author's own copyright

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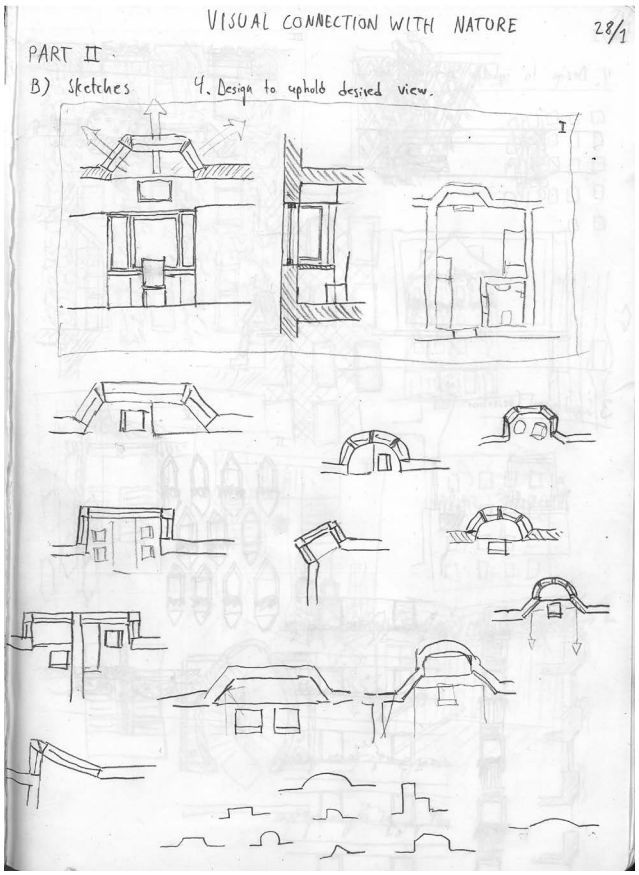
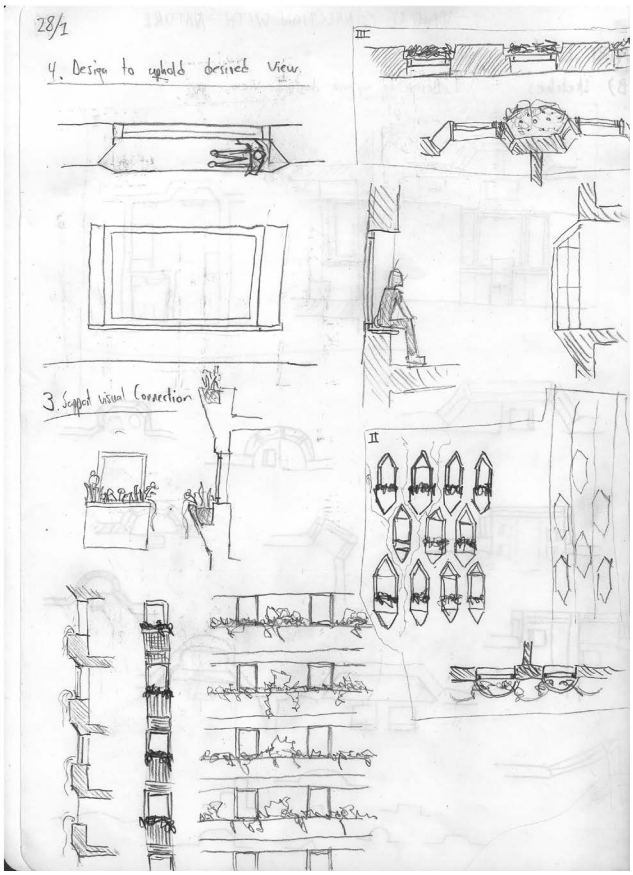
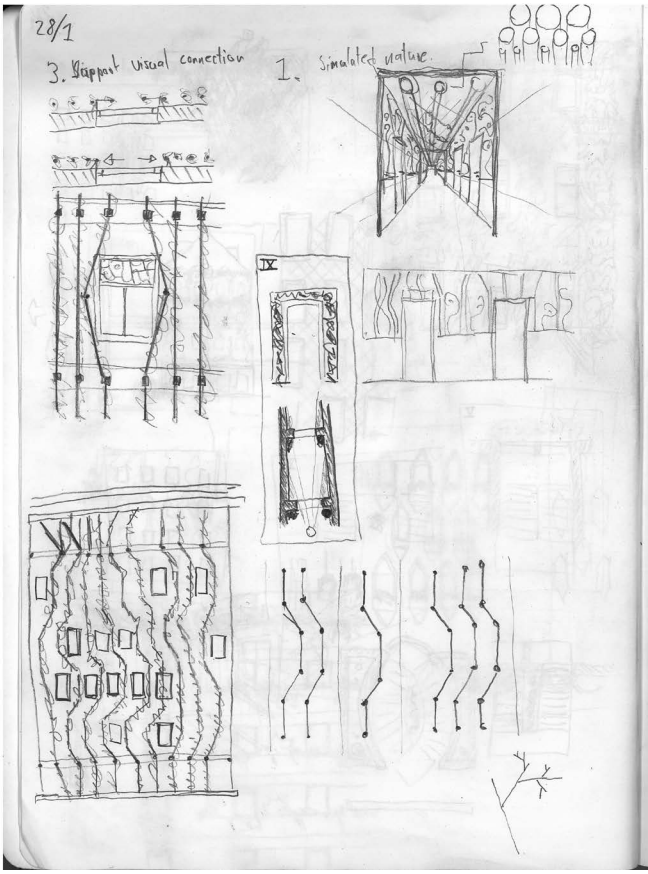
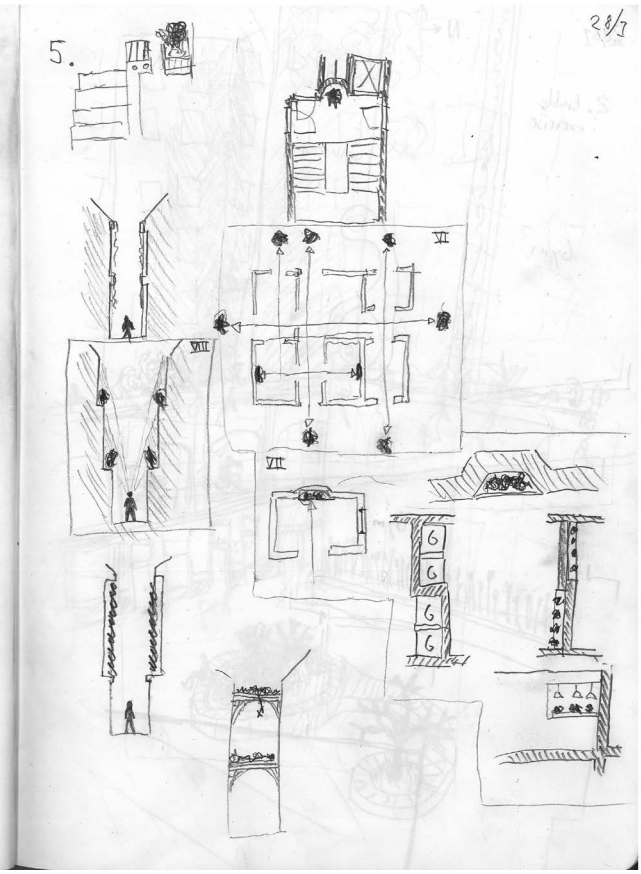
BRAINSTORM SKETCHES OF EACH PATTERN

P1: Visual Connection With Nature



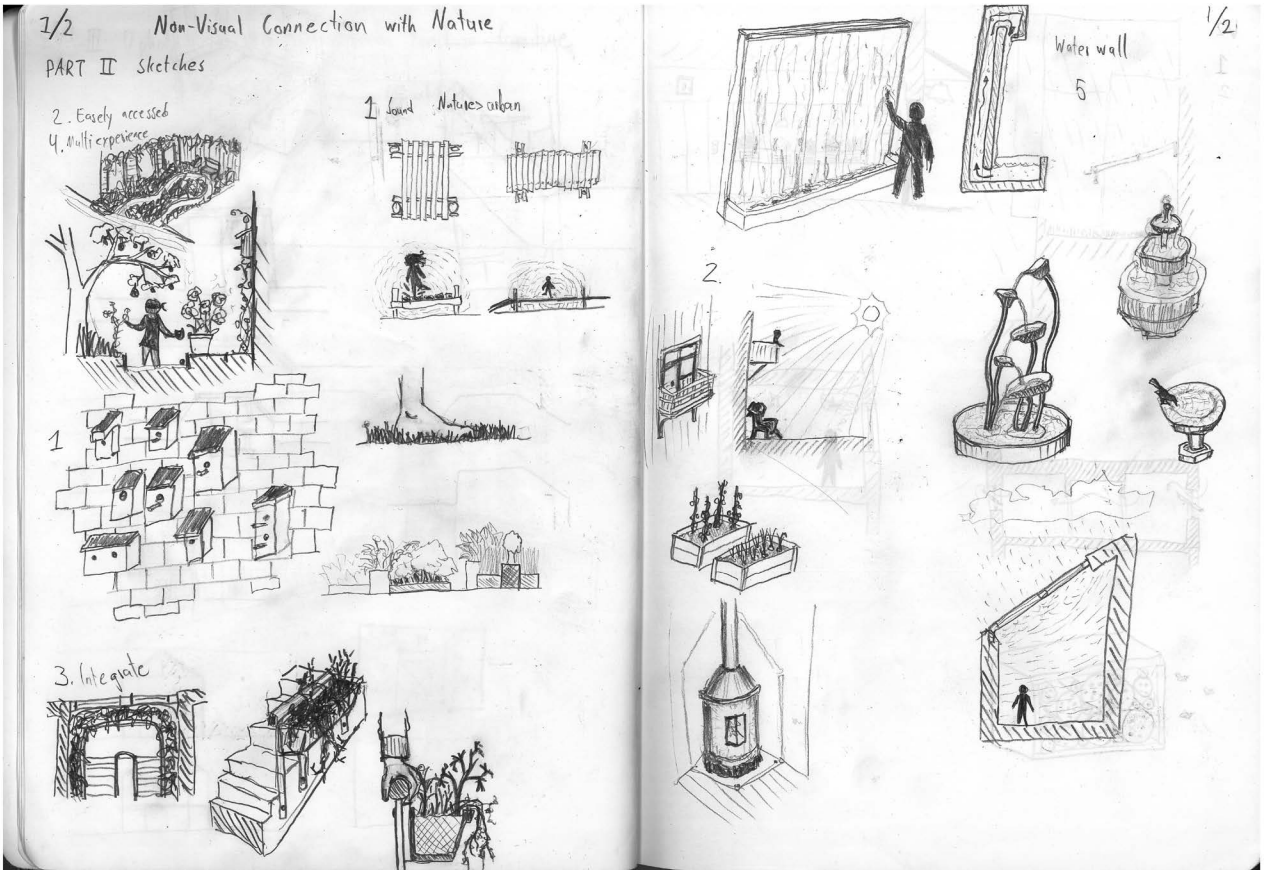




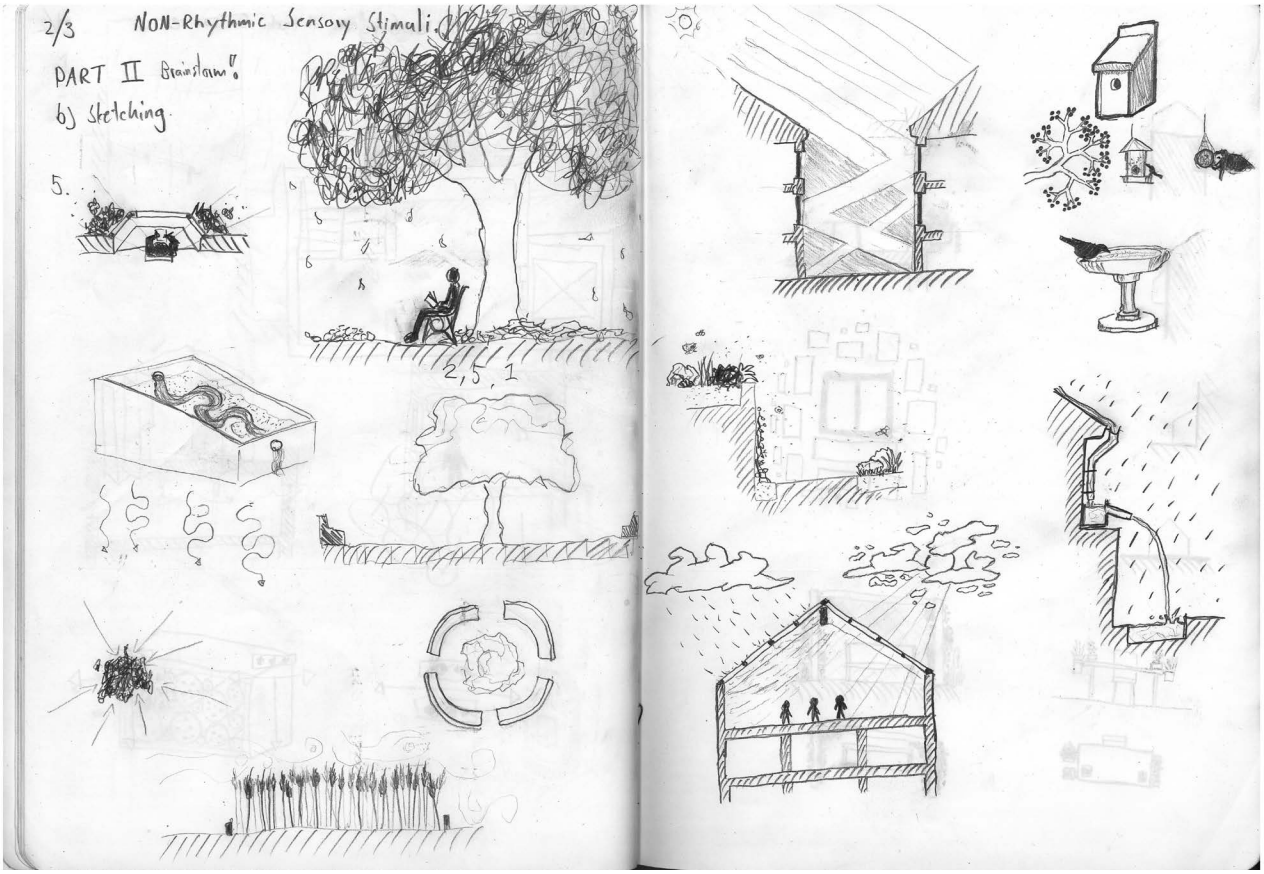


BRAINSTORM SKETCHES OF EACH PATTERN

P2: Non-Visual Connection With Nature

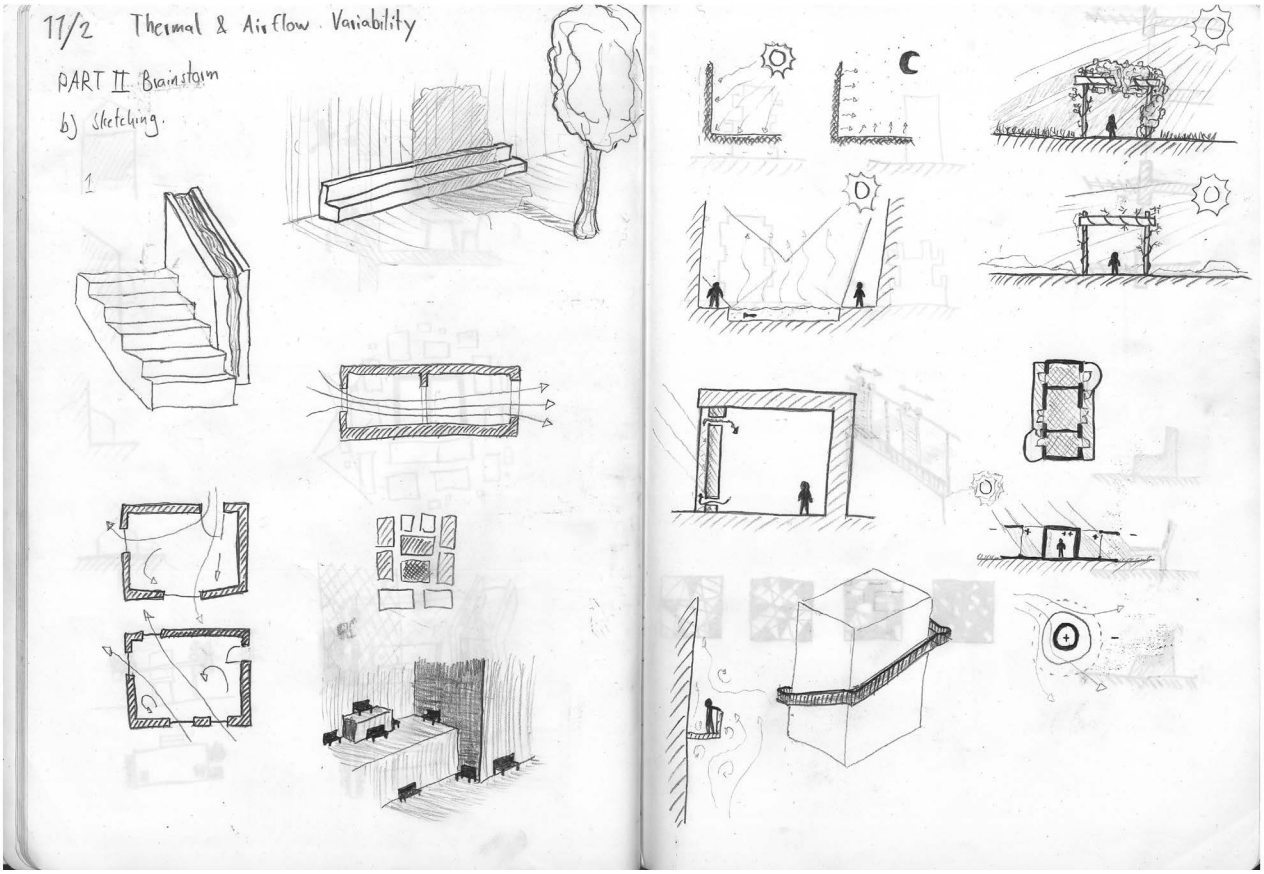


P3: Non-Rhythmic Sensory Stimuli

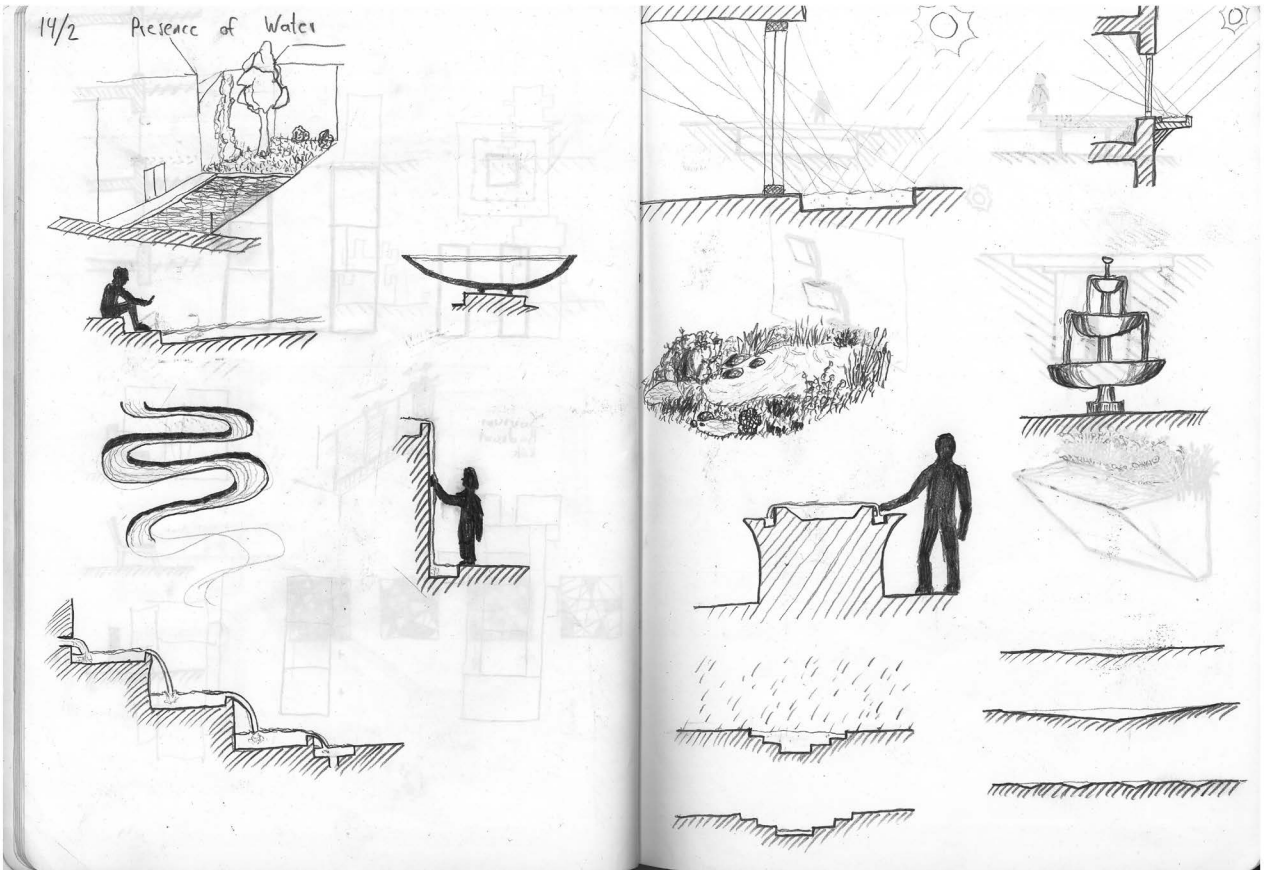


BRAINSTORM SKETCHES OF EACH PATTERN

P4: Thermal & Airflow Variability

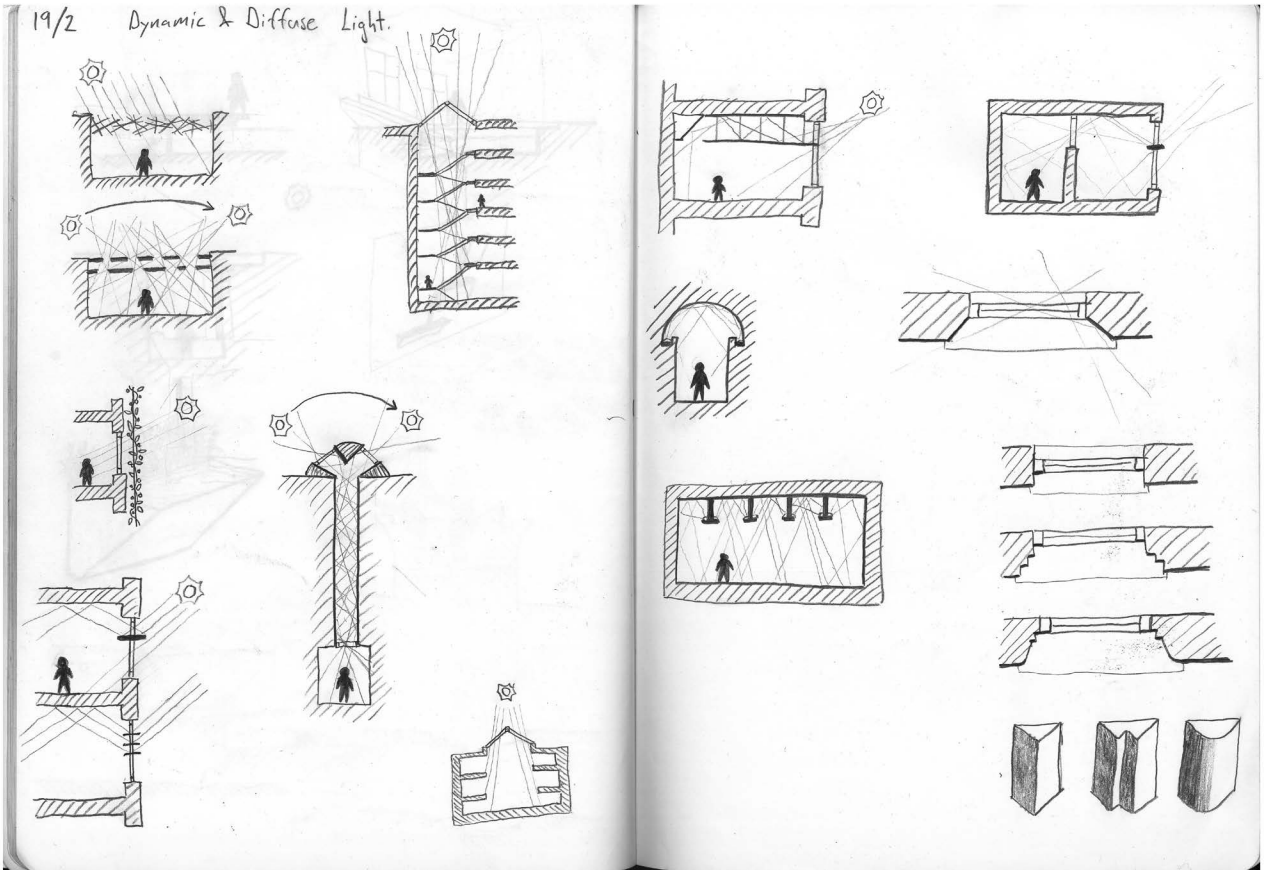


P5: Presence of Water

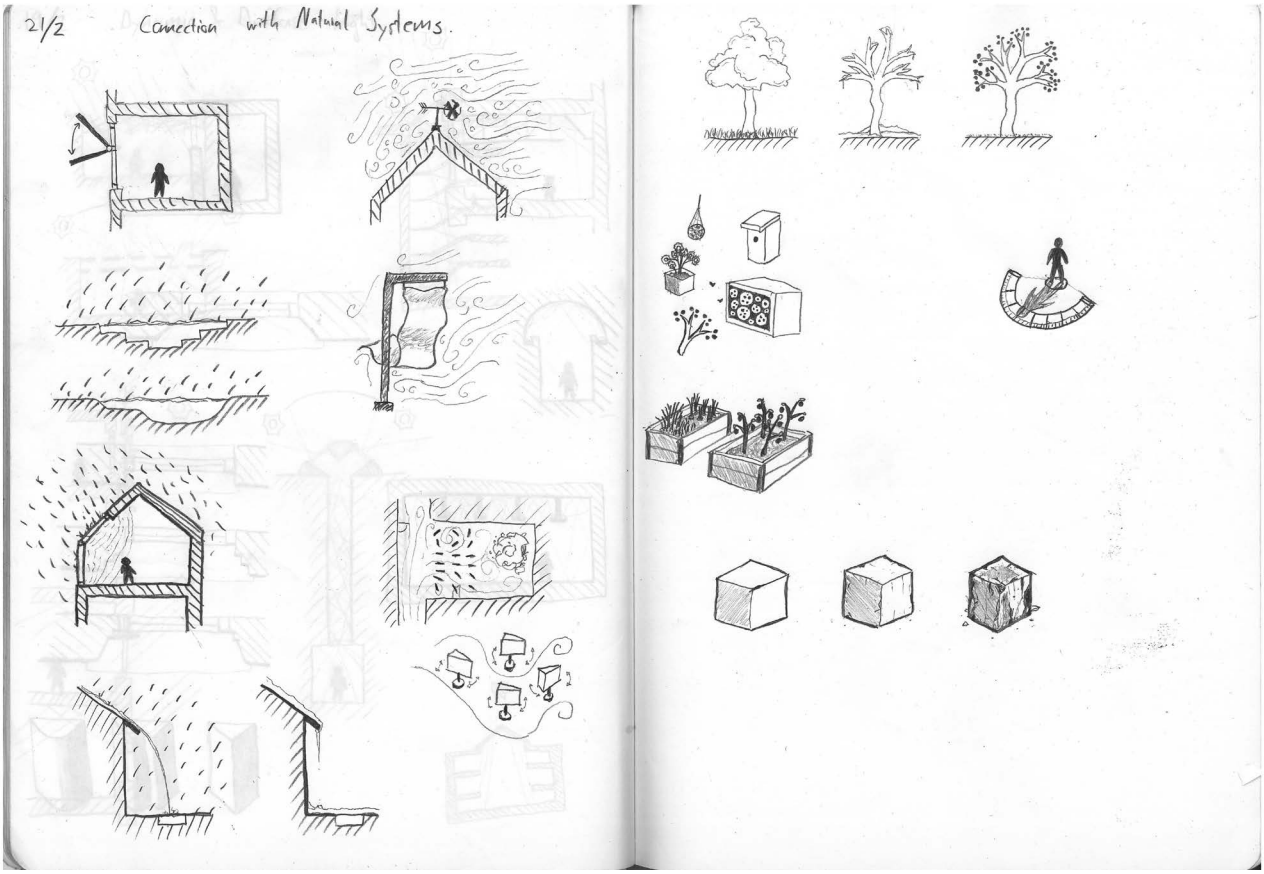


BRAINSTORM SKETCHES OF EACH PATTERN

P6: Dynamic & Diffuse Light

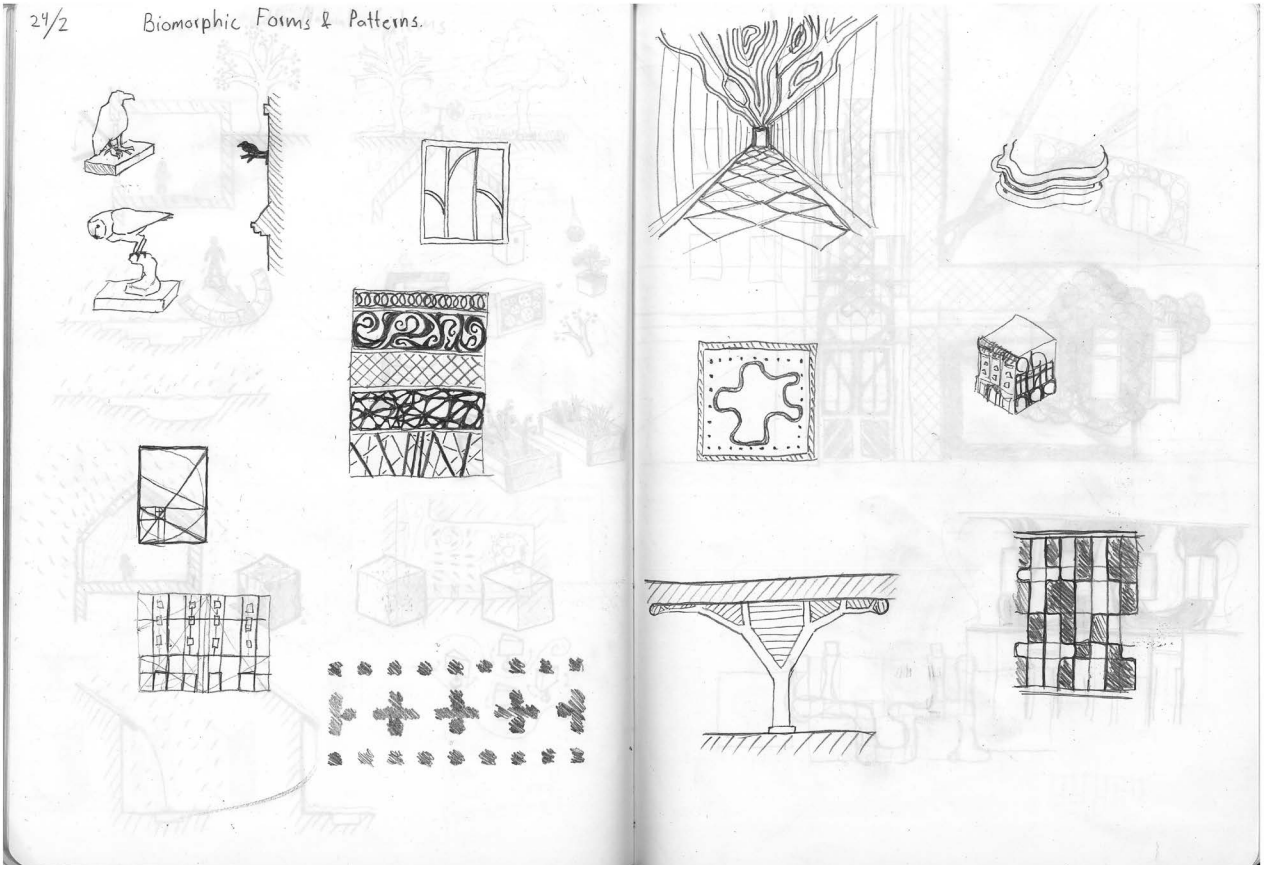


P7: Connection With Natural Systems

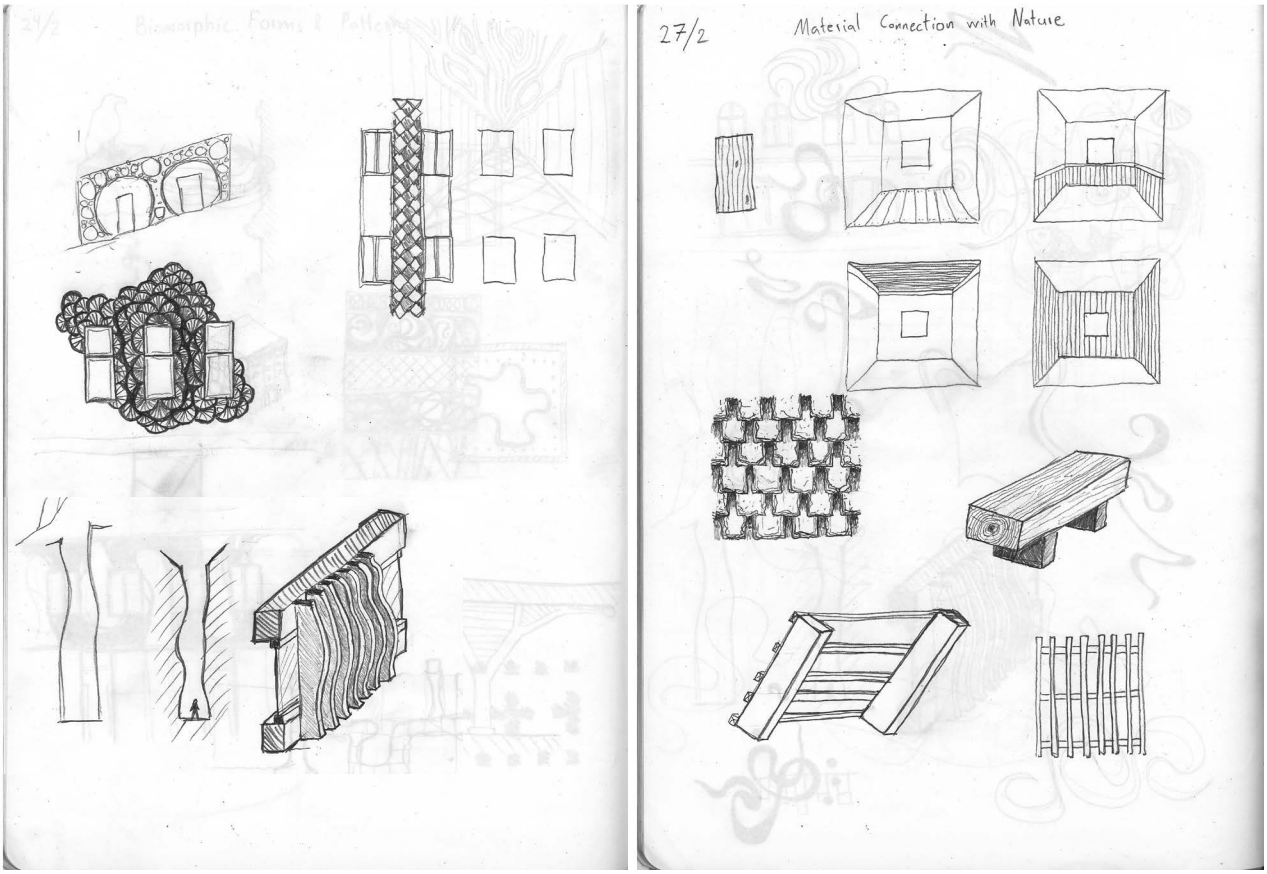


BRAINSTORM SKETCHES OF EACH PATTERN

P8: Biomorphic Form & Patterns



P9: Material Connection with Nature



7.2 PROCESS - SITE

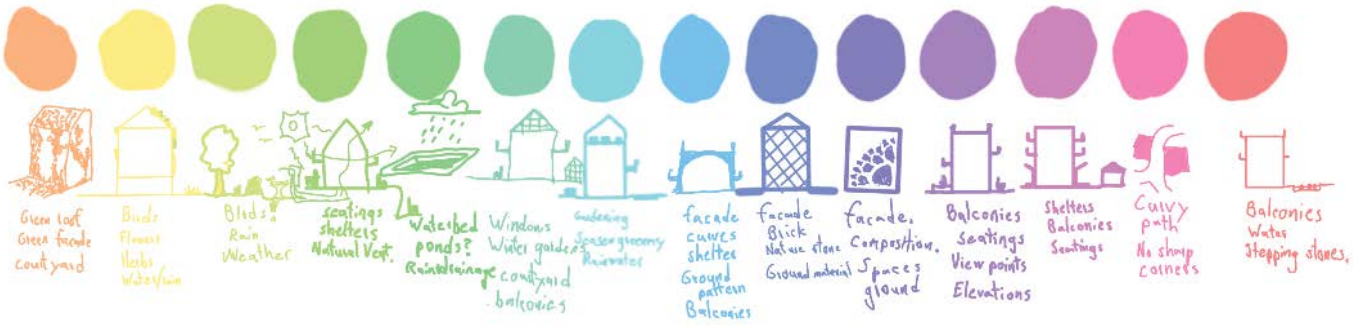
SITE MODEL 1:200

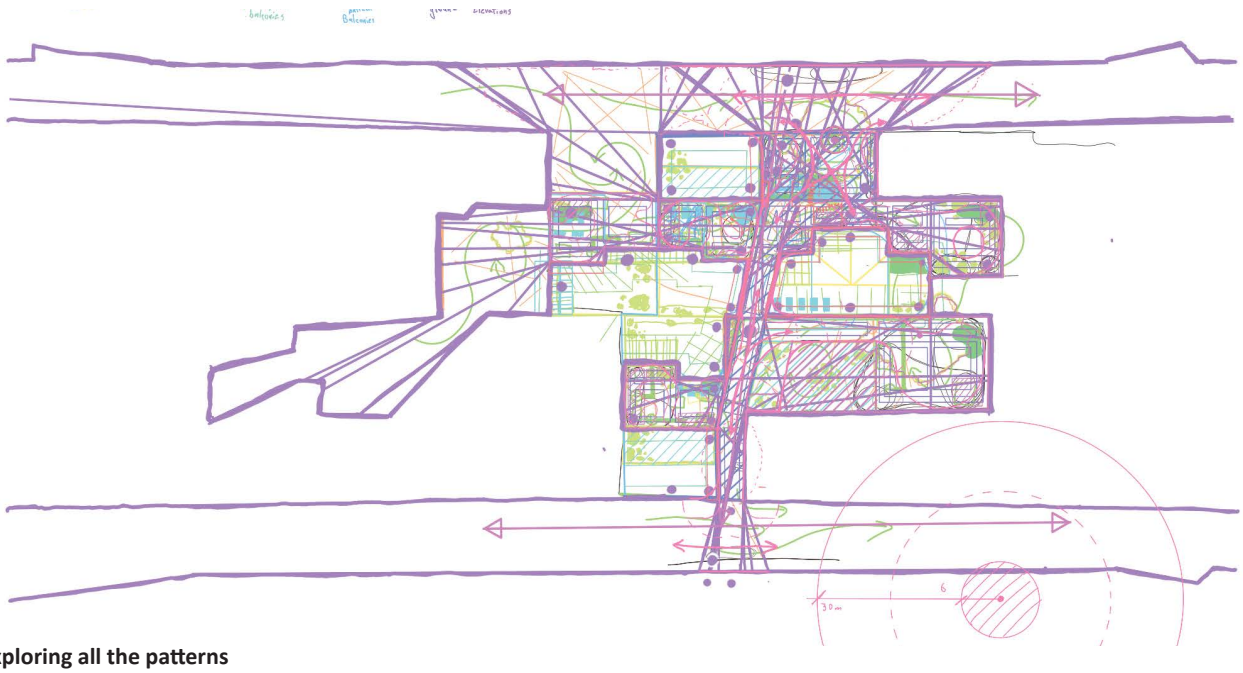
The idea was to have the model for the final exhibition,but everything changed when the pandemic arrived.

7.3 PROCESS - DESIGN

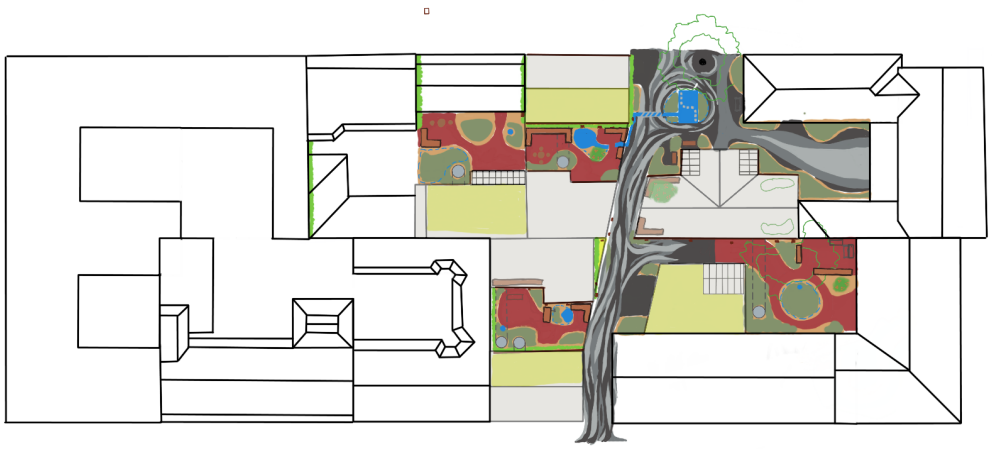
EXPLORING THE WHOLE SITE

Analysis of all the the patterns



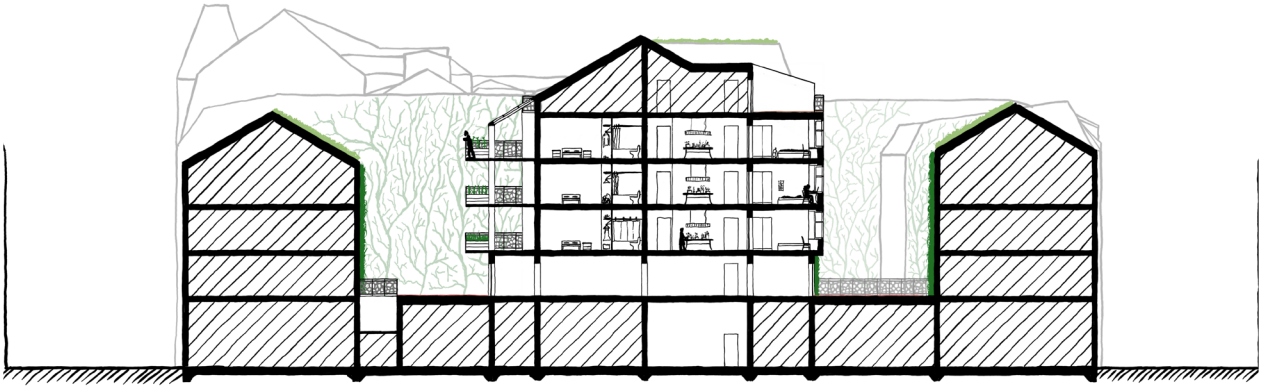


Exploring all the patterns



REMOVED IN-DEPTH EXPLORATION OF THE WHOLE SITE

Section and interior of the middle building



Exploring courtyards, passage, square, facades, roofs & apartments became a bit to much, and there was also no clear focus on the health aspect

CHALMERS

UNIVERSITY OF TECHNOLOGY

AN EXPLORATION OF

BIOPHILIC DESIGN

JOEL EKELÖF

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CHALMERS UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF ARCHITECTURE & CIVIL ENGINEERING

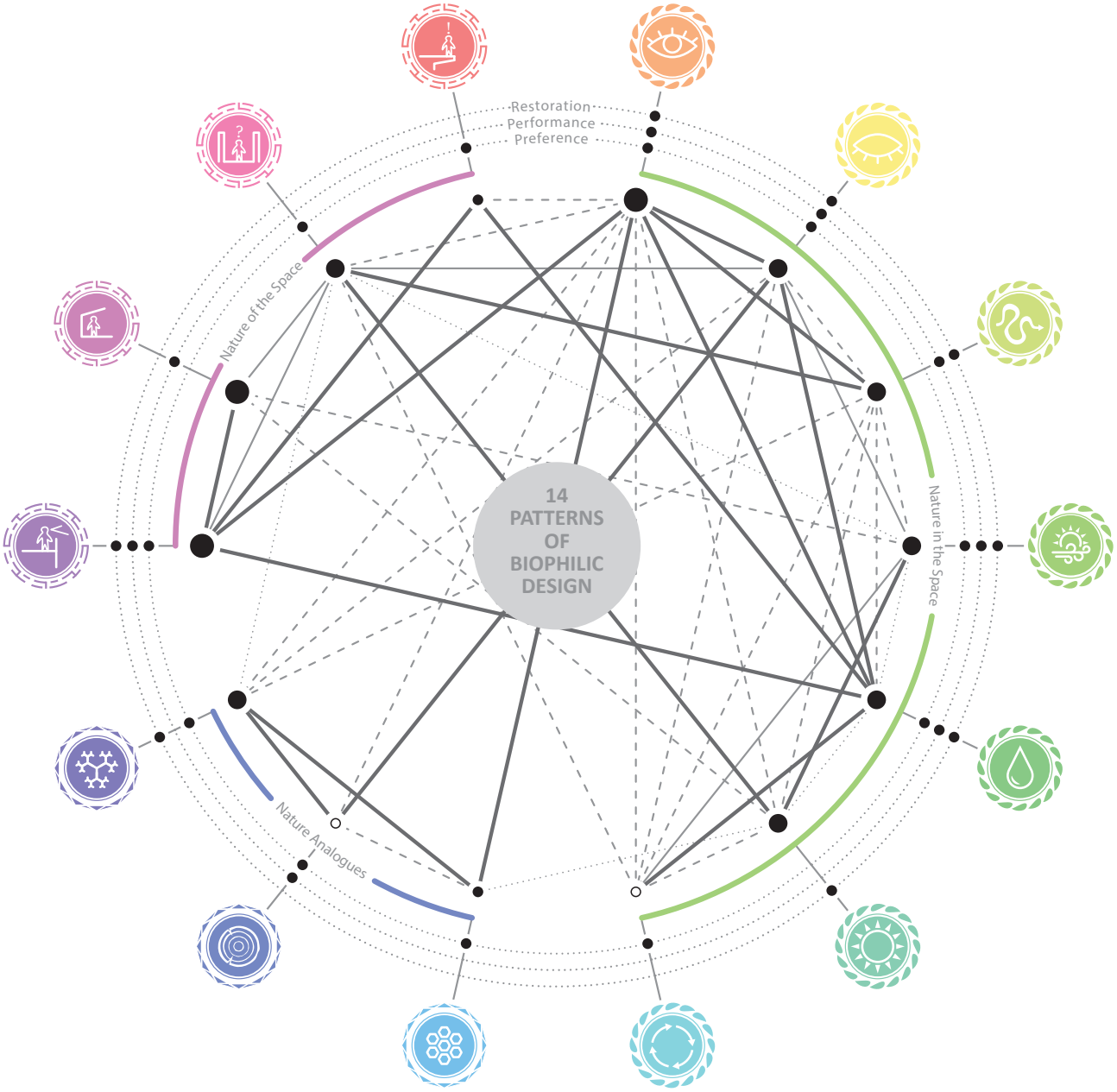
MASTERS PROGRAMME

OF ARCHITECTURE & PLANNING BEYOND SUSTAINABILITY

STUDIO: BUILDING DESIGN FOR SUSTAINABILITY

EXAMINER: LIANE THUVANDER • SUPERVISOR: WALTER UNTERRAINER

GOTHENBURG • SWEDEN • 2020



It is a chestnut tree on the back page

CHALMERS SCHOOL OF ARCHITECTURE

DEPARTMENT OF ARCHITECTURE & CIVIL ENGINEERING

EXAMINER: LIANE THUVANDER • SUPERVISOR: WALTER UNTERRAINER