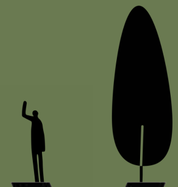
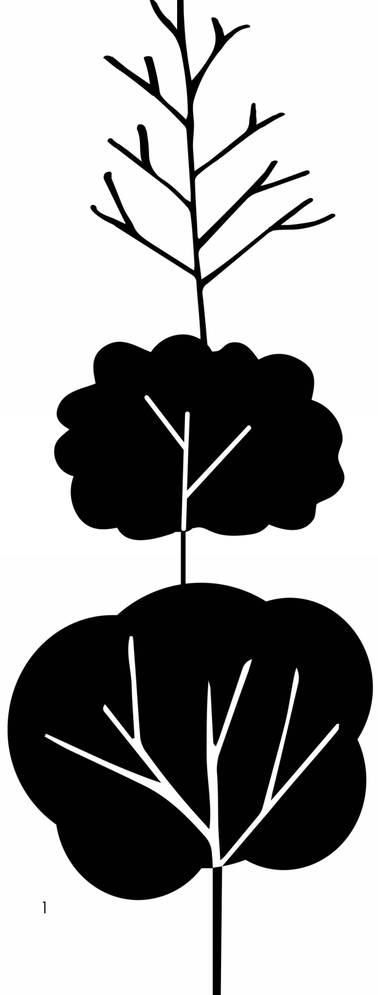


vertical urban forestry



vertical urban forestry

bringing the forest back to the city

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Thesis External Advisor: Mikołaj Gomółka

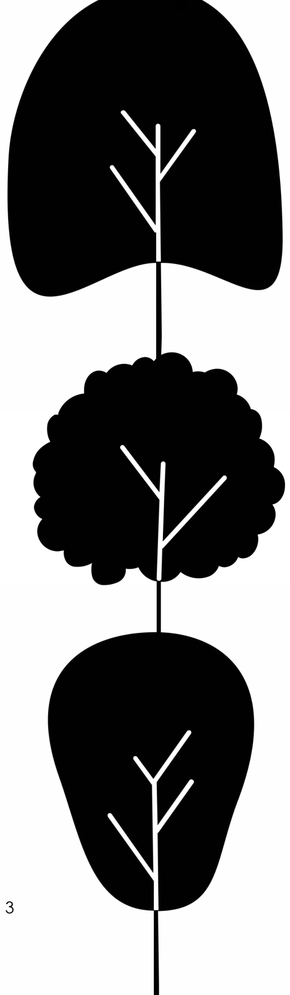
Thesis Director: Claudia Bernasconi

ARCH 5100-5200 Thesis Studio

ARCH 5110-5210 Thesis Research Methods

Fall 2023 – Winter 2024

vertical urban forestry



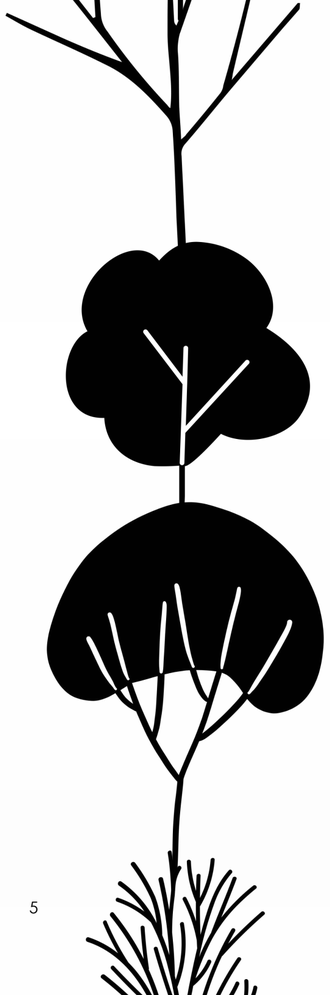
"- Są z żywego drzewa - kiwnął głową wiedźmin. - Tak właśnie mieszkają driady, tak budują swoje domy. Żadna driada, nigdy, nie skrzywdzi drzewa, rąbiąc je czy piłując. One kochają drzewa. Potrafią jednak sprawić, by gałęzie rosły tak, by powstały domki."

(Andrzej Sapkowski, 2014)

"- They are made of living wood - the witcher nodded. - This is how dryads live, this is how they build their houses. No dryad will ever harm a tree by chopping or sawing it. They love trees. However, they can make the branches grow to create houses."

(Andrzej Sapkowski, 2014)

vertical urban forestry



acknowledgments

Mamo, Tato, mam nadzieję, że jesteście świadomi, że w minionym roku stanowiliście dla mnie gigantyczne oparcie. Prawdopodobnie nie napisałabym niniejszej pracy magisterskiej bez Waszej pomocy i wiary we mnie. Dziękuję.

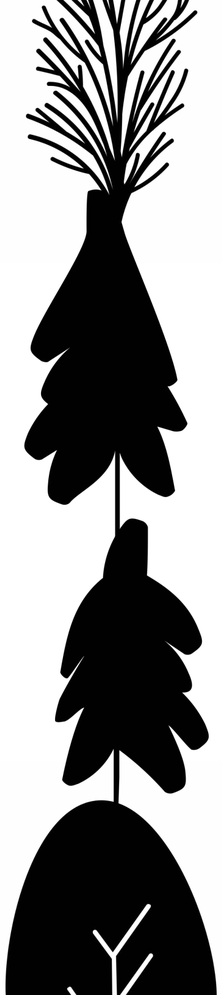
Kuba, Tobie również najserdeczniej dziękuję za znoszenie moich humorów i dobre słowo, gdy go potrzebowałam. Odległość to przeszkoda, którą pokonaliśmy z lekkością.

Mikołaj, Julia, Claudia, dziękuję Wam za konstruktywną krytykę i pomoc merytoryczną. Dzięki Wam pokochałam architekturę jeszcze mocniej.

Mom, Dad, I hope You know You have been a massive support for me over the past year. I probably wouldn't have written this master's thesis without Your help and belief in me. Thank You.

Kuba, I sincerely thank You for putting up with my moods and Your kind words when I needed them. Distance is an obstacle that we overcame with ease.

Mikołaj, Julia, and Claudia, thank You for Your constructive criticism and substantive help. Thanks to You, I fell in love with architecture.



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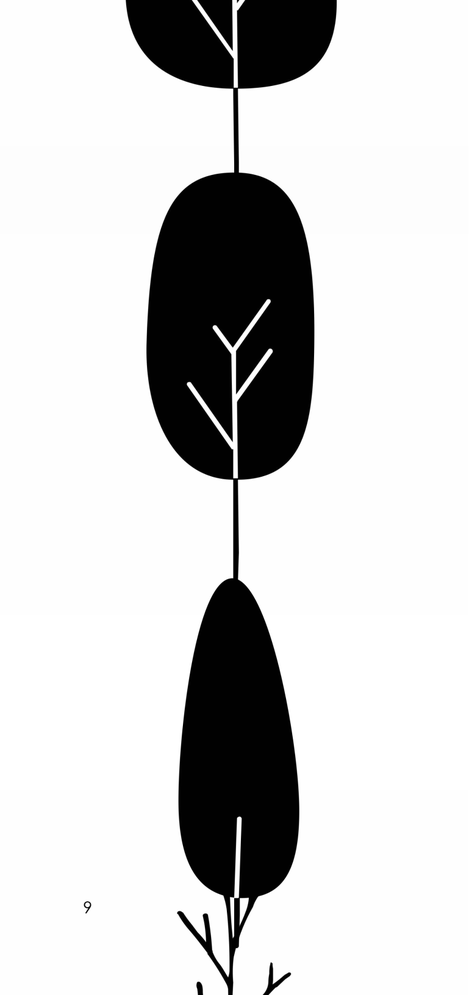


abstract

The general focus of the thesis investigation was the pushing need for richer urban tree canopy, as well as the possible solutions for tackling the lack of it. Various studies have proven that trees are a significant part of the urban tissue. However, the growing population, rising land prices, and developing climate change require a push for improvement in both the quality and quantity of arborescent architectural design. The research developed in the thesis investigation explored vertical forestry in the urban context along with the silviculture strategies that could further the design of high-quality urban interiors/ corridors. The end product of the thesis investigation is the Vertical Urban Forestry Manifesto, which supports effective (not only) vertical urban forestry design alongside an exemplary case study design solution – Replanning/Replanting Żelazna, as well as an Instagram account - @vertical.urban.forestry. The mixed methodology work included data-driven mapping, architectural models, architectural drawings, diagramming, and photography. The thesis investigation shed light on an innovative understanding of urban interiors and corridors as bearing not only circulation but also city enhancement function. Moreover, it further proved the significance of forestry and silviculture in urban design. Vertical urban forestry is under constant development, ranging from different types of research to multiple design attempts. This investigation evidenced the innovative, crucial, theoretical aspects, attempting to popularize the knowledge and present them as the future standard of urban design practice.

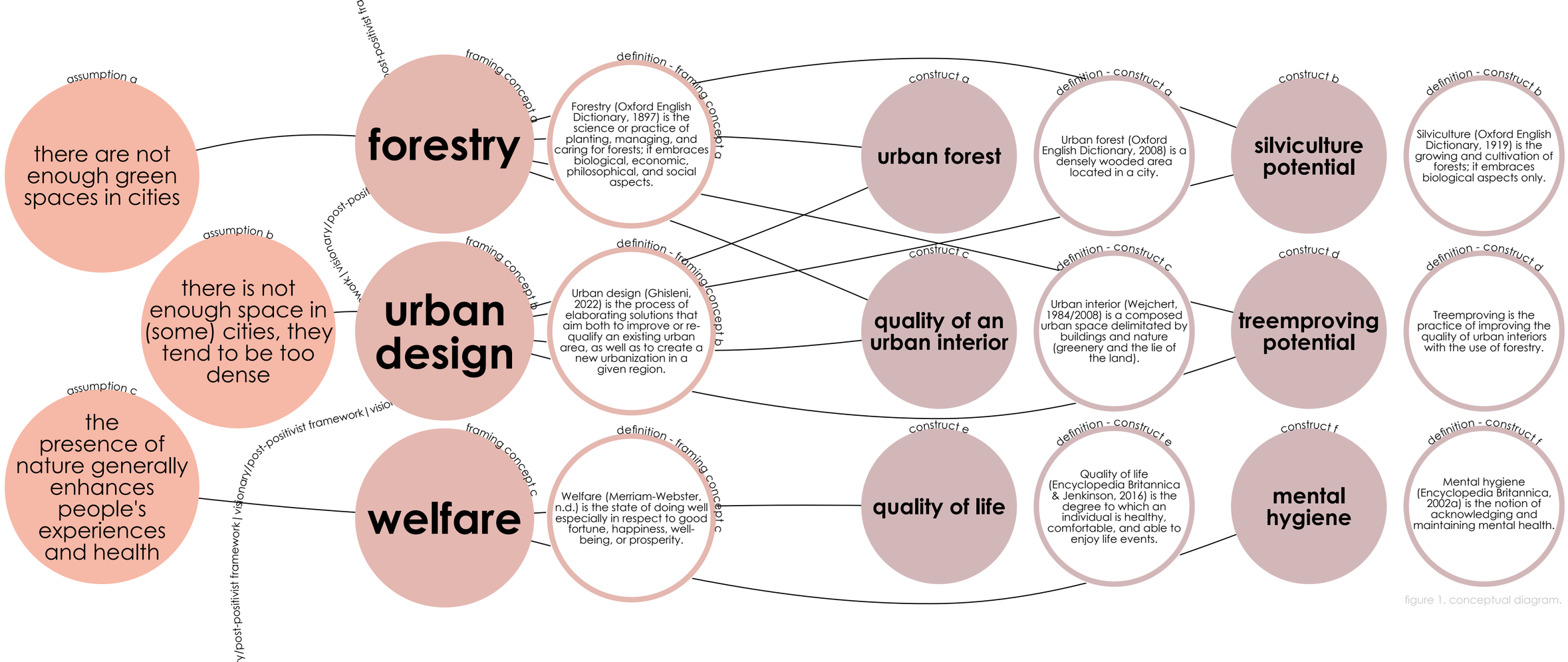
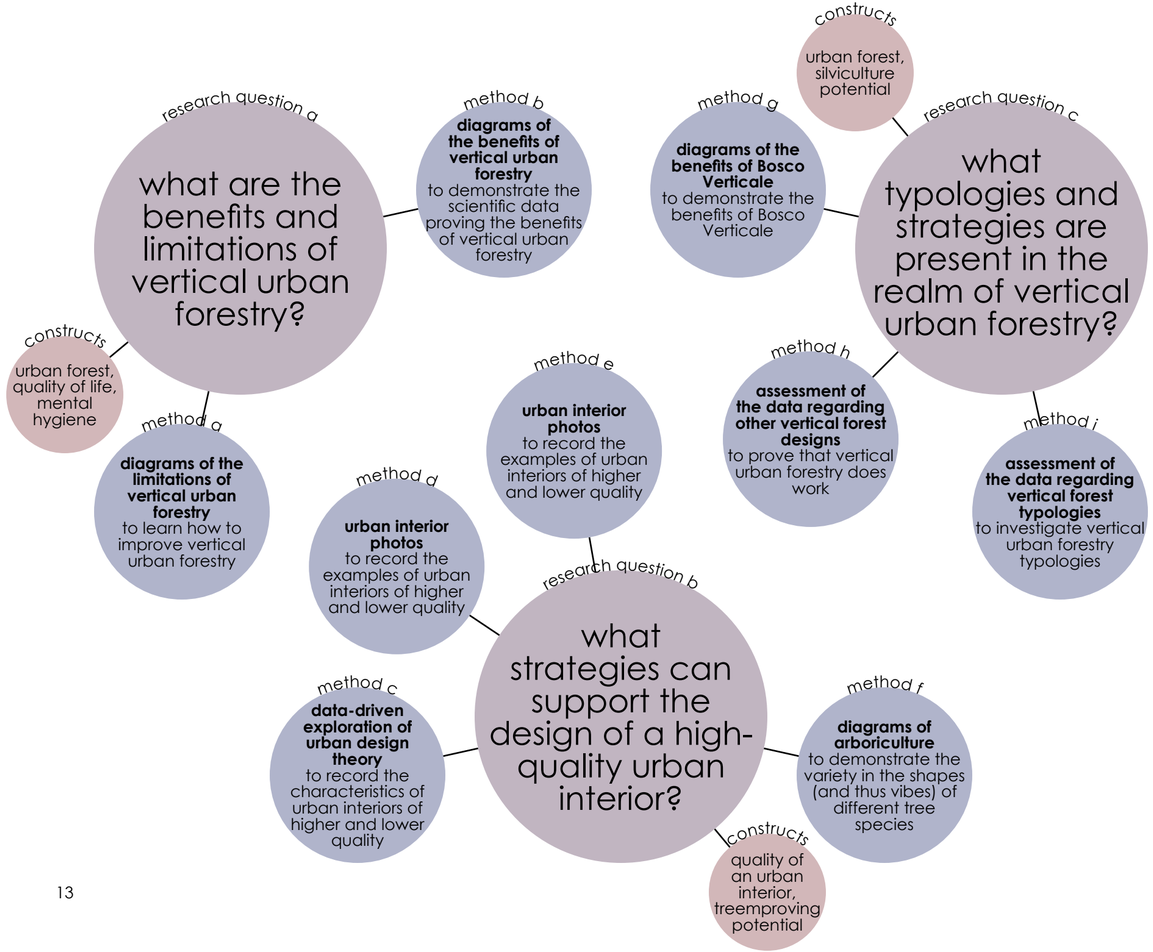


figure 1. conceptual diagram.



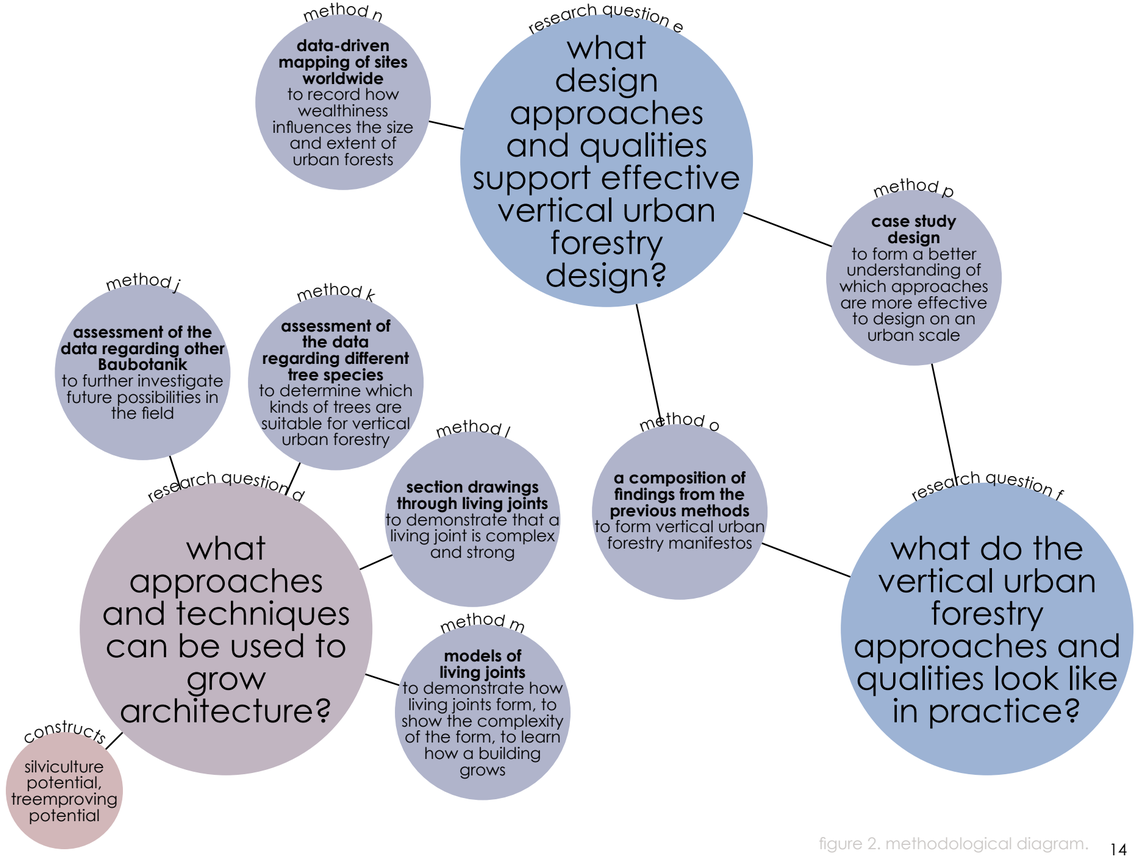
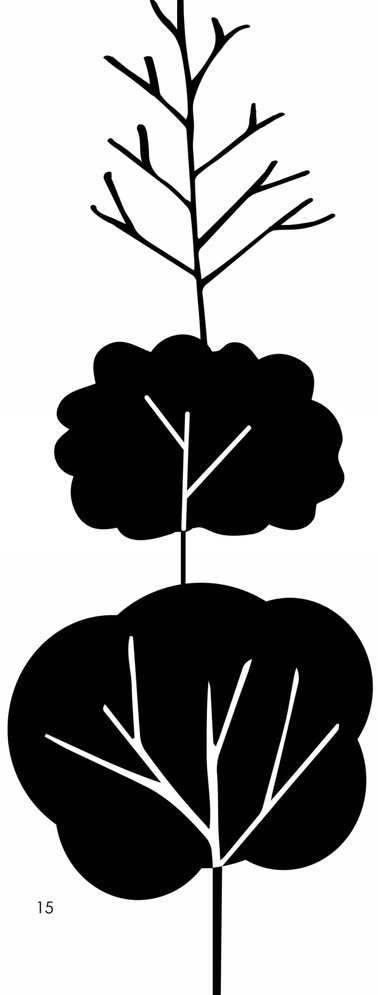


figure 2. methodological diagram.



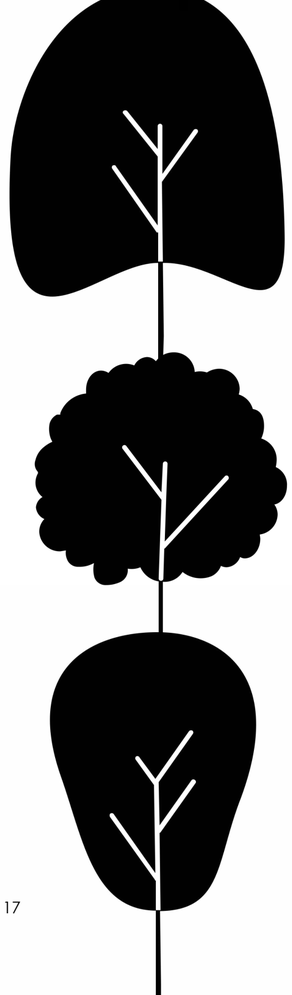
thesis statement

The everyday hustle and bustle can get exhausting and unbearable. Everyone likes to take a break occasionally and jog, walk the dog, or take a romantic stroll in the nearby park. There is a tendency to escape the average, gray, dull reality and hide amidst luscious tree branches. No wonder. The presence of nature generally enhances people's experiences and health. Therewithal, cities become denser and denser, and consequently, there are not enough verdurous urban spaces.

Vertical urban forestry emerged as a possible solution to the problem. It juggled the framing concepts of forestry, urban design, and welfare very well. Moreover, trees provide countless benefits in the urban context, such as the heat island effect, noise, and pollution reduction. They retain water, provide shading, increase plot market values, improve mental health, and decrease gun violence and vandalism. Furthermore, vertical urban forestry has already proved to thrive in various building typologies, such as multifamily residential, single-family housing, parking, and more.

Stefano Boeri Architectural Studio's work provided one take on vertical urban forestry. They incorporate hundreds of trees and smaller plants into buildings by planting them in cantilevered balconies-pots. There is an undeniable beauty in the straightforwardness of this idea. Nonetheless, a fresher take on the subject has emerged in recent years. Designers from the Office for Living Architecture claimed that with their innovative technique – Baubotanik – it was possible to grow buildings' elevations from living trees. Over time, as trees grow and fuse (or inosculate), they take over the structural support function of the scaffolding to the point that it can be removed. The Office for Living Architecture defined Baubotanik as "a form of architecture in which structures are created through the interaction of natural plant growth and technical joining methods."

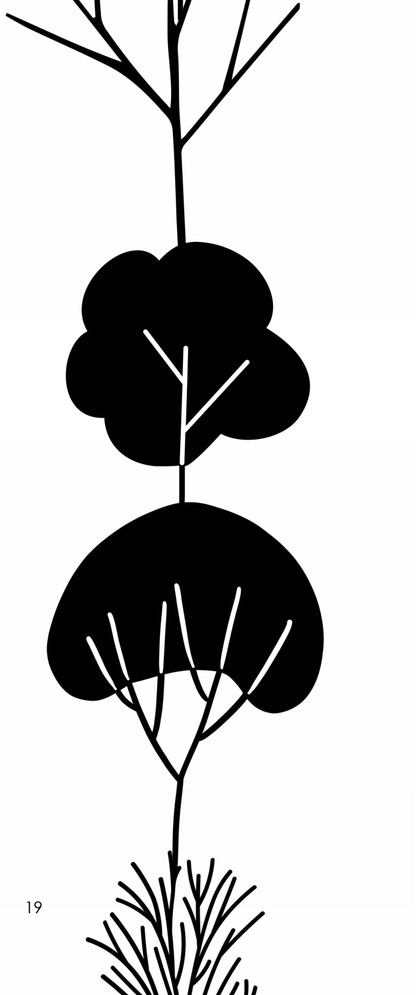
The thesis investigation attempted to explore vertical forestry in the urban context and the strategies that could support the design of a high-quality urban interior/corridor. The end product of the study was the Vertical Urban Forestry Manifestos, supporting effective vertical urban forestry design alongside an exemplary case study design solution – Replanning/Replanting Żelazna.



Sublime designs have already been carried out regarding vertical urban forestry, and immense resources are available if one knows where to look for them. However, the knowledge and legacy mentioned above are dispersed and unarranged, somewhat unavailable to the general public. The pushing need to systematize the knowledge on the subject and make it more accessible and available sparked the composition of the Vertical Urban Forestry Manifestos and the creation of an Instagram account - @vertical.urban.forestry. They both try to suggest accurate solutions and draw attention to the subjects and issues in need of consideration pre-green-design instead of preparing a list of architectural dos and don'ts.

The body of work included mixed methodology work, both deductive and inductive reasoning. Firstly, the benefits and limitations of vertical urban forestry were determined in the form of diagrams to demonstrate the scientific data proving the advantages of vertical urban forestry, as well as the awareness that it has some limitations, and learn how to improve it to avoid making similar mistakes in the future. Secondly, research on high-quality urban interior design was done to record the characteristics of higher-quality and lower-quality urban interiors. Later, the existing and future strategies for incorporating urban forestry into architecture were explored in depth. The above included data-driven mapping, photography, and diagramming of Bosco Verticale; vertical urban forestry typology search/ exploration; and living joints drawings and models. Additionally, several smaller experiments, such as diagramming arboriculture and urban silviculture strategies or data-driven mapping of sites worldwide, were carried out. Finally, the Vertical Urban Forestry Manifestos were written as a composition of findings from the previous methods, and an exemplary case study design - Replanning/ Replanting Zelazna was executed.

Plenty of vertical urban forestry limitations make it hard to execute the more visionary designs at this moment in time. Firstly, this branch of architecture is highly constrained by tree growth limits. Secondly, although strategies and technologies are constantly being developed, planting trees all over buildings' elevations is still extortionate. It is also dangerous – the field is too young to have developed regulations in building codes. Not to mention that trees are heavy - it isn't easy to foresee their development and growth patterns, and they need excessive amounts of underground space to grow roots, so they endanger the structural stability of the structures. Lastly, urban forestry could be executed horizontally; why do it vertically and deal with the above problems?



One of the more significant limitations of the study was that the formed Vertical Urban Forestry Manifestos could only serve as an information resource. The field of research studied was/is still in its infancy, and it will take plenty of time and patience to develop it enough for it to become commonly recognized and thus regulated. Another critique of the Vertical Urban Forestry Manifestos is that they weren't directed at any particular audience, neither highly educated architects/landscape architects, nor municipalities, nor everymen. The lack of specified recipients made the language choice vague in some cases and idiosyncratic in others. However, the overall goal of the piece was to spark interest in the subject rather than explain every single bit of information extremely exhaustively. Moreover, the case study design proposal - Replanning/ Replanting Želazna was only conceptual and visionary, having considered the price of the net result.

Nevertheless, vertical urban forestry is irrecusably a significant and highly promising architectural branch under constant development. In the future, once the price, weight, and regulatory problems are solved, it will be, beyond controversy, a go-to urban design solution.

what do you mean vertical urban forestry?

figure 3.1. the urban design of tomorrow.

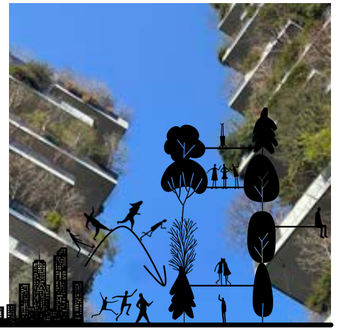


figure 3.2. Bosco Verticale.

figure 3.3. Stepping Park House.

figure 3.5. Prefectural International Hall.

figure 3.6. Lovell International School.

figure 3.7. Jakob Factory.

More and more people are moving to cities, which means they are becoming denser and denser. People need more and more houses, apartments, schools, workplaces, and, generally, shelters. Moreover, this process is unstoppable. Green open space is almost consigned to history. On top of that, the green open space, with trees in particular, brings so much quality to everyday life. In this thesis investigation, the three broad areas of interest were the interconnecting forestry, urban design, and welfare. Would it be possible to combine them in an improved, innovative manner to create tomorrow's green and arborous urban design?

Forestry (Oxford English Dictionary, 1897) is the science or practice of planting, managing, and caring for forests; it embraces biological, economic, philosophical, and social aspects. Urban design (Ghisleni, 2022) elaborates solutions to improve or re-qualify an existing urban area and create new urbanization in a given region. According to Encyclopedia Britannica (1998), urban forestry is a significant branch of forestry that comprehends the care and management of trees in urban settings (both publicly and privately owned). Urban forestry strongly advocates for the role of trees in urban infrastructure (ibid). Summing up, urban forestry aims at finding new ways of incorporating a more extensive tree canopy in urban settings. As per Forest Service United States Department of Agriculture (2023), it comes in many different shapes and sizes: urban parks, street trees, river promenades, coastal promenades, landscaped boulevards, greenways, urban gardens, single trees, wetlands, shelter belts, but also treed balconies and roofs in a variety of building typologies (multifamily residential, single-family housing, parking, office buildings, schools, factories, churches, and many more).

Taking a different perspective, according to Jorgensen (1986), urban forestry is the intelligent management of trees to use their potential to the fullest, physiologically, sociologically, and economically. The term was first used in 1965 because its' precursor - arboriculture (the study of single tree cultivation) - was insufficient (ibid). Another term, silviculture, which is the growing and cultivation of forests, also did not fully grasp the idea's depth because it only embraced biological aspects (Oxford English Dictionary, 1919). Underneath, three definitions from Encyclopedia Britannica approximate the complexity of urban forestry further.

"Physiology is the study of the functioning of living organisms, animal or plant, and of the functioning of their constituent tissues or cells." (Encyclopedia Britannica, 2000)

"Sociology is a social science that studies human societies, their interactions, and the processes that preserve and change them. It examines the dynamics of constituent parts of societies such as institutions, communities, populations, and gender, racial, or age groups. Sociology also studies social status or stratification, social movements, social change, and societal disorder in the form of crime, deviance, and revolution." (Encyclopedia Britannica, 2002b)

"Economics is a social science that analyzes and describes wealth's production, distribution, and consumption." (Encyclopedia Britannica, 2005)

figure 3.4. Bentley Bay - Parking Garage.

figure 3.8. Kościół Jana Kantego.

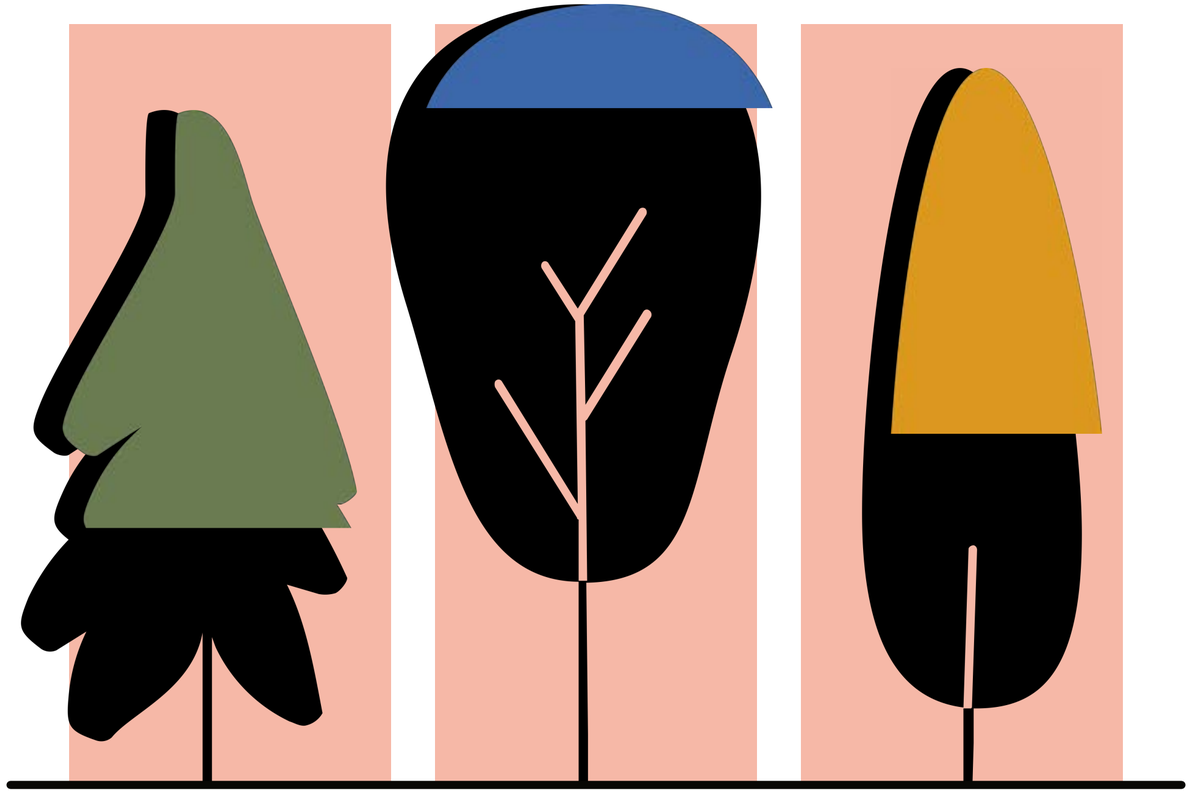


figure 3. 9. 60% water.

figure 3. 10. 18% carbon.

figure 3. 11. 50% of DNA.

Verticality is an abstract construct coined for orientation in space. It refers to a position or direction perpendicular to the horizontal plane. Hybridizing verticality and urban forestry is a promising solution for the future of urban design. According to Stefano Boeri Architectural Studio (2018b), by 2030, 60% of the global population is projected to live in urban areas - this means that in 6 years, 5.1 billion people will live in cities. These cities now consume 75% of the global natural resources and account for 60% of carbon dioxide emissions (ibid). That is why it is crucial to make cities liveable. Caring about welfare, quality of life, and mental hygiene is crucial. Trees are one of the most accessible means of alleviating the city tissue. As per McDonald et al. (2019), there would have been twice as many yearly heat-related deaths without trees. His research concluded that the urban tree canopy would get more crucial in the years to come due to its remarkable heat-reducing qualities. In compliance with Berland et al. (2017), urban stormwater runoff might sometimes be a problem that cannot be solved just by using gray infrastructure; green infrastructure is an irreplaceable addition. Trees can help manage stormwater runoff in various ways: storage, evapotranspiration, and infiltration; they can also work well with other green infrastructure solutions (ibid). Many tree characteristics also improve shading, plot market value, and aesthetics (ibid). They also reduce noise and pollution (ibid). South et al. (2018) defended the concept of a space's aesthetics improving its user's mental condition. Her research also indicated that a drop in gun violence and vandalism follows and that improving a space's aesthetics is inexpensive. When did we turn away from nature and choose city jungles over literal forests?

What went wrong, and how can it be undone?

One last fact framing the investigation was that many other plants, not only trees, could improve urban life quality. However, considering the bookish definition of urban forestry, the research focused mainly on trees. Moreover, according to Davis (2022), people and trees are alike. We are both about 60% water, we are both about 18% carbon, and we share about 50% of DNA (ibid). We both have a peak life span of about 80 years (ibid).

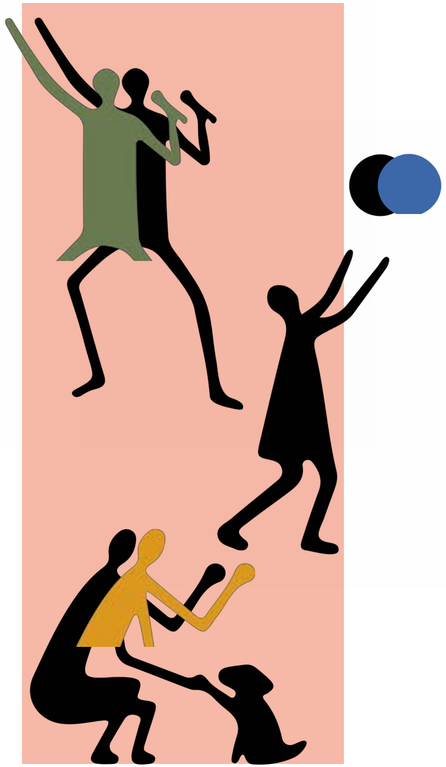


figure 3. 12. 60% H2O, 18% C, 50% DNA.


barking up the wrong tree?

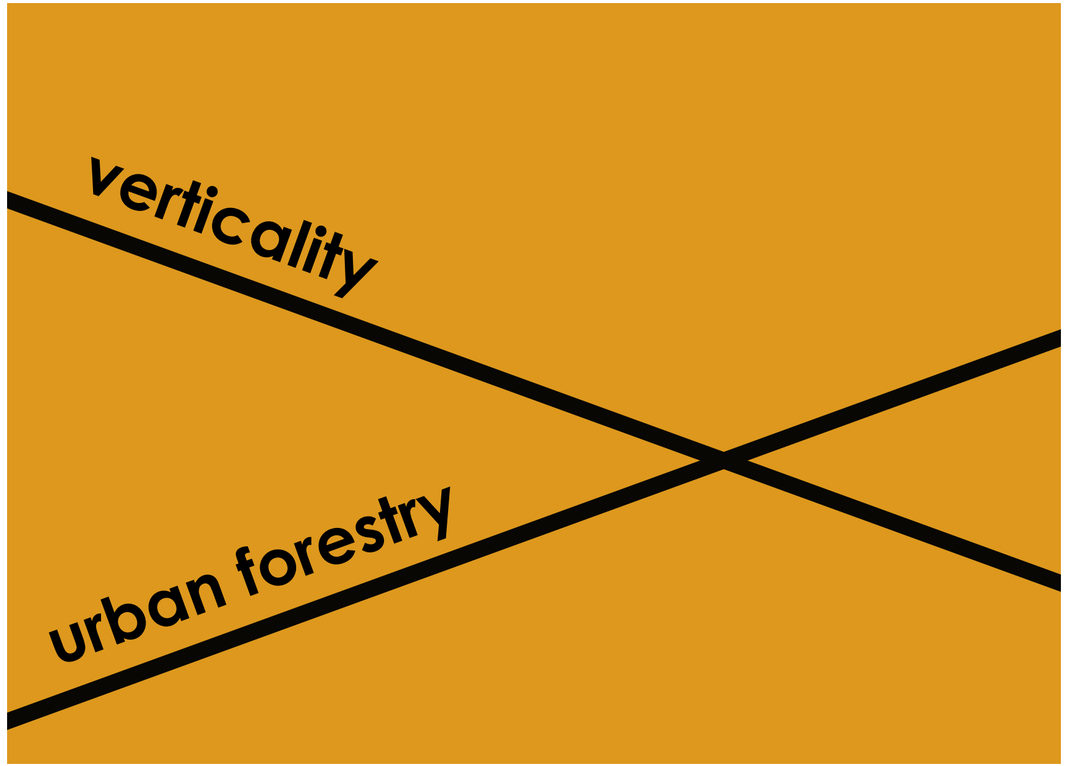


figure 4.1. a research gap was present in bridging urban forestry and verticality.

Is vertical urban forestry the future of urban design? What are the benefits and limitations of vertical urban forestry? What strategies can support the design of a high-quality urban interior? What typologies and strategies are present in the realm of vertical urban forestry? What approaches and techniques can be used to grow architecture? What design approaches and qualities support effective vertical urban forestry design? What do the vertical urban forestry approaches and qualities look like in practice? Is vertical urban forestry ever going to be ordinary?

A research gap was present in bridging urban forestry and verticality. The work intended to deepen the subject and weigh its benefits and limitations. The central relevance was to popularize the topic of vertical urban forestry and make it an ordinary, everyday design technique.

The research took a constructivist/ visionary approach with elements of a post-positivist one. The research was questioned considering infinite aspects, but it was done objectively.

The guiding assumptions of the thesis were that there needs to be more green spaces in cities, there needs to be more space in (some) cities because they tend to be too dense, and that the presence of nature generally enhances people's experiences and health. Numerous studies proved that adding greenery improves the overall quality of the urban tissue. Additionally, the number of trees in today's cities must be increased. Moreover, most metropolitan areas do not have the space to guarantee the necessary treemproving (the practice of improving the quality of urban interiors with the use of forestry).

The thesis investigation was sparked by a city in Italy - Milan. Stefano Boeri Architectural Studio did an outstanding job there, literally placing trees on all elevations of two residential towers of their design. But it was not only that - Milanese people have a different mindset regarding forestry. They put trees on their balconies and roofs of their own volition.

Bosco Verticale, among other designs by Stefano Boeri Architectural Studio, was one of the precedents that most influenced the thesis' approach to urbanization and afforestation. The project vividly proved that vertical afforestation is indeed possible among urban tissue. Moreover, it manifested urban forestry's positive influences on the inhabitants' mental hygiene and quality of life.

Other precedents that significantly influenced the present work were all the experimental Baubotanik studies conducted by the Office for Living Architecture. They proved and manifested all that Bosco Verticale did and even more. They took vertical urban forestry a step further, incorporating the trees into the urban tissue and the structural, load-bearing part of the building.

figure 4.2. Bosco Verticale.

figure 4.3. Plane Tree Cube.

figure 4.4. @vertical.urban.forestry.

figure 4.5. the streets of Milan 1.

figure 4.6. the streets of Milan 2.

figure 4.8. the streets of Milan 4.

figure 4.9. the streets of Milan 5.

figure 4.10. the streets of Milan 6.

The investigation sparked a pushing need to create a vertical urban forestry movement to underline and explain that people should care about urban interiors as much as they care about regular interiors. The effects of that pushing need were the Vertical Urban Forestry Manifestos and an Instagram account - @vertical.urban.forestry - publishing content about the "hows" and the "whys" of vertical urban forestry. Vertical Urban Forestry Manifestos focused on narrowing the research to form semplice and appealing information bundles. They are recommendations on what to remember for urban planners, both professional and novice. This creative tool gathered collective knowledge to help future architects or designers create projects creatively implementing trees. The number of tree implementation advantages drastically surpasses the number of disadvantages. The above expansive program called for mixed methodology methods and was possible to be carried out through thorough research: diagramming the limitations and the benefits of vertical urban forestry, the exploration of urban design and urban interiors, the assessment of the already-commonplace vertical urban forestry solutions, Baubotanik assessment, the assessment of the data regarding different tree species, data-driven mapping of sites worldwide, and an exemplary case study design solution - Replanning/Replanting Železna. The overall goal of the thesis investigation was to check whether verticality is the solution to the problem of the lack of urban tree canopy.

There is a way to welcome the forest back to the city, and let me knock your socks off on how to do it!

figure 4.7. the streets of Milan 3.

figure 4.11. the streets of Milan 7.

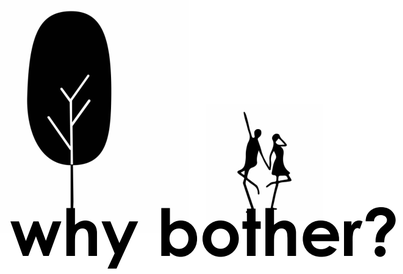

why bother?

figure 5.1. urban heat island effect a.

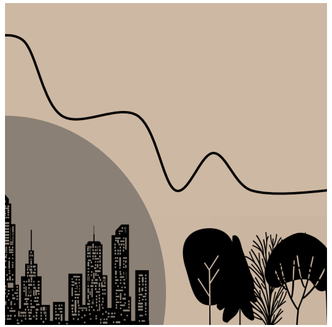


figure 5.2. urban heat island effect b.

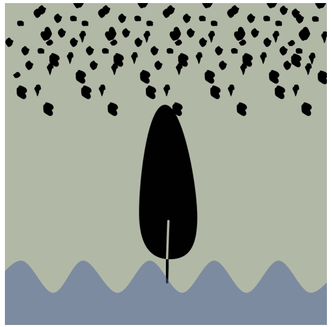


figure 5.3. water retention.

figure 5.5. plot market value.

figure 5.6. noise reduction.

figure 5.7. pollution reduction.

According to McDonald et al. (2019), high air temperatures cause 1200 deaths in the United States annually, making them one of the most dangerous weather-related public health threats. They are also the reason behind high electricity usage (ibid). The researchers wanted to know how much the urban forests improved the abovementioned situation (ibid). They mapped 97 cities and studied how much the urban tree canopy helped during heat waves (ibid). It turned out that without trees, there would have been twice as many heat-related deaths yearly (ibid). The conclusion was that the urban tree canopy would get more crucial in the coming years (ibid).

According to Berland et al. (2017), urban stormwater runoff might be an unsolvable problem with just the use of gray infrastructure; green infrastructure is an irreplaceable addition. Trees help manage stormwater runoff in various ways: storage, evapotranspiration, and infiltration; they also work well with other green infrastructure solutions (ibid). Additionally, many tree characteristics improve the overall shading, plot market value, and aesthetics (ibid). They also reduce noise and pollution (ibid). Because of the above arguments, many cities in the US have decided to increase their tree canopy to solve the stormwater runoff issues (ibid). Despite the growing interest, there were still several obstacles concerning using trees for water retention: the particular performance of different species and the arboriculture-related and organizational challenges (ibid).

"Health disparities are the preventable differences in the burden of disease, injury, violence, or opportunities to achieve optimal health that are experienced by socially disadvantaged populations." (Centers for Disease Control and Prevention, 2020)

"There is a growing body of evidence that green space can have an impact on mental health, and that is particularly important for people living in poorer neighborhoods." (South et al., 2018)

South et al. (2018) defended the concept of a space's aesthetics improving its users' mental condition. The researchers decided to examine if the public lots influence the mental health of the neighboring inhabitants (ibid). They randomly chose 541 lots scattered around Philadelphia and divided them into three groups (ibid). The first group got the complete greening treatment, the second was tidied up a bit, and the third stayed unchanged (ibid). The researchers asked 342 randomly chosen neighboring inhabitants about their mental health 18 months before and after the experiment (ibid). The survey proved that the mental health of the neighboring inhabitants in the first group (complete greening treatment) had improved significantly (ibid). The article also noted that a drop in gun violence and vandalism followed and that improving a space's aesthetics was inexpensive (ibid).

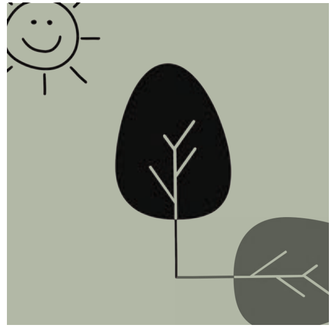


figure 5.4. shading.

figure 5.8. mental health improvement.

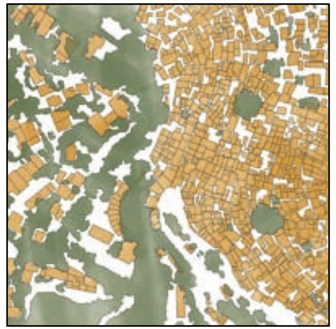


figure 5.9. Rio de Janeiro, houses & trees.

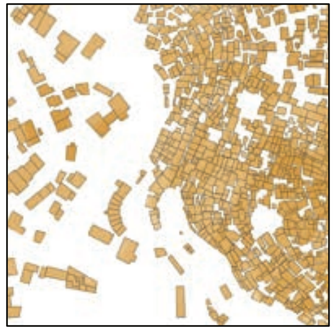


figure 5.10. Rio de Janeiro, houses.

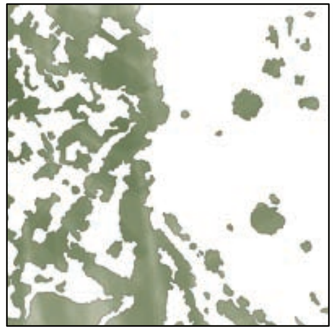


figure 5.11. Rio de Janeiro, trees.

figure 5.19. cities - impact b.

figure 5.20. cities - impact c.

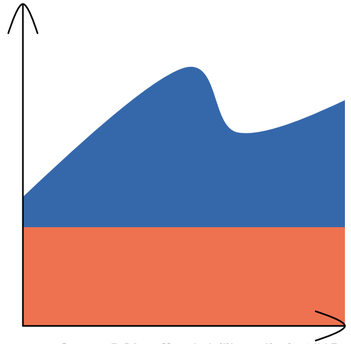


figure 5.21. affordability ratio in NYC.

Another compelling article (Arch Daily & Belitardo, 2023) pointed out that the urban tree canopy was much more extensive in the wealthier, more abundant city districts. They have more significant funds than the poorer quarters, so they can buy, plant, and maintain luscious greenery (ibid). At the same time, they are less densely populated, as all inhabitants want substantial privacy, so as a consequence, there is more space for greenery (ibid). Additionally, the more green a neighborhood is, the more attractive it is for future acquirers, so it gets more expensive (ibid). The spiral propels itself, and the aerial views prove it even further. Having known that greenery improved mental health and decreased gun violence and vandalism (South et al., 2018), the conclusion revealed itself. Green space and health disparities are severe problems that should be addressed (visit appendix a for more information on the subject).

Everyone knows that trees reduce the heat island effect, noise, and pollution. Everybody knows that trees retain stormwater. Everybody knows that trees improve shading and mental health. However, what is more? According to Stefano Boeri Architectural Studio (2018b), by 2030, 60% of the global population is projected to live in urban areas, which means that in 7 years, 5.1 billion people will live in cities; cities which consume 75% of the world's natural resources and account for more than 70% of global carbon dioxide emissions.

Another argument in this discussion is the rising land prices. There is no universal rule on what one can afford based on income. However, the average home used to cost about 2.6 times the median income. It was the ratio that real estate agents often cited as a threshold for affordability. If a family's annual revenue was $100,000, according to this formula, they could afford a $260,000 home. In most states nowadays, a household earning the state's median income is not even close to affording a typical home (Chang, 2023). Let us go vertical instead of horizontal!

Moreover, the world is on the verge of an architectural revolution. The COVID-19 pandemic is an extraordinary window of opportunity. The Paimio Sanatorium, by Hugo Alvar Henrik and Aino Aalto, had characteristics designed with tuberculosis patients in mind. The minimalist, blank, empty spaces of modernist architecture fit tuberculosis well. They were associated with hygiene. Just like tuberculosis somehow shaped modernism, COVID-19 can and will influence near architecture's future. How about ensuring easy access to nature and, thus, trees, no matter where we live, work, study, or sleep (Chayka, 2020)?

figure 5.18. cities - impact a.

figure 5.22. Paimio Sanatorium.

is Bosco Verticale flawless?

One of the designs approximating the idea of urban forestry is Bosco Verticale, two residential towers in Milan, Italy, designed by Stefano Boeri Architectural Studio. An unpretending treasure is hidden behind the catchy name - the buildings nourish 800 living trees on their facades. According to Stefano Boeri Architectural Studio (2014), this remarkable elevation created an extraordinary internal microclimate, regulating humidity, producing oxygen, and absorbing carbon dioxide. Construction-wise, this green curtain was made of cantilevered balconies-pots, housing the trees and other plants (ibid). The choice of the particular species was not coincidental (ibid). Botanists and ethologists researched and studied them for three years (ibid). Then, they planted them in a nursery in Como, Italy, in 2010 to grow and mature, experiencing conditions similar to those they would have in their future forever home (ibid). Bosco Verticale is an excellent example of the thoughtful implementation of urban forestry into the dense city tissue, letting people live surrounded by leaves, butterflies, and bird chirps. Stefano Boeri Architectural Studio engages in various urban forestry projects, from apartment buildings to master urban plans. Nevertheless, Bosco Verticale is immensely important because of its precursory role in the field and undeniable fame.

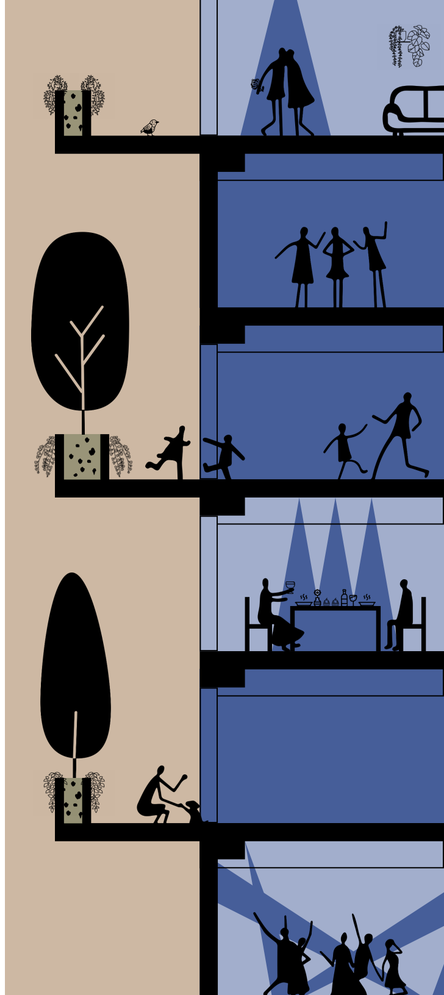
Bosco Verticale is the crown jewel of the vertical urban forestry world. However, it was also the world's first well-known and advertised vertical forest, meaning many conclusions can be drawn, and a lot can be learned from its mistakes to avoid making them in the future. Firstly, the two residential towers were situated in a very fortunate way. Most surrounding buildings are old, making Bosco Verticale stand out positively. After all, it is easy to look above average in an average setting. Secondly, the two residential towers were a development that required significant insulation. Fortunately, the neighboring buildings are shorter, making the accommodation of the insolation needs almost effortless. Furthermore, the layouts are generally functional, with expansive, wide balconies. Still, the buildings are symmetrical and north-south oriented, which can be managed with different species of trees. However, what seems illogical is the human aspect of the problem. The inhabitants of Bosco Verticale need access to sunlight as well. Do the north-oriented apartments get enough sunlight throughout the day?

In contrast, the colors and shapes of the elevations of the two residential towers change throughout the year, making them non-homogeneous. Furthermore, the section was designed very well, allowing for total privacy. In summer, the trees of Bosco Verticale screen from direct solar radiation, decreasing the temperature inside of the building, whereas, in winter, they let the light in, getting rid of the overall gloomy feeling (Arch Daily, 2015).

Moreover, the trees screen from the wind. To achieve that, they needed to be planted in their balconies-pots as matured and grown trees instead of young and weak seedlings, which is why they had been meticulously cultivated near Como since the summer of 2010. This process got them used to the physical conditions similar to those they have now once replanted. Additionally, the trees of Bosco Verticale decrease noise (Arch Daily, 2015).

← figure 6.1. Bosco Verticale - map.

figure 6.2. Bosco Verticale - section. →



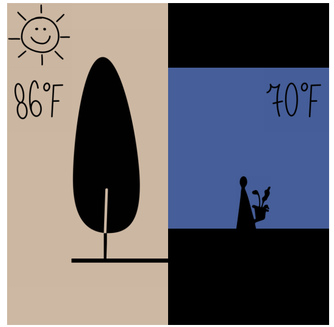


figure 6.3. screens from direct radiation.

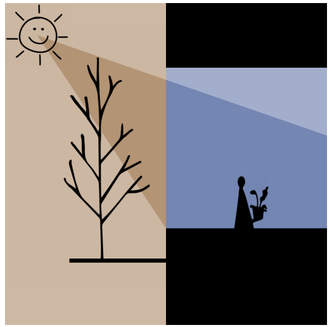


figure 6.4. lets the light in.

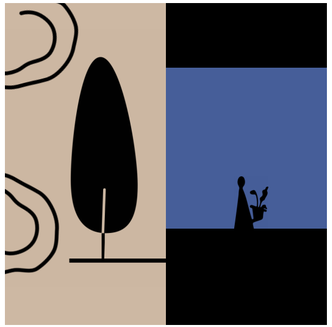


figure 6.5. screens from the wind.

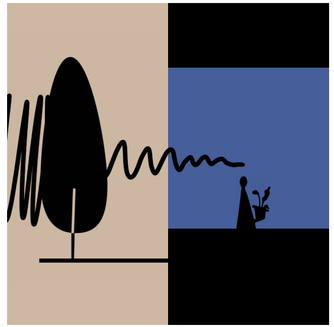


figure 6.6. decreases noise.

figure 6.7. turns CO2 into O2.

figure 6.8. traps dust particles.

Withal, the two forested towers turn carbon dioxide into oxygen. Assuming that one hectare of forest equals 350 trees, Bosco Verticale is equivalent to 2 hectares of forest, making it the lungs of the neighborhood. It also means that the design significantly increased Milan's biodiversity (more than 120 introduced species). On average, each person residing in the building owns two trees and 48 smaller plants, trees and plants that trap dust particles, improving the quality of the everyday life of the inhabitants. The vegetation was carefully designed to filter out car pollution, which is a massive problem in big cities like Milan (Arch Daily, 2015).

Everyone knows and talks about Bosco Verticale because it is the pioneering design in the field. Few know that Stefano Boeri Architectural Studio designed many more buildings and urban plans with vertical urban forestry in mind.

Verdemare Lungomare Bari

The design transformed an existing parking lot into an apartment building. The architects wanted to reduce the heat island effect, hinder the humid microclimate of the location, and mitigate carbon dioxide emissions. Verdemare Lungomare Bari comprised 150 apartments of different shapes and sizes (from 50 to 150 square meters, 538 to 1,615 square feet), **100 trees**, and **20,000 smaller plants**. The architects predicted a rainwater harvesting system to optimize water conservation (Stefano Boeri Architectural Studio, 2022a).

Vertical Forest Dubai

The design comprised 2 apartment towers hosting **2,640 trees** and **27,600 smaller plants**, greenhouses, and hydroponic gardens. The abovementioned is not the only aspect of this design being green. As Dubai's climatic zone does not get much precipitation, the architects implemented several water conservation technologies into the design: desalination and greywater recovery. Additionally, they predicted photovoltaic surfaces producing 5,100 kilowatt-hours of clean energy and storing it in hydrogen batteries (Stefano Boeri Architectural Studio, 2022b).

Bosconavigli Milan

The design was prepared with vertical urban forestry in mind and alluded to the traditional Lombard courtyard typology. **170 trees** were predicted to be planted on the elevations of the building. Much attention was also channeled to preserving an old large solitary elm tree growing on the plot, a historical symbol of the area. The architects wanted to achieve a spiral progression of the terraces ("outdoor rooms") to allow for maximum privacy for the future inhabitants and accommodate the tallest trees. Rainwater harvesting and recovery systems were also implemented into the design (Stefano Boeri Architectural Studio, 2018a).

figure 6.9. Bosco Verticale. →

figure 6.10. Verdemare Lungomare Bari.

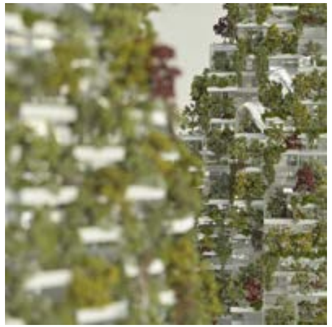


figure 6.11. Vertical Forest Dubai.

figure 6.12. Bosconavigli Milan.

figure 6.14. Vertical Forest Eindhoven.

figure 6.15. Vertical Forest Huanggang.

figure 6.16. Vertical Forest Cairo.

Wonderwoods Utrecht

Wonderwoods Utrecht comprised 200 flats, **360 trees**, and **9,640 smaller plants**, producing 41 tons of oxygen and absorbing 5.4 tons of carbon dioxide annually. It was also calculated that the microclimate created by all of the plants would reduce the temperature inside of the building as well as air conditioning. The design was also equipped with an irrigation system. On top of that, the ground floor and the rooftop garden were dedicated to becoming a worldwide vertical urban forestry research center (Stefano Boeri Architectural Studio, 2017c).

Trudo Vertical Forest Eindhoven

The building comprised 125 flats, each with at least one tree and 20 smaller plants (**135 trees** and **8,365 smaller plants** total). The maintenance of the entire complex was composed to be managed directly by the developer. The fact that the plot was a former Philips Electronics company site further enforced the idea of the trees ad litteram processing pollution by converting carbon dioxide into oxygen. The building was also designed with the idea that the trees would cool it down. Furthermore, rainwater collection and irrigation systems were projected (Stefano Boeri Architectural Studio, 2017b).

Easyhome Vertical Forest Huanggang

The design comprised five towers planted with **404 trees** and **4,620 smaller plants,** producing 11 tons of oxygen and absorbing 22 tons of carbon dioxide annually. The main objective was to integrate architecture with nature (Stefano Boeri Architectural Studio, 2017a).

Vertical Forest Cairo

The three residential and commercial cubes comprised 180 apartments of different shapes and sizes, **350 trees**, and **14,000 smaller plants**. The plants were meticulously chosen to help decrease the temperature inside the building complex, ensure shade, and provide better ventilation and air quality. The space around the buildings was designed as a public park. Vertical Forest Cairo was intended to become a part of Greener Cairo – a broader project aiming to make the city more ecological (Stefano Boeri Architectural Studio, 2019).

Vertical Forest Nanjing

Vertical Forest Nanjing was the first design of its kind in Asia. The idea behind it was that the plants would be able to purify the highly polluted air of Nanjing. The building comprised **800 trees** and **2,500 smaller plants**, producing 16.5 tons of oxygen and absorbing 18 tons of carbon dioxide annually. Unlike other Boeri Architectural Studio designs, it was not designed as a residential complex; instead, the two towers were to house offices, shops, restaurants, a school, a museum, a swimming pool, a club, and a hotel (Stefano Boeri Architectural Studio, 2016).

figure 6.13. Wonderwoods Utrecht.

figure 6.17. Vertical Forest Nanjing.

why bring urban forestry and architecture together?

figure 7.1. it is expensive.

figure 7.2. it is almost too heavy.

figure 7.3. not enough room for the roots.

figure 7.8. David's photograph.

figure 7.9. Emma's photograph.

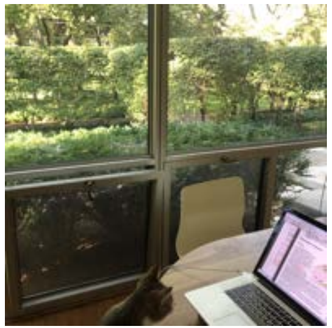


figure 7.10. Georgia's photograph.

What are the critiques of vertical urban forestry? Firstly, it is expensive. Secondly, trees and soil are almost too heavy for the load-bearing capacities of buildings. Furthermore, there isn't enough room for the roots. The trees survive but do not thrive and grow big. The plants need to be maintained. Who is going to take care of them? How will the trees be replaced? How often will they need to be replaced? Limbs break in big storms. What happens when a limb falls off the building? There are no building codes regulating that. All those critiques are valid and well-grounded; however, research proves that people naturally lean towards trees.

The photovoice experiment intended to examine whether people notice urban forests (or the lack of them) in their everyday lives. The participants were asked to photograph what they could see through the window during the weekend, wherever they went. Then, they were requested to describe what they liked/did not like about the view and what they would change. As expected, the participants touched upon the issue of urban greenery. Moreover, surprisingly, they underlined the importance of trees among other vegetation. They also made some other excellent points about the aesthetics, lighting, fresh air, privacy, and traffic noises.

Brianna: "The reflections are bad, but this is the outside of my apartment window this morning. I see other apartment buildings and our dog park. I wish the buildings were more appealing. But I like the tree and how the sun bleeds into my room in the morning. I enjoy seeing people play with their dogs and enjoying life."

Charles: "I love my window in my room. It is facing towards the west at the highest point in the house. I get a beautiful view of my backyard willow tree and amazing sunset views. I also see my little lake in the back, which is always full of a rich ecosystem of various animals and critters. I have the window open to get some fresh air wind in the space."

David: "Alternatively, my home office opens up to a garden view that is mentally relaxing and soothing — a mental break during those stressful deadlines."

Emma: "It is the view from my bedroom. I wouldn't say I like that there's no view, and I barely have any privacy with the neighbors' window on the other side. I would love it if there were no house, but one thing I would change is to have the fence higher and put a green wall."

Georgia: "I prefer to work in my dining room rather than my university office for the natural view, the easily operable windows, and the lack of traffic noise. I often have my front door open as well. I also enjoy waking up to the view of nature every day."

Isa: "I like how everything looks here! I like the green and the trees; however, I want to add flowers or bushes to my lawn to make it more private and colorful!"

Check out appendix b for the complete list of narratives and photographs.

figure 7.4. there are no building codes.

figure 7.12. Isa's photograph.

bringing urban forestry and architecture together, how?

figure 8.1. Garden House - plan.

figure 8.2. Garden House - perspective.

figure 8.3. Baubotanik Footbridge.

figure 8.5. Garden House - close-up.

figure 8.6. Garden House by night.

figure 8.7. Green Living Room.

Al Borde Architects

The house's owner, Jose, had always treated living among nature as a ritual. He had always lived a nomadic life but decided it was high time he had a place of his own. As he used to study Ecology and Conservation, he wanted to smoothen the boundary between himself and his surroundings. Thus, he collaborated with Al Borde Architects to create his own home. As a result, the building somehow blurred the boundary between nature and architecture, for example, by dividing the houseroom into three hybrid cubatures (the central pavilion – the social area of the house, the shower pavilion, and the toilet pavilion), forcing the inhabitant to go outside to get from one to another, or using living trees as structural supports for the roof. On top of the above mentioned, the design utilized vernacular practices, such as agave flowers, dry maize leaves (both used for the roof), soil (removed during the excavation process, used for the adobe walls), stone (used for foundations and flooring), and the Lechero trees commonly found in Ecuador. Using the living Lechero trees as the building's structural supports was risky because they had never been used in such a way. They had only been used in living fences, Ecuadorian hedges consisting of a wire unfurled between the trees (Arch Daily, 2023).

"One of the things that excite us is when we are discovering which technologies we can build with or which vernacular knowledge we can use to work on the construction, and one of the pieces of knowledge that have interested us a lot since we knew about it was the "living fences." We thought living fences is a very logical knowledge, and it is so logical that sometimes it goes unnoticed. When the solutions are so rational that no one sees them, we are even more excited about them." (Arch Daily, 2023)

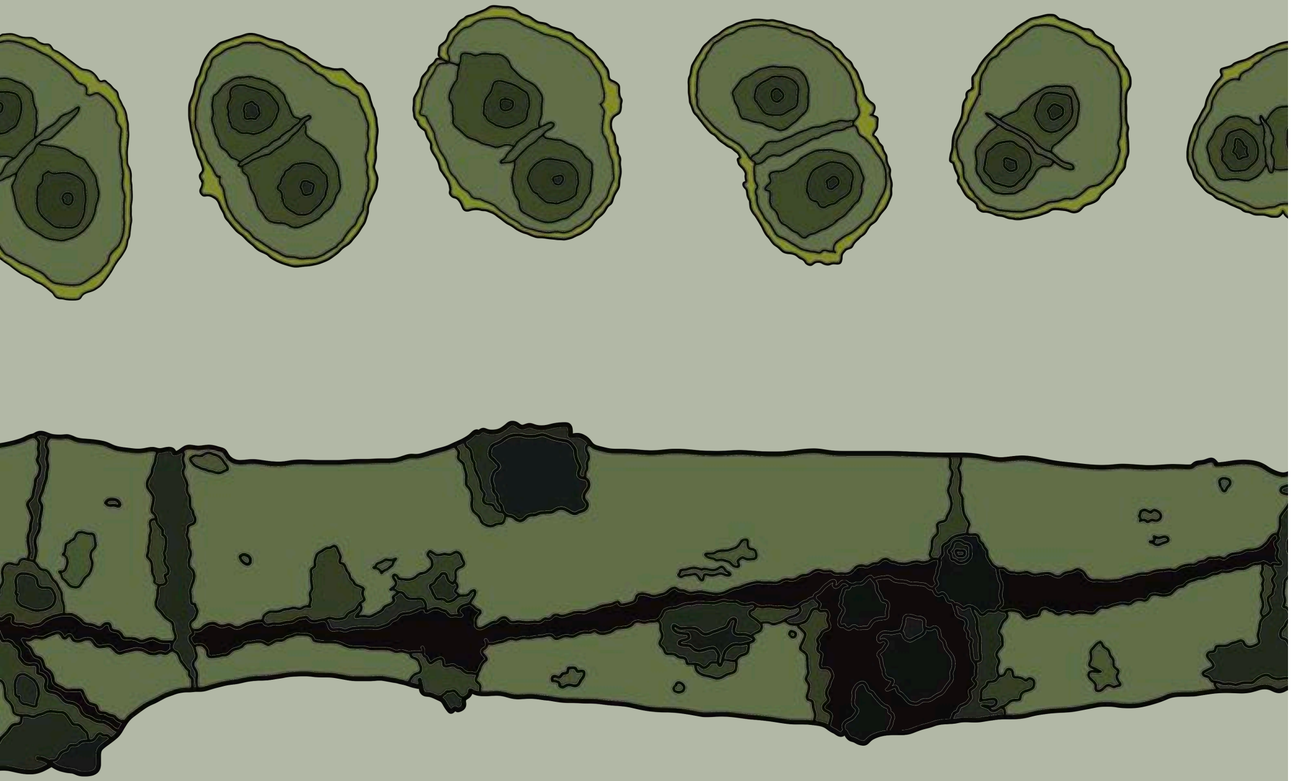
The architects decided to bury the roots of the 3-meter-high trees (9.8 feet) 1 meter (3.3 feet) below the ground level. It was a great idea - the first fresh sprouts took root in as little as a few weeks, and only 5 out of the 46 trees (11%) used did not adopt. Another design aspect that proved symbiosis with nature was using a permaculture system (which Jose developed and built on his own). It consisted of two filtering systems, one filtering black water and the other filtering gray water (Arch Daily, 2021).

The Greenman Project

Bob, Dalfsen, Netherlands, built a house with his own fair hands for as little as 1000 euros. He did so using recycled materials he found online and living trees. Bob constructed the load-bearing walls of the house from big (0.5x0.5x1 meter, 1.6x1.6x3.3 feet) fiber planters filled with soil, in which he afterward planted elm and ash trees. Over time, as the trees grew, Bob linked their branches with nails and screws, combining their sap streams and creating an individualistic tree system supporting the structural load of the roof. He estimated the process of the tree connection would take five years to complete and the process of gaining total structural stability - ten to fifteen years. As Bob described, restoring the connection between nature and his daily life inspired him to take on this project (Mindful Building & Living, 2022).

figure 8.4. Baubotanik Tower.

figure 8.8. Baubotanik Street Typology.



← figure 8.9. living joints - sections.

"Well, in these times, everybody is talking about CO2, of course, and instead of a CO2-neutral building, this is an O2-positive building, so the house will, from the start, already take in CO2 and provide oxygen, and it will clean the air." (Mindful Building & Living, 2022)

Bob listed other advantages of the design: that the building looked different each season, the trees' excellent insulation properties, and the ability to repair themselves, strengthening themselves where needed most (like a real-life living cantilever beam). He called the above a future-proof way of building. Instead of maintaining the building every once and then dealing with moisture or insulation problems, one has to water and bind the trees. Furthermore, even that, over time, ceases to be a problem - the bigger the tree system, the less watering it needs - just like a forest can thrive with rain only, no artificial watering (Mindful Building & Living, 2022).

It is recommended that the trees used for house construction be found locally, meaning they would already be adapted to the climate conditions of the particular location. Additionally, one would have to consider the specific species' insolation needs. Bob chose elm trees in his house for the more sunny eastern facade and ash trees for the shaded western facade. He planned on using various fruit trees from one species family on the southern elevation (Mindful Building & Living, 2022).

Office for Living Architecture

Trees had always been there. They had seen and prevailed through all the destruction that homo sapiens had inflicted on Earth. Ferdinand Ludwig and Daniel Schönle from the Office for Living Architecture (Stuttgart, Germany) tried to restore the connection between humankind and nature through Baubotanik (from German "der Bau," which means "building," and "die Botanik," which means "botany") - an architectural method of growing structures from living plants. Timber buildings are usually commended for their sustainability because the CO2 absorbed by the trees in their lifespans is locked down in the building's structure. Baubotanik is an architectural movement advocating for designing and building so that the CO2 is not locked down but actively absorbed by the building's structure, advocating for designing and building with living trees. Inosculation is a natural process of branches, trunks, and roots nearby, shedding bark and fusing, growing together. The idea behind the Office for Living Architecture's designs is to mimic the abovementioned process: to prune, graft, weave, and bend the trees planted next to a supporting scaffolding. Over time, the manicured tree system would grow stauncher to the point that it would gain extensive structural support properties and even partially eat the original construction system up or make it redundant to the point that it could be removed (Arch Daily & Oommen, 2015).

figure 8.10. accidental inosculation.

figure 8.11. deliberate inosculation.

figure 8.12. hornbeam.

figure 8.13. london plane tree.

figure 8.15. small-leaved lime.

Apart from being structurally stable and beautiful, living architecture asserts very primitive needs: it provides oxygen, aliment, and shelter and prevents soil erosion. Additionally, trees reduce stormwater runoff, improve water quality through the roots, and have excellent cooling down/shading and sound-proofing properties. They also welcome birds and insects, allowing for biodiversity. Another advantage of a tree system over a traditional take on vertical urban forestry is its multidimensionality (Arch Daily & Oommen, 2015).

However, not all tree species are eligible to be living building materials. They need to be flexible and bouncy with thin and flaky bark so that it is easy to graft them, for instance, hornbeam (Carpinus), London plane tree (Platanus), Norway maple (Acer platanoides), small-leaved lime (Tilia cordata), white willow (Salix alba), birch, and poplar (Arch Daily & Oommen, 2015).

Examples of the designs by the Office for Living Architecture include the Baubotanik Footbridge, the Baubotanik Tower, the Residential Trees, the Green Living Room, the Baubotanik Street Typology, and the Plane Tree Cube (Ludwig & Schönle, 2022).

Architects Ferdinand Ludwig and Daniel Schönle got their inspiration (and historical reference) from Tanzlinden, a German tradition of dancing on a platform placed in the tree crown, and the Khasi People's footbridges made from the roots of living trees. They wanted to transfer the abovementioned historical approaches into modern, present-day architecture. The architects wanted their innovative idea to be a casual, everyday addition to architecture rather than a complicated and unnecessary alternative to traditional building techniques. Ludwig and Schönle described their idea of living architecture as constructing the tree itself. They referred to the topic as screwing a lot of young trees together to create one extensive tree system. In the architects' opinion, over time, it would not be possible to notice the screws because the tree tissue would overgrow them. The term for that is taken from German - die Überwallung - and means "growing over." Ludwig and Schönle predicted it would take eighteen years for the tree system to retain the construction loads of the whole structure and become its' columns (the Plane Tree Cube). They also predicted that the tree system would eventually create a roof, merging the individualistic tree crowns (Dirksen, 2017).

"In the Middle Ages, the city wall separated the "wild nature" of the forest from the artificial place of the city, which was largely tree-free. Later, in the 18th and especially 19th centuries, urban expansions and the creation of parks and boulevards in the city led to the first spatial mixing at the level of urban planning. Baubotanik continues this on the scale of architecture by fusing trees and buildings." (Office for Living Architecture, 2023)

figure 8.14. norway maple.

figure 8.16. white willow.

figure 8.17. sketch problem - photo 1.

figure 8.18. sketch problem - photo 2.

sketch problem

The sketch problem addressed implementing living trees as structural supports. Having researched the different methods of growing buildings that architects globally experimented with, it was decided to model the most promising one. The model-making process taught several lessons about growing buildings' elevations. Firstly, the fragility of the string covered in plaster mimicked one of a young tree's branches very well. Additionally, they both turned more and more stable over time. Secondly, the material was the most fragile when not fully interconnected - the cut pieces of the net knotted from the string, just like the newly sprouted branches, were merely touching one another. Hence, the overall structure was not sturdy at the beginning. When the model finally stiffened, it was visible that the patterns and shapes created by the string were irregular and complex while somehow figuring out the way to structural stability, just like the branches of the interconnecting trees – overgrowing with tissue in certain places to support themselves better. One problem solved with the making of the model was to see how the human's eye-level perspective looking outside from the viewing balconies looked. All online photographs presented only how the whole structure looked from the ground level.

As mentioned above, model-making taught quite a bit about the characteristics of the material. Thanks to that, the techniques of manicuring the young, fresh tree parts to mold them into carrying the structural loads of a building started to seem more apparent. The preparation of the three physical models explaining the latter design stages aided the understanding of the complexity of a network that living trees can make. It helped the performance of the fact that it might be possible to grow buildings. A deep understanding of all those concepts later on aided significantly in forming the Vertical Urban Forestry Manifestos.

What emerged from the sketch problem exploration and somehow became more apparent was that, as a general rule, architects usually prefer to avoid vertical forestry and choose not to situate trees on their buildings. The reason behind the above is relatively simple – trees are not considered architectural enough. They are usually used to pull the wool over the developers' eyes when choosing one design over another. It makes architects hate vertical forestry. However, the idea of growing buildings and thus making the trees an inseparable structural part of the elevation is different; it is mind-blowing and mindset-changing. It cements architecture and vertical forestry for good, making it a probable and highly wanted solution.

figure 8.19. sketch problem - photo 3.

figure 8.20. sketch problem - photo 4.

what is the urban context?

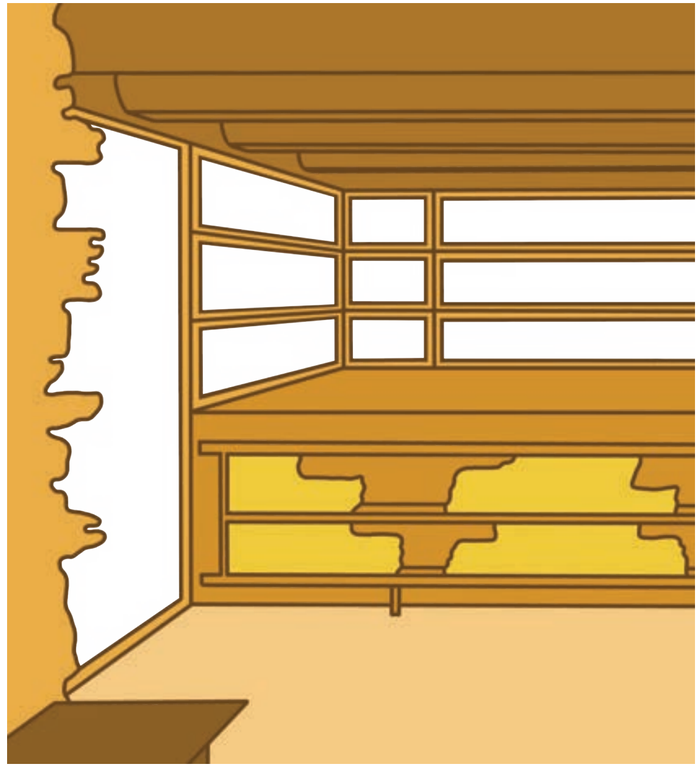


figure 9.1. a regular interior.

figure 9.2. birch.

figure 9.4. maple.

An urban interior is a composed urban space delimitated by buildings and nature (greenery and the lie of the land). The fundamental elements of the interior composition are the floor, the walls, and the ceiling. Similarly, the essential elements of urban composition are the urban floor, the urban walls, and the urban ceiling (Wejchert, 1984/2008).

In pondering the urban issue, greenery is only considered one of many other issues. Consequently, it is detached from pondering various elements of the urban tissue, especially the architectural complexes/clusters, granting them the leading, dominant role. That way, greenery tends to be overlooked and treated as an addition or supplementation to the city tissue. As a consequence, urban greenery tends to be a rather coincidental form. It is also worth mentioning how hard it is to design an urban interior so that the greenery effortlessly and harmoniously blends with the city tissue. The urbanization processes of the twentieth century, the city tissue stepping into the suburbs (untouched, unspoiled, treed, and non-homogenous suburbs), and applying high-density development (allowing for farther views from the apartments located at a greater altitude) fundamentally changed the role that greenery had as an element of urban composition. Contradistinctively to the dense nineteenth-century towns, where urban greenery was usually present only in the form of small parks or plazas, the need to provide each apartment with greenery as excessively as possible, whether directly or at a distance, as well as inscribing the architectural developments into the landscape/topography exponentiated (Wejchert, 1984/2008). Moreover, nowadays, skyscrapers mushrooming downtowns lack the excessive view of the suburban greenery thanks to variable overshadowing. Is vertical urban forestry the only logical solution to the problem of permanent integration of architectural design and greenery?

One of the most significantly problematic urban spaces of nowadays, in terms of the lack of greenery, is the intensively overdeveloped districts where there are precisely no natural values, where the urban planning mission/demand is to reshape an urban interior to consist of both the urban tissue and the greenery. Moreover, the said greenery should be an element of urban composition that is equally important to architecture itself because only the joint, several, and indissociable designs of the whole allow for the benefit of the intended space shape (Wejchert, 1984/2008).

figure 9.3. willow.

figure 9.5. spruce.

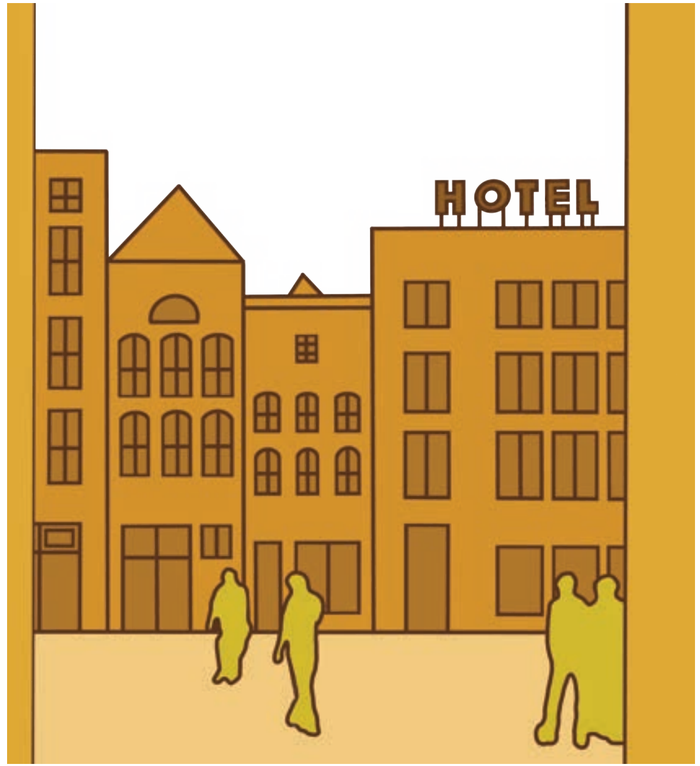


figure 9.6. an urban interior.

figure 9.7. linden.

figure 9.9. oak.

Most attention must be devoted to trees because of their significance in urban composition. The possibility of fitting their characteristics, shape, size, and taint against the background of various environmental qualities and upkeep techniques constitute great virtues of trees in urban composition. “A tree in a city” often-times means an image of a modest sycamore, linden, or hawthorn, the most popular urban trees on the cusp of the nineteenth and twentieth centuries, planted alongside narrow, scantly insolated streets-canyons. It is worth it to erase this false image. The immensity of tree species, the variety of their crowns, the denseness or clarity, the slenderness or umbrageous spread, the glossy or matte leaves, the sumptuousness of taints in spring, summer, and fall, the changeability of the form in winter, when the leaves fall away and uncover the distinct outline of limbs and branches, all constitute a luxury which, utilized wisely, would enable to create urban compositions incomparably more beautiful than those made based on the fossilized habits of the previous century. Almost all climates and nearly all natural environments offer a variety of trees. Recognizing their properties, forms, and the changeability of the said forms, as well as their performance under various insolation conditions of a day, allows for an immensely positive change in the urban design of tomorrow (Wejchert, 1984/2008).

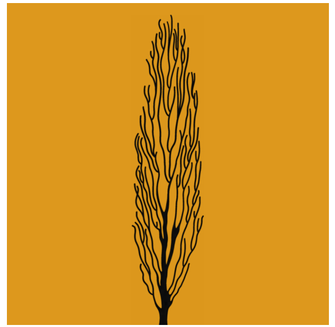


figure 9.8. poplar.

figure 9.10. beech.


treemproving?

figure 10.1. a solitary tree.

figure 10.2. a group of solitary trees.

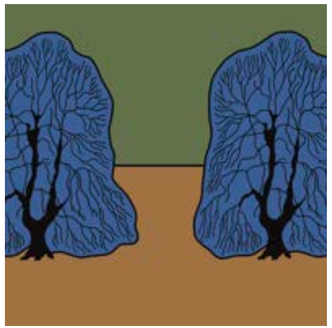


figure 10.3. a tree gate.

figure 10.5. a guiding tree array.

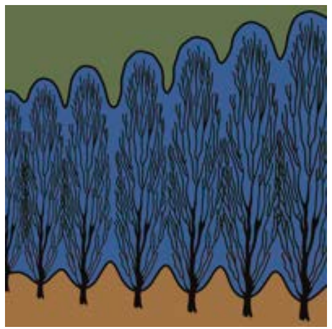


figure 10.6. a blocking tree array.

figure 10.7. a tree avenue.

Treemproving is the practice of improving the quality of urban interiors using forestry. Treemproving could treemprove the quality of urban interiors.

And how would they do that?

Tree species are like architectural styles. Each looks different, accounts for various feelings, and gives a different vibe. A solitary tree becomes a spatial dominant, a living monument, and a group of solitary trees gives off a sense of inclusion. Tree trunks and the crowns of a tree gate make what is placed between them spatially dominant. A tree tracery, a series of tree gates, also makes what is placed between the trees spatially dominant. A tree array could be guiding the eye forward or blocking the view. A tree avenue blocks the side views, making what is on the inside the most solemn. A tree backstage exposes the significance of what is in front of it. Tree rhythms create different spatial conditions (Wejchert, 1984/2008).

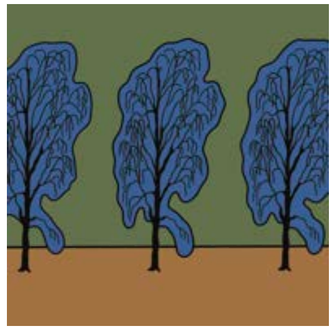


figure 10.4. a tree tracery.

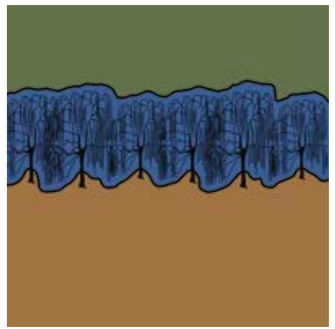
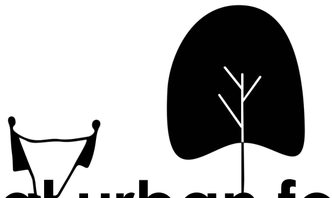


figure 10.8. a tree backstage.



vertical urban forestry manifestos

Proximity to nature needs to be considered a human right. There are way too many urban spaces designed with automobiles, income, and furiousness in mind instead of walkability, well-being, and tranquility. For too long, today's cities have been designed with little regard for high-quality green and walkable urban interiors. The problematic situation has recently started to shift and change. However, the green urban design of tomorrow has much more to offer than anyone could have ever thought. Urban forestry of tomorrow is much more than just a bare addition of a few trees here and there. Architecture stands on the verge of a verdant, arborescent revolution. A blooming revolution covered in flower petals and surrounded by the sounds of chirping birds.

Adding a green filter to the ponderation about the architecture of tomorrow is a step in the right direction. Today's cities need to be rethought and reevaluated regarding the presence of trees and other smaller greenery. It is not about planting a tree or two but designing urban interiors with high functional and aesthetic qualities, focusing primarily on forestry. The question is not how to add trees to a design but how to make the trees the design. And the answer is more straightforward than one may think.

Of course, it is just the beginning of the revolution, and urban forestry is still in its infancy. It is just taking a few steps in the right direction, merging cities and forests and thus creating the real urban jungle. For now, the designs can only be visionary because the suggested techniques are costly, there are no facilities to maintain the plants, and there are no bona fide regulations or building codes. However, slowly, stride by stride, architecture will get there one day. And on that day, being in the middle of the verdant revolution will be worth every step of the way. And how to get there? Nothing easier.

ordinariness

2

climatic conditions & needs

Let's start with the basics. Each species has different needs regarding sunlight, water conditions, air quality, habitat requirements, and food demand. Different climate zones provide those. Therewithal, often, urban renovation and expansion areas are stripped of vegetation. Hence, a designer's pre-design proposal should internalize the species native to the designed area and try to stick to them. Or at least to those with the exact/similar requirements. The design basis should be the potential vegetation, i.e., the one with the best opportunities/probability to develop/ thrive under the given conditions and after their transformation. Unmistakably, priority is given to the existing vegetation, and the designer should be particularly meticulous to respect it.

On top of that, it is crucial to consider the appearance of the final design under different weather conditions. On the one hand, everyone would like to experience verdant urban interiors in sunny, pleasing conditions only. However, on the other hand, trees and other plants need water and precipitation to grow. Moreover, day-to-day city life can get seriously overwhelming; there is no reason to make it even duller. Verdant urban interiors can and ought to look astonishing and breathtaking both when it is sunny and when it rains/snows/hails, both in spring and winter.

Moreover, since sunlight is the only source of energy for plants, their entire growth pattern is optimized to make the best possible use of the available light energy. Having known the above, designers ought to watch out for asymmetrical light conditions, as the trunks of trees exposed to light on one side can gradually bend towards the light source.

Another aspect of climatic/weather conditions influencing the growth patterns of trees and other plants is wind. Moreover, designers should consider it as a possible future means of seed transportation. Thanks to (not necessarily) solid windy conditions, planting one tree on the plot could result in the seeds of that same species getting naturally distributed to the broader urban context/ surroundings in the foreseeable future.

3

As a general rule, trees improve space. It is a very bold statement but a very unpretending one. Even the most atrocious, obnoxious urban interior could benefit from adding vegetation. Plant a tree or two, add some vines or flowers, and suddenly, a scary, inhospitable alleyway becomes a cute, edgy café spot. The secret to success is to understand plants: their needs, how they develop, what they benefit from, and their limitations, and design accordingly.

It is all about finding the multidimensional symbiotic relationships between architecture and vegetation. For instance, urban architecture is usually shaped into geometric compositions and interiors. Counter-wise, vegetation has a wild, free-form spirit. Ergo, greenery can be a buffer that soothes and softens the geometry of urban architecture.

On the one hand, trees improve space. However, on the other hand, trees need space. Trees need space to develop, thrive, and grow properly. Planting numerous trees close to one another may result in plants competing and crowding each other out.

space

4

underground connections

Having proved that trees need space, it must be underlined that every tree requires growing space above and below ground to meet its resource needs. There is a need to acknowledge that the vertical axis refers not only to what happens above the ground but also to what continues below the ground.

The above observation opened up the research to the symbiotic relationships below ground. Trees form outstanding symbiotic relationships with mycelium, called mycorrhizae, exchanging nutrients, water, and sugars. However, the aforementioned is not the only typical exchange of resources in the kingdom of plants. Other commonly known symbiotic benefits include, for example, strengthening the immune system, protecting against pathogens, reducing disease risk, alluring pollinators, and keeping away/repelling parasites, insects, and rodents. Plants utilize teamwork to strive. Designers should acknowledge, respect, admire, and get inspired by that.

A similar occurrence, regarding the vertical axis having continuation both above and below ground, occurs concerning the urban heat island effect. Soil mimics the physical properties of the air located above. As the greenhouse effect increases air temperature, trapping it inside the troposphere, the soil temperature below also increases. This particular phenomenon is amplified by the temperature of the urban tissue being visibly higher than the suburban or natural tissue. Urban soil temperature is higher than forest soil temperature.

Another aspect of the importance of soil in the verdant, arborescent design process is its' absorbance. There are multiple flood regulation techniques; however, porous surfaces, allowing water to soak into the ground, seem the easiest and most apparent. It is beneficial both ecologically and aesthetically to avoid paving over urban floors. An addition of a rain garden, a land depression planted with hydrophilous plants where water could stand and create a small pond in a flood emergency, would not hurt. When planning a rain garden, the designer should consider that soil soaks in almost everything like a sponge. Considering all that, it would be advisable not to put any rain gardens in areas of high toxicity danger.

Lastly, soil is a living habitat for various organisms, for instance, moles, earthworms, and toads. Hence, the designer should take into consideration their possible needs.

5

fauna & flora

Forests, just like soil, provide a living habitat for various species. Architecture could also gain the ability mentioned above by introducing the vertical aspect to urban forestry. For example, thanks to the 900 trees and over 20,000 shrubs and smaller plants incorporated into its' elevation, Bosco Verticale can provide a living habitat for various species of birds and insects. If architecture used vertical urban forestry daily, the biodiversity of cities and urbanized areas would increase significantly.

Moreover, flora can be used as an inspiration source, such as biophilia, and as a means of urban design – Baubotanik.

On top of that, it is worth mentioning that the existing greenery is a treasure and should be treated as such, especially the eldest trees. A certain level of respect should be paid to the already existing greenery. After all, it takes a long time to grow a tree. Through the decades, they have seen the good, the bad, and the ugly. As time passes, trees get bigger and stronger, becoming essential, dominant elements of composition.

6

In the realm of verdant urban design, time can be viewed through two lenses: scale and biological life cycle. Plants gain size over time, and architecture stays unchanged. It is essential to realize that early on in the design phase and pick a species that compliments the building now and will continue to do so. Or, if the plant is already present on site, design architecture so that it will accommodate its needs and not disturb it composition-wise.

The biological life cycle lens informs that different plant species sprout and die out at various times of the year. Designers should be highly aware of the above and mix slow-sprouting and fast-sprouting and evergreen species in their designs to make them pleasing to the eye throughout the year. Designers should also play around with various textures and mesmerizing shapes.

Another take on time is reconsidering how long it takes to grow a tree and how easy it has become to take advantage of it. A single-family house contains 90 m3 of timber, corresponding to 3000 m2 of forest. A good contractor can erect a brand-new wooden house in a matter of weeks and a great one – in a matter of days. However, even considering the perfect environment and conditions, it takes 80 years to grow a tree, let alone a whole forest - food for thought.

time

7

trees in buildings vs. buildings in trees

People used to live among nature daily. As the years went by, we abandoned nature's company and, tempted by advancement, industry, and technology, adjourned to cities. At the moment, we long lush and luscious greenery. Hence, we put trees in buildings, incorporating them on a smaller scale – adding one or two in the courtyard or on the roof, or a more extensive scale – placing them on balconies all over the elevation. We put buildings in trees as well. Who hasn't heard about tree houses? The point is that we long for greenery and forestry in our daily lives. There is a longing for change. There is a longing for a paradigm shift where we join buildings and trees or trees and buildings. Buildingtree? Treelding? Architree? Treetecture?

Baubotanik is the answer to the question. It is a fusion of a building and a tree, a tree and a building. New tree-related research fields, such as biotecture or tree statics, have developed thanks to Baubotanik.

Baubotanik is a real bundle of mischief. At first, it influences and endangers the load-bearing capacity of the building. After all, it is an added „unnecessary" load. However, with tree trunks getting thicker and thicker, more robust, their load-bearing capacity increases, and the building can „rest."

Other alternative methods of green architecture also positively influence how our cities look and function, such as mycelium blocks, rammed earth, hempcrete, and many more. And they are highly encouraged! The point is to avoid becoming intoxicated on tree urban design and greenscamming, but rather to take a step back and reconsider urban design on both micro- and macro-scale: to think about the more prominent „whys" and „hows" of the greener urban design of tomorrow.

regeneration & wound healing

Baubotanik derives, to a large extent, from inosculation, a perfectly natural phenomenon of roots, trunks, or branches of two (or more) trees fusing and growing together. A lot of tree species are commonly known to do that, among other things, apple, almond, ash, beech, chestnut, elm, ficus, grape, hazelnut, hornbeam, linden, maple, spruce, olive, peach, pear, privet, sycamore, and willow. Baubotanik takes inosculation and imitates it artificially through a graft-like process to manicure trees into artificially manufactured structures.

In Baubotanik, buildings-trees grow their construction, maintain and self-repair it. Imagine a building that would never require restoration work! A genuine paradigm shift!

9

Firstly, don't try to be God. There are limits to tree growth, and that's natural. So, don't try to change that, whether with Baubotanik or not.

Another aspect worth mentioning when considering scale is time. The play between the building scale and the tree scale is an enjoyable one. There is no universal rule or guideline on which building sizes go well with which tree sizes (or the other way round). The designer ought to feel the urban interior and accommodate its needs. On top of that, as mentioned earlier, it is imperative to consider time in the bigger picture. The designer should remember that trees (and other plants) will inevitably grow and change in size, thus influencing (if not changing completely) the reception of the said urban interior.

scale

10

Designers must conduct their designs from the human perspective, not only considering and merely glimpsing at plan and section drawings. The „muggle" urban interior users/spectators seldom experience them from those irrational perspectives/angles. They feel the space from the ground level, looking forward, which is why composition is that important. And if something feels good from the human perspective, it is OK that it looks next to irrational in the plan drawing. Who cares?

Above and beyond, the added greenery should enhance and improve the composition, not go against it. Feel the space, feel its requirements, feel its needs. Trees can be composed based on contrast or similarity. Contrast and similarity can be based on foliage, texture, shape, size, or color. And all of the items mentioned above can be layered, creating truly unique and inimitable compositions. Have you ever heard of Fallingwater? It is a perfect example of treemproving – improving the sensu lato quality of space reception embracing trees. Frank Lloyd Wright was a master of treemproving and composing nature into the design (or should we say composing design into nature?).

Another compelling aspect of composition is how it reacts to light. Shapes and sizes are the most important in views against the light. In other views, textures and colors play a significant role.

composition

11

Color is hugely tightly correlated to shade, shadow, and texture. Different taints appear in various ways, whether experienced in light or shadow, on a smooth or coarse plane, and in contrast to other taints.

The designer should also remember that, in urban composition, colors fade away into the distance. What seems very vivid close at hand looks washed out at a more significant distance. Urban planners can easily fake apparent changes in the distance between the observer and the elements of urban composition. Using more yellows, oranges, and reds guarantees an apparent zooming in (pretending that an object is closer than it is). Greens and blues aid an apparent zooming out (pretending that an object is further away than it is).

color

12

Noise can get overwhelming in the busy urban corridors. Ditto; the urban heat island effect can be a real pain in the neck. Greenery (trees, in particular) can be a highly effective element of noise and temperature reduction when used in specific manners. They are the most effective when utilized as a compact partition, a dense cluster. They can be placed longitudinally or circularly. On top of that, designers ought to remember that leaf loss reduces muffling by 40-60%. Therefore, both deciduous and evergreen trees should be included in treemproving projects.

All in all, trees solve almost all big city life problems!

noise & temperature

replanning/replanting żelazna

figure 11.1. żelazna street - photo 1.

figure 11.2. żelazna street - photo 2.

figure 11.3. żelazna street - photo 3.

figure 11.4. żelazna street - photo 4.

figure 11.5. żelazna street - photo 5.

figure 11.6. żelazna street - photo 6.

figure 11.7. żelazna street - photo 7.

figure 11.8. żelazna street - photo 8.

figure 11.9. żelazna street - photo 9.

figure 11.10. żelazna street - photo 10.

figure 11.11. żelazna street - photo 11.

figure 11.12. żelazna - collage - present.

figure 11.13. pessimist design execution.

figure 11.14. Bosco Verticale Warsaw.

figure 11.16. restoration.

The last part of the thesis investigation was a case study conceptual design proposal - Replanning/Replanting Żelazna. It aimed at proving that vertical urban forestry could thrive even in a city as complex as Warsaw. It explored the possibility of turning Żelazna Street into a globally known site, a tourist attraction. The exemplary case study design proposal presupposed eight steps to achieve the abovementioned goal.

STEP 1 Bosco Verticale Warsaw

Alongside the urban corridor, the design established two plots to be developed into the Bosco Verticale Warsaw complex. One of the sites, Żelazna 66a, would become a residential building, and the other one, Żelazna 87a, would take a vertical parking lot function. Both of them would function as plant nurseries. Every 5 to 10 years, the trees on the elevations would be replanted alongside the urban corridor, and the empty balconies-pots would be replaced with new seedlings. That way, the structural stability of the building would not be endangered as the trees develop and grow.

STEP 2 Baubotanik

Five buildings favored the Baubotanik potential the most during the design development process. Overall, Żelazna Street has a funky, squiggly frontage edge, so it would undoubtedly benefit from getting reorganized in a little less chaotic manner. Thanks to Baubotanik, two buildings, Żelazna 82 and Chłodna 22, would be given a facade shift by getting a significant terrace extension.

The three remaining buildings, Chłodna 15, Żelazna 58/62, and Żelazna 71, would be given a Baubotanik transformation for aesthetic reasons.

STEP 3 restoration

The buildings in need, Żelazna 66b and Żelazna 64, would be completely restored due to historic preservation, safety, and aesthetics. The remaining buildings needing a make-over would get slight renovation works such as painting, minor replacements, or insulation enhancement.

STEP 4 tissue transformation

Through urban corridor analysis, it became evident that the Żelazna Street section between Solidarności Avenue and Grzybowska Street tends to fluctuate in width - sometimes there is one traffic lane in each direction, and sometimes there are two, primarily upon a crossing. Indeed, it is a convenient solution during rush hour as more cars can fit on the road. However, simultaneously, it encourages dangerous situations on the road at any other time of the day. As an attempt to systematize and control the fluctuating traffic lane situation, only one lane in each direction would be provided. The saved space could be utilized as a wide pedestrian passage and a bicycle lane, prioritizing pedestrian and cyclist movement over car drivers. On top of that, the pedestrian space would be set as the primary one, influencing the car lane to fluctuate in level upon a crossing.

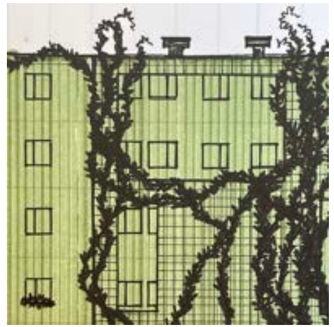


figure 11.15. Baubotanik.

figure 11.17. tissue transformation.

figure 11.18. optimistic design execution.

figure 11.19. Jewish Ghetto Memorial.

figure 11.21. trees.

STEP 5 Jewish Ghetto Memorial Park

A significant chunk of Żelazna Street used to be a part of the Jewish Ghetto. One of the gates to the Jewish Ghetto used to be located at the Żelazna - Grzybowska intersection. The remnants of the gate could do as the Jewish Ghetto Memorial Park. It would be a living monument, a romantic park, overgrown with nature, reminding the users of the urban corridor about the Holocaust tragedy. The greenery would metaphorically speak about history.

STEP 6 parking lots

As the street tissue transformation would guarantee extensive pedestrian space, it would eliminate most parking spots simultaneously. New parking spots would be added to make up for the eliminated ones. As mentioned above, one parking lot would be part of the Bosco Verticale Warsaw complex, and two more would be placed underground - underneath the two most extensive treed spaces.

STEP 7 trees

As simple as that, the design presupposed adding 407 free-standing trees.

STEP 8 endowment program

To turn Żelazna Street into a green tourist attraction, a street-wide endowment program towards private greenery and forestry visible from the street would be introduced. It would encourage the neighborhood's inhabitants to participate in the project and extend the urban tree canopy even more.

figure 11.20. parking lots.

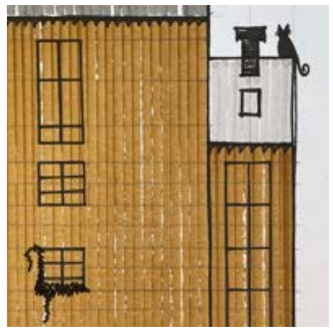


figure 11.22. endowment program.

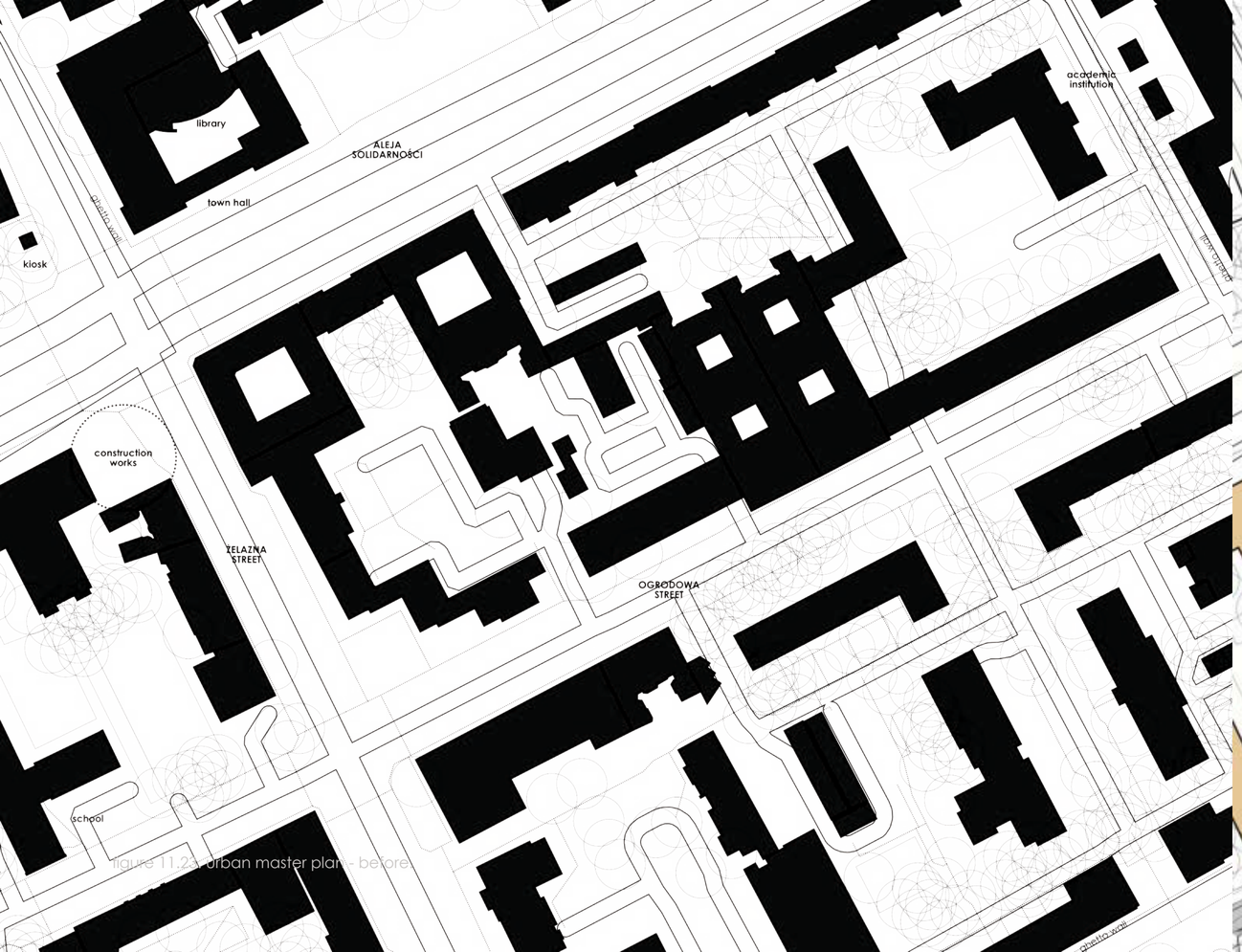


figure 11.23 urban master plan - before

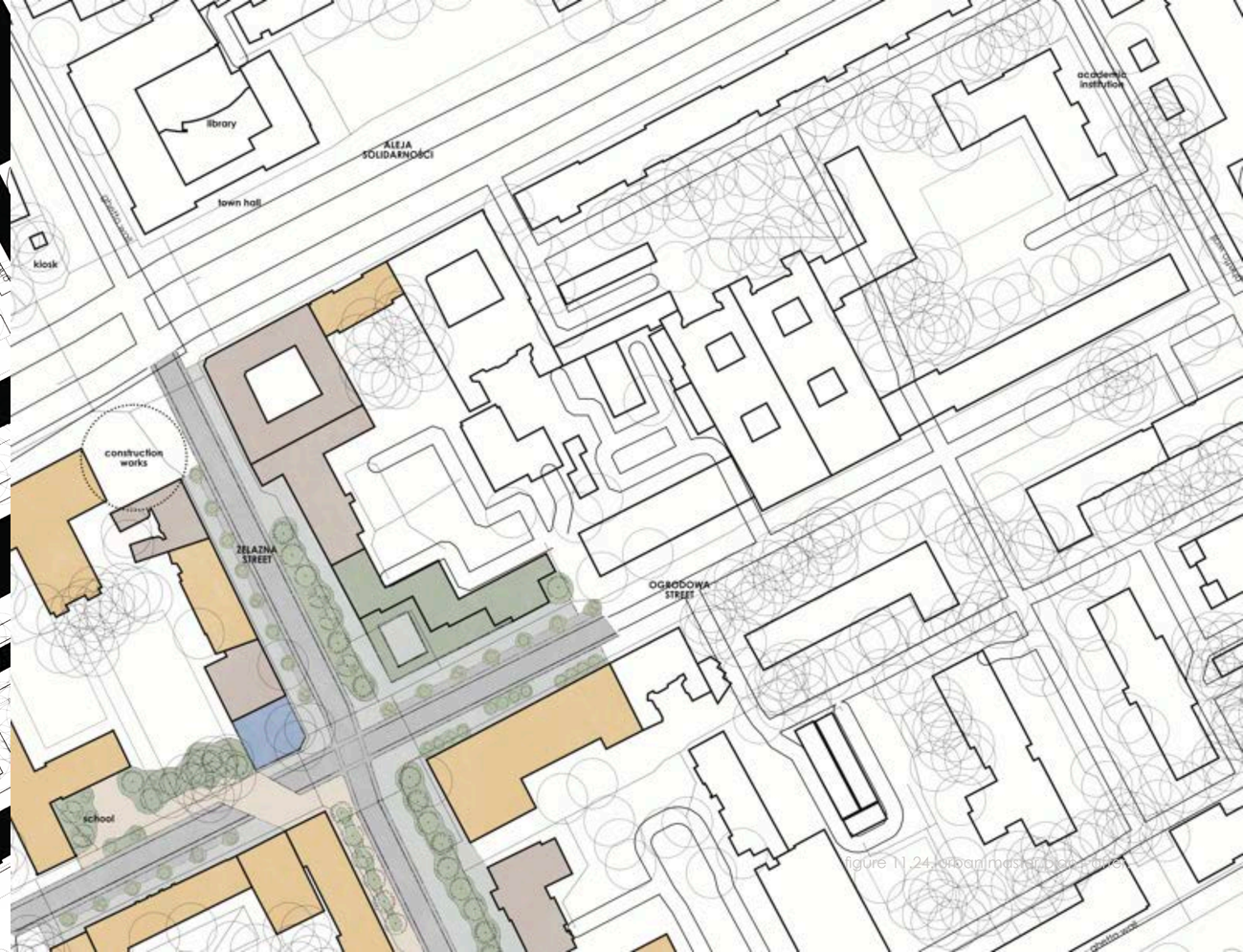


figure 11.24 urban master plan - after

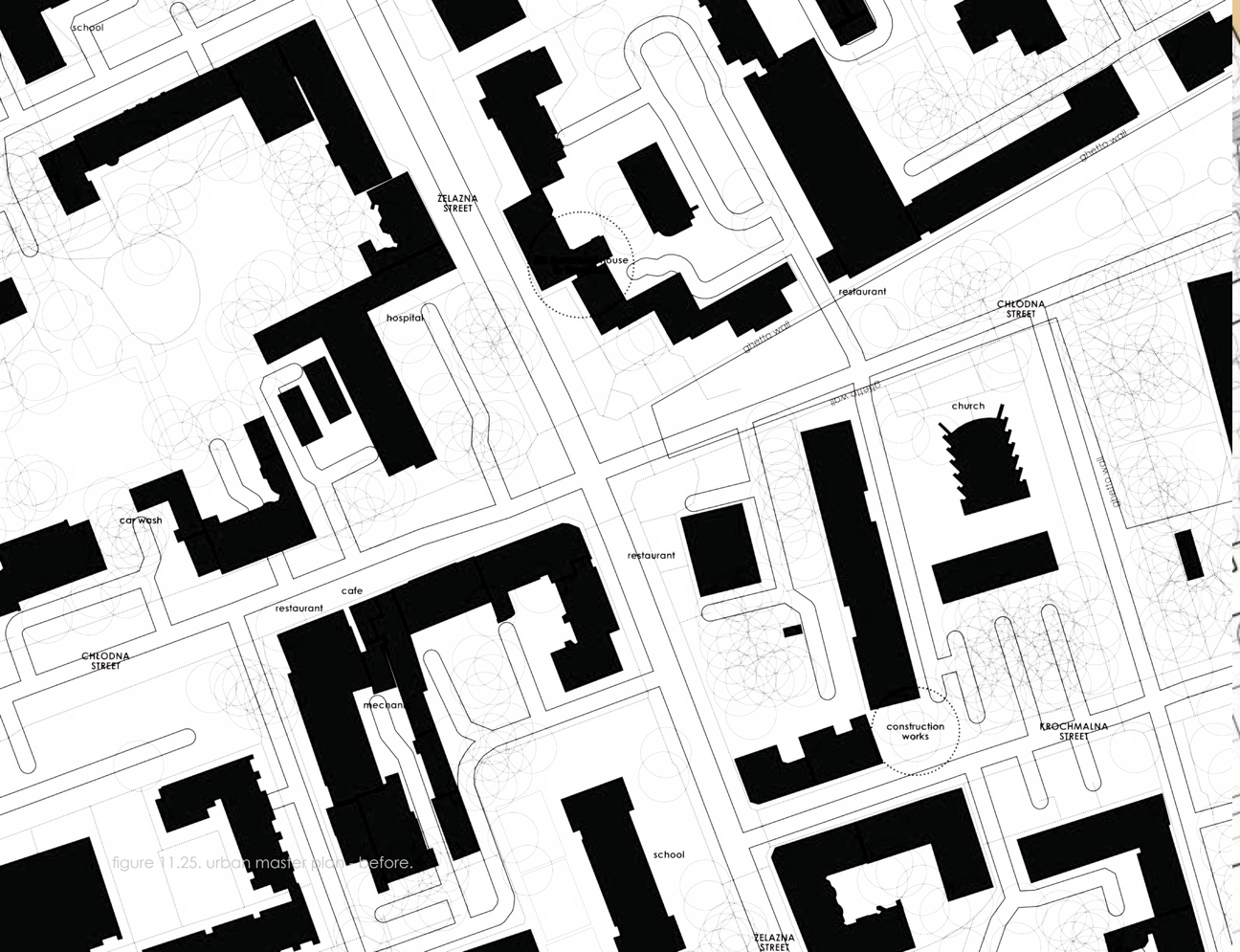
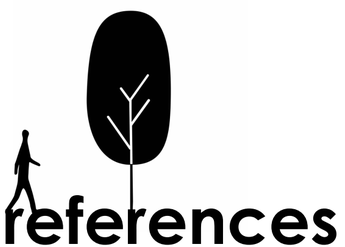


figure 11.25. urban master plan - before.

figure 11.26. urban master plan - after.

figure 11.27. urban master plan - before.

figure 11.28. urban master plan - after.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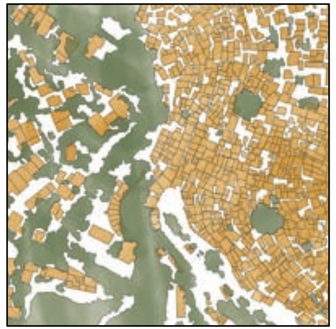

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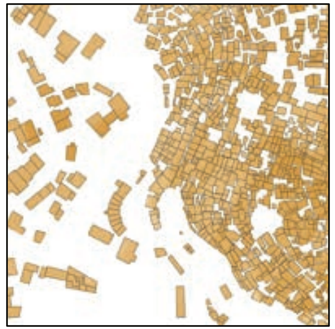

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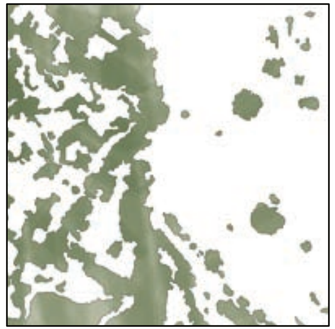

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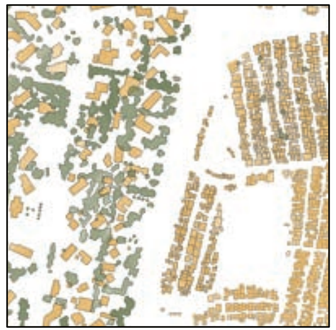

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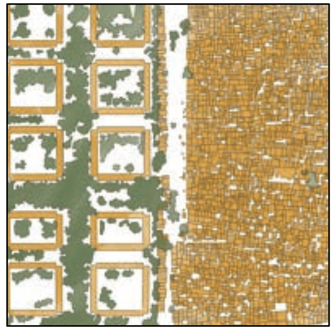

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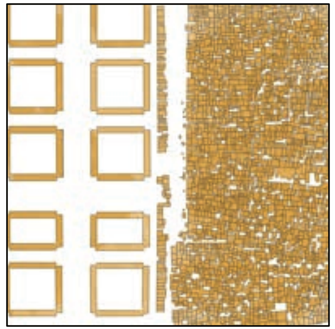

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appendix b

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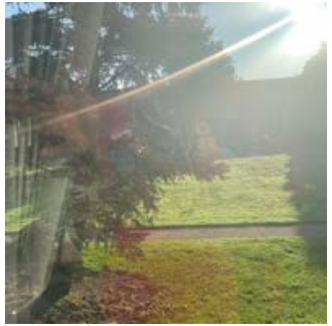

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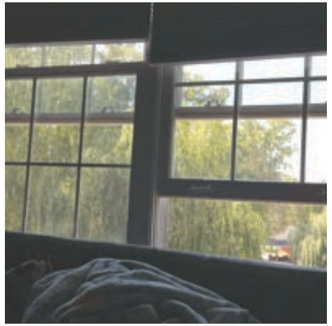

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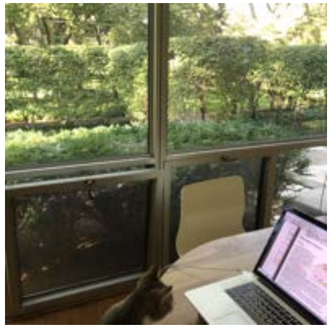

figure 7.10. Georgia's photograph.

figure 7.11. Harper's photograph.

Ashley: "I took some photos of different views that caught my eye. This one is a view from my apartment. It is from my bedroom, but I only see that if I walk up to the window because the windows are pretty high on the wall."

Brianna: "The reflections are bad, but this is the outside of my apartment window this morning. I see other apartment buildings and our dog park. I wish the buildings were more appealing. But I like the tree and how the sun bleeds into my room in the morning. I enjoy seeing people play with their dogs and enjoying life."

Charles: "I love my window in my room. It is facing towards the west at the highest point in the house. I get a beautiful view of my backyard willow tree and amazing sunset views. I also see my little lake in the back, which is always full of a rich ecosystem of various animals and critters. I have the window open to get some fresh air wind in the space."

David: "Alternatively, my home office opens up to a garden view that is mentally relaxing and soothing — a mental break during those stressful deadlines."

Emma: "It is the view from my bedroom. I wouldn't say I like that there's no view, and I barely have any privacy with the neighbors' window on the other side. I would love it if there were no house, but one thing I would change is to have the fence higher and put a green wall."

Georgia: "I prefer to work in my dining room rather than my university office for the natural view, the easily operable windows, and the lack of traffic noise. I often have my front door open as well. I also enjoy waking up to the view of nature every day."

Harper: "The view is from my bedroom towards my backyard. We live surrounded by trees. :)"

Isa: "I like how everything looks here! I like the green and the trees; however, I want to add flowers or bushes to my lawn to make it more private and colorful!"

Julia: "This is the view from my desk at school; I never really paid attention to it until asked. The picture speaks for itself. It is a parking lot, and I cannot even park there to watch my vehicle. I am not bothered by the view because it is a temporary working space, and I do not spend much time there. In any other case, I would be concerned."

figure 7.8. David's photograph.

figure 7.12. Isa's photograph.

figure 7.13. Julia's photograph.