

PLANTING URBAN BUILDINGS

Cooling and Connection in the Built Environment

Hannah Peterangelo

Miami University
Oxford, Ohio
2020

Advisor: _____
(Mary Rogero)

Reader: _____
(Patrizio Martinelli)

Consultant: _____
(Sergio Sanabria)

Consultant: _____
(John Blake)

ABSTRACT:

Urban architectural design and construction is advancing toward greater symbiosis with the natural environment. A complex and promising trend situates plants on the building exterior, encouraging absorptive surfaces and bringing water retention to both the built and natural city surface. In the past, cities primarily bridged the human made and existing world with parks, street trees, and small planters. Expanding the possible context of planted surface to building edges provides greater continuity across the entire city, without threatening the human connection cities facilitate. In addition to the benefits of water retention and visual appeal, plants also mitigate heat island effect, expand habitats, provide insulation to buildings, shade interiors and streets, and provide psychological benefits to humans.

Vegetative integration with urban buildings is explored through current events, historical and recent examples, and anecdotes. This analysis aims for balance between simple but troubled installations and more effective but complex costly designs. The merits and struggles of each are evaluated to determine general best practices and next steps. Urban buildings integrating plants add a layer of complexity to projects already marked by notably intense collaboration between technical experts. However, the public can improve even an experts' understanding with engagement. There is wisdom existing in contractors, gardeners, and everyday people, whose lived experience provides a human scale understanding of complex issues.

There is a consensus that psychology and ecologically integrating plants with urban buildings more would improve city life. Regularly though, concerns emerge over cost of adding plants to buildings due to initial cost and continued maintenance following installation. People worry work will be too extensive, plants will die, and resources will be wasted along with time and money. Mitigation of worry requires a paradigm shift. If many people desire greater connection a view of nature, they must also, if perhaps only subconsciously, desire a connection with nature themselves. What if integrating plants with buildings was seen less as a declarative art piece with difficult maintenance required, and more as an opportunity to bring gardening and connection to urban dwellers?

“PEOPLE SHOULD ALWAYS BE CONSCIOUS THAT THEY ARE PART OF THE NATURAL WORLD, INEXTRICABLY TIED TO THE ECOLOGICAL PROCESSES THAT SUSTAIN THEIR LIVES.”¹

ISOLATION & CONNECTION:

I emerge from under the cool canopy of park trees, onto the concrete in blinding hot sunlight to gaze up at a particularly beautiful building on Michigan Avenue in Chicago. The Carbide and Carbon Building (Figure 1). So dark a green, in some light, it appears black, and gold accents touch its corners and cornices – it is beautiful, but also menacing. Not as cold as functionalist modern buildings; still, there is something intimidating about its design. I imagine it being used in a movie set as the backdrop for a sinister but also stylish CEO, visually reinforcing their power. Inwardly I appreciate its Art Deco detailing, while also wondering what might help soften the intimidation. “If only there were real greenery.” Visions of the building transformed and made friendly by plants always accompany this familiar idea. If you ever see me wandering around gazing at



Figure 1 Eric Alex Rogers, “St. Jane Hotel (Carbide and Carbon Building),” Chicago, IL, <http://www.architecture.org/learn/resources/buildings-of-chicago/building/carbide-and-carbon-building/>

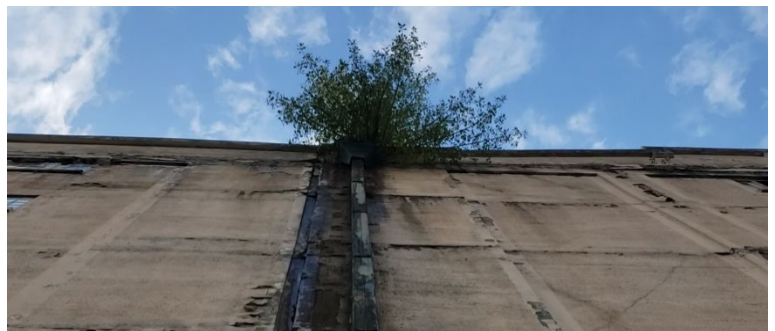


Figure 2 Hannah Peterangelo (author), “Rainspout Plant,” Dayton, OH. August 6, 2020

¹ William Cronon, “The Trouble with Wilderness” in *Uncommon Ground: Rethinking the Human Place in Nature*. (New York: W. W. Norton & Co., 1995) 87. Quote from Ecological Historian, William Cronon’s influential essay. The essay details how our descriptions of “wilderness” separate us from and damage our ability to recognize what we consider “wild” as something we are connected to.

buildings, you now know what I'm imagining. Alternately, noticing buildings with plants *voluntarily* finding their way to gutters, crevices, and rooftops (**Figure 2**) make me smile despite my knowledge this is not particularly good for the building. Usually facilitated by clogged gutters, or a crack in the building's exterior seal, allow dirt and debris to accumulate and the plant to take root. These roots work their way into the cracks and as they grow, the cracks grow too. Not ideal for a building, whose primary objective is to keep water out, and shelter us. I don't smile because I don't care about damage to buildings. I smile because plants are so pleasant they are worth some risk and extra planning.

I wandered Chicago a year ago. Now, in 2020, people across the world are social distancing due to the pandemic. The proliferation of plants and animals returning provides one bright spot to our current isolation. Awareness of our dependence on one another and the natural world is expanding. Whereas before, people commented on connection in a philosophical way, now it is evident as a fundamental physical fact. For safety, we cut ourselves from most of our usual connections, and despite this, our continued survival depends on food stores, health care workers, delivery personnel, and still other connections for our mental health. Also, the darker side of connection shows in the death and illness spreading around us. Covid-19 and past pandemics wreak sudden damage if left unaddressed. Scientific studies show each decade since 1980 infectious disease “more than tripled.” Speaking on behalf of the Sustainable Europe Research Institute, their vice-president and ecologist Joachim Spangenberg notes “By disrupting ecosystems, we have created the conditions that allow animal viruses to cross over into human populations.”²

How does pandemic relate to problems and potential solutions in architecture? There are many implications. Broadly, recent events cause people to look more deliberately at related large scale issues like global warming's potential for disaster if left unaddressed. Covid-19 is spurring what was already an expanding call for sustainable building practices that respect our relationship with the Earth. And if there is anything encouraging about the pandemic, it is the demonstration of human ability to adapt, given urgent attention.

² Charli Shield, “Coronavirus Pandemic Linked to Destruction of Wildlife and World's Ecosystems,” *Deutsche Welt*, April 14, 2020, <https://www.dw.com/en/coronavirus-pandemic-linked-to-destruction-of-wildlife-and-worlds-ecosystems/a-53078480>.

CITIES AND PLANTS:

In 2019, before the pandemic began, economists anticipated city areas to expand 66% by 2050.³ The current need for social distancing and potential future pandemics raises a new question. Moving forward, will humans be less comfortable with the close quarters of cities? Growth could be reduced if discomfort with close quarters and expanded ease with remote communication leaves lasting changes on interaction. We should be prepared to adapt to cultural shifts caused by the pandemic. If reduction in city size occurs, the open spaces create opportunities to alter current infrastructure to bring in more greenery. Alternatively, if cities continue to grow, the imperative to build more ecologically sound buildings is even greater. Currently, despite cities occupying only 2% of Earth's surface, they demand 75% of the used resources.⁴ There is an irony here. Though city residents tend to be liberal in embracing forward thinking technology and eco-friendly design, the way cities currently function make them more detrimental to the environment than rural areas. Geographically, cities present the largest opportunity for improving how buildings affect the environment, and training architects are currently scrambling for every possible method to realign buildings and ecosystems.

The importance of creating buildings that use less energy and behave more efficiently cannot be overstated. This exploration focuses on the interaction between plants and building exteriors, but there are many methods for creating smarter buildings. Therefore, these ideas would best function in tandem with other efforts for sustainability, such as use of renewable energy, recyclable materials, and designing the geometry of a building according to what works well for both its function and its climate. A building's shape also affects interior spaces as well as the success of plants so will be explored more later.

To discern why integrating plants with city architecture is a promising ecologically; it is helpful to first consider how buildings without plants behave. The predominantly hard surfaces of buildings dispel water and disrupt the usual absorbency of earth's surfaces. To address runoff, cities divert

³ X. Li, Y. Zhou, J. Eom, S. Yu, & G.R. Asrar, "Projecting Global Urban Area Growth Through 2100 Based on Historical Time Series Data and Future Shared Socioeconomic Pathways." *Earth's Future*, no. 7. (2019): 351-352, <https://doi.org/10.1029/2019EF001152>. Projects 66% growth by 2050

⁴ "Resource Efficiency & Green Economy." UNEP - UN Environment Programme. September 26, 2017, <http://www.unenvironment.org/explore-topics/resource-efficiency/what-we-do/cities/resource-efficiency-green-economy>.

storm water to underground sewer systems. This also subverts former natural water routes. The lack of water retention on the city surface results in heat island effect. I describe experiencing a heat change stepping from below the tree canopy to the sidewalk, in Chicago. Most are familiar with the dread, on a hot day, of stepping from a park into a parking lot. This makes local temperatures of cities are unnaturally high, “on average 5–9°C warmer”⁵ (9-16°F warmer), when compared to the adjacent rural areas. This is inhospitable to biodiversity, and more demanding on energy resources to artificially cool spaces. Combine existing local temperatures in cities with the threat of Global Warming, and vegetation in cities emerges as an opportunity not only aesthetic, but also practical. As mentioned, sewer diversion works to redirect water, but when substantial rains overpower them, flooding results. Planted surfaces fix this by capturing and retaining rainwater. In addition to mitigating flooding, water distributed more evenly across surfaces also helps cool planted areas.



Figure 3 Parks

Parks (**Figure 3**) are a good initial step to help absorption in cities, but adding them is only successful for city life to a point. As noted by journalist, city planning theoretician, and economist Jane Jacobs, after a certain threshold, parks in a city cease to be useful for human activities. Once too expansive, they separate the urban fabric necessary for communities to function and in some cases are added before meeting basic human needs. Have you ever seen a park put into a food desert (an area without accessibility to grocery stores for residents)? Not a good move. Parks can also pose safety risks if not well patrolled. Jacobs notes

⁵ “Cities Can Fight Climate Change and Improve Lives by Finding New Ways to Be Cool.” UN Environment. October 10, 2019, <http://www.unenvironment.org/news-and-stories/story/cities-can-fight-climate-change-and-improve-lives-finding-new-ways-be-cool>.

patrolling need not always involve active policing. Good design encourages active engagement between citizens by making visibility and interaction easier. Visibility is why streets with storefronts feel safer than back alleys with no view to streets beyond.⁶ This is also reflected by Leon Krier's (Figure 4) observation of balance between public and private spaces.⁷ If introducing too many parks – aka too much public space - in a city leads to safety problems and disconnect between residents, the natural conclusion, is to bring more vegetation to the building surfaces.

Carlo Becker developed the idea of a Stadtschwamm or Sponge City in Berlin, Germany. With planted buildings (Figure 5), bioswales (planted depressions by roads to absorb runoff), and permeable pavements, Berlin is working to mitigate flooding. Use of permeable pavements for roads and sidewalks aids absorption. Done in conjunction with planted areas to limit erosion caused by water movement through soil, these efforts can also eliminate need for storm water sewers. This is already done in several cities across the world.

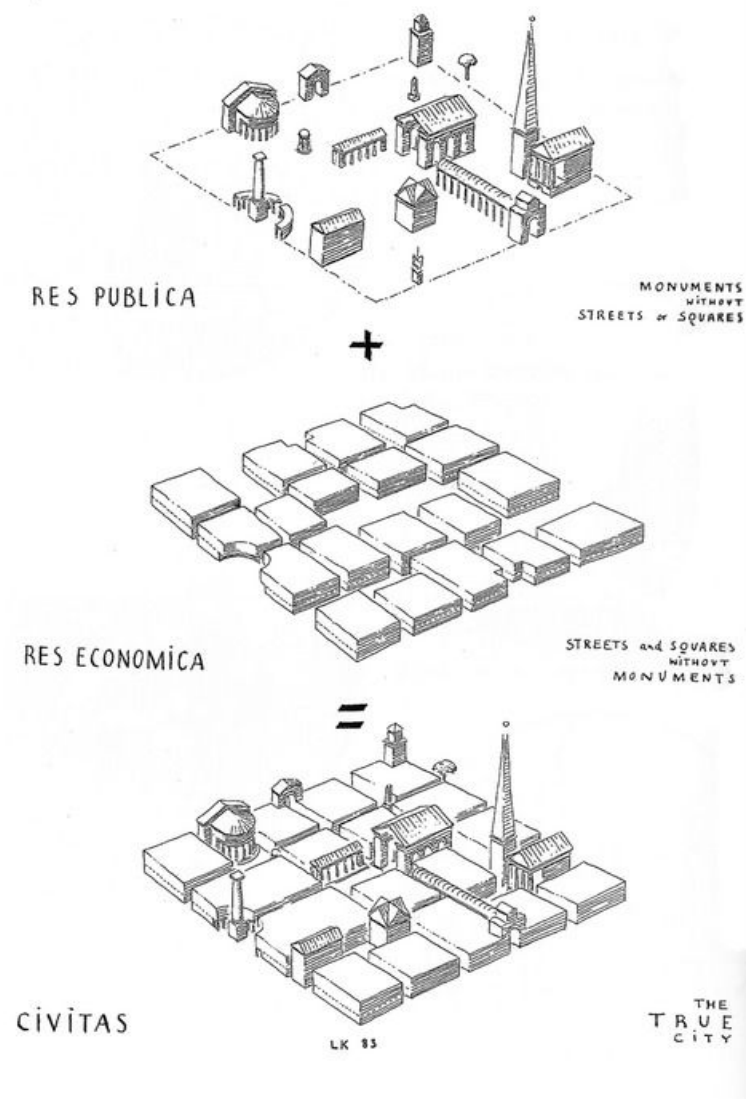


Figure 4 Leon Krier, *The Architecture of Community*, (Washington, DC: Island Press, 2009), 28.

⁶ Jane Jacobs, *The Death and Life of Great American Cities*, (New York: Vintage Books, 1992), 15. Jacobs notes, after sharing a local's comments about a park underutilized in a struggling neighborhood that "there is a quality even meaner than outright ugliness or disorder, and this meaner quality is the dishonest mask of pretended order, achieved by ignoring or suppressing the real order that is struggling to exist and to be served."

⁷ Leon Krier, *The Architecture of Community*, (Washington, DC: Island Press, 2009), 28-29. Krier shows that a well balanced city engages both monumental and economic considerations. The sketches also suggest how proportions of public vs private space affect the success of a city.



Figure 5 Nils Zimmerman, “Sponge City: Berlin Plans for a Hotter Climate,” *Deutsche Welt*, July 22, 2016. <https://www.dw.com/en/sponge-city-berlin-plans-for-a-hotter-climate/a-19420517>.



Figure 6 Elizabeth Fazzare, “Exclusive Look Inside Singapore’s Stunning Eden Garden Tower,” *Architectural Digest*, Published August 20, 2020, <https://www.admiddleeast.com/art-design/design/exclusive-look-inside-thomas-heatherwicks-eden-tower-singapore>

Urban Hydrologist, Heiko Seiker, guides new development in Berlin so that they handle all runoff water on site.⁸ China is another place using plants' sponging ability. Landscape architect, Kongjian Yu is a prolific designer of wetlands in Chinese cities not only aiding absorption but also encouraging biodiversity.⁹

Areas with a monsoon season (and year round humid wet climates) experience some of the worst flooding. By the time the rainy monsoon season arrives their water table is already nearly if not entirely saturated. One place addressing monsoons is Singapore. As a wealthy city nation, Singapore enacted government incentives to integrate greenery with buildings, with more examples of planted buildings than any other place in my search. One example is in the newly built Eden Garden Tower, the first residential project created by Thomas Heatherwick's firm (**Figure 6**). Of the project, he notes "What biophilia is engaging with is that emotion. It's not just about plants; it's about seeing movement, having change, hearing sound, and smelling smells, all these micro-effects we take for granted until they are missing from new developments."¹⁰ Biophilia is defined as love of living things, and is associated with the movement to integrate plants and architecture more closely. Switzerland took a stance in 2005 to make all flat roofs - green roofs.¹¹

Urban buildings integrating plants add a layer of complexity to projects already marked by notably intense collaboration between technical experts. That said, the general concepts can be understood by the public and improved by their engagement. Architects sometimes miss the opportunity to learn from the wisdom existing in builders and gardeners, whose lived experience can be instructive for making complex ideas more palatable and sustainably possible.

⁸ Gloria Kurnik. "Berlin Is Becoming a Sponge City ." Bloomberg via Youtube, August 23, 2017. Accessed January 23, 2020, <https://www.youtube.com/watch?v=uWjGGvY65jk>. Video explaining the idea of the sponge city (or Stadtschamm) explored in Berlin, Germany. Flood footage at 3:20.

⁹ World Economic Forum, "This man is turning cities into giant sponges to save lives," Published August 28, 2019, Youtube, <https://www.youtube.com/watch?v=U37gst79pGc>

¹⁰ Elizabeth Fazzare, "Exclusive Look Inside Singapore's Stunning Eden Garden Tower," *Architectural Digest*, Published August 20, 2020, <https://www.admiddleeast.com/art-design/design/exclusive-look-inside-thomas-heatherwicks-eden-tower-singapore>

¹¹ S. Brenneisen, "Space for urban wildlife: designing green roofs as habitats in Switzerland," *Urban Habitats* 4 (1), 2006. 27–36, www.urbanhabitats.org.

If plants help mental and physical well-being, how do we make sure planted buildings are accessible to more people? From an emotional standpoint, accessibility to many is what is right. But even from a technical standpoint, the benefits to the city and the world will be limited if only the wealthiest builders create green infrastructure. As the ideas become better known, and methods for implementing are more easily available the price will decrease. Governments aid ecological construction with tax breaks, guidelines, and a number of other incentives. There are ways regular people can be involved as well.

RECIPROCity:

The current pandemic provides anecdotal evidence - among existing scientific evidence – showing people are comforted both mentally and physically by nature.¹² Experts are even recommending, in earnest, that people hug trees to gain comfort if unable to hug their loved ones.¹³ Long before the pandemic began, calls to improve the relationship between buildings and natural environments were underway. These reactions show the underlying desire humans have for interaction with plants. If health experts are recommending communing with nature as one solution to the stress of modern life, can expanded knowledge and involvement from regular citizens looking for balance solve the question of how plant maintenance might happen for more than the upper class?

Human attraction to plants may be initially an aesthetic reaction, but this is only the preliminary attraction. Helping nurture something to come to life is its own reward, and the more people discover its benefits, the more viable plant integration with buildings will be. Not everyone will gravitate toward learning to tend plants in their high rise apartment building, just as not everyone in the suburbs wants to garden. However, like music and sports, plants are already a widespread and relatively common interest. And there are ways that building design subconsciously influences how people interact with the space. People intuit, according to spatial layout and visibility, whether they are welcome in an area and to what degree they can alter the space. Good architects know how to

¹² Gregory N. Bratman, Christopher B. Anderson, Marc G. Berman, Bobby Cochran, Sjerp de Vries, Jon Flanders, Carl Folke, et al. "Nature and Mental Health: An Ecosystem Service Perspective." *Science Advances* 5, no. 7. (2019), <https://doi.org/10.1126/sciadv.aax0903>. Scientific study on the benefit of nature to mental health.

¹³ Larissa Kyzer, "Forest Service Recommends Hugging Trees While You Can't Hug Others," April 10, 2020 from Iceland Review, <https://www.icelandreview.com/nature-travel/forest-service-recommends-hugging-trees-while-you-cant-hug-others/>

help users find the bathroom even without direct signage, and likewise, the access and connection between a living space and the planted area will tell users, even without a contract, whether or not they are allowed to interact. Architects can make spaces that encourage interaction between occupants and plants. To see the embodiment of joy caused by plants, look at Christopher, Instagram moniker PlantKween. They encapsulate both excitement and technical knowledge, a combination many – even amateur - plant lovers acquire, though Christopher is hardly an amateur. With a giant smile and happy captions, they demonstrate scientific understanding of plant care need not be cumbersome. In a recent post, a trip to explore a local plant nursery results in a new plant for their niece, who PlantKween happily passes their plant love and knowledge to. “Ms. Peperomia caperata Rosso is native to Brazil, South America & Central America. This kween’s scene is partial sun... morning or evening sun, but does not enjoy full direct sun. She ain’t about that sunburn dahling. I’ve also found this kween to do particularly well with artificial grow lights.” (Figure 4) Brooklyn based with 247,000 followers (as of writing), PlantKween helps spread knowledge and



Figure 7 Christopher @PlantKween "Trip to nursery with niece." Instagram Photo, August 13, 2020, <https://www.instagram.com/plantkween/?hl=en>

encouragement growing “green girls” is not only a pastime for the suburbs.¹⁴ Though not all garden enthusiasts can provide scientific plant names, regular people often possess deep knowledge of the particular requirements of different plants, and the excitement is normal. That said, mid and high rise buildings, even if designed to accommodate large planters with integrated drainage and protection from moisture, are not perfectly analogous to a home’s yard. Even if substantial, planters will not be as deep. Planters on a balconied residence are most closely analogous to the area of yard directly adjacent to the house. Here, homeowners turn their attention to protecting the foundation’s stability. To encourage urban inhabitants to garden in the sky, is also to encourage them to step into a caretaking role for the building. This will require resources for caretakers to learn the potential risks certain plants pose, and whether the plant is well suited to the space. With free phone applications like Google Lens and iNaturalist, help is easy to obtain. Anyone can learn what a plant is and its ideal conditions. It is only a matter of sharing how to access this information. Recent high-tech developments of artificial intelligence pattern recognition are not the only way to find valuable information though.

Indigenous wisdom, particularly if one can find knowledge from the area where building, is marvelously instructive. Robin Wall Kimmerer is a botanist who shares her journey learning to meld her identity as both a scientist and a Native American in the book *Braiding Sweetgrass*. She advocates for “reciprocity” in interactions. She describes the difficulty in engaging in reciprocity with a market economy, but how we still do it for plants, each other, and with how we spend our money when able.¹⁵ As one example of reciprocity between plants and humans, she shares the wisdom of planting the Three Sisters: corn,

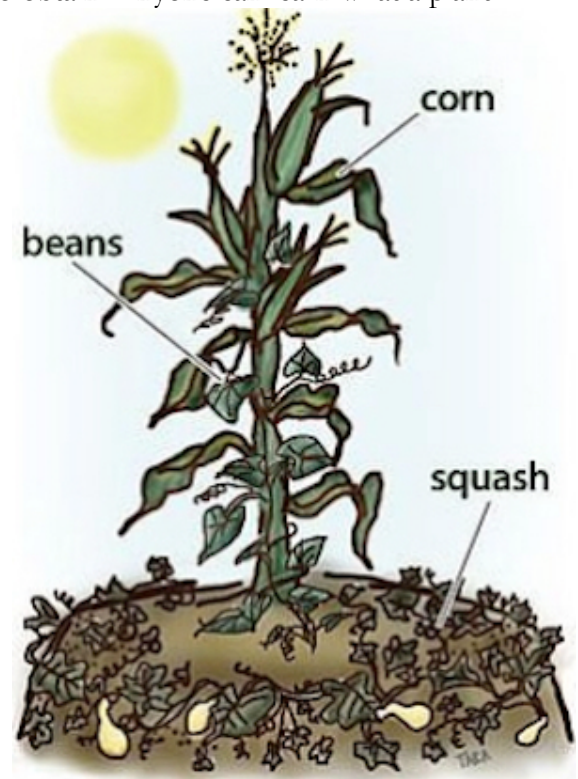


Figure 8 Technology Exchange Lab, "Native American Three Sisters Gardens," Accessed September 6, 2020, <https://www.techxlab.org/solutions/old-farmer-s-almanac-native-american-three-sisters-gardens>

¹⁴ Christopher @PlantKween "Trip to nursery with niece." Instagram Photo, August 13, 2020, <https://www.instagram.com/plantkween/?hl=en>

¹⁵ Robin Wall Kimmerer, “The Honorable Harvest,” in *Braiding Sweetgrass*. (Minneapolis, MN: Milkweed Editions, 2013) 175-201. Reciprocity is discussed throughout the entire book, but the particular discussion on how to live honorably with the land is discussed in “The Honorable Harvest.”

beans, and squash (**Figure 8**). Not only is there reciprocity between the us and the plants, these three, when planted together also behave symbiotically. The corn grows first as a sturdy structure, the beans second, climbing the structure provided by the corn, the squash comes last and stays low to the ground, shading and helping the earth retain moisture. Kimmerer provides additional botanical information to the wisdom of her ancestors. The beans capture Nitrogen from the air, as most plants are unable to, and is converted for use. Extra deposits of Nitrogen form on the beans roots and help feed the other two plants. The three sisters provide an example of food wisdom, though the lesson can be applied to symbiosis between other plants as well.¹⁶ She asserts fear comes from ignorance of something, and admits the fear of the unknown some experience when going to the woods; she encounters while in a city.¹⁷ Even those able to acknowledge their love of plants encounter fear. They worry they will not keep plants alive. A culture shift needs to occur. We need to not only love plants, but forgive ourselves the knowledge we lacked that resulted in so much harm to the planet. The more people overcome fear of their shortcomings and embrace learning, the more capable we will be to overcome the damage done to the earth.

In the 19th century, Frederick Law Olmsted popularized the idea of integrating parks into the increasingly dirty and crowded cities transformed by the Industrial Revolution. Largely thanks to Olmsted, parks are the most common way we are able to enjoy nature in cities today. In an essay surveying his creations, the author notes “Key to his belief in himself was the ability to envision the future shape of the landscape, to guide it over time, and to imagine human intervention as potentially beneficial.”¹⁸ Whether we help ecosystems depends on actively learning from and planning for how natural materials and systems operate. Olmsted was so skilled in mimicking natural systems, many people think his parks are naturally occurring landscapes. Even Yellowstone and Niagara, though shaped around existing landscapes, involved extensive interventions. Central Park

¹⁶ Robin Wall Kimmerer, “The Three Sisters,” in *Braiding Sweetgrass*. (Minneapolis, MN: Milkweed Editions, 2013) 128-140.

¹⁷ Ibid, 223.

¹⁸ Anne Whiston Spirn, “Constructing Nature: the Legacy of Frederick Law Olmsted,” in *Uncommon Ground: Rethinking the Human Place in Nature*, 1995. 102.

and Boston's "Emerald Necklace" (Figure 9) are almost entirely humanmade.¹⁹ The 1970s brought advancement from the architecture community as people grew more aware of the negative impacts of buildings on the environment, and began to make changes.²⁰

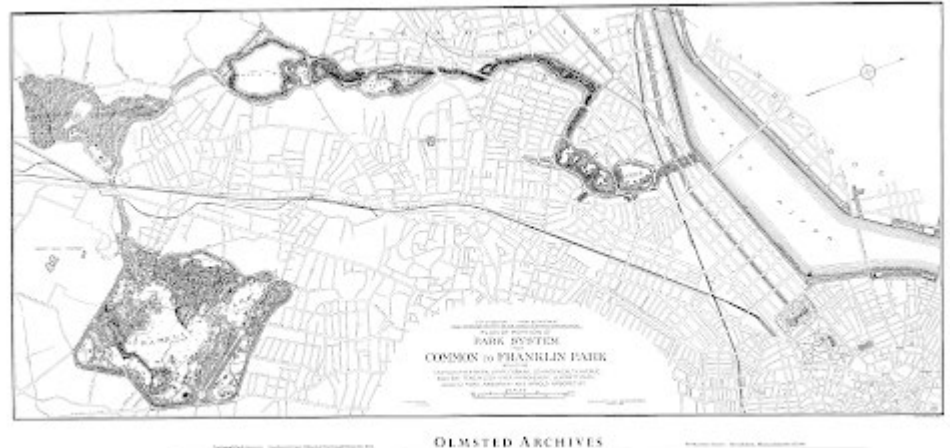


Figure 9 Sebastian Jordana, "The Indicator: The Responsibility of Beauty," ArchDaily, January 04, 2013, <https://www.archdaily.com/314434/the-indicator-the-responsibility-of-beauty/50e5f577b3fc4b170d00005e-the-indicator-the-responsibility-of-beauty-photo>

DIGGING DEEPER - EXAMPLES, ANECDOTES, AND STUDIES:

Discussion of built examples so far addressed why to build with plants. The next examples delve into closer detail to discern how to achieve benefits and overcome difficulties. One starting point when determining how to approach a project with the aim of ecological harmony, is to follow principles of biomimicry. Biomimicry is defined as "the study of the structure and function of living things as models for the creation of materials or products by reverse engineering."²¹ From *Architecture Follows Nature: Biomimetic Principles for Innovative Design*, Michael Pawlyn recommends:

"The starting point for such investigation can occur at either large design scale, such as that of a city or neighborhood, looking for inspiration in the complexity and interrelatedness of ecosystems, or by choosing one element of an animal as focus of inspiration, for example starting with an animal skin to use as model for the design of a building envelope."²²

¹⁹ Ibid, 91, 112.

²⁰ James Wines, "Green Architecture," *Encyclopedia Britannica*, September 25, 2019. Accessed May 20, 2020. <https://www.britannica.com/art/green-architecture>.

²¹ "Biomimetics." Wiktionary. Accessed May 17, 2020, <https://en.wiktionary.org/wiki/biomimetics>.

²² Michael Pawlyn. *Biomimicry in Architecture*. London: Riba Publishing, 2011, 29.



Figures 10 Ian Mutuli, “National Library in Singapore by Ken Yeang, and Effort Towards Sustainability in the Tropics,” Archute, January 2, 2016, <https://www.archute.com/national-library-in-singapore-by-ken-yeang-an-effort-towards-sustainability-in-the-tropics/>

The focus so far has been primarily on ecosystems as inspiration for larger scale examples. Zooming into smaller scale interaction between plants, buildings, and humans is also helpful. How we achieve larger impacts will be done piece by piece at the human scale, and some cumbersome concepts, can be more easily understood by considering information we naturally understand from interacting in physical space.

The benefit of water absorption and the resultant evaporative cooling effect was explained at the city scale and most naturally can be understood as the same effect sweating has for us. Ken Yeang’s National Library in Singapore (**Figures 10**) provides an example of cooling at a single site level.

Completed in 2005, its “skycourts” harness the cooling of the 6300 square meters (67,813 square feet) of planted space and also apply other passive cooling methods. By making the spaces covered overhead by glass but open on the sides, cross ventilation moves through these planted areas to cool the space and reduce its energy consumption and reliance on air conditioning. *Grüne Hause, Tropische Gärten* is a book of case studies on 3 architects, Ken Yeang being one, compiled for an exhibition showcasing buildings integrating plants and architecture. The book estimates a typical building of the National Library’s size and function operates on 230 kWh / sq m / yr (kilowatt hours per square meter per year). This library was monitored and shown to consume only 185 kWh

/sq m / yr, a 20% reduction in energy use compared to a typical building of its size and function in Singapore. Spaces that are somewhat enclosed and utilize cooling using cross ventilation show one way architecture and plants work symbiotically.



Figure 11 Green Roofs

Rooftop and façade plants subjected to direct sunlight also have the potential to benefit architecture. Being less enclosed, these plants are less affected by the shape of building, and more by the surrounding climate. There are different kinds of green roofs (**Figure 11**). One typical installation type (intensive green roofs) have a drainage layer (or layers), soil of various depths, and plants in garden beds installed on a roof or balcony. Another type are modular thin components that are mass produced and can be ordered from companies for installation (extensive green roofs). The size of planter makes a vast difference in not only what can be planted, but also the amount of attention it will need.

At approximately 15 cm (6 inches) thick, extensive green roofs' modular components usually use sedum, common name stone crop, planted in trays similar what you could buy at a plant nursery. They use this plant because its succulent thick leaves like full sunlight and it is difficult to kill. They add a grid for laying out and attaching the trays of plants to the roof. The benefit of this method is that installation is simple, they are lightweight, handled by the company that makes them, and if a plant dies, it's easy to trade out whichever component(s) failed. Those familiar with purchasing trays from a nursery can anticipate the potential problem though. After buying that four inch nursery pot, what is usually recommended if you don't have much of a green thumb? It should be transplanted to a larger, absorptive, clay pot so that it doesn't dry out so quickly, otherwise watering is going to be a constant requirement. A large planter is like a bathtub filled with water. Small plant trays are like glasses of water. Arrayed in the same footprint of a bathtub, which can hold more water? The bathtub. Likewise, larger planters create much greater opportunity for more absorption, more evaporative cooling, and greater ease of maintenance.

Also, once the soil dries entirely it is going to require incremental watering sessions before the water will do anything other than go straight through the soil and out the bottom of the extensive roof trays. When there is no moisture left to attract additional water (water's attraction to itself is called

capillary attraction), soil does poor job absorbing water, and that soil sits in a container with holes in the bottom. Clients and architects alike are lured into this narrative that these small simple components will make lives simpler and more sustainable when, unless the site has temperate Californian conditions, it is unlikely components this small will easily survive.

Misconception number one states smaller components equate to easier care. People make this choice out of fear they do not know enough about plants to dependably care for them, so they want something that can easily be fixed once they inevitably kill the plants. For architects and the specialists they're working with to make more effective installations, they need to trust clients and the clients need to trust themselves (or those working for them) that it will be easier to learn about the needs of plants and provide for them, than to constantly replace something because of trying so desperately to find something that required no attention at all. Plants require attention and ongoing work. This does not have to be as difficult or negative as some assume though. This does not mean plant 100 square meters of elaborate rooftop and trust that you will learn to garden overnight. Start with the bathtub sized planter though, it will be easier to care for than thin tiny trays. Experimenting with small pots because you don't want to kill a larger plant is what indoor and small potted plants are for, not acres of monoculture trays of sedum. Also, different plants prefer different root depths. Trust in the ability to learn, but also trust more experienced experts to tell you which plants will thrive given the particular conditions.

In addition to the size of planted areas, the medium for planting also can affect success. A study published in 2016 shows how various mediums and plant sizes affect temperature reduction on a rooftop. The researchers set up large tanks and planters on a rooftop in Taichung, Taiwan. They tested the temperature below various depths of water, water with aquatic plants at different heights (low and high) in the tanks, and compared that with plants of different heights growing in solid soil.²³ A similar study published in 2005 studying temperature did not analyze hydroponic (water) effects on temperature but was more extensive in size, covering an entire parking garage in green roof, rather than a few square feet (or about a bathtub size) of planter or tank. These researchers

²³ Yi-Yu Huang, Chien-Teh Chen, Yen-Chi Tsai. "Reduction of Temperatures and Temperature Fluctuations by Hydroponic Green Roofs in a Subtropical Urban Climate." *Energy and Buildings* 129, (July 16, 2016): 174–185.

conducted their study in Singapore, creating and monitoring this green roof which was also designed to compare varying plant heights.²⁴

Because these were conducted in different places, comparing temperature changes side by side is not helpful. The general lessons are evident though. As expected, temperature was reduced by the presence of plants compared to the bare roof also measured. Water alone did a decent job reducing temperature, and was aided slightly with aquatic plants added. The 2016 study also showed the solid soil medium slightly outperformed the water, though the height of plants did not matter much. The 2005 study, being larger, introduced the challenge that some green roofs encounter. Certain patches of lower growth died back and the soil below dried out. Soil exposed, and without the shade and evaporative cooling of plants above, it was not only as warm as the roof below, these areas were in fact hotter.

The two studies together teach a lesson. Plants in solid soil have the potential to outperform water at reducing temperature, but also risk hotter conditions than bare roof if the plants die or are too sparse. The 2016 researchers also noted greater difficulty in maintaining the plants in solid soil and more trouble with weeds. This returns us to our familiar challenge of maintenance. Anecdotally, in my own small survey, 50% of respondents saw ongoing future maintenance as the greatest difficulty in implementing plants among buildings (out of five possible options to choose from plus a sixth fill in the blank option). Just as absorption, cooling, and maintenance is affected by sizing methods, the amount of maintenance required is also dependent on the plants installed and attention to how they change.

Consider, for example, my sister's kitchen garden which I helped tend last summer. I found it beset with crabgrass a foot high. Though the herbs, fruit, and vegetables were intermixed, they had grown slender and "leggy," having to compete with the weeds for light. In the same way trees reach skyward in a forest when light is limited, or houseplants become spindly in a room without enough light, the weeds were choking out what my sister planted. So, I began weeding.

²⁴ Wong Nyuk Hien, Tan Puay Yok, and Chen Yu, "Study of Thermal Performance of Extensive Rooftop Greenery Systems in the Tropical Climate," *Building and Environment* 42, (2007): 53.

As I pulled though, I realized a function the crab grass served. Despite the hot day, the fact it had not recently rained, nor had my sister the chance to water recently, the soil beneath the crab grass was damp. It grew thick and high enough that it shaded the soil from the heat, and that area was cool. My sister and her husband had – quite understandably due to the pandemic, pregnancy, full time jobs, and three children – left it nearly untended. (And not to worry I quarantined before and after visiting). This weed was cooling this particular location. As I removed weeds, the soil dried to a cracked hard surface and I began to worry. I exposed the desired plants to their needed light, only to realize they may have a more difficult time surviving without the crabgrass to retain moisture. It seems obvious now, but without the example to show me, it is somewhat counter intuitive.

This teaches us about Misconception Number Two, which states that more plants and more dense foliage requires more water and maintenance, when in fact it results in less need of water and attention. While it's true more plants will take in more water, the shading they provide also keeps soil from becoming overheated. When soil becomes overheated water quickly evaporates into the air. Luckily, as I removed crab grass, I discovered an unknown low growing ground cover. Probably a weed by most definitions, but it may balance the garden's needs. Something low growing to allow my sister's plants enough light, but able to fill in below to shade the earth and retain moisture.

Though more urban buildings go up with plants integrated each year, most of the elaborate designs require maintenance by experts. This is said with the utmost respect because these trailblazers are nothing short of living art, both designed and cared for, by artists in my opinion. But it does present a limitation for whether such goals could be brought to everyday life. Patrick Blanc is the botanist artist that developed modern green walls (**Figure 12**), and his work is the prime example of this artistry. His green walls use a method of planting inspired by cliff faces with pockets of greenery. He describes his system as:

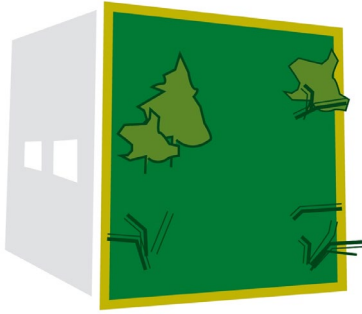


Figure 12 Green Wall

“two layers of polyamide felt stapled to plates of expanded PVC with a thickness of 10 mm (0.4 in) are affixed to metal scaffolding. The felt layer, with its strong water retaining capacities, allows planting at a remarkable density of 20-30 plants per sq m (2 to 3 per sq ft). A drip irrigation system at the top delivers a diluted fertilizer mixture, allowing the transplanted vegetation to flourish.” faces north to shield from harshest sunlight, has a wide array of plants including "Begonias, Pachysandras, Heucheras, Ferns, Sedges, Mosses and Liverworts.”²⁵

Is it reasonable to imagine planted buildings could thrive in any situation other than the context of paid experts? Yes, if the building is designed to allow safe access to planted areas and encourage occupants to take ownership of their planted area.



Figure 13 Green Facade

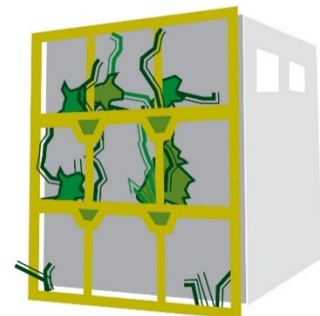


Figure 14 Planter Facade

Examples of strategies that allow intelligent interconnection and irrigation, but can more easily accommodate access are a similar sounding but slightly different approach. Green facades (**Figure 13**) are marked by climbing plants, with plants rooted at the base of a structure that is offset from the exterior wall of the building. They are limited by how long the vines can grow. Planter facades (**Figure 14**) are like green facades, but have planters at various levels, essentially combining several previous ideas into one. so that both climbing and non climbing plants can fill the space. They are more dense than green facades, while more accessible than green walls. Some involve smaller planters more akin to window boxes, while others are freestanding and offset from the building, creating a new space and more aptly combing green roofs and green facades. In addition to allowing for easier accessibility for maintenance, Planter facades can help balance the weight distribution on a building which can be top heavy and result in reverberation issues if too much weight is focused on the roof on too tall a building.

²⁵ Johanna Agerman Ross, *Vitamin Green*, London: Phaidon Press Limited, 2012. 190-193.

LOOKING FORWARD:

Do urban buildings host the opportunity to bring plant life, community, and symbiotic connection between earth and city dwellers? They do. Plants cool surfaces. Architecture and ecosystems interact regardless, so we might as well coexist cohesively. With overall design - a string of planted areas facilitating water flow helps drive connection with the landscape. In the details – considering material and soil selection, root space according to native plant accommodation, position with sunlight, and overall climate ensure dense foliage can grow. However, not all can be planned for with the long art of plant growth. The slow development of plants means there is time to correct errors as we learn.

Plants are not so different from humans and they aid our wellbeing. Given enough space, attention, and gentle encouragement when young; plants grow to be almost entirely self-sustaining. Once established, they still need help occasionally, but are no longer fragile. While you can plan for plants, and it's good to help them toward the correct placement early, they're not entirely predictable and require adaptability. People often are not deterred by similar characteristics of raising children, and with plants you can kill a few while learning without too much guilt. This is because each time we fail, we learn. There are many encouraging signs people long for greater connection with the Earth. As architects, we can respond with buildings that harmonize.

BIBLIOGRAPHY

Bratman, Gregory N., Christopher B. Anderson, Marc G. Berman, Bobby Cochran, Sjerp de Vries, Jon Flanders, Carl Folke, et al. "Nature and Mental Health: An Ecosystem Service Perspective." *Science Advances* 5, no. 7 (July 1, 2019): <https://doi.org/10.1126/sciadv.aax0903>.

Brenneisen, Stephan. "Space for Urban Wildlife: Design Green Roofs as Habitats." *Urban Habitats* (January 2006).

Christopher @PlantKween "Trip to nursery with niece." Instagram Photo, August 13, 2020, <https://www.instagram.com/plantkween/?hl=en>

Cronon, William. "The Trouble With Wilderness." In *Uncommon Ground: Rethinking the Human Place in Nature*, edited by William Cronon, 69-90. New York: W. W. Norton & Co., 1995.

Fazzare, Elizabeth. "Exclusive Look Inside Singapore's Stunning Eden Garden Tower." *Architectural Digest*, Published August 20, 2020, <https://www.admiddleeast.com/art-design/design/exclusive-look-inside-thomas-heatherwicks-eden-tower-singapore>

Huang, Yi-Yu, Chien-Teh Chen, Yen-Chi Tsai. "Reduction of Temperatures and Temperature Fluctuations by Hydroponic Green Roofs in a Subtropical Urban Climate." *Energy and Buildings* 129, (July 16, 2016): 174–185.

Jacobs, Jane. *The Death and Life of Great American Cities*. New York: Vintage Books Edition, 1992. Original 1961.

Jordana, Sebastian. "The Indicator: The Responsibility of Beauty," ArchDaily, January 04, 2013, <https://www.archdaily.com/314434/the-indicator-the-responsibility-of-beauty/50e5f577b3fc4b170d00005e-the-indicator-the-responsibility-of-beauty-photo>

Kimmerer, Robin Wall. *Braiding Sweetgrass*. Minneapolis: Milkweed Editions, 2013.

Kurnik, Gloria. "Berlin Is Becoming a Sponge City." Bloomberg, Youtube. Published August 23, 2017 <https://www.youtube.com/watch?v=uWjGGvY65jk>.

Krier, Leon. *The Architecture of Community*. Washington, DC: Island Press, 2009, 28-29.

Kyzer, Larissa. "Forest Service Recommends Hugging Trees While You Can't Hug Others." April 10, 2020. Iceland Review. <https://www.icelandreview.com/nature-travel/forest-service-recommends-hugging-trees-while-you-cant-hug-others/>

Li, X., Y. Zhou, J. Eom, S. Yu, & G. R. Asrar. "Projecting Global Urban Area Growth Through 2100 Based on Historical Time Series Data and Future Shared Socioeconomic Pathways." *Earth's Future*, no. 7. (2019), 351–362: <https://doi.org/10.1029/2019EF001152>

Mutuli, Ian. "National Library in Singapore by Ken Yeang, and Effort Towards Sustainability in the Tropics." Archute, January 2, 2016, <https://www.archute.com/national-library-in-singapore-by-ken-yeang-an-effort-towards-sustainability-in-the-tropics/>

Pawlyn, Michael. *Biomimicry in Architecture*. London: Riba Publishing, 2011.

Ross, Johanna Agerman. *Vitamin Green*. London: Phaidon Press Limited, 2012.

Shield, Charli. "Coronavirus Pandemic Linked to Destruction of Wildlife and World's Ecosystems." *Deutsche Welt*, April 14, 2020. <https://www.dw.com/en/coronavirus-pandemic-linked-to-destruction-of-wildlife-and-worlds-ecosystems/a-53078480>.

Spirn, Anne Whiston. *Constructing Nature: the Legacy of Frederick Law Olmsted*. in *Uncommon Ground: Rethinking the Human Place in Nature*, 1995. 91-113.

U. N. Environment Programme. “Cities Can Fight Climate Change and Improve Lives by Finding New Ways to Be Cool.” Published October 10, 2019. <http://www.unenvironment.org/news-and-stories/story/cities-can-fight-climate-change-and-improve-lives-finding-new-ways-be-cool>.

U.N. Environment Programme. “Resource Efficiency & Green Economy.” Published September 26, 2017. <http://www.unenvironment.org/explore-topics/resource-efficiency/what-we-do/cities/resource-efficiency-green-economy>.

Wiktionary. “Biomimetics.” Accessed May 17, 2020. <https://en.wiktionary.org/wiki/biomimetics>.

Wines, James. “Green Architecture.” Encyclopedia Britannica. Published September 25, 2019. <https://www.britannica.com/art/green-architecture>.

Wong, N. H., D. K. W. Cheong, H. Yan, J. Soh, C. L. Ong, and A. Sia. “The Effects of Rooftop Garden on Energy Consumption of a Commercial Building in Singapore.” *Energy and Buildings* 35, no. 4. (May 2003): 353-364.

Wong, Nyuk Hien, Tan Puay Yok, and Chen Yu. “Study of Thermal Performance of Extensive Rooftop Greenery Systems in the Tropical Climate.” *Building and Environment* 42, (2007): 25-54.

World Economic Forum. “This man is turning cities into giant sponges to save lives.” Published August 28, 2019 on Youtube. <https://www.youtube.com/watch?v=U37gst79pGc>

Zimmerman, Nils. “Sponge City: Berlin Plans for a Hotter Climate.” *Deutsche Welt*, July 22, 2016. <https://www.dw.com/en/sponge-city-berlin-plans-for-a-hotter-climate/a-19420517>.

ADDITIONAL INFLUENCE:

Berndtsson, Justyna Czemieli. "Green Roof Performance Towards Management of Runoff Water Quantity and Quality: A Review." *Ecological Engineering* 36 (2010) 351-360.

Chicago Park District, The Official Website. "History of Chicago's Park." Accessed May 17, 2020. <https://www.chicagoparkdistrict.com/about-us/history-chicagos-park>.

Cogdell, Christina. *Toward a Living Architecture? Complexism and Biology in Generative Design*. Minneapolis: University of Minnesota Press, 2018.

Dalley, Stephanie. *The Mystery of the Hanging Garden of Babylon: An Elusive World Wonder Traced*. New York: Oxford University Press, 2015.

Duany, Andres, and Emily Talen, eds. *Landscape Urbanism and Its Discontents: Dissimulating the Sustainable City*. Gabriola Island: New Society Publishers, 2013.

Exploring Alternatives. "Beautiful Tiny Turf House in Iceland - Full Tour & Interview." Published September 28, 2016, Youtube. <https://www.youtube.com/watch?v=7JFwLyrdJw>

Kennedy, Joseph F. *The Art of Natural Building: Design, Construction, Resources*. Gabriola Island, BC: New Society Publishers, ed. 2002.

Mazzoleni, Ilaria, and Shauna Price. *Architecture Follows Nature: Biomimetic Principles for Innovative Design*. Biomimetics Series. Boca Raton: CRC Press, 2013.

Muller, Brook. "Archipelagoes of Weak Formed Buildings: Contemporary Ecology Informing Contemporary Architecture." *Archipelagos: Outposts of the Americas/ Enclaves amidst Technology*. 1st ed. Washington, DC: ACSA Press, 2004.

Riley, Benjamin. “The State of the Art of Living Walls: Lessons Learned.” *Building and Environment* 114 (March 2017). 219–232. <https://doi.org/10.1016/j.buildenv.2016.12.016>.

Smisek, Peter. “When Trees Meet Buildings” *The BIM*. Published August 1, 2018. Article and Video, 11:26. <https://www.theb1m.com/video/when-trees-meet-buildings> .

Spyropoulos, Theodore. *Adaptive Ecologies: Correlated Systems of Living*. London: AA Publications, 2013.

Steele, James. *Ecological Architecture: A Critical History*. London: Thames & Hudson, 2005.

Viollet-le-Duc, Eugene-Emmanuel. *The Architectural Theory of Viollet-Le-Duc*, edited by M.F. Hearn. Massachusetts Institute of Technology, 1990.

Waldheim, Charles. *Landscape as Urbanism: A General Theory*. Princeton: Princeton University Press, 2016.

Zaera-Polo, Alejandro et al.. “Façade.” In *Elements of Architecture*, edited by Rem Koolhaas, ##. Venezia: Marsilio, 2014.

ADDENDUM

Since completing the written thesis in September 2020, I continued expanding my understanding of connecting between the built, ecological, and human environment from the standpoint of Dayton, Ohio as a case study until now, May 2021.

To begin, it must be noted the significance of the Great Flood of 1913 on Dayton history for the last 100 years. Because the surrounding areas's topography creates a bowl around the downtown area, with downtown as the low point, the flood waters filled and devastated much of the city. After the flood, the effects of which can be seen on the timeline page I've included, many residents fled the downtown area and the city suffered tremendously economically²⁶. Then in the 1950s and 60s highway construction began throughout the United States, and I-75's construction along the western edge of downtown Dayton created a visual and physical disconnect between the neighborhoods west of the city and downtown. These events largely resulted in the distribution of income with higher income in the surrounding suburbs. In addition, the highway served as a barrier of segregation between the Eastern side of Dayton's surrounding areas being predominantly white and those cut off on the west being primarily African American.

Besides the highway separating people and neighborhoods by income and race, the highways also were a shift from earlier discussion about connecting cities with park systems.

"Before World War 2, Dayton, along with many other cities in the United States, was pre-occupied with how to alleviate heavy traffic and congestion in its downtown area. Talk of creating a network of parkways was proposed as far back as the 1920s, but by the end of the war the discussion had shifted to building a network of higher-speed, limited-access freeways instead."²⁷

This suggests the paradigm shift occurring now, returning to ideas of parkways, is actually less revolutionary, and rather a return to an idea disrupted by the alternative goal that became prevalent

²⁶ "Great Flood of 1913," Dayton History Books Online, Accessed November 2020, <https://www.daytonhistorybooks.com/page/page/1566099.htm>
"Various Maps of Dayton, Ohio," Library of Congress, Accessed November 2020, <https://www.loc.gov/resource/g3707o.ar077100/?r=:0.461,0.639,0.514,0.528,0>
"Work / Flood," Snow, Accessed December 2020, <https://www.andysnow.com/>

²⁷ "Not Quite Halfway There: Dayton, Ohio's I-675 Bypass," America's Canceled Highways, Published June 27, 2019. <https://americascanceledhighways.com/2019/06/27/not-quite-halfway-there-dayton-ohios-i-675-bypass/>

after the war to connect between cities. Either way, we're dealing with questions of connection, and it makes sense with the cities connected to focus on the effect for our community and ecological connections.

To address this question, I chose a site going over Salem Avenue and under and over the I-75 overpass as the Phase 1 Seed that would begin reconnecting downtown to the western neighborhoods. This phase involves an occupied bridge, community square with retail that extends below the I-75 overpass and a land bridge spanning over the highway as well as adding bike paths to the highway and repurposing the off ramp from the highway to a planted bike path. For the retail I chose for the community square I used a way of addressing community uplifting I developed prior to school with my friend, Alex Bohler at Hatch Architects. It utilizes Maslow's Hierarchy of Needs to break down how amenities break down as far as need. The base of the pyramid is Physiological and Safety which were the primary areas I focused on. For this I included mixed income housing and a grocery store. I also considered programming that could satisfy multiple needs at once. The additional needs going up the pyramid are Belongingness, Esteem, and Self Actualization. To see more detail on this analysis, refer to the page with a pyramid and circle which further breaks down my assessment of which programming could satisfy multiple needs and which I chose to focus on for this particular project.²⁸ Phase 2 is the Growth phase, and involves adding 2 additional inhabited bridges across the river and densifying the urban fabric along the river's edge around the west side of downtown. Phase 3 is Reconnection and involves the final step in interconnecting between the central downtown area and the pockets beginning to activate west on 3rd Street and Salem Avenue.

From some of the sketches included as well as the overall design of Phase 1's Seed it may be evident I drew inspiration from the form of the highway. Why draw inspiration from the highway when it's been a blight on the land that disconnected the downtown east side of the river from the neighborhoods on the west? A practical reason is that gradual elevation changes and sinuous paths make sense both for circulation and water movement over large areas. But the other parallel, that I hope the project elicits, is a contrast in size between my project and the highway system. Despite how massive my project is architecturally, looking at it next to the highway, it's tiny. Now imagine

²⁸ "Maslow's Hierarchy of Needs," Wikipedia. Accessed May 2021.
https://en.wikipedia.org/wiki/Maslow%27s_hierarchy_of_needs

what the government paid to put those highways in to connect between cities. Now imagine, what if the federal government paid to reconnect cut off neighborhoods back to their urban centers with community and ecologically driven spaces?

I hope this project can serve as a source of inspiration for communities feeling disconnected in any way and would like to end with a quote Jane Jacobs begins with for her book *the Death and Life of Great American Cities*. It is a quote by Oliver Wendell Holmes, Jr. which feels appropriate with the difficult year we've all had.

“Until lately the best thing that I was able to think of in favor of civilization, apart from blind acceptance of the order of the universe, was that it made possible the artist, the poet, the philosopher, and the man of science. But I think that is not the greatest thing. Now I believe that the greatest thing is a matter that comes directly home to us all. When it is said that we are too much occupied with the means of living to live, I answer that the chief worth of civilization is just that it makes the means of living more complex; that it calls for great and combined intellectual efforts, instead of simple, uncoordinated ones, in order that the crowd may be fed and clothed and housed and moved from place to place. Because more complex and intense intellectual efforts mean a fuller and richer life. They mean more life. Life is an end in itself, and the only question as to whether it is worth living is whether you have enough of it.

I will add but a word. We are all very near despair. The sheathing that floats us over its waves is compounded of hope, faith in the unexplainable worth and sure issue of effort, and the deep, subconscious content which comes from the exercise of our powers.”²⁹

I tried to make my thesis a part of this hope and know the limitation of being only one person engaging with so many issues. I would welcome further engagement with anyone wishing to open this conversation whether to challenge it, develop it, or encourage it's possibilities in reality.

²⁹ Jacobs, *The Death and Life of Great American Cities*, (New York: Vintage Books Edition, 1961), 2.

BIBLIOGRAPHY

America's Canceled Highways. "Not Quite Halfway There: Dayton, Ohio's I-675 Bypass."

Published June 27, 2019. <https://americascanceledhighways.com/2019/06/27/not-quite-halfway-there-dayton-ohios-i-675-bypass/>

Dayton History Books Online. "Great Flood of 1913." Accessed November 2020.

<https://www.daytonhistorybooks.com/page/page/1566099.htm>

Jacobs, Jane. *The Death and Life of Great American Cities*. New York: Vintage Books Edition, 1992. Original 1961.

Library of Congress. "Various Maps of Dayton, Ohio." Accessed November 2020.

<https://www.loc.gov/resource/g3707o.ar077100/?r=0.461,0.639,0.514,0.528,0>

Snow, Andy. "Work / Flood." Accessed December 2020. <https://www.andysnow.com/>

Wikipedia. "Maslow's Hierarchy of Needs." Accessed May 2021.

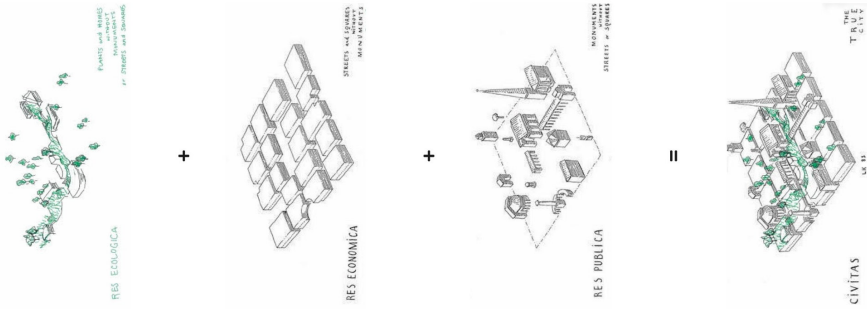
https://en.wikipedia.org/wiki/Maslow%27s_hierarchy_of_needs

THEORY

“People should always be conscious that they are part of the natural world, inextricably tied to the ecological processes that sustain their lives.”

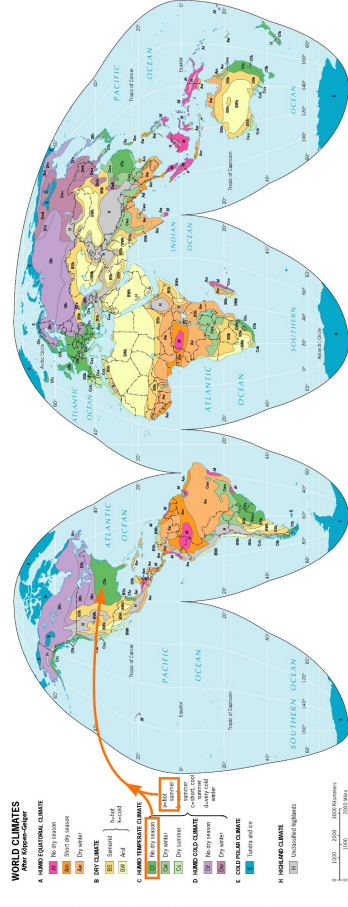
WILLIAM CRONON - THE TROUBLE WITH WILDERNESS

ECOLOGY + LEON KRIER'S CIVITAS DIAGRAM



GLOBAL CONCERNS & CHARACTERISTICS

WORLD CLIMATE ZONES



CLIMATE ZONES CHANGING

Tropics expanding by 30 miles/decade

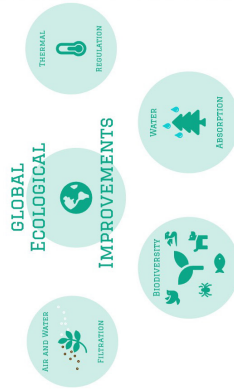


Reorienting the Map: The Tropics and the Climate Zones Are Shifting

Global warming is shifting climate zones around the world. Climate zones are shifting toward the poles, and the tropics are expanding. This is a result of the greenhouse effect, which is trapping heat in the atmosphere. The tropics are expanding by 30 miles per decade.

ECOLOGY

Return landscape's natural function of water absorption, thermal regulation, and increased biodiversity to more of the city's land area. Achieve this by taking cues from scientific observations of existing ecosystems



ECONOMY

Address logistical complexity, allowing primary benefits previously listed to be achieved, and closed loop systems introduced. The returns from improved health and closed loop systems, in turn, offset initial costs



CONNECTION

Bring plans to cities without disconnecting people in cities, to provide residents with the psychological benefit plans provide



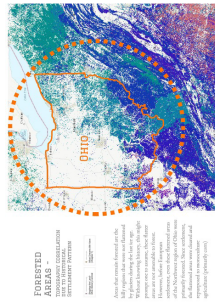
GOALS

INFLUENTIAL BOOKS



SITE ANALYSIS

DAYTON, OHIO HISTORY



14,000 BCE
GLACIAL PERIOD
 North & Western *of* Ohio mostly flattened

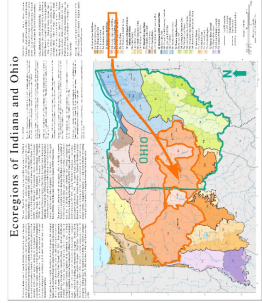
1000 BCE - 1795 CE
NATIVE AMERICANS IN SURROUNDING AREAS

1795
TASKIYAH TERRITORY
 Miamians and Shawnees displaced in region. Some evidence they tried to warn settlers.

1800s
ADENA & HOPWELL
 First mound-building period in surrounding areas

1819
DAYTON FOUNDED
 785

until 1907
RAPID INDUSTRIAL GROWTH
 Many factories per capita than anywhere else in country - Cash Register, Automobile and the vacuum cleaner were from Dayton



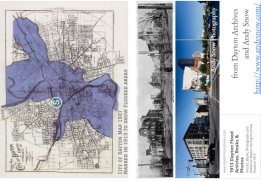
1700s
EUROPEAN EXPLORATION
 ... John Smith's map and others with 'Whites, Ash, Red' ...



1851
FIRST RAILROAD



1870
CANALS AND RAILROADS ESTABLISHED BY THIS TIME

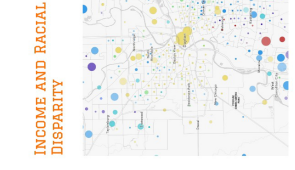
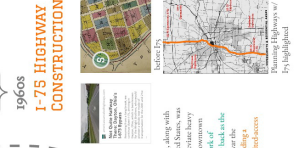
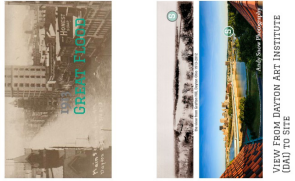


1960
DAYTON POPULATION PEAKS: 282,000



2020
DAYTON POPULATION: ~140,000

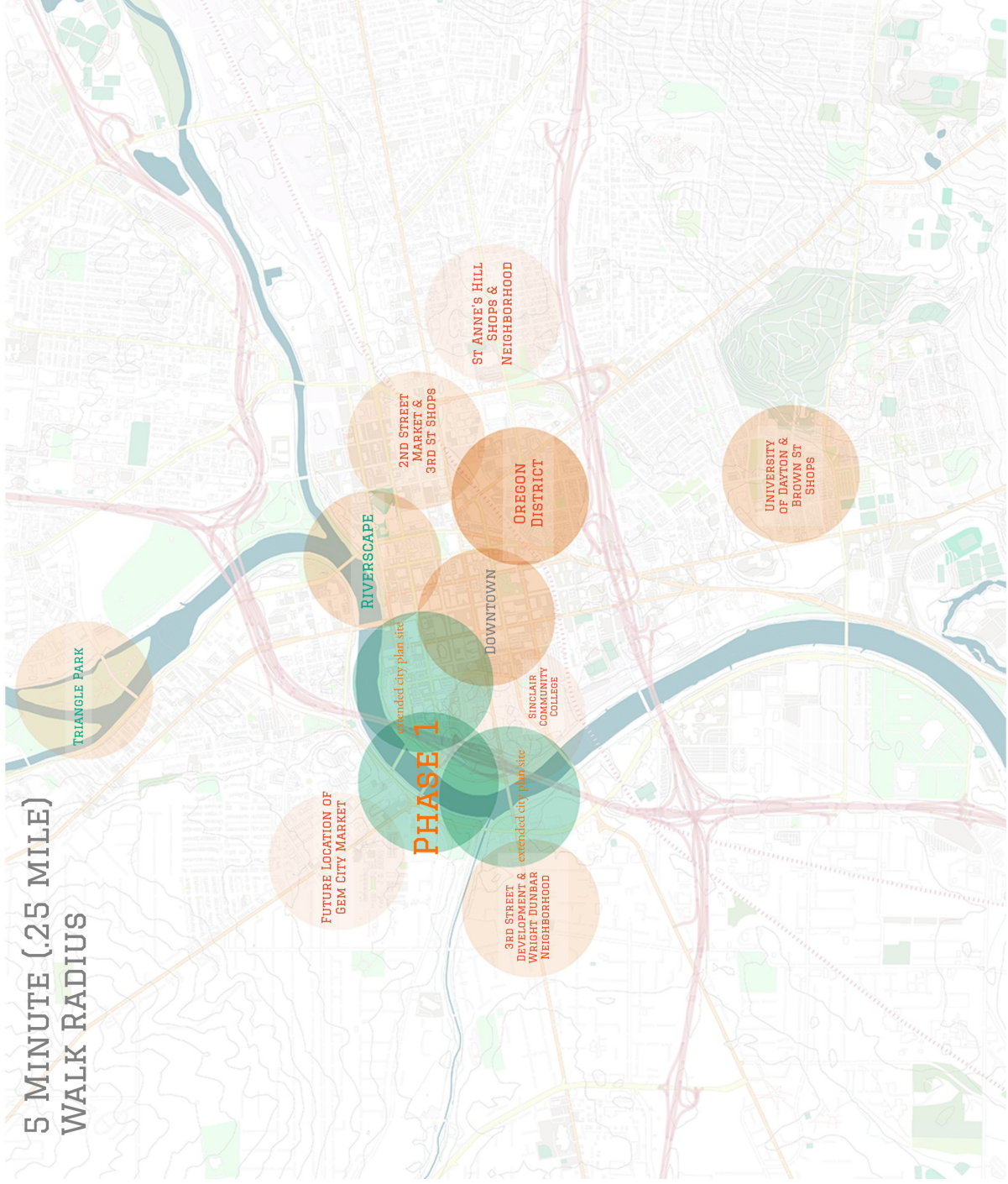
20_?
FUTURE REUNITES DAYTON'S NATURE



VIEW FROM DAYTON ART INSTITUTE GROUND SITE

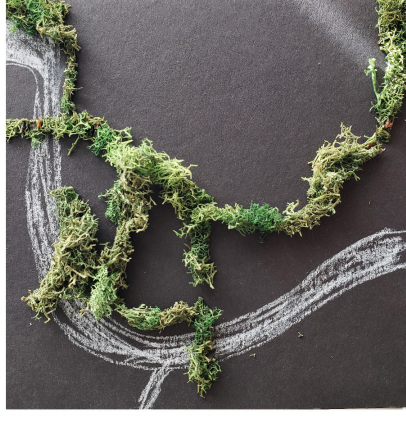
SITE ANALYSIS

5 MINUTE (.25 MILE)
WALK RADIUS



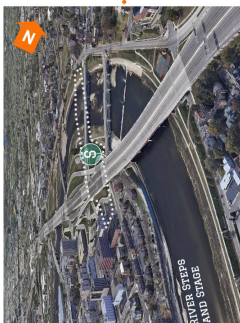
EXISTING ATTRACTORS ARE ORANGE
SITE FILLS IN DISCONNECTION BETWEEN IN GREEN

CONCEPT MODELS

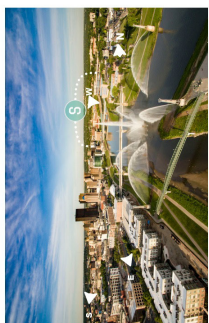


SITE ANALYSIS

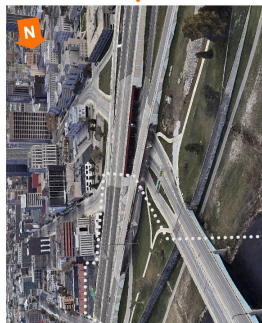
SITE'S IMMEDIATE CONNECTIONS



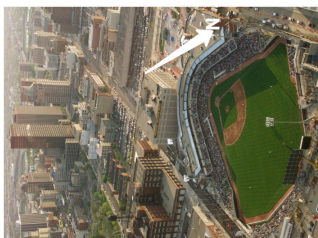
VIEW FROM MCPHERSON TOWN (NORTH OF DOWNTOWN) TO SITE



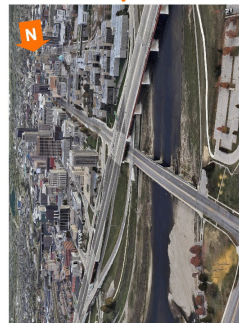
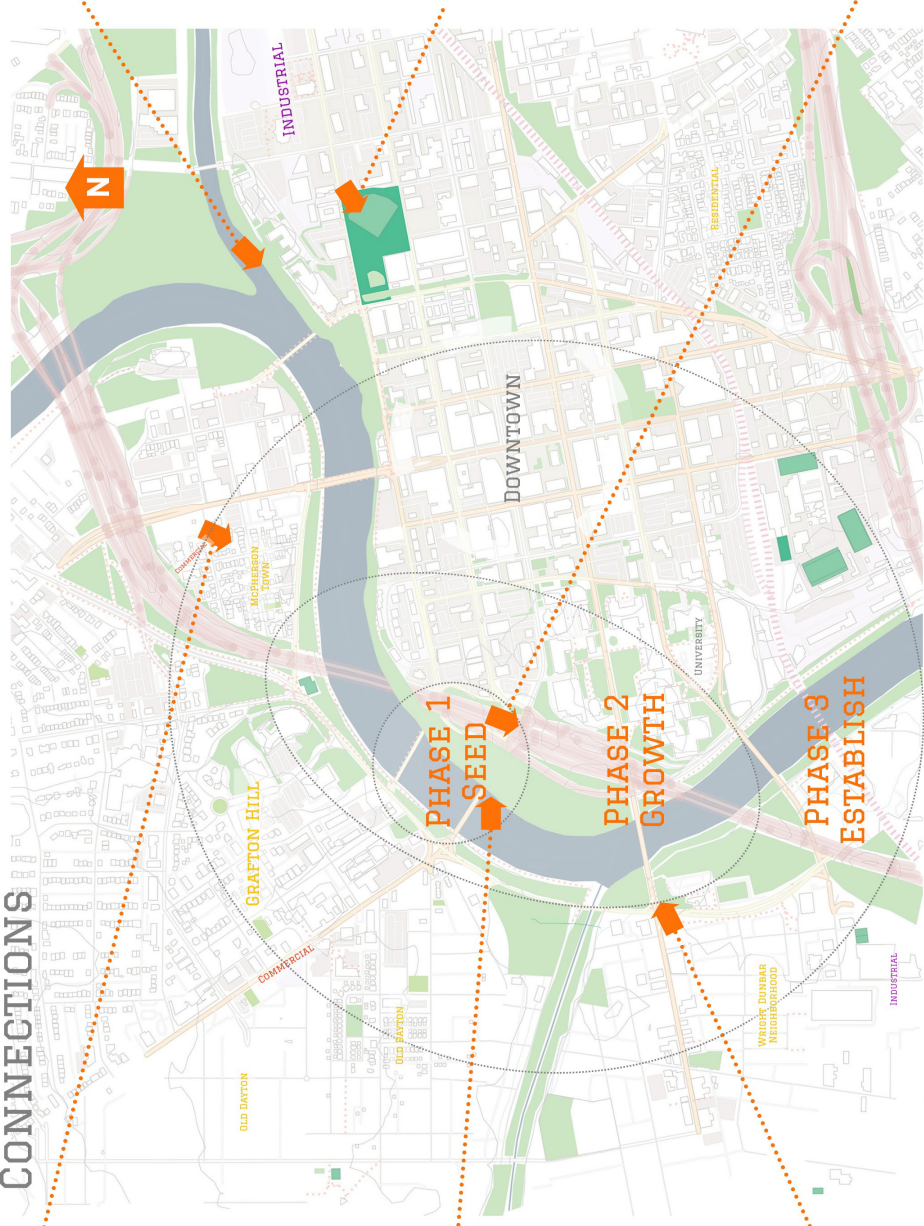
FOUNTAINS AND RIVERSCAPE



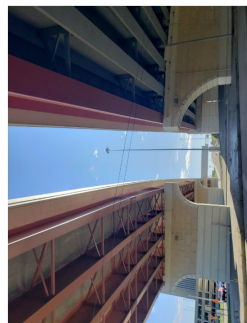
PHASE 1. PLANT THE SEED
Initial Bridge and City Connection



VIEW WEST FROM BALL PARK



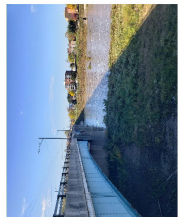
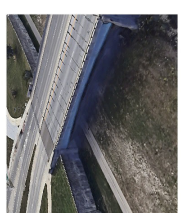
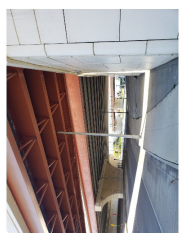
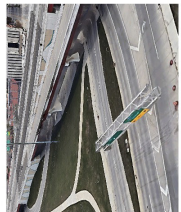
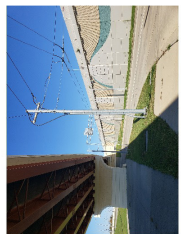
PHASE 2. GROWTH
New Neighborhood Bridges and City Connections



BELOW OVERPASS



ADDITIONAL PHASE 1 SITE PHOTOS



DESIGN

CONNECTIONS IN THE CITY



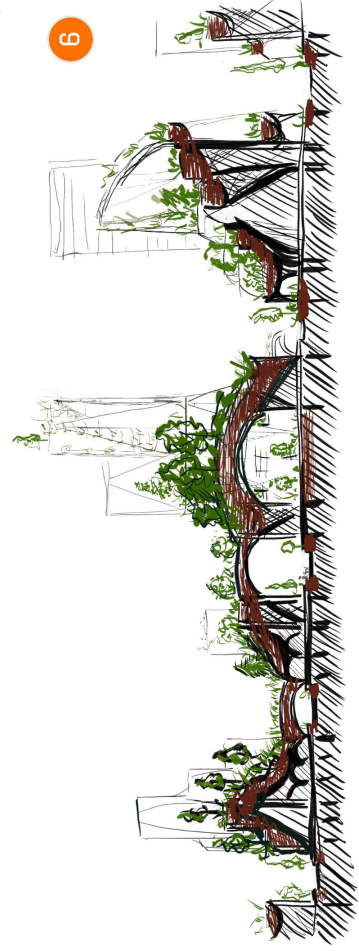
STRATEGIES W/IN THE CITY TO RETAIN URBAN FABRIC

- Land Bridge
- Planted Linear Park weaving btwn city buildings w/in block (either over retail or parking)
- Scaffolding lifting planted areas and providing edge conditions
- Planted Tower w/ parking, offices and retail at base
- Town Houses w/ private gardens
- community Garden in center of homes

EARLY SKETCH OF CITY ECOLOGY INTEGRATION



DESIGN

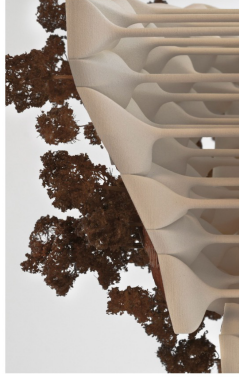


DESIGN

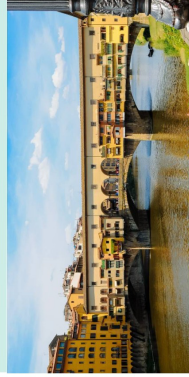
SEE PREVIOUS PAGE FOR KEY

PRECEDENTS

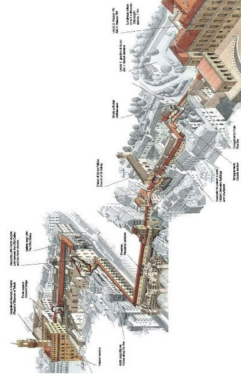
NYC LITTLE ISLAND
HEATHERWICK



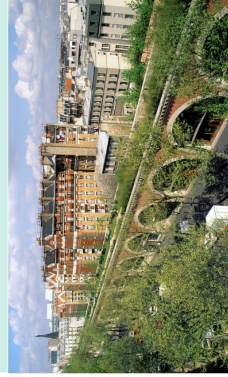
PONTE VECCHIO



VASARI CORRIDOR



PARIS'S PROMENADE PLANTÉE

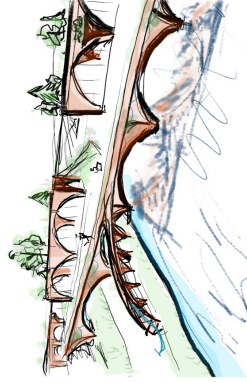


MY DESIGNS

1
LAND BRIDGE OVER
RIVER



2
HABITABLE BRIDGE

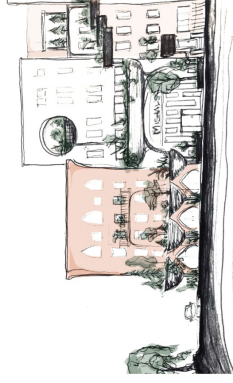


3
BELOW 1-75 OVERPASS

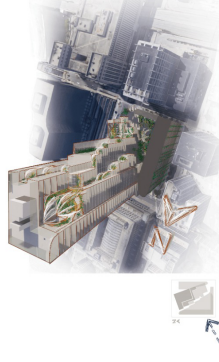


MY DESIGNS

4
PLANTED RETAIL &
HOUSING W/IN CITY



5
PLANTED TOWER



6
ELEVATED PARK
BTWN BUILDINGS & PEDESTRIAN STREET



PRECEDENTS

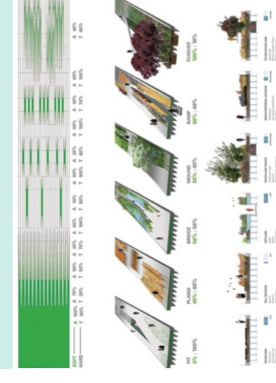
MIDDLE SCHOOL ON SHOPPING CENTER
BASIL SWITZERLAND
HERZOG AND DE MEURON



ONE CENTRAL PARK
JEAN NOUVEL W/ PATRICK BLANC



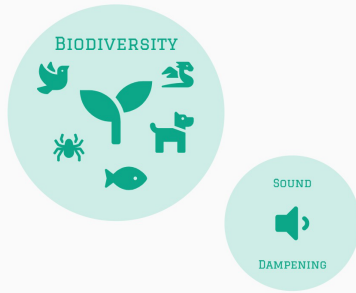
HIGHLINE
DILLER SCOFIDIO AND RENFRO



DESIGN

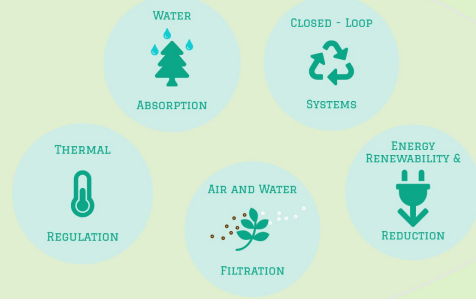
ECOLOGICAL CITY

STRUCTURAL PLANT INTEGRATION

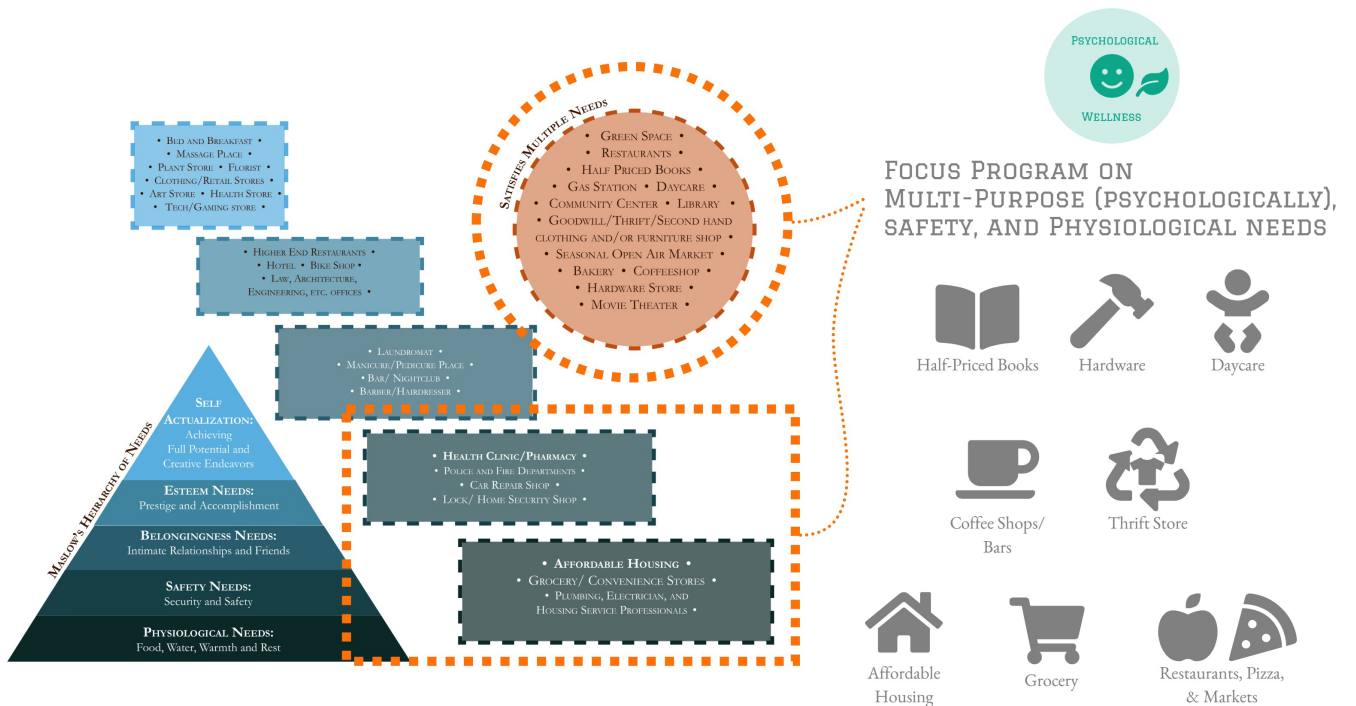


ECONOMIC CITY

RETAINING WATER, CONSERVE ENERGY, EQUILIBRATING TEMPERATURE, CLOSED LOOP SYSTEMS, AND NATURAL FILTRATION ALL SAVE MONEY



PSYCHOLOGICAL WELLNESS - COMMUNITY ANALYSIS



DESIGN

PLANT INTEGRATION METHODS

PRIMARY FOCUS



WINDOW BOXES



GREEN WALLS



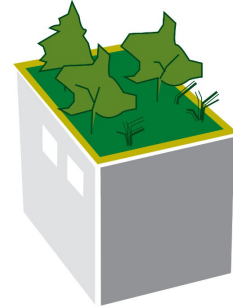
GREEN FACADE



RETAINING WALLS



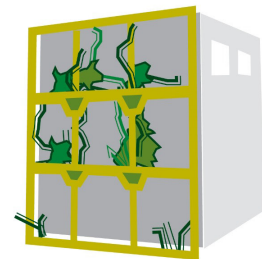
PARKS



GREEN ROOFS



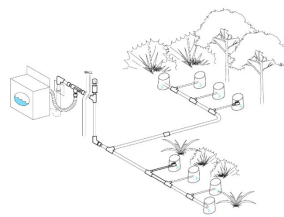
BIOSWALES



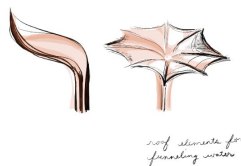
VERTICAL GARDENS

ADDITIONAL SUPPLEMENTAL CONSIDERATIONS

GREY WATER SYSTEMS



FUNNELING WATER



BUILDING ENVELOPE PERMEABILITY



ARCTIC
Most Air Tight
(building is bundled up in a coat to stay warm)



DAYTON, OHIO
Adaptable to Season
(Building needs to be able to open up in summer and bundle up in Winter)



TROPICS
Least Air Tight
(building can walk around naked!)

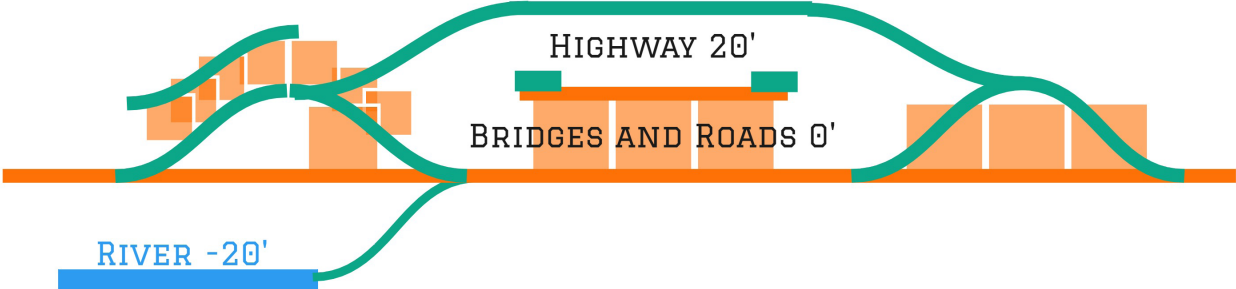
FERROCK



DESIGN

PLANTED BUILDINGS 0 - 40'

w/ Pedestrian Connections to River -20' - 0'



CONTEXT AXON



DESIGN

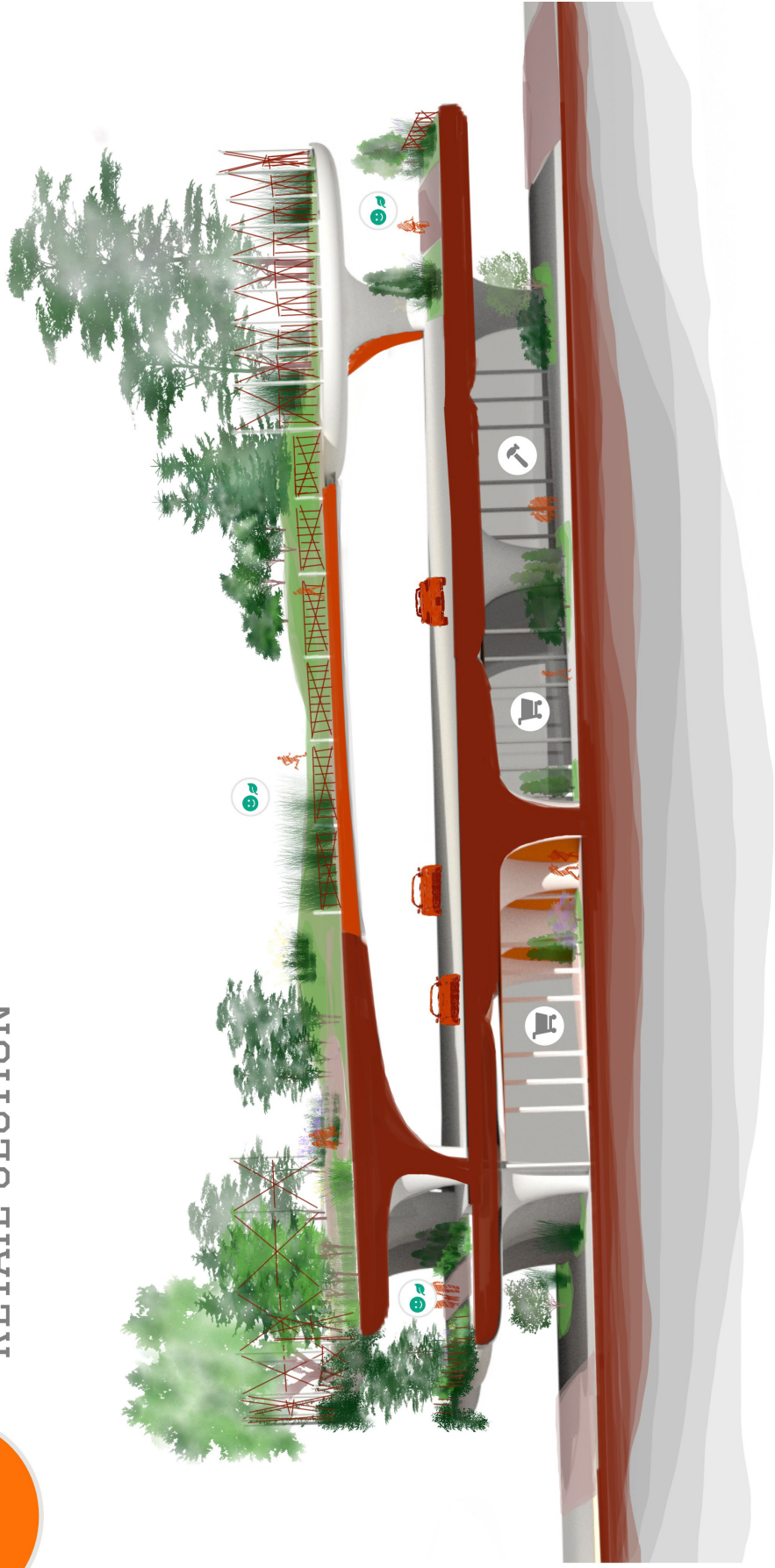
PROGRAM PLAN



DESIGN



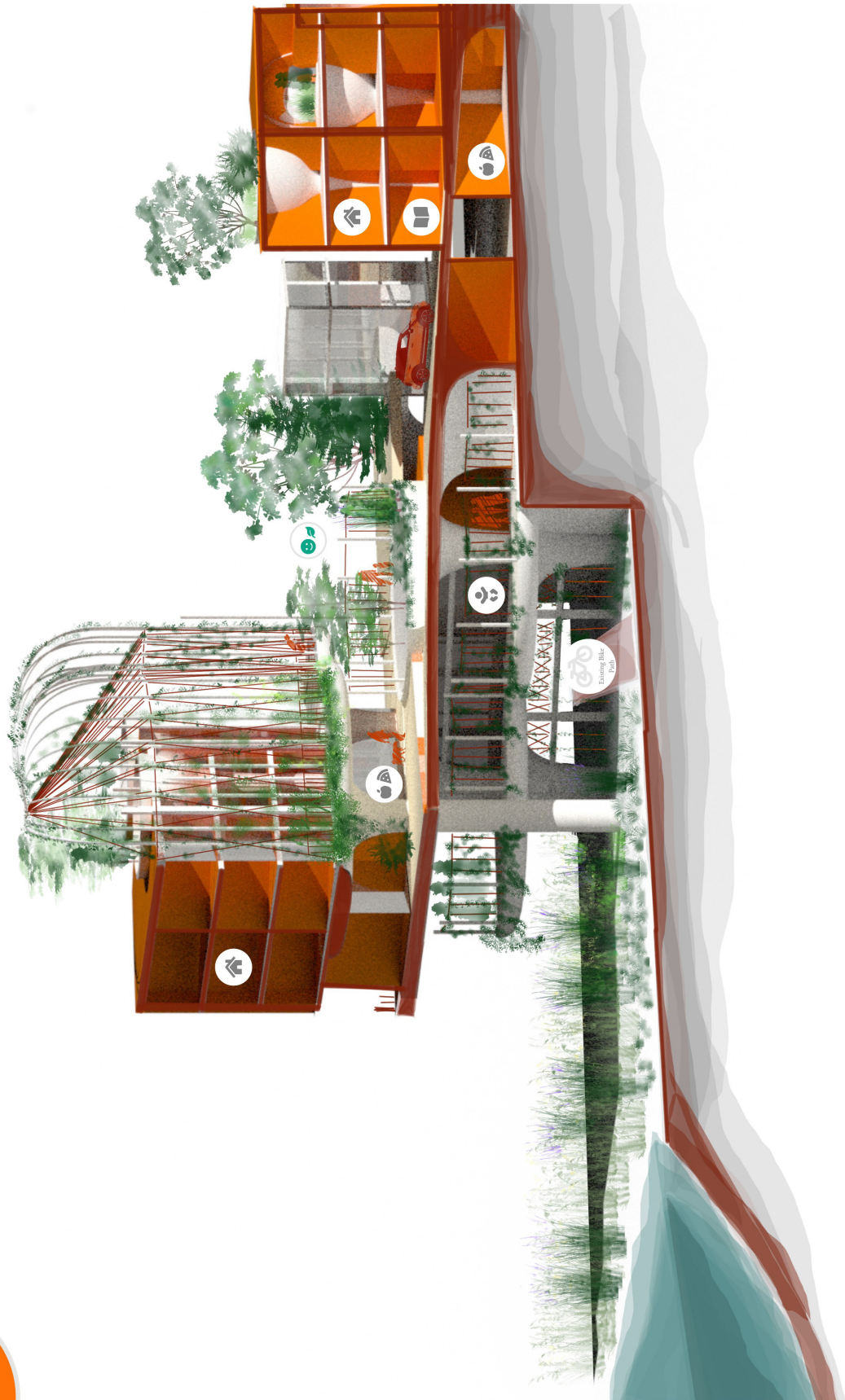
LAND BRIDGE /
HIGHWAY /
RETAIL SECTION



DESIGN

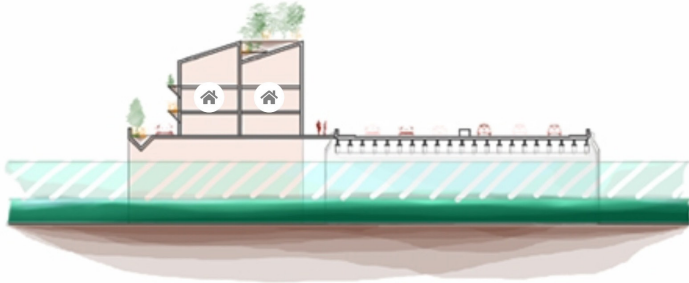


COMMUNITY SQUARE
SECTION



DESIGN

OCCUPIED BRIDGE SECTIONS



VARIABLE MODULE SIZES

