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Greening Urban Spaces: Harnessing Houseplants to Reclaim Ecosystem Services

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Abstract

This paper addresses how there is a lack of green spaces and access to nature within big cities, and thus, we lose the ecosystem services provided naturally by plants, such as clean air and mental well-being. By filling an interior space with houseplants, some of these ecosystem services can be brought and utilized indoors. Chapter one describes the benefits of plant ecosystem services on human life and how human alteration, such as urbanization and the creation of large cities, diminishes the availability and accessibility of these natural systems. Chapter two examines the environmental history of human relationships with plants. For centuries, humans have connected with and used plants as a form of livelihood, and thus, many people even view plants as fellow living beings. The access to many of these natural ecosystem services plants provide has been lost due to human alterations over time. Chapter three discusses environmental health and psychology and how plants positively alter mental health, such as the benefits of stress relief, aesthetics, and leisure. This chapter also delves into plants' effects on human health, such as the benefits of growing one's own food, plants as medicine, the impact plants make on indoor and outdoor environments like air quality, and how these services can be recreated indoors. Chapter four introduces environmental design and architecture and how plant aesthetics can go beyond basic design so plants can become fully integrated into our lives. Finally, chapter five proposes initiatives that act upon the accessibility and awareness of these disciplines. It addresses solutions such as increased accessibility and availability to houseplants, along with solutions for design like rooftop/community gardens and long-term resolutions related to education.

Keywords: ecosystem services, urbanization, houseplants, environment, health, psychology, environmental history, education, design, availability

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Introduction: An Urban Playground

Imagine you are taking a walk on a nearby trail. Imagine the plants you see and the animals that are stirring within them. Envision the earth below your feet as you pick them up and set them back down, the smells of the air wisping around you, maybe even the sounds of water rushing nearby. How does this make you feel? Are you excited to be surrounded by nature? Perhaps your body is feeling calm, and the worries of the day are slipping away. Your breath might feel light and your body warm. Now that you have entered this place, I want you to think about how you got there. Was it a quick drive? Maybe you hopped on a train for an hour? Or perhaps you stepped into your backyard? Consider yourself lucky if all it took to get to such a place was only seconds or minutes away. While this might be the case for some, "Today, some 56% of the world's population – 4.4 billion inhabitants – live in cities,"[1] and many of these people do not have this luxury. With this number expected to double by 2050, almost seven out of ten people will live in urban settings.[2]

Now that you have pictured what this would look like in today's world, imagine what you would need to do to be surrounded by nature in the 18th century. Much easier, isn't it? Historically, humans and plants have lived side by side, utilizing each other for their many resources. Whether for health benefits, leisure, or even something as simple as shade to sit under, in today's times, within concrete jungles, we lose this ability to directly coincide with our natural counterparts. The inaccessibility of plants is a vast topic that covers more than just access to public green spaces. This can include what it looks like when you look out your window, the price of plants at the local nursery or bodega, or even the access to knowledge about plants.

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[1] "Understanding Poverty: Urban Development Overview," World Bank, https://www.worldbank.org/en/topic/urbandevelopment/overview.
[2] Ibid.

Although the preservation of green spaces within cities has become more prominent in recent years, there are still ways that we as individuals can co-exist and bring nature into our own personal spaces.

This brings us to houseplants. Perhaps you have a sad plant on your coffee table begging to be watered, or a house full of fake plants, or possibly you are like me and can't find any more space in your shoebox apartment to fit another plant, and yet you still find a way. Regardless of how green your thumb may or may not be, I suggest getting prepared to find a way to incorporate these living beings into your home. There are many different types of house plants that range from big to small, edible to inedible, and easy to care for versus more dramatic than a husky, but almost all (other than the manufactured plastic ones) will improve your surroundings and your lifestyle.

In this paper, I will delve into what natural ecosystem services plants provide for us, how this was always a part of human life, and how this has changed since the start of the Industrial Revolution and the booming growth of cities. In chapter two, I will also expand on how humans have used plants for protection, medicine, food, and shelter and how differing groups of people may view plants differently. In chapter three, I will address how houseplants positively impact mental health and how plants have been used for medicine. I will also tackle the tremendous amount of physical health benefits plants have, along with the possibilities of growing one's food. In chapter four, I will introduce environmental design ideas like green roofs, living walls, and biophilic design. In collaboration with this, in chapter five, I will pose solutions to the direct and indirect inaccessibility of plants within urban settings. Plants, specifically houseplants, will be the key to connecting with nature within large urban environments.

Chapter 1: What Do Plants Actually Do for Us?

Many of us go on with our lives without appreciating the world around us and the earth we are able to call home. So caught up in the busy hustle of our lives, we take for granted the land and resources we get for free. With over half of the population living within cities, many are concerned with paying the rent or what will be for their next meal but fail to consider what occurs in the background of our lives that allows for our days to continue on. The walk to the metro on the way to work as we dash under trees that provide us shade when we work up a sweat to catch the train, or the bee getting pollen from the flower bed planted next to the lot where we park our car; all things we are too busy to acknowledge are constantly working all around us. Nature provides for us so we can afford to do the things we love. Hidden in sidewalk cracks and parking lots, these plants are providing us with free services. While it may be easier to acknowledge these services if you are surrounded by nature on vacation or if you live in a rural or suburban area, regardless, these plants do more for us than most of us realize. Even for those already sharing their homes with plants, take a minute to thank them and show them a little love because these living creatures are helping to bring the natural world inside.

Ecosystem Services of Plants in the Wild. Ecosystem services are provided by many different species of plants, animals, microorganisms, and more that co-exist within an ecosystem. Ecosystems can vary from biome to biome and even include the nonliving matter within these biomes. To take this one step further, each unique ecosystem provides people with a wide range of benefits. These benefits are often sorted into four categories: provisioning, regulating, cultural, and supporting services. Provisioning services are things we gain directly from the earth, such as water, food, and raw materials like wood. Regulating services can often be overlooked but make a significant impact if the ecosystems providing them are destroyed. Flood control, pollination,

air and water quality, and climate control are all forms of regulating services. Swimming in the ocean, skiing down a mountain, and hiking through a rainforest are cultural services as they provide humans with leisure, aesthetic, and spiritual activities. Supporting services are what allow these other functions to thrive. The oxygen cycle, photosynthesis, nutrient-rich soil, and the water cycle are some examples of supporting services. Though supporting services do not always directly affect humans, without them, we would not have anything else.

The ecosystem does far more than just provide for the plants and animals that call it home. The ecosystem greatly matters for human health, which I will discuss in chapter three. It can be challenging to address the direct changes linked to human health that occur from ecosystem change because there are often many factors at play. However, for a baseline, humans need the collaboration of all ecosystem services for food, water, shelter, clean air, and a consistent climate.[3] Of course, life wouldn't be possible without these essential services, but many other services are also working to provide the best outcomes for human health. Direct health impacts like floods, heatwaves, water shortages, etc., are easier to quantify. However, indirect health impacts like reduced food yield, population displacement, and depletion of natural medicines can result from human interference and change on these services.[4] At the rate humans are adapting to fulfill their needs, if we continue down this path, we could damage the earth to a point that could create irreversible destruction. However, we can make changes that allow human populations to adapt and avoid disease and harm caused by ecosystem disturbance. Preventing, limiting, and managing our effects on the environment can help us avoid this as a preemptive

[3] Carlos Corvalan, et al., *Millennium Ecosystem Assessment. Ecosystems and Human-Wellbeing: Health Synthesis* (World Health Organization Press, 2005): 1, https://www.millenniumassessment.org/documents/document.357.aspx.pdf.
[4] Ibid., 2.

measure for the future, in collaboration with making changes to protect people from the damage that has already occurred.[5]

The combination of the four ecosystem services allow humans to live on this planet without having added costs. For example, we are already starting to see the effects of the loss of bees and how, without natural pollinators, there could come a time when crops will need to be pollinated by hand, leading to significant price increases for food. One of the most prominent reasons for the loss of ecosystem services is due to urbanization and industrialization. Many of the environmental issues we are facing go hand in hand. As we continue to grow as a population, we need to continue to make changes and alter the world around us. Our population growth is exponential, and we have added almost 6 billion people in the last 100 years. To adapt to this and to allow for this growth, we have created technology and ideas to feed and provide resources for all these people. As I will address in chapter two, the Industrial and Green Revolutions have been major drivers for this population growth. They also happen to be the main push for urbanization. To continue to meet our needs, we have begun to destroy many of our ecosystem services through climate change, global warming, deforestation, desertification, etc., and unfortunately, this can also affect people and other living things unequally. Though we would be able to find ways around some "environmental changes by culture and technology, [the human race] is fundamentally dependent on the flow of ecosystem services."[6]

Nature Vs. Urban Infrastructure. With the rapid growth of urbanization, land use must be altered from natural environments to account for the increase in needed infrastructure. A study on the effects of land use in Binhai, China, a coastal city, acknowledges the strain that new land use

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[5] Corvalan, *Health Synthesis,* 8.
[6] Walter V Reid et al., *Millennium Ecosystem Assessment. Ecosystems and Human Well-Being Synthesis* (Island Press, 2005): V, http://www.millenniumassessment.org/documents/document.356.aspx.pdf.

transitions are creating. This transition has caused a 26% decrease in environmental service values over the past 25 years.[7] Although this is just one case, this study could be recreated in most of the world's growing cities, which would probably result in a similar impact. Along with this, the addition of new infrastructure also limits direct light, both on the city streets and light that shines through windows. Lack of direct sunlight inhibits plants from growing to their full potential, which limits their ability to perform their essential services. The loss of biodiversity also becomes a concern due to a lack of space and light. When plants aren't able to live in an ecosystem with an array of species, they will not properly germinate with other plants. Biodiversity can be measured both within a species and between different species and the ecosystem. The lack of inner species biodiversity can lead to susceptibility to disease and lack of resiliency to change, which can eventually result in extinction and impact other animals in these ecosystems. As I will continue to address throughout the paper, many urban changes lead to the loss of biodiversity. Biodiversity loss can, moreover, be a concern on a global level and create issues like vulnerability to natural disasters and disease, which can then cause further problems. Poor food and energy security, health risks, loss of clean water, damage to cultural services like social relations, and even the decline of freedom to make choices, as variety will decrease, are all possible consequences.[8]

However, studies show that the effects of urbanization on plants vary from city to city. Location, climate, size, geography, history, economics, culture, and land use impact urbanization in different ways, and thus the impact on green spaces and plants. We can categorize land into

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[7] Hualou Long et al., "Effects of Land Use Transitions Due to Rapid Urbanization on Ecosystem Services: Implications for Urban Planning in the New Developing Area of China," *Habitat International* 44, (October 2014): 539, https://doi.org/10.1016/j.habitatint.2014.10.011.

[8] Anantha Kumar Duraiappah and Shahid Naeem, *Millennium Ecosystem Assessment. Ecosystems and Human Well-Being: Biodiversity Synthesis* (World Resources Institute, 2005): 30-31, https://www.millenniumassessment.org/documents/document.354.aspx.pdf.

four distinct groups: urban, suburban, rural, and natural. Urban spaces are places with dense high-rise buildings and large residential areas.[9] Suburban areas are classified as places with relatively high vegetation cover and low-rise homes. Rural areas consist of low-density housing and commonly are areas containing farmland. Natural spaces are considered areas with little to no human alteration.[10] By comparing these areas, it is apparent that urban spaces are significantly lower in plant diversity and native plant richness; it is true, however, as mentioned, that the effects of urbanization also affect different types of plants inversely.[11] Regardless, these low amounts of diversity then cause adverse impacts on other forms of biodiversity and animal life.

A reason for the decline in plant diversity in urban areas often results from the need to clear land for infrastructure use. In many places, this is achieved, but with the consequence of deforestation. Within natural and rural areas, deforestation often occurs to clear land for farming and agriculture purposes, but deforestation and fragmentation also occur when clearing land for urban developments. The consequences of deforestation are vast: loss of carbon sinks, which take carbon and pollutants out of the atmosphere, loss of biodiversity and habitats, soil erosion, and negative changes to water and water quality. Fragmentation, which involves breaking forests into smaller sections, also has similar consequences. The Amazon rainforest, which is partly located in the Manaus Metropolitan region in Brazil, has experienced extreme deforestation due to the impacts of urbanization. In 1950, 36% of Brazil's population lived in urban areas; this percentage is supposed to reach 90% by 2050.[12] As this move to urban settings continues to

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[9] Youchen Hou et al., "Negative effects of urbanization on plants: A global meta-analysis," *Ecology and evolution* 13, (March 2023): 2, doi:10.1002/ece3.9894.
[10] Ibid., 2.
[11] Ibid., 4.
[12] Yara L.F. Santos et al., "Amazon deforestation and urban expansion: Simulating future growth in the Manaus Metropolitan Region, Brazil," *Journal of Environmental Management* 304 (2022): 1, https://doi.org/10.1016/j.jenvman.2021.114279.

increase, this region could see an increase of over 100% of their deforested areas.[13] This example is important because the Amazon rainforest is the largest tropical rainforest in the world. When situations like this continue to occur all over the world, we are speeding up the loss of our ecosystem services.

Another effect of adding new infrastructure is that the value of existing land in cities skyrockets. In New York City, Central Park provides an abundance of green space for its public, but the price that must be paid to be in close vicinity of Central Park is unattainable for most residents. Issues like money are vital regarding the accessibility of nature in urban environments. Without proper economic status, the cost of living in view or having easy access to nature presents a significant barrier. Within cities, if someone is in a higher financial situation, they can move to greener and cleaner neighborhoods, which further affects the disproportion of accessibility to not only nature but also ecosystem services such as improved air quality. I will expand upon and address solutions for this barrier in chapters three and five.

The availability of nurseries and places to purchase plants is another restricting factor related to economic status. Within these wealthier neighborhoods, there are more likely to be shops to buy plants, as they are often considered a luxury. Even if there are ways to access these shops, the price of the plants themselves usually prevents people from acquiring them. This cause-and-effect chain of economic status is rooted in the rapid development of cities and the strain on limited land. Another factor that limits access to plants in cities can occur within many unique living and working settings. For example, students who live in dorm rooms or people who must constantly move for jobs or housing market changes, it becomes difficult to move with and keep plants alive during the moving process. This can also be seen within spaces such as

[13] Santos, “Amazon deforestation and urban expansion,” 10.

office buildings or hospitals. In my subsequent chapters, I will address the effects of plants in areas such as these and how they can aid under challenging circumstances.

Houseplant Heroes. In more ways than one, it has been proven that houseplants help the ecosystems we build inside our homes. Throughout this paper, I will discuss many obstacles and reasons for ecosystem service loss. It can be challenging to access the benefits of ecosystem services for several different reasons, and thus unfortunately, not as many people take advantage of them. In chapter five, I will propose solutions that tackle design, availability, accessibility, public use, and education. While the want for and hobby of houseplants seems to be rising in recent years, as I will reference in chapter two, still, many people are discouraged from forming biocentric spaces. Biocentrism is the idea that all living things hold equal moral/intrinsic value, and having this focus within a home or workspace brings many benefits. In the next chapter, I will argue that Westernized culture has led us away from biocentric views, but I will also incorporate beliefs and ideas from a diverse range of thought that view plant life differently.

Depending on the biome, different species of plants provide various ecosystem services. One of the most common ecosystem services that many people take for granted every day is the provisioning service of food. Though simple on the surface, if we were to lose or damage the supporting services plants need to survive, such as the nutrient and water cycle and photosynthesis, this provisioning service could be at a much smaller capacity than it is now. In chapters three and four, I will expand upon this provisioning service provided by plants when I address how, as individuals, we can have plants in our homes that provide food along with other benefits. Another prominent provisioning service plants provide is medicine. Like food, plants have been used as medicine for centuries, along with shelter and other native uses which fall

under the idea of ethnobotany. Within chapters two and three, I will expand upon ethnobotany; the origins of native plants being used as things like medicine, shelter, and food.

As we make many changes to our lifestyles, our access to and availability of food is also changing. Urban agriculture is increasing in popularity as it brings positive variation and addition of green space, pollution mitigation, and community and economic advantages. As I will mention in chapters three, four, and five, urban agriculture brings many benefits to our cities and can come in many forms for personal and public use. Integrating a variety of disciplines like design, education, and physical and mental health, urban agriculture promotes our ecosystem services through rapid urbanization. Since we are losing our ecosystem services around the globe, it is vital to introduce new and improved sustainable ideas like urban agriculture into our central settings and lifestyles. Thinking towards the future, as mentioned, if we continue down the path of destroying many of our natural ecosystem services, more problems will arise, like food insecurity. While an autonomous city would be hard to construct, the push of urban agriculture can urge cities toward becoming resilient. While food is not the only factor, "a resilient city can better absorb various shocks and stresses to which they may be exposed, including world food supply problems."[14] Similar to the way we need biodiversity to avoid vulnerability, we need to foster resiliency, and plants are one route to doing so.

Commonly, when thinking about what plants provide, air quality improvement is another significant topic that comes to mind. Air quality regulation falls under regulating services. Taking in CO_2 and releasing oxygen through photosynthesis, plants filter out air pollutants and improve the air quality around us. This is especially important in large cities where air pollution

[14] Robert L France, *Integrated Urban Agriculture: Precedents, Practices, Prospects*, (Green Frigate Books, 2016): 259, https://search-ebscohost-com.avoserv2.library.fordham.edu/login.aspx?direct=true&db=e000xna&AN=1295148&site=eds-live.

is much more significant, and thus, people are at higher risk of health issues. Air pollution is rising due to human interference. Urbanization and increased carbon emissions from transportation, manufacturing industries, and food production are all significant causes. Within urban areas, intense heating is also an issue due to the lack of absorption from green spaces like grasses and trees. I will discuss the importance of environmental health in chapter three, which also discusses mental health and wellness. I will address these problems in context with design ideas and solutions in chapters four and five, including green roofs and rooftop gardens.

To introduce the topic, a study on how houseplants help improve indoor air quality through photosynthesis via the reduction of ozone was conducted by using three common, low-maintenance houseplants: the snake plant, spider plant, and golden pothos. Within all three test chambers, the "ozone depletion rates were higher within chambers that contained plants than within control chambers without plants."[15] While this also occurs outdoors in nature and is an essential regulating ecosystem service, indoor ozone reduction can support the relief of respiratory illnesses. In tandem with this, plants can also increase the relative humidity in the air and decrease dust buildup to both relax people and decrease potential allergens from dust.[16] In large cities, there already is a reduced amount of plants filtering out air pollutants than there would be in rural areas, and combined with this, the number of people that live and emit pollutants in such concentrated regions makes this pollution even worse. It is crucial to address outdoor pollution as it can quickly and easily enter inside and remain trapped indoors. As

[15] Heather L Papinchak et al., "Effectiveness of Houseplants in Reducing the Indoor Air Pollutant Ozone," *HortTechnology* 19, (January 2009): 286, https://doi.org/10.21273/HORTTECH.19.2.286.
[16] Kent D Kobayashi et al., "Using Houseplants To Clean Indoor Air," *Cooperative Extension Service*, (December 2007): 1, https://scholarspace.manoa.hawaii.edu/server/api/core/bitstreams/0f325391-d69d-457c-86cf-62423d53430e/content.

mentioned, I will expand upon this in detail in chapter three, but this is just the tip of the iceberg as to what houseplants can do for us.

Also, within chapter three, where we will also delve into mental health and environmental psychology, one of the primary ecosystem services that benefits mental health falls under the category of cultural services. The aesthetics of outdoor plants in large cities comes at a significant cost because this land is often utilized for other reasons, so for the many who are not privileged to live by nature within cities, we can try to bring plant aesthetics indoors. Although I do not devote a chapter to environmental justice, this topic will be addressed primarily because poor physical and mental health often occurs in children and adults who are disproportionally affected within urban settings. However, more than just within homes, plants and connections with natural environments affect people's mental well-being in schools, offices, hospitals, etc., and the loss of ecosystem services often increases in areas of low socio-economic status or in marginalized communities. I will continue to address why it is key to break this barrier.

In chapter four, I will detail the importance of environmental and biophilic design and how we can find ways to bring nature into our indoor spaces to receive cultural services. These ideas and the significance of green roofs and living walls in design fosters well-being and community which plays upon all other benefits of plants in natural and artificial, urbanized settings. While these few ideas just touch the surface of the amount of ecosystem services plants provide, I will go into further detail on these services and their loss in the following chapters.

Bringing together the ecosystem services that plants provide in the wild, combined with the limiting factors that we put on plants because of the growth in urbanization, gives us a deeper perspective on why plants can be so beneficial to human beings. When we find accessible ways

to bring these outside services into our homes, we can try to regain what is slowly being lost from urbanization.

Chapter 2: Origins of Humans' Relations with Plants

Plants and humans have grown beside each other since the start of time, relying on one another for resources and survival. As the world around us changes and humans change the world, this relationship must also adapt. The study of this is called environmental history, the relationship of humans and nature over changing times. Many environmental historians say these two things are so connected that "human societies and individuals are interrelated with the environment in mutual change [which] deserves constant recognition in the writing of history."[17] Utilizing environmental history, can help find the causes and effects of the ecological problems we are currently dealing with.

Environmental history allows us to investigate past relations of how humans have co-existed with plants and how these plants have improved people's quality of life. This can date back so far that, even in a time when the science of how plants aid us wasn't available, humans could find positives within nature so much as to treat plants as living beings. This chapter will also look at how urbanization over time has led to the decline of these close human-plant relationships.

Early Connections. The connection between humans and plants dates all the way back to the beginning of human evolution. Over 20,000 years ago, humans did not have domesticated plants to rely on, and they found them in the wild by hunting and gathering.[18] The domestication of plants to improve crops for food established a cultural shift for humans; "to settle into

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[17] J. Donald Hughes, *What Is Environmental History?* (Polity Press, 2016): 1, https://search-ebscohost-com.avoserv2.library.fordham.edu/login.aspx?direct=true&db=nlebk&AN=1105629&site=eds-live.
[18] Barbara Schaal, "Plants and People: Our Shared History and Future," *PLANTS, PEOPLE, PLANET* 1, (December 2018):15 https://doi.org/10.1002/ppp3.12.

permanent towns, populations grew, and the division of labor was established."[19] Eventually, different areas around the globe led to new types of plants being domesticated, which ultimately helped foster trade worldwide, further spreading the ideas of plant domestication and more.

After early domestication, plants began to be domesticated for more than just food, but for splendor and decoration. Around 5,000 years ago, the ancient Egyptians started to bring ferns and palms into their homes for aesthetic purposes and to display wealth.[20] As time went on, the ancient Greeks and Romans did the same. During the Roman Empire, the many emperors built gardens within their palace walls to display wealth and beauty, as well as for places designed for relaxation, food, and tranquility. Without knowing the scientific benefits, the Romans made space to have these vast gardens, even within city walls, as it benefited the people. There are many examples of gardens in the ancient world, such as the Hanging Gardens of Babylon in about 600 BC, which show us that plant cultivation has always used for more than just food, but also for the benefits they provided.

In these ancient times, the early philosophers began to relate their ideas to plants and nature. According to the pre-Socratic philosopher Empedocles, who lived around 490-430 BCE, all living beings were connected by the four elements, which allowed all these beings, plants included, to feel pleasure and pain.[21] As philosophers such as Plato and Aristotle began to study plant and human similarities and differences, they began to lean away from the idea that plants and humans are alike due to plant's lack of "volition, choice, intelligence, and communication," and while this creates a zoocentric ideology focused on animals, on the other hand, there are

[19] Schaal, "Plants and People: Our Shared History and Future," 16.
[20] Duncan Hilder, "A History of Houseplants," The Plant Runner, 2023, https://theplantrunner.com/blogs/the-plant-runner-blog/a-horticulturalists-history-of-houseplants.
[21] Matthew Hall, *Plants as Persons a Philosophical Botany* (State University of New York Press, 2011): 18.

parts of plant's autonomy that are unable to be recreated by humans.[22] But still, ,any of these philosophers would disconnect plant and human life by noting differences. However, a common thread throughout most of their teachings was that they still found many similarities between the two.

Aristotle separated plants from animals and humans due to their lack of perception. Still, despite this, even he was able to discover that plants respond to external stimuli in a similar way to animals. Theophrastus, also recognized as the Father of Botany, came along to deepen and reconsider Aristotle's work and ideas. Compared to Aristotle and other previous thinkers, Theophrastus thought that plants should be analyzed separately from a zoocentric lens and instead recognize that they are complex on their own and deeply dependent upon their environment.[23] For Theophrastus, awareness of the environment is what considers plants to have perception. Plants can be classified as having preferences and enjoyment as to what environment they grow in and are able to flourish in.[24] Taking this idea into agriculture, he recognized cultivation as a collaboration and mutual relationship between plants and humans because if a plant accepts modifications it was given, this was because it knew this would aid in its achievements.[25] Aristotle and Theophrastus demonstrate two contrasting early ideas of plant and human relationships: exclusion and separation versus inclusion and connection. In Western society and through the further formation of botanic ideals, the Aristotelian perception does seem to hold the significant influence, as do anthropocentric and zoocentric ideals.[26] However, slowly, we are incorporating the importance of aligning humanistic values with ecological values in what

[22] Hall, *Plants as Persons a Philosophical Botany*, 24.
[23] Ibid., 29.
[24] Ibid., 33.
[25] Ibid., 34.
[26] Ibid., 35.

is known as eco-humanism. Humanist ideas like dignity and justice, combined with climate stability, sustainability, and biodiversity, all work together so humans and the environment can work at their fullest potential. Furthermore, this idea works to see "nature not as a commodity to own and use egotistically but as a community to join harmoniously and respectfully."[27]

Following in the footsteps of Aristotelian ideas, we can see this further perceived in Western culture when we look through the teachings and lessons of Christianity. While some biblical passages indicate "horizontal relationships"[28] between humans and animals, it has not been shown that this same notion has been given to plants. Throughout many Christian sources, plants are viewed as "the radical Other" and are "subjected to the processes of backgrounding and domination."[29] In the example of Noah's ark, we see this separation between plants and animals because when God calls for the great flood, which is said to wipe out "all flesh in which is the breadth of life under heaven," when Noah takes two of each animal on the boat with him, this did not include plants.[30] While this argument for and against the inclusivity of plants in the bible and Christian traditions could be made either way, one common factor that strings through many of these ideas is that plants are subject and intended for human use and exploitation.

Looking through the lens of religion, plants have a deep-rooted connection within other religions like Hinduism and Buddhism. As I will continue to expand upon in the following chapters, ethnobotany, or the study of a region's native plants and their uses, is significant in these religions because of the importance of sacred plants and their relationships with deities. In some instances, it can be argued that Buddhists and Hindus have a similar view on plants as

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[27]Nimrod Aloni and Wiel Veugelers, "Ecohumanism, Democratic Culture and Activist Pedagogy: Attending to What the Known Demands of Us," *Educational Philosophy and Theory*, (2023): 3, doi:10.1080/00131857.2023.2295216.
[28] Hall, *Plants as Persons a Philosophical Botany*, 57.
[29] Ibid., 57.
[30] Ibid., 59.

Christianity and Western teachings and that plants are disconnected from human beings. However, it is more common in these religions for plants to hold a more profound connection or be associated with symbols or ideas of significance. Considering the Hinduist notion that everything manifests and originates from one ultimate reality or Brahman, this idea includes plants. It is part of why sacred plants are associated with deities or divine beings.[31] In chapter four, I will expand upon the importance of sacred plants in religious settings through the use of design.

Indigenous teachings. Indigenous philosophies and worldviews are essential to address as a counter to the anthropocentric Western view on plants. Although they have a deep history, many people still recognize and acknowledge plants as fellow life forms today. Many native peoples believe that the land will give and provide for its people if we take care of the earth in return. One example of this belief rooted within indigenous culture is forest gardens. Forest gardens are areas with native plants growing within their confines, which are cared for from generation to generation.[32] As previously mentioned, this is commonly referred to as ethnobotany, and the relationship that people use and connect with native plants as forms of shelter and food and for spiritual and religious reasons. Another key part of ethnobotany is the use of plants as medicine. While this goes beyond just indigenous people and is a part of other cultures, this idea will be expanded upon in chapter three. While forest gardens represent a specific example, they speak to the fact that these ideas are rooted within the culture of these people.

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[31] Hall, *Plants as Persons a Philosophical Botany*, 74.
[32] Nancy J. Turner, *Plants, People, and Places : The Roles of Ethnobotany and Ethnoecology in Indigenous Peoples' Land Rights in Canada and Beyond* (McGill-Queen's University Press, 2020): 91-94, https://search-ebscohost-com.avoserv2.library.fordham.edu/login.aspx?direct=true&db=e000xna&AN=2406450&site=eds-live.

Storytelling and writing are common ways to spread these relationships throughout generations. In most indigenous stories, there is "a recognition of the kinship between human beings and the natural world… based upon shared heritage and substance."[33] In "The Honorable Harvest" by Robin Wall Kimmerer, she notes the relationship between giving and taking from the earth. She describes bright green leeks and how they are almost yelling out to her to pick them for her harvest. But to honor the land before she picks them, "I explain why I've come and ask their permission to harvest, inquiring politely if they would be willing to share."[34] She does this because this is what her ancestors have done, and she wants to honor both them and the land. She later poses the problem of "the need to resolve inescapable tension between honoring life around us and taking it in order to live."[35] This is a problematic boundary, especially within growing urban settings.

Another example of the kinship relations between humans and nature is found in an Australian Indigenous teaching that follows the idea of Dreaming beings. These Dreaming beings are thought to be spirit ancestors that shaped the Australian landscape. "This is an immediate, earthy kinship" because the Dreaming beings originated within the earth and have come from the ground. [36] While this is a particular example, this philosophy also teaches that everything comes from the ground and thus is all interconnected as kin. The idea of kinship also comes in academic form as "new animism." Animists are described as "people who recognize that the world is full of persons, only some who are human, and that life is always lived in relationship with others."[37] This description aims not to give human characteristics to plants but

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[33] Hall, *Plants as Persons a Philosophical Botany*, 100.
[34] Robin Wall Kimmerer, *Braiding Sweetgrass: Indigenous Wisdom, Scientific Knowledge, and the Teachings of Plants* (Milkweed Editions, 2013): 175, https://search-ebscohost-com.avoserv2.library.fordham.edu/login.aspx?direct=true&db=nlebk&AN=683745&site=eds-live.
[35] Ibid., 177.
[36] Hall, *Plants as Persons a Philosophical Botany*, 101.
[37] Ibid., 105.

to recognize them as having their own perspective, similar to Theophrastus's findings. Plants are like their own species of person. To relate this idea to the example given by Robin Wall Kimmerer, when she decides to harvest from the earth, while this is harming the plant from an animist perspective, this is still necessary for a human to survive. The large difference between Western and Indigenous teachings is "that the harm done to individual plants is not ignored or backgrounded."[38]

Following the idea of kinship and connection to the natural world, this is prominently shown through the concept of totemism. While there are debates on the origin of this idea, totemism, shown in places like Northern America and Australia, is a form of society set up that tends to follow a few characteristics. These societies are composed of groups of people united by a real or fictitious kinship that commonly extends beyond a local tribe. These groups are distinguished by a plant or animal, and this becomes the symbol of the clan. The relationship with this symbol of the natural world is so strong that it is "conceived as related to the clan, and to every member of it…and each individual specimen of this object or animal is the subject of taboos and/or prohibitions: subject to certain limitations or ceremonies, it cannot be injured, killed or eaten."[39] Through research, many different ideas are studied about why totemism exists, such as religious institutions, personal connection, or even the theory of having an eternal soul live on within the chosen symbol. Still, totemism displays these deep connections with the natural world that emphasize the profound connections people have created and fostered with animals and nature, predominantly plants.

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[38] Hall, *Plants as Persons a Philosophical Botany*, 111.
[39] Gerard Lucas, *The Vicissitudes of Totemism: One Hundred Years After Totem and Taboo* (Routledge, 2015): 2, https://search-ebscohost-com.avoserv2.library.fordham.edu/login.aspx?direct=true&db=e000xna&AN=1072439&site=eds-live.

Looking at urbanization through the lens of indigenous teachings, there are many things that we can learn and become inspired by. When building large cities, we take away all the things that the earth provides us and alter it to fit our needs. According to indigenous people, the earth already provides us with everything we need to survive. While it would be impossible to make everyone in society follow these teachings, acknowledging the importance of taking care of the earth we still have left is essential. We can partially do this through plants. Using plants for their natural resources is what we were intended to do, but we must make sure that we return the favor by caring for them just as they care for us.

Industrial Revolution. From the transition of early and ancient life, another significant spike in plants and their indoor utilization occurred because of the Industrial Revolution around 1800. The Industrial Revolution, which provided large-scale machinery, power sources, transportation, and materials, in tandem with the Green Revolution, which brought new advances to the agriculture sector, led to the boom of urbanization more than ever. Improved machinery, selective breeding, GMOs, and fertilizers allowed for increased food production. The increased amount of food led to an increased population, which was needed to sustain the number of people moving away from rural farming lands and into cities to get factory jobs. Because of the influx of people moving into cities, this was a driving factor for urbanization, and the continuous push that we still see today in optimizing land use in cities to provide more and more housing and needed infrastructure. This transition, while allowing us to be where we are now, puts an added strain on our environment because of the added use of fossil fuel, land degradation, and pollution.

These new advances that occurred within the agriculture sector also meant advances for plants used for personal use. After the Industrial Revolution took hold, a significant boom in the

demand for houseplants occurred during the mid-1800s to the early 1900s, also known as the Victorian era. While many houseplants were still reserved for the wealthy, who had time to appreciate and care for their plants, an ample cause of this boom was the creation of the terrarium. The accidental invention of the terrarium occurred in 1842 in London by Nathaniel Bagshaw Ward; when he attempted to raise a moth in a sealed jar, he noticed that a fern spore grew, and he soon realized that he could control the environment that was sealed in these jars. During a time when homes were filled with air pollution due to the burning of coal, a terrarium was a small, unpolluted environment.[40] Because of this, terrariums boomed in popularity, and if you were lucky enough to have one, it also stood as a symbol of status and brought joy to those who had them. During the Victorian era, there was also a significant spike in the appreciation of other art forms that recognized nature, such as poetry and art.[41]

Along with the creation and popularity of the terrarium, caring for houseplants became a hobby for those who had the time. Due to the Industrial Revolution, children would eventually move away from home or be busy at work, and if this were the case, it could get quite lonely for a middle-class woman. There have been many instances where mothers turned to houseplants as an alternative to their children. In an 1880s home journal, one woman writes, "I am a middle-aged woman with only one child, a daughter, who is grown up, so all my spare time is given to my flowers. They are to me as children."[42] This display of plant motherhood displays the emerging bond between humans and plants that came about post-Industrial Revolution.

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[40] Matthew Wills, "The Accidental Invention of Terrariums" JSTOR Daily, 2018, https://daily.jstor.org/the-accidental-invention-of-terrariums/.
[41] Hilder, "A History of Houseplants."
[42] Ann Garascia, "Her Flowers Are Her Children': Cultivating Victorian Houseplant Motherhood in Colonial Archives" *Journal of Ecohumanism* 2, (2023): 21, https://doi.org/10.33182/joe.v2i1.2892.

While Britain might have set the way with the invention of the terrarium, another significant impact on the appreciation of nature occurred in the United States because of the establishment of the National Parks Service. While the service itself was not established until 1912, Yellowstone was the first national park to be preserved in 1872. The preservation of large land areas showed an appreciation for beauty, leisure, and environmental health. As discussed in the earlier section, preserving land like this is an indigenous ideal as well. Unfortunately, there were some cons to creating these parks, such as "the administration of American national parks often involved the forced removal of Native American Indians" [43] and more, at the time, this progression towards the protection of nature and ecosystem services led toward increased availability and knowledge on the topic.

Current Relationships. During WWII, when men and children went off to war and women had to take roles at office jobs, many of these women brought flowers and plants into their workspaces to give them a homier feel. With modern propagation and breeding techniques that making houseplants easier to care for and more affordable, availability improved. Houseplants became almost similar to fashion or art and thus go through trends. Houseplants could be used within design and architecture as another form of art. In 1984, the term biophilia was coined by Erich Fromm and Edward O. Wilson. The term derives from ancient Greek, 'bio,' which means life, and 'philia,' which means love, combined to mean the love for life.[44] In this definition, life represents living organisms as well as nature. Fromm's definition of the word, defined as "the passionate love of life and of all that is alive," together with Wilson's definition of the word, "our innate tendency to focus upon life and life-like forms and, in some instances, to

[43] Hughes, *What Is Environmental History?* 17.
[44] Giuseppe Barbiero and Rita Berto, "Biophilia as Evolutionary Adaptation: An Onto- and Phylogenetic Framework for Biophilic Design," *Frontiers in Psychology,* (July 2021), doi:10.3389/fpsyg.2021.700709.

affiliate with them emotionally,"[45] we can interpret that biophilia takes on the role of seeing and acknowledging nature alongside human values and needs, similar to that of Theophrastus and eco-humanism. I will continue to address this idea further in chapters four and five when I discuss environmental design. Notably because, the goal of biophilic design "is to give back to human beings living in urban environments the possibility of maintaining contact with Nature."[46]

A study completed in 1989 by NASA was one of the first scientifically proven cases to demonstrate that houseplants help the air quality inside homes, which I will go into further detail in chapter three.[47] With increased scientific knowledge about houseplants' benefits, availability, and affordability, the craze for houseplants skyrocketed. In recent years, there has been an even increased interest in lawn and gardening activities, including houseplants. In the 2022 National Garden Survey, this participation has shown a 5-year trend in about 80% of households taking part in these activities. Indoor houseplant gardening has been shown to increase more and more each year, outweighing other lawn and gardening activities.[48] We can see a reflection of some of this popularity online demonstrated by a large number of plant influencers on social media sites, appealing to many of the younger generations.[49] Conduction of a Google search trend analysis for words like houseplant, botany, plant, etc. has also displayed a significant increase in the popularity of these trends, especially shown online.[50]

In an article released by Architectural Digest, they categorized some of the popular houseplant trends that have changed throughout the past 75 or so years. As mentioned before, in

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[45] Barbiero, "Biophilia as Evolutionary Adaptation."
[46] Ibid.
[47] B. C. Wolverton et al., "A Study of Interior Landscape Plants for Indoor Air Pollution Abatement," (Sverdrup Technology, Inc., 1989), https://ntrs.nasa.gov/api/citations/19930072988/downloads/19930072988.pdf.
[48]Jim Feison, "2023 National Gardening Survey," *The National Gardening Association*, https://gardenresearch.com/view/national-gardening-survey-2023-edition/.
[49] Rory Burke et al., "Botanical Boom: A New Opportunity to Promote the Public Appreciation of Botany," *Plants, People, Planet,* (July 2022): 339, doi:10.1002/ppp3.10257.
[50] Ibid.

the 1940s, women would adorn their homes and offices with plants during WWII. In the 1950s, tropical and exotic plants became the current craze. Combined with the fascination at the time for tiki culture, having a tropical plant inside the home that otherwise could not grow in many of these environments was a fun and striking idea. In the 1960s and with the suburbanization of the US, the urge to have quick and easy furniture and home decorations grew in popularity, leading to a wider variety of easy-to-care-for plants becoming mainstream.[51] In the 70s, the trends for houseplants kept growing due to the increase in nature-focused/hippie lifestyles. Hanging plants and macrame fit perfectly with the interior design trends at the time. In the 1980s, there was a move towards fake and plastic plants, but this time also gave rise to a trend we still see today: the "American mall atrium and food court, brimming with skylit flora and ornamental fountains."[52] In subsequent decades, attention to many different styles and cultures was seen in plant trends, like bamboo and desert cacti. Like fashion, architecture, and interior design, houseplants have followed a vast array of change and trend peaks, conforming to the current times. In chapter four, I will continue to address the importance of environmental design, but from a broader perspective.

Understanding past relationships between humans and plants we can acknowledge the shift towards urbanization that has created a divide. Losing our ecosystem services within cities creates a snowball effect that worsens further environmental problems. In the following chapter, I will emphasize the importance of the physical and mental benefits plant ecosystem services provide and why it is important to protect and encourage the use of these services.

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[51] Wretched Flowers, "The Most Iconic Houseplant Trends Through the Decades," Architectural Digest, 2021, https://www.architecturaldigest.com/story/houseplant-trends-history.
[52] Ibid.

Chapter 3: Cultivating Wellness from a Green Life

Taking care of oneself and their body is essential to live a long and healthy life. While there are many avenues to achieve a higher quality of physical and mental health, like dieting, exercise, and medication, these often can be difficult to do. While none are wrong, what if I told you there is an even easier solution to caring for ourselves? Yes, I'm talking about plants. The ecosystem services that plants provide already improve our physical and mental health, so why not bring these into our homes to better receive these benefits? Improved air quality, focus, creativity, and a boosted mood are just some examples of what these plants provide. If done properly, our houseplants can even provide sources of organic food or medicine. While this touches the surface of what plants can offer us, if we put in even a little effort to take care of our plants, they will take care of us right back.

Environmental health and psychology work hand in hand to bring benefits from the environment to human beings. Without understanding these ideas, the basis for other environmental and human relations would be lacking. As I will address in chapter four, biophilic design creates a space that connects humans with nature. However, this is based on the understanding of how our relationship with nature shapes us as individuals, which is done through environmental psychology. These psychological effects are vital in many other aspects like schools, offices, and homes. The cultural services plants provide constitute a significant reason for studying environmental psychology. In tandem with other ecosystem services, we can help boost our environmental health benefits too.

A Breath of Fresh Air. As discussed in chapter one, natural air filtration is a vital regulating service provided by plants. During photosynthesis, plants take in carbon dioxide and other common pollutants like formaldehyde, carbon monoxide, and nitrogen oxides, which can

be harmful to humans if large amounts are inhaled. Another positive way plants help improve air quality is the release of oxygen into the air. In homes, especially urban apartments, air circulation between indoor and outdoor air is less common, so having houseplants as a direct source of oxygen improves this circulation.

Urban air pollutants come in many different forms and from many sources. In urban and suburban areas, particulate matter is the air pollutant with the highest number of associated health problems and premature deaths. Depending on the city, burning fossil fuels on industrial levels, and residential levels, for heating and cooking, releases a vast amount of particulate matter. The transportation and agriculture sectors are also large emitters. In some instances, road dust and debris, construction operations, and even sea salt in coastal areas add to these levels.[53] When particulate matter is inhaled into the lungs, it can result in cardiovascular and pulmonary diseases: coughing, asthma, bronchitis, strokes, heart attacks, and death are all possible consequences.[54] Other than residential burning, many of these sources result in outdoor air pollution. Still, in many cases, outdoor air pollution is the prominent cause of indoor air pollution, as these particulates frequently enter inside. While reduction at the source is an ideal solution to reducing particulate matter, this does not always occur easily; solutions like tree planting and emphasis on green spaces can be a cheaper and more viable solution that simultaneously provides community and cultural advantages.

According to the *Air Quality Life Index* in 2022, the most polluted countries in the world were Chad, Iraq, Pakistan, Bahrain, and Bangladesh, with the most polluted city being Lahore,

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[53] Rob McDonald et al., *Planting Healthy Air: A Global Analysis of the Role of Urban Trees in Addressing Particulate Matter Pollution and Extreme Heat* (The Nature Conservatory, 2016): 10, https://www.nature.org/content/dam/tnc/nature/en/documents/20160825_PHA_Report_Final.pdf.
[54] Ibid., 11.

Pakistan, at 97.4 micrograms of PM 2.5.[55] To put this into perspective, the World Health Organization guideline for healthy air is just below five micrograms. Lahore stands at about 80 times the recommended limit, making it unsafe to exercise outdoors, open windows, and even go outside without a mask. While occasional exposure to poor air quality will most likely not result in long-term health issues, living in large cities with poor air quality dramatically increases the risk of illness and death. In 2019, four percent of global deaths were attributed to indoor air pollution.[56] While this may not seem like a high percentage, in a global context, this is over 300 million people dying from air pollution and its associated illnesses per year. Unfortunately, there is a disproportionate distribution of these deaths, as most are concentrated in Sub-Saharan Africa and Asia, and these deaths often get overshadowed by other risk factors for people living in these places, such as poor sanitation and clean water.[57] On a global scale, pollution-related illnesses and deaths occur more within low-income regions, but unfortunately, low-income neighborhoods within larger cities also face parallel inequalities. Since lower-income neighborhoods are often situated by busy roads or factories, the particulate matter in the air is greater. There is also less chance of parks and green spaces near these areas, which does not allow plants to filter the air, making this cycle build further upon itself.

Addressing the environmental factors that lead to health issues in adults, and especially children, is essential. Still, to entirely reduce or eliminate some of these problems, we must also acknowledge the social and economic factors that disproportionally affect health, growth, and development. Environmental justice merges many different ideas to bring to light that there is

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[55] "Here Are the Most Polluted Cities in the U.S. and World," AQLI, 2023, https://aqli.epic.uchicago.edu/news/here-are-the-most-polluted-cities-in-the-u-s-and-world/.
[56] Hannah Ritchie and Max Roser, "Indoor Air Pollution," Our World in Data, 2023, https://ourworldindata.org/indoor-air-pollution.
[57] Ibid.

unequal distribution of environmental risks within marginalized communities.[58] Though the environmental justice movement is gaining popularity in the US, there are still many barriers that need to be overcome. Children tend to be at higher risk for many environmental factors because they are still developing, and often, these problems can even show up later in life. Analyzing this issue environmentally, home, school, and community environments, such as location, design, open space, and condition, influence children's diets and levels of physical activity and can even shape their interactions with others and the world around them.[59] Those who face disadvantages in social and economic circumstances are at higher risk of facing environmental health problems, which, unfortunately, creates a cycle of disparity. Although not an easy feat, breaking this cycle is possible with aqueduct resources and energy devoted to the cause, mainly because, if not addressed, it can become even costlier in the long run.[60] This not only needs to be tackled in the aspects of personal homes and lives for children, but it also becomes imperative to address in school settings. In chapter five, I will propose solutions to this problem.

Another source of significant health concerns for everyone within cities is excessive heat and ambient air temperatures. Due to climate change, we are seeing extreme hot and cold temperatures. Exposure to extreme heat over short- and long-term periods can cause an array of problems. Acute exposure to heat can lead to dehydration, heat cramps, and fainting. Continuous exposure can lead to heat exhaustion and heat stroke, leading to brain, kidney, heart, and muscle damage, comas, and even death.[61] Some standard solutions within cities aim to reduce heat storage. Cool roofs, made with or coated in materials that reflect heat, and cool pavements made

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[58] Anna Grear, *Environmental Justice,* (Edward Elgar Publishing Limited, 2020), https://search-ebscohost-com.avoserv2.library.fordham.edu/login.aspx?direct=true&db=cat00989a&AN=ford.3763838&site=eds-live.
[59] Leslie Rubin and Joav Merrick, *Environmental Health: Home, School and Community* (Nova Science Publishers, Inc, 2014): 3, https://search-ebscohost-com.avoserv2.library.fordham.edu/login.aspx?direct=true&db=e000xna&AN=666154&site=eds-live.
[60] Rubin, *Environmental Health: Home, School and Community*, 7.
[61] McDonald, *Planting Healthy Air,* 16.

of specific materials or paints are industrialized solutions to this problem.[62] While these have been found to help, nature provides us with natural ways to reduce heat, through its regulating services. Plants and grasses naturally have a higher light reflectivity or albedo than artificial materials like concrete. Having more green spaces in cities can help reduce excessive heat storage. In chapters four and five, I will address the importance of green roofs as a solution to this problem and many others.

While the causes, effects, and solutions of outdoor and indoor air quality and heat retention are vast, we have an easy solution to this problem. In a study about the benefits of existing street trees done in 245 cities, which equals about a quarter of the world's urban population, there is more than sufficient data calculating these benefits. The current tree stock in these cities provides over 100 million people with a significant reduction in particulate matter and heat reduction.[63] If this is the amount with the current quantity of trees, these benefits can grow significantly with the addition of more trees and green spaces. As I previously stated, outdoor air pollution easily enters indoor spaces, so bringing these benefits indoors or into our communities is an excellent solution for a fraction of the cost of major infrastructure changes.

Natural Remedies. The most important of the plant provisioning ecosystem service provided to us from the beginning is, of course, food. Even if someone doesn't eat many plant-based products, plants are still the start of the energy chain for humans because plants are the only living beings that can capture energy from the sun and turn it into chemical energy for us or other animals to consume. Access to space and other materials needed to grow a garden with enough food to sustain oneself is arduous, especially within cities. But growing your own food, or at least some of it, has excellent benefits for both physical and mental health. For many,

[62] McDonald, *Planting Healthy Air,* 18.
[63] Ibid., 2.

gardening is a hobby that allows for stress relief and relaxation. If gardening is not your ideal activity, this is not the only mental health benefit plants can bring us, but I will touch upon this more in the next section. Organic/homegrown foods eliminate the possibility of the use of pesticides, fertilizers, and GMOs. While these are not always bad for people, they can have both short- and long-term health effects on humans, such as effects on the nervous system, reproductive health, and possible carcinogens. Along with this, pesticides and fertilizers in industrial farming create significant problems for our environment. Water, air, and soil pollution from agricultural runoff and unintended harm to natural and essential biodiversity like pollinators and other forms of wildlife are, unfortunately, some of the direct effects. Besides the lack of chemical use, homegrown foods can be more nutritious, help reduce food waste, and help save money. Although having a garden of large variety is difficult in cities, in chapter five, I will expand upon solutions for having edible plants. Still, plants such as herbs, leafy greens, and root vegetables are great options to grow inside or in rooftop/community gardens because they often don't require much space or attention.

The addition of urban agriculture to cities allows for the increase of green spaces and the minimization of pollution and can even benefit the economy and community. As mentioned in chapter one, creating resilient cities is something that needs to worked towards for the future. As stated, the issue of environmental injustice makes people have unequal access to environmental services. One of these aspects is food insecurity. Having limited or no access to fresh and healthy foods within certain areas is referred to as a food desert. Many marginalized areas do not have grocery stores or stores containing any or reasonably priced nutritious foods. When I mention solutions for this in chapter five, urban agriculture and rooftop gardens combined with education and access can help prevent from food insecurity and injustice.

Besides food, plants have also been used as different types of medicine. While many diverse medical uses exist and have been around for centuries, and though the medical field has greatly improved, many over-the-counter medications still use plant-based formulas. If we go to pharmacies and buy natural remedies, why can't we just grow some of these remedies ourselves? Plants such as aloe, chamomile, and lavender are just a few examples of plants that can appear to be just a regular houseplant but have many hidden health benefits.

Embedded deep within human survival is how we distinguish plants from nourishment versus poison. The primary way we have learned this is through taste. Typically, "plants that don't wish to be eaten often manufacture bitter-tasting alkaloids," and those that wish to be eaten produce sugars, "so as a general rule, sweet is good, bitter is bad."[64] Over short and long periods of time, animals and humans go through trial and error regarding what plants result in what outcomes; luckily, with ethnobotany, we can cut down on most of this process.

To further develop the study of ethnobotany the practice of natural medicine greatly encompasses this. As briefly mentioned in chapter two, ethnobotany is the study of how people utilize their region's native plants for purposes such as medicine, shelter, clothing, etc. This concept comes forth in many ways, and people use this study not only for human benefits but even for livestock and animal advantages. To provide a current example, when raising farm animals, it has been proven that resistance and the cost of synthetic drugs pose problems, but adding specific plants into an animal's feed and diet can alter their reliance on synthetic drugs.[65] However, ethnobotany has deeper historical and indigenous roots than just this. In the previous chapter, when I addressed indigenous cultures and their relationships with the land, it is believed

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[64] Michael Pollan, *The Botany of Desire*, (Random House, 2002): 114.
[65] José L. Martinez et al., *Ethnobotany: Ethnopharmacology to Bioactive Compounds*, (CRC Press, 2023): 2, https://search-ebscohost-com.avoserv2.library.fordham.edu/login.aspx?direct=true&db=nlebk&AN=3547972&site=eds-live.

that if you take care of nature, it will provide back for you; however, how different societies have utilized a variety of plants for medicinal use must be looked at on a case-to-case basis.

According to the World Health Organization, "about 60% of the world's population still relies on traditional medicine and 80% of the population in developing countries depends almost entirely on traditional medical practices, in particular, herbal remedies, for their primary health care."[66] Today, we can utilize ethnobotany to further our current medicinal practices. In finding a cure for COVID-19, researchers turned to the bioactive substance resveratrol, which is present in many plants like grapes, blueberries, cranberries, etc. This substance has also been proven to improve other respiratory conditions like asthma and pneumonia. As we move forward and make advances in our pharmaceutical industry, it is crucial to acknowledge bio substances because, often, this can lead to the avoidance of side effects from modern drugs.[67] This is just one example of many; connecting plants and previous knowledge with current trends gives us an even deeper perspective on what plants provide for us.

Growing Your Mind. In addition to the many physical health benefits plants can provide, they also offer a multitude of mental health benefits. Having and taking care of plants gives people a hobby. One study measured the brain waves and blood pressure of subjects watering plants versus a group performing a computer task. The results of the study showed that the participants watering the plants had reduced blood pressure and improved happiness compared to the computer group.[68] While the action of watering plants caused these positive changes, just having plants within an indoor environment can increase happiness, reduce stress, and boost

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[66] José L. Martinez et al., *Ethnobotany: From the Traditional to Ethnopharmacology*, (CRC Press, 2023): 53, https://search-ebscohost-com.avoserv2.library.fordham.edu/login.aspx?direct=true&db=nlebk&AN=3517747&site=eds-live.
[67] Martinez, *Ethnobotany: Ethnopharmacology to Bioactive Compounds*, 50.
[68] Ahmad Hassan and Deshun Zhang, "Promoting Adult Health: The Neurophysiological Benefits of Watering Plants and Engaging in Mental Tasks within Designed Environments," *BMC Psychology* 11, (October 2023), https://doi.org/10.1186/s40359-023-01362-5.

productivity and attention. In a different study done on a group of elementary school students, they measured the brain waves before and after introducing "four different visual stimuli: an actual plant, artificial plant, photograph of a plant, and no plant."[69] The results showed that the actual plant boosted the attention and concentration of children at a greater rate than the fake and photographed plants.[70] Unfortunately, many schools and offices do not spend resources on plants for their indoor environments, but if they did, it would not only increase the happiness of employees and students but would also improve their ability to produce/work. Within large cities, these environmental services are lost, and when a kid looks out the window and can't access nature either outside or inside their surrounding environment, this negatively hinders them and their learning. Along with improved mental health benefits, plants add to the home's aesthetic, which not only furthers the benefits of having a hobby but also living or working in a space that makes people feel comfortable and homey, as well as improves happiness. I will expand upon this in chapter four when I address environmental and biophilic design.

While plants have always had this natural mental health-boosting effect, studies that have come out of the recent COVID-19 pandemic were able to delve deeper into why sources of nature significantly benefit mental health, especially while being stuck at home. During the height of the pandemic, people were not allowed to leave their homes unless necessary, so this robbed many city dwellers of interactions with nature. This, along with many other effects of the pandemic, made people struggle severely with mental health. A study that measured people's levels of depression and anxiety concluded that people with houseplants or green window views

[69] Yun-Ah Oh et al., "Real Foliage Plants as Visual Stimuli to Improve Concentration and Attention in Elementary Students," *International Journal of Environmental Research and Public Health* 16, (March 2019), https://doi.org/10.3390/ijerph16050796.
[70] Ibid.

had reduced levels of stress and depression compared to those without.[71] Having plants or a view of plants gave these people the illusion that they were "away from home," allowing for escape and thus part of the reason for the results of the study.[72]

A popular practice that originated in Japan, known as *shinrin-yoku,* or forest bathing, is an example of how people reconnect with nature by waking up their senses and finding inner stillness.[73] Although forest bathing, and this type of cultural service, has existed for centuries, many new ideas exist on how it can evolve in the modern world. One study tried to recreate forest bathing during the pandemic in the digital world.[74] While this showed signs of health benefits, another study was conducted on bringing forest bathing indoors more naturally. One of the reasons that forest bathing is so effective is because it has "been linked to the biogenic volatile organic compounds released by plants," and this study assessed how houseplants release this compound and its effects.[75] In the results of the study, they claim that the compounds released by the certain houseplants they tested resulted in" boosting immunity and health protection, which can thus be exploited in 'indoor forest bathing' approaches, that we propose not only for private houses but also public spaces, such as offices, hospitals, and schools."[76]

Within office spaces, analyzing the environmental psychology of workers provides many benefits in this sphere. Job and environmental satisfaction can lead to increased and improved

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[71] Angel M Dzhambov et al., "Does Greenery Experienced Indoors and Outdoors Provide an Escape and Support Mental Health during the COVID-19 Quarantine?" *Environmental Research* 196, (May 2021), https://doi.org/10.1016/j.envres.2020.110420.
[72] Ibid.
[73] Hiroko Oe and Yasuyuki Yamaoka, "The Impact of the Digital Environment on Eco-Friendly Behavioral Change towards Nature: Exploring the Concept of Forest Bathing without Forest," *SocioEconomic Challenges* 7, (2023), https://doi.org/10.61093/sec.7(3).76-93.2023.
[74] Oe, "The Impact of the Digital Environment on Eco-Friendly Behavioral Change towards Nature."
[75] Valentina Roviello et al., "Evaluating in Silico the Potential Health and Environmental Benefits of Houseplant Volatile Organic Compounds for an Emerging 'Indoor Forest Bathing' Approach," *International Journal of Environmental Research and Public Health* 19, (December 2021), https://doi.org/10.3390/ijerph19010273.
[76] Ibid.

performance and psychological and physiological benefits. Individuals tend to respond to their environments through three different basic types of processing: cognitive, emotional, and physiological. Cognitive is initial thinking, emotional is the mood creator, and physiological is how we display these feelings, such as sweating, shaking, heart rate changes, etc.[77] Physical properties such as lighting, sound, color, and air quality primarily drive these responses. In chapter four, I will address biophilic design and how to utilize these aspects to foster the unity of the natural environment with our surroundings to alter our cognitive, emotional, and physiological responses.

Having house plants in homes, offices, and schools has been proven effective for more reasons than one. Improved happiness, attention, creativity, and boosted immunity, along with reduced stress, anxiety, and depression, are services that plants provide us at no cost. If plants are so beneficial to us, then why do more people and places not surround themselves with them? While this is a difficult question to answer outright, in the next chapter, I will delve into environmental design and how this can be a way to incorporate plants into living and working environments as a way of life.

Chapter 4: Plant Roommates

Once we understand the environmental history of urbanization and environmental psychology and health, we know that a life co-existing with plants provides us benefits. Yet, we must focus on reincorporating these plants back into our urban environments in this lifetime. Environmental architecture and design are the building blocks for this plant-human relationship

[77] Jorge Valentín and Lucila Gamez, *Environmental Psychology: New Developments* (Nova Science Publishers, Inc, 2010): 40, https://search-ebscohost-com.avoserv2.library.fordham.edu/login.aspx?direct=true&db=e000xna&AN=339885&site=eds-live.

within cities. From sustainable construction to a green lifestyle, all the way to buying and using the prettiest planter box, these all have a similar thread, "an emphasis on environments rather than buildings, on collaboration with other professions, and on close attention to social and environmental constraints."[78] Utilizing environmental design within older cities poses its own barriers as it is hard to uproot what has already been made in place, but with newer cities, we face other challenges like pricing; nonetheless, for both the people in these cities and the environment, moving forward with green design sets us ahead in many ways.

Useful Aesthetics. Bringing green design into homes, schools, offices, etc., is one of the ways we can gain the effects of plant ecosystem services indoors. As mentioned in the previous chapter, having plants and gardening as a hobby is proven to boost mental health, so imagine what it is like being in an indoor space with nature surrounding you. Cultural services, such as the aesthetics of plants bring positive mental health benefits as well, and we can help receive this through different ways of design.

In chapter two, I addressed the historical reasons for the start of houseplant trends and some of the most popular trends over the past 75 years. Until recent years, when research on the benefits of plants became available, we still saw a significant desire to own plants. Another example of this from the 1850s to the early 1900s, was when Victorians displayed another large show of this desire, which came in the form of pteridomania or fern fever. Every household had a potted fern at the time, and the wealthier a household, the rarity and variety of these plants increased. This craze became so big that you could hold the occupation title of fern collector,

[78] Avigail Sachs, *Environmental Design: Architecture, Politics, and Science in Postwar America*. *Midcentury: Architecture, Landscape, Urbanism, and Design*, (University of Virginia Press, 2018): 8, https://search-ebscohost-com.avoserv2.library.fordham.edu/login.aspx?direct=true&db=e000xna&AN=1848522&site=eds-live.

enter forests, and gather ferns by hand to sell.[79] Eventually, independent fern collectors were overrun by commercial collectors, and this fever died down. The idea of pteridomania shines light on the idea that beauty in the form of plants has long been cherished, and we have found new ways to co-exist with plants in our current industrialized society.

Also mentioned in previous chapters, ethnobotany is the study of how people interact with the native plants in their areas. In chapter three, I noted the importance of ethnobotany in medicine and the pharmaceutical world. When addressing environmental design, we must make note of past usage of plants as forms of shelter. Just as with medicine, specific plant use for shelter varies depending on region and needs, such as the materials available and the climate. Of course, what used to be one of the most common materials for building shelters was wood. Still, when this was not available, and before the metal and concrete resources we have today, people would need to find other options. One instance of this occurred in the late 1800s in the US when people moved out to the Great American Prairie. This region was scarce in trees and stones, so building materials for homes needed to be unique. What was abundant in this area was tall grasses and prairie sod, which consisted of the grasses, its roots, and surrounding dirt. Homesteaders in this area harvested large strips of sod and cut them into bricks to use for the walls and roofs of their homes.[80] They provided excellent insulation in the winter and stayed cool during the summer. Ethnobotany and the understanding of past usage of plants within infrastructure has paved the way for many of our current design ideas.

One contemporary popular design idea comes in the form of living walls. As it sounds, living walls are a form of uniform greenery that grows vertically along a wall, possibly equipped

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[79] Cynthia Green, "When Ferns Were All the Rage," JSTOR Daily, 2017, https://daily.jstor.org/when-ferns-were-all-the-rage/.
[80] "Life in a Sod House: More Information," Smithsonian National Museum of American History, https://amhistory.si.edu/ourstory/activities/sodhouse/more.html.

with irrigation systems, and grows off a nutritional substrate.[81] Living walls bring many benefits indoors, such as improved air quality, insulation, and reduced noise pollution. In many cases, "a living wall of just ten square meters can reduce noise pollution by 40 percent," [82] and depending on the size, it can be even more. Noise pollution is one of the drawbacks of urbanization, and especially within older buildings, living walls can be better noise insulators than many common building materials. Besides environmental benefits, there are health benefits associated with living walls, too. As stated in the previous chapter, having plants within your home provides the illusion of being out in nature, and even within an urban setting, having reduced noise and improved air quality adds to this feeling.

Green walls can also be used outdoors as environmental architecture or within public spaces such as libraries or schools, creating social benefits. Along with the previously stated benefits, living walls provide shade, landscaping, and unite tourists and locals in a space of unity.[83] Having a well-designed area draws people in and can create a vibrant community. One example of a living wall in a large city that has achieved this is the outdoor wall of the CiaxaForum museum in Madrid, Spain. Designed by the French botanist Patrick Blanc, the 78-foot wall has over 250 plants picked to survive Madrid's climate, and when standing next to the wall, an actual temperature difference can be felt.[84] While this is not the extent of their benefits, indoor and outdoor living walls are a prominent step for environmental architecture and design and are even easily recreated in many spaces, including urban apartments, to promote cultural ecosystem services and desgin.

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[81] Manika Goel et al., "Living Walls Enhancing the Urban Realm: A Review," *Environmental Science and Pollution Research* 29, (2022), https://doi.org/10.1007/s11356-022-19501-7.
[82] Ibid.
[83] Ibid.
[84] Madrid, "Caixaforum Vertical Garden," Official tourism website, https://www.esmadrid.com/en/tourist-information/caixaforum-vertical-garden#:~:text=Based%20on%20his%20own%20theory,a%20living%20piece%20of%20art.

Another popular example of environmental urban design is green roofs/gardens. Like living walls, the idea of green roofs is straightforward, being that it is precisely what it sounds like, but the benefits go beyond its simplicity. Replacing a typical asphalt, metal, or concrete roof with plants and greenery further evolves ideas of green infrastructure, and we can address "stormwater management, temperature control, pollution reduction, reclamation of urban wastelands, public health and lifestyle, and also provide a raft of economic benefits."[85] As stated in chapter one, some of the earliest examples of gardens and green roofs come from the Hanging Gardens of Babylon, which partly existed to help control the temperature in arid climates. As these trends continued and changed over time, post-WWII was the revival of green roofs, as space in urban cities started to dwindle.[86] Green roofs have been introduced to different cities for different reasons, such as lack of space, environmental benefits, public health, economics, and art, all of which have private and public benefits.

A private benefit of green roofs and living walls is reduced energy consumption. Since roofs help regulate temperature control, heaters and air conditioners will need to be run at less constant times, thus reducing energy usage. Research published by the National Research Council of Canada said that certain green roofs have been able to reduce air conditioning use in the summer by about 75 percent.[87] Another example of a private benefit is greater market value. As I stated when addressing living walls, green infrastructure creates social benefits, and on top of this, green roofs can increase a building's marketability, causing its value to rise. This is so important because within cities, the price of space can be costly.

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[85] Graeme Hopkins and Christine Goodwin, *Living architecture: Green roofs and walls* (CSIRO Pub., 2011): 2, https://eds-s-ebscohost-com.avoserv2.library.fordham.edu/eds/detail/detail?vid=0&sid=bc858982-fdbc-45b2-ac0f-cb506691a4a2%40redis&bdata=JnNpdGU9ZWRzLWxpdmU%3d#AN=3190969&db=e000xna.
[86] Ibid., 3.
[87] "About Green Roofs," Green Roofs for Healthy Cities, https://greenroofs.org/about-green-roofs.

Reduced water consumption is a public benefit of green infrastructure. On a typical roof, when it rains, the water washes away, and it becomes hard for it to reenter the water cycle because it cannot penetrate through sidewalks and streets. When it rains on green rooftops, the water soaks into the plants and substrate and can then be precipitated back into the water cycle to help our regulating and supporting services. This is also helpful for stormwater management because if there is runoff, it delays the time it takes for the water to enter the sewer systems. Green roofs also reduce waste because they prolong the life of the roofing materials, and recycled products can even be used in the growing substrate.[88] Along with this, one of the most significant things urbanization creates, as discussed in chapter one, is biodiversity loss, and green roofs and walls can spark biodiversity back up. Another public benefit can result from the use of rooftop gardens for urban agriculture, as mentioned in the previous chapter. Over the past chapters, most of the problems I have mentioned have resulted from a loss of ecosystem services, and when we add non-environmentally friendly urban infrastructure into the mix, we further take this away, but a green roof can recreate these benefits in unused spaces.

In Osaka, Japan, the architecture company Jerde turned a dormant baseball stadium into a retail and entertainment site with an eight-level rooftop garden. The plan for the idea was to create a sense of unity between people and nature within this crowded business district. Although this is an enormous project, turning an unused space into something that fosters and creates community and business while doing so with an environmental lens is one of the major ideas of environmental design. Utilizing green roofs and living walls in the same piece of infrastructure "create[s] a living architecture, where the formally inert built form of concrete, steel, timber, and glass come alive- breathing, cooling cleansing, and recycling."[89]

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[88] Hopkins, *Living architecture: Green roofs and walls*, 40.
[89] Ibid., 2.

Biophilic Design. A majority of the private and public benefits I addressed from green roofs and living walls are mostly beneficial in terms of sustainability. Cutting down on energy use, water management, pollution reduction, etc., bring benefits to people as well as the environment, yet these types of environmental design are greatly focused on sustainability. A few of the other advantages I described, like the social benefits, tend to fall more under the category of biophilic design. While many environmental design ideas can be composed of the interactions between humans and nature, biophilic design tends to rely more strongly on this aspect than on the element of sustainability. However, both concepts "share the fundamental idea that nature needs to be treasured and protected."[90]

As I introduced in chapter two, biophilia is the combination of the words love and life; life meaning nature and living organisms. When you ask someone where their happy place is, you often receive responses like a sandy beach, lying beneath the stars, or listening to the sound of a stream running.[91] All these ideas display this imbedded connection with nature. Edward O. Wilson describes the origins of this idea as an instinctual feeling; humans are drawn towards living organisms over the inanimate, like a moth drawn to the light. [92] Wilson looks at this relationship with the hopes that once we can better understand other organisms, we can learn to greater appreciate and co-exist with them and ourselves. As we continue down the path of urbanization and industrialization, we split further and further from this relationship. We do this in both the physical sense, as we move into concrete cities and close our walls off to the natural world elsewhere, but also in a long-term overarching sense, as we are slowly destroying the natural life around us due to climate change, loss of biodiversity, deforestation, etc. Wilson states

[90] Sally Coulthard, *Biophilia: You + Nature + Home* (Kyle Books, 2020): 21.
[91] Ibid., 6.
[92] Edward O. Wilson, *Biophilia* (Cambridge, Mass: Harvard University Press, 1984), 2.

that rather than throwing ourselves into new innovations and industries to solve these problems; we must foster an understanding of our biological surroundings.[93]

Bringing this idea into the design world, the purpose of biophilic design "is to create artificial environments as similar as possible to natural ones, to ensure the positive effect that Nature has on people's health and wellbeing."[94] Over time, we have been able to discover what desires humans want in order to foster a connection with nature. These tend to fall into two categories based on our evolutionary adaptations and desires. The first need that we must fulfill falls within "light, protection and control, air, and views," which satisfies the want of finding a safe and comfortable place to live, while the other category aims to fulfill our search for resources and food, things such as "greenery; curiosity; materials, and finishing and colors."[95] Combining these two aspects gives us the psychological and physical advantages that we gain from our ecosystem services.

To fulfill these two categories within a home or indoor space, there are three fundamental rules to follow that allow for these needs to be maximized. Rule one is to ensure that you are in direct physical contact with nature.[96] This could easily be fulfilled by plants and flowers, but also with more abstract ideas such as a wood-burning fire. The second rule is to bring in many aspects and things that remind you of the natural world, such as colors, patterns, and textures.[97] The last rule is to ensure you are living so that you are connected to nature and natural rhythms. Allowing for plenty of natural light, following a circadian rhythm, or living in tune with the seasons are all examples of how to live this way.[98] Following these rules will work harmoniously alongside our

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[93] Wilson, *Biophilia*, 123.
[94] Barbiero, "Biophilia as Evolutionary Adaptation."
[95] Ibid.
[96] Coulthard, *Biophilia: You + Nature + Home*, 7.
[97] Ibid., 7.
[98] Ibid., 7.

innate desires of nature to immerse ourselves in biophilic design. In chapter five when I propose my solutions, I will offer ideas on how to replicate this.

Beyond Design. Green roofs and living walls can be considered in terms of large-scale retail buildings, malls, and museums, but they can also be incorporated within smaller-scale apartments, offices, and schools. When designing a new building, there are many ways to bring in green and biophilic design. It can be as simple as building large windows, but when building new infrastructure isn't possible, we must look at other ways to adapt to what has already been created. Rooftop gardens can be made as education centers in schools to help kids understand how plants and food grow and how they impact the environment. Unfortunately, creating a rooftop garden requires money, resources, and time, which isn't always possible, especially in lower-income areas. However, certain non-profits can help bring these resources in. To combat this, on a smaller scale, within the classroom, having plants throughout the room and even having children grow their own plants can be beneficial. Having access to plants and nature in university buildings is also equally important. Having plants of one's own in a dorm room can be difficult because of the lack of light and space, and keeping the plants alive also poses issues. Still, a university could supply or have plants in libraries and classrooms. Planning and designing these ideas also fosters a sense of community, but I will expand upon this idea further in chapter five.[99] The same goes for office spaces as well. In a case study measuring employer satisfaction and performance in office spaces, something as simple as desks facing a window can be a design choice to improve all aspects of an office.[100]

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[99] Claire Latané, *Schools that heal design with mental health in mind* (Island Press, 2021): 2, https://eds-s-ebscohost-com.avoserv2.library.fordham.edu/eds/ebookviewer/ebook/ZTAwMHhuYV9fMjkwNzQ0OF9fQU41?sid=2afa68c9-6fdd-423d-a340-214605981527@redis&vid=1&format=EB&lpid=lp_27&rid=0.

[100] Ahmed Khaled Aboulfotouh et al., "The Impact of Workspace Location and Indoor Environmental Quality on Employees' Satisfaction within Office Buildings: A Case Study in Cairo," *Indoor and Built Environment* 31, (2020), https://doi.org/10.1177/1420326x20944561.

Through many studies, it has been proven that children have a deep connection with nature. Often, a child's first experiences with nature create a fundamental relationship with how they view the environment. This has been important to study because, as we move into urbanization, these first experiences often occur at lower levels. Coupled with the dangers of city living and lack of space to connect with nature, time spent playing in nature decreases, and time spent indoors and engaging with technology dramatically increases.[101] As I mentioned in the previous chapter, there are also many other cons of children growing up in cities because of consequences like increased respiratory illness, higher risk for obesity, and a lack of motivation to protect nature. When children grow up away from nature, their connection with nature does not go as deep as it could. The biophilic feelings and connections we create are stimulated by past experiences; however, they can continuously adapt and change over time.

A study done in Aosta Valley, Italy, measured the Biophilic Quality Index (BQI) of a primary school. The BQI calculates how biophilic a building is, which was designed to help architects merge nature with design for sustainability and biophilic design.[102] The study found that having a biophilic-centered school allowed the children to flourish and establish a deeper connection with nature.[103] This study set a path so that can also be done with adults in buildings like office spaces. The concept of the child-nature disconnect is also discussed through the term "nature-deficit disorder." While not an actual medical condition, Richard Louv, who coined the term in his book *Last Child in the Woods*, described the importance for humans and children to have a connection with nature.[104] The rapid acceleration of the move away from nature comes at

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[101] Barbiero, "Biophilia as Evolutionary Adaptation."
[102] Giuseppe Barbiero and Rita Berto, "The Biophilic Quality Index. A Tool to Improve a Building from "Green" to Restorative," *Vis. Sustain* (2017): 38, 10.13135/2384-8677/2333.
[103] Barbiero, "Biophilia as Evolutionary Adaptation."
[104] Richard Louv, *Last Child in the Woods: Saving Our Children from Nature-Deficit Disorder*, (Books of Chapel Hill, 2008), https://search-ebscohost-com.avoserv2.library.fordham.edu/login.aspx?direct=true&db=cat00989a&AN=ford.2427622&site=eds-live.

a cost; we miss out on all things gained from nature. Louv emphasizes the importance of incorporating environment and education, especially at young ages.

In chapter two, I touched on the history of plants in religious spheres like Buddhism and Hinduism. Design is also important to address in religious settings because many beliefs and ideas are linked with the natural world, such as plants and animals. A study done in Jajpur, India, found and categorized the reasons for the use of about 85 different plant species within temples and on temple grounds. Plants used in temple rituals, ornamentals, sacred use, totem plants, and platforms for god were among the most common uses found.[105] The propagation of many sacred plants also helps contribute to the maintenance of biodiversity if these practices continue.[106] However, the protection of many of these religious places is starting to lessen in certain areas, possibly attributed to socio-economic and cultural reasons like industrialization and the spread of Western culture.[107] Regardless, plant use in religious spaces is important to acknowledge as we touch on the ideas of ethnobotany, which is needed to further understand and expand upon environmental design.

Environmental design and architecture come from creating new things from the ground up and altering what already exists to adapt to our new lifestyles. We have moved away from a plant-human co-existing lifestyle because of intense urbanization, but through design, we can find a way to merge our old and new lifestyles as we move forward into the future to continue to

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[105] Rajballav Mohanty et al., "Role of Temples and Other Holy Places in Plant Conservation of Odisha, India," *International Journal of Conservation Science* 3, (October 2012): 303, https://www.researchgate.net/publication/283890827_Role_of_Temples_and_Other_Holy_Places_in_Plant_Conservation_of_Odisha_India.

[106] Adil Mir et al., "Ecological and Ethnomedicinal Values of Sacred Plants in Some Major Temples of Bhopal, India," *International Journal of Current Microbiology and Applied Sciences* 7, (January 2018): 1630, https://doi.org/10.20546/ijcmas.2018.701.198.

[107] Mohanty, "Role of Temples and Other Holy Places in Plant Conservation of Odisha, India," 307.

emphasize cultural ecosystem services. In the next chapter, I will expand upon and introduce new solutions that will help us achieve this.

Chapter 5: Moving Towards a Greener Home

Throughout my paper, I have discussed the importance of the ecosystem services plants provide. In chapter one, I addressed how and why these ecosystem services have always been an essential part of our lives and how we can utilize these services indoors. In chapter two, it was important to understand the environmental history of our relationships with plants and how urbanization has moved us away from this connection we once had. In chapter three, we explore the environmental psychology and health benefits plants bring us mentally and physically. Lastly, in chapter four, we recognize the importance of environmental design and architecture that allows for environmental innovations in an urbanized setting. Bringing all these disciplines together, we can create new solutions, as well as make advances on other ideas to move forward to build greener homes and lifestyles within cities.

Designing Your Space. The importance of designing and creating a biophilic space, as tackled in the previous chapter, is essential to utilize the full benefits of ecosystem services provided by plants. Having our artificial spaces as similar as we can to the natural world through biophilic design makes an enormous impact within urban settings. We can cultivate biophilia within home, work, and community settings.

The home is one of the more accessible spaces to incorporate biophilic design, but it also is one of the more important spaces to design as this is where we spend most of our time. The three key aspects to keep in mind, physical contact, things that remind you of nature, and natural rhythms, all come into consideration in home design. Introducing natural materials benefits our

mental health because we connect to our environment of evolutionary adaptation, a conceptual place to which a species adapted over time and is thus ancestrally connected to.[108] This is essentially what makes a home feel homey. Natural materials that can be added for this effect are wood, wool, stone, bamboo, and, of course, flowers and plants. Finding these materials that are native to the region in which you live can also create an even more ethnobotanical and eco-friendly style.[109] The next significant design choice is color. Color can affect our emotions and instill feelings within us, dependent upon shade, hue, and placement. After blue, green is the second most common color that occurs in the natural world, and we commonly associate it with growth, forests, fields, and plants.[110] Studies show that the cones in our eyes are most sensitive to the wavelengths of green, and because of this exposure, it induces calmness in our brains.[111] Incorporating colors of the natural world, like the sky, sea, earth, and plants, intensifies our biophilic connections, and within work and office spaces, this is also vital to create.

Creating a biophilic environment within offices and work settings has been proven to offer many benefits. As chapter four mentions, these benefits can range from improved mood and concentration to enhanced task completion and reduced stress. Attention restoration theory is focused on the idea that concentration can be restored and improved with exposure to natural environments.[112] Attention fatigue occurs with exposure to tasks that have little or no motivational draw, and over time, this can lead to poor decision-making and develop into other health-related issues like obesity.[113] Attention restoration theory allows for benefits like "the

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[108] Kevin Bennett, "Environment of Evolutionary Adaptedness (EEA)," *Encyclopedia of Personality and Individual Differences,* (2018): 2, https://doi.org/10.1007/978-3-319-28099-8_1627-1.
[109] Coulthard, *Biophilia: You + Nature + Home*, 33.
[110] Ibid., 33.
[111] Ibid., 51.
[112] Heather Ohly et al., "Attention Restoration Theory: A Systematic Review of the Attention Restoration Potential of Exposure to Natural Environments," *Journal of Toxicology and Environmental Health, Part B* 19, (2016): 305, doi:10.1080/10937404.2016.1196155.
[113] Ibid., 305.

chance to 'be away' from everyday stresses,"[114] similar to what was mentioned in chapter three that plants within indoor spaces can create a vacation-like feeling in the mind. The importance of creating an environment to avoid attention fatigue is a positive for both companies and employees.

The subsequent important design concepts to consider are patterns and shapes. Specific shapes and patterns tend to be more visually appealing than others, and often, these are the patterns that follow natural shapes and motifs.[115] Fractal patterns like leaf veins, rivers, and snowflakes are repeated geometric patterns that vary in size.[116] Ferns, dandelions, and leaves often display complex fractal patterns. Spirals are another familiar natural shape. Sunflowers, succulents, and shells all provide very visually appealing patterns to our eyes. Curves and circles also provide natural shape to environments, as opposed to much of our current architecture, which follows sharp edges, rectangles, and squares that rarely ever occur in nature. Light, sound, and temperature are also important to consider when designing an indoor space. There are many ways to incorporate natural light and views indoors to create comfort and lean towards a biophilic environment. Another way to foster attention restoration is through the use of microbreaks. A study that analyzed two different groups of students, showing one group a 40-second view of a green roof and the other a 40-second view of a concrete roof, found that the group that viewed the green roof had improved attention-restoring benefits compared to the other group.[117] A microbreak like this can easily be incorporated within offices and schools. Window views, exposure to green spaces, and biophilic design can be solutions to work towards this.

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[114] Ohly, "Attention Restoration Theory," 306.
[115] Coulthard, *Biophilia: You + Nature + Home*, 65.
[116] Ibid., 65.
[117] Kate E. Lee et al., "40-second green roof views sustain attention: The role of micro-breaks in attention restoration," *Journal of Environmental Psychology* 42, (2015): 187, https://doi.org/10.1016/j.jenvp.2015.04.003.

Theories like the environment of evolutionary adeptness and attention restoration theory work together with the study of environmental psychology to shape our indoor environments and improve our connection with nature in our homes and workspaces, which can then also be fostered within community environments.

Availability. Now that you might have decided to fill your home with plants and receive all their benefits, the next battle you might be facing is how to actually get these plants. In chapter one, I mentioned the idea of how people in dorms, or in other situations where people are often moving, find it very hard to move plants. In other situations, depending on the area, having the privilege of a plant nursery or other places to buy plants nearby is rare. Although, with new apps and websites, some delivery services can deliver smaller plants from grocery stores and home improvement stores, this limits the options of being able to pick out the exact one you want, as well as the size and other option limitations. Another boundary that could be faced is plant care. While I will discuss this issue deeper later in this chapter, after having a plant for a long time, as it grows, repotting plants can be a large obstacle to face as well as with the changing of the seasons, different plants require different levels of care and sunlight, that a city space may not have. Finding plants to fit into the environment of a specific apartment or home can be tricky, too, and there can often be a nervousness that comes with committing to buying a new plant because it may not thrive or survive.

Depending on the situation, people might face all or even some of these boundaries and obstacles. To avoid this, I am proposing a plant rental service. While plant rental services already exist, based on my research, I could only find short-term rentals for parties, weddings, and other events; none were long-term for schools, homes, offices, etc. Creating a company that would lease out plants can relieve many of these previously stated burdens. The company would be

comprised of a delivery and pickup service, located in many large cities, and would alleviate the need to have either a car or a local store. In the app/website, there would be a current picture of each plant, information that describes what kind it is, how to care for it, the size, and any other vital information. The company would allow for different time lengths to rent the plant out, based on varying needs, which could always be extended or shortened. While kickstarting the company could pose challenges, just like any other business, a long-term plant rental can allow for people to experience the benefits of houseplants. Whether this company is used for people who want an easy start getting into the hobby of houseplants, or for a student, or for a multitude of other reasons, this solution could be a start to aiding and broadening the availability of houseplants.

Accessibility. Another limiting factor that can significantly affect people wanting to have a green-filled home is price and space. Depending on the type of plant and size, small plants can range from less than ten dollars to upwards of a hundred dollars, and larger plants typically range from about fifty to a few hundred dollars. Price can also vary depending on where the plants are purchased from. A cheaper option might be a home improvement store, which will most likely have fewer options, or a nursery, which will typically have more options but will often be more expensive.

As mentioned previously, space within city buildings is often quite limited, so one of the solutions I wanted to propose was the use of hydroponic systems. Instead of soil, hydroponics uses a nutrient-rich water-based solution to grow plants, which can save space and make plant care easier. Many of these systems also utilize growing lights that can speed up the process of growing and provide a source of light when there is little or no other source available. One of the main selling points of hydroponic systems is that they focus on growing food, which is an

excellent solution to what was stated in chapter three about urban agriculture. Although this all seems great, the biggest con of these systems is the price. For many smaller systems that are only about a foot long, the cheaper options are about 70 dollars, and the ones about 3 feet or longer are about 800 to 1,000 dollars. So, while hydroponics solves some of the other problems of growing houseplants in cities, this doesn't solve the problem of accessibility.

Unfortunately, hydroponic systems aren't for everyone, but other solutions exist. Maximizing available space to its full potential is critical in apartment living. Solutions like hanging planters, vertical gardens, which can be smaller versions of living walls, plant shelves, tabletop gardens, and magnetic planters are all great space-saving solutions at lower prices. Furthering these ideas, many studies suggest purchasing certain plants over others based on what is trying to be achieved. Cheap, easy to care for, low-light, and fast-growing, the snake plant is one of the best houseplants, especially for beginners. Some other popular options are the philodendron, peace lily, pothos, spider plant, and aloe vera. With affordable prices, these beautiful plants will provide all the benefits of having them in your home.

Public Use. As stated in chapter four, the use of green roofs is a great way to turn unused space into environmentally beneficial designs. Although green roofs do not have the added benefits of improved indoor air quality, having a rooftop garden can supply people with private and public benefits, as mentioned in chapter four, and personal benefits, like fresh food, as discussed in chapter three. Dependent upon city, building, and other safety regulations, rooftop gardens can be cheap and easily maintainable spaces to greenify a building.

Since green roofs have been around for quite a long time but don't seem to be growing in popularity in many existing or new buildings, a new solution should be proposed to increase the number of green roofs and gardens. Due to the number of rules and regulations many cities and

buildings have, it is often slightly more challenging to set up plants on a shared roof rather than within an apartment. To make this a smoother process, I propose having a city/government policy in place. In some counties in California, there is a rebate that is available for homeowners. If they are willing to replace their water-intensive grass with drought-tolerant landscaping, they can be given money to spend on this change.[118] I think that if large cities were to do something similar, but with empty rooftop space, this would create an incentive for building owners to want to build green roofs and gardens. If the city or county pays or offers tax rebates for the majority of the resources needed to make this, not only will the city and environment benefit from better storm management, increased biodiversity, and more, but the building owner and residents will also benefit from reduced energy use and increased market value, as discussed in chapter four. While the city must spend money and resources to help kickstart the expansion of green roofs, in the long run, everyone benefits. This would be an incentive for the owners of private buildings such as apartments and homes. And this would also create an incentive for public buildings, just as living walls were able to develop a sense of community, these green roofs and gardens will also provide a similar social benefit.

New York City already has a program in place for green roof tax abatement. This program provides a one-year property tax abatement for building a green roof, for both residential and commercial buildings in NYC.[119] Although situation-specific, to apply for this abatement, a green roof is classified as a growth medium and a vegetation layer of hardy plants and must cover at least 50% of the roof's space. The tax abatement is equal to $5.23 per square

[118] "Cash for Grass Rebate Program," Department of Public Works, https://dpw.lacounty.gov/wwd/web/Conservation/CashforGrass.aspx/?utm_source=synlawn&utm_medium=corp&utm_campaign=news.
[119] "Green Roof Tax Abatement," NYC Department of Finance, https://www.nyc.gov/site/finance/property/landlords-green-roof.page.

foot and caps at $200,000 or the amount of property tax due for that building.[120] While this can be significantly expanded to consider more than just growth medium and vegetation, this preexisting program is a positive step in the right direction to further foster community and education that can be recreated in other cities.

Education. Considering design, availability, accessibility, and public use, even when finding solutions to these barriers, there will almost always be the limiting factor of education. Brought up in most of my chapters, having children and students surrounded by a natural environment consisting of plants provides countless advantages, and along with this, teaching students about how plants are beneficial is key in fostering others excitement and knowledge on building a greener life. In school, we are often taught about how plants photosynthesize with sunlight and water and provide us with the food and nutrients we need, but more often than not, how to actually care for these plants can be overlooked. Educating people on how to care for plants is one of the simple solutions that will lead to more people having plants. The stress of worrying if someone will be able to care for a plant often deters people from having them. A recent survey found that "67% of millennials find taking care of plants a challenge," [121] which limits the expansion of other plant-related solutions. If someone is unwilling to care for a plant, the bottom line is, they simply won't have them, but education can fix this. Once we can set a baseline for education, whether that comes from school at an early age, internet access, or word of mouth, this can create additional and new options for more solutions and steps towards the future.

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[120] "Green Roof Tax Abatement."
[121] Anne Wallace, "Survey Shows 67% of Millennials Find Taking Care of Plants a Challenge," Deseret News, 2020, https://www.deseret.com/u-s-world/2020/1/27/21083948/millennials-pressures-plant-parenting-survey-parenthood-houseplant.

Having a standard for education in schooling, especially within urban areas, on ecosystem services and plant education is crucial. As addressed in chapter three, it is vital that children connect with the environment to foster a biocentric life. When children grow up in urban areas, they often lack the immersion of the natural world, which also can cause poor health. In addition, children who are adversely affected by lower socio-economic status in their home lives must be able to experience an environment that can provide these needs for them, and most often, that would be in a school setting. Cultivating biophilic schools and education curricula can aim towards promoting and making positive changes for the future. The company GrowNYC is a non-profit organization in New York City that helps to improve access to fresh, locally grown food and green spaces. It also educates children on the importance of nature, healthy food, and sustainability.[122] Organizations like GrowNYC are imperative ways that schools and educators can teach and give a hands-on experience to children for little to no cost and to remediate effects of environmental injustice and promote urban agriculture.

It is essential to address education both within school settings with young children but also for adults and those who are attempting to further their knowledge of plants and ecosystem services. For the statistic mentioned above, urging adults to learn about plant care and benefits will allow for change within homes and build and improve the community. The barriers to overcome for this age group are most likely time, money, and interest. To solve this, having classes for adults that they can take with friends, family, or co-workers to introduce people to these ideas is a solution. For example, an East Coast-based company called Bonsai Bar offers classes at breweries in multiple states and locations where participants can learn about the art of bonsai and create their own tree to take home. Companies such as this can be a great way to

[122] "GrowNYC Education," GrowNYC, https://www.grownyc.org/education.

introduce people to plant care and would even work well for company events, date nights, etc. Having a variety of online and in-person activities that are available and accessible to an extensive array of people while being able to engage and excite people could expand education in a enjoyable way.

As more and more people become educated and learn about the importance of our ecosystem and its services, we must simultaneously help people develop an eco-humanist mindset. As chapter two mentions, an intersection between ecological and humanist ideas fosters an environment that focuses on human values and environmental importance. To do this, it is vital to examine and reform our use of plants. When we consider plant welfare, we are then forced to address how, in this society, we often use and abuse plants.[123] Waste, overconsumption, and poor habits dwindle the ecosystem services plants can provide us. Learning to care for the environment as we progress with urbanization must be considered hand in hand. This will then further allow and encourage people to understand all other related disciplines.

Whether it is these specific policies or bringing these overall ideas together, this is what is going to create the shift towards greener homes. Impacting people, places, animals, and more, ecosystem services can be brought back into our urban lives to improve our way of living.

[123] Hall, *Plants as Persons a Philosophical Botany*, 163.

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