RE-ENTANGLING THE URBAN HABITAT:

Exploring Housing Through an Architecture of Biodiversity

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A thesis
submitted in partial fulfillment of the
requirements for the degrees of

Master of Landscape Architecture

Master of Architecture

UNIVERSITY OF WASHINGTON
2023

Committee:

Ken Yocom
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Program authorized to offer degree:

College of Built Environments

UNIVERSITY OF WASHINGTON

Abstract

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The last century has seen a dramatic decline in species populations and diversity across the globe. Today's methods of constructing cities and inhabiting regional landscapes has overwhelmed the homeostasis of Earth's life support systems, fundamentally threatening the survival of Earth's vast biodiversity. In order to repair the degradation of landscapes both within cities and across their vital hinterlands, it is imperative that we continue evolving global attitudes of architecture toward a regenerative entanglement of our cities and the material geographies on which they depend. This thesis explores radical design theories that help to contextualize and advocate for regional opportunities for optimizing biodiversity at various scales. By re-entangling the urban habitat through the urgent mechanism of housing construction, we can prioritize essential landscape services of CO_2 sequestration and habitat regeneration while creating equitable urban form in the coming decades.

I recognize that it is a privilege to work, study, and live on these lands and waters of the Central Salish Sea, which are the ancestral territories of the Duwamish (dxʷdəwʔabš), Suquamish (suq̓ʷabš) and Muckleshoot tribes. They are the original caretakers of these forests, rivers, lakes, and ocean, and it is with gratitude that I acknowledge their ongoing stewardship and hope to share this thesis in respect of their heritage and care for this sacred landscape.

ACKNOWLEDGEMENTS

I would also like to thank my thesis committee Ken Yocom and Rick Mohler whose commitments to teaching and advocacy continue to inspire me to create positive change in the world. Additionally, for all the teachers and mentors who have shared their gifts of education with me throughout my life, I am immensely grateful.

Thank you to my family and friends who have always been amazingly supportive.

Endless thanks to Liz for her unconditional love throughout this adventure of life!

TABLE OF CONTENTS

CHAPTER 1

Ch. 1 introduction

Problem Statement

The development of land in Seattle for the purposes of building residential units has dramatically transformed urban and regional landscapes, and have adversely contributed to habitat destruction and biodiversity loss. The ecological footprint of contemporary building practices far outpaces the carrying capacity of earth's natural resources, and needs radical and urgent transformations.

Claim

To envision a zero-carbon, biodiverse future of equitable urban development, mixed-use housing developments ought to balance the urgent needs for human shelter with essential regeneration of natural resources and biological diversity.

Demonstration

A key component to climate adaptation in urban areas is prioritizing biodiversity in multiscalar, multispatial, and multitemporal ways (Pierce et al., 2022.) In order to reduce the threat of urbanization at the cost of the natural environment, biodiversity optimization must be employed as a key architectural value in the development of housing settlements. This project aims to examine biodiversity regeneration within the design of the built environment, and to demonstrate a multifamily housing typology that promotes healthy habitat stewardship across urban and regional geographies.

Key Thesis Questions

What is an Architecture of Biodiversity? How can architects prioritize biodiversity most effectively?

How can we simultaneously promote urban density and optimal urban forestry?

In what ways can contemporary architecture employ regenerative ecological values?

Figure 1.1. Image Credits: Peter Essick, from *Aerials of the American Dream*

INTRODUCTION

The present conditions of architecture are rapidly evolving with transformations in technology, information, material innovations, and economic forces. Yet, the threats presented by the multifarious challenges of climate change are among the most pressing imperatives for new formulations of architecture in the 21st century. Urgent needs for adaptation to rising global temperatures are presenting novel issues in the built environment from disaster response and mitigation to housing supply and infrastructure. This thesis investigates the concurrence of biodiversity loss as a result of rapid human development, and the growing housing needs for an expanding human population. The purpose is to advance strategies for creating optimized habitats for all life forms, while adapting and mitigating conditional challenges of climate change at urban and regional scales.

Examining such strategies reveals a range of scales at which strategic thinking around architecture and landscape design has immense opportunity to advance urgent biodiversity goals while contributing positively to human housing settlements. This thesis builds upon existing literature across diverse disciplines to articulate the importance of investigating multiscalar and multimodal issues within the built environment. In order to understand the coherence of topics explored in this thesis, Chapter 2 explores various theoretical frameworks to situate strategies at a range of scales, both spatially and temporally. Examining the **evolution of regenerative design** theories and relavent emergent design processes allows us to construct new strategies for addressing these issues of habitat optimization in contemporary architecture practices. Contextualization of these methods is provided in Chapter 3 to ground the following design project within local conditions regarding these issues. Ultimately, a design proposal presented in Chapter 4 offers a pragmatic vision for the paper's theoretical framework within the context of a specific Seattle project site.

To contextualize the relevant frameworks presented in Chapter 2, I first draw on some authors whose work revealed to me the purpose of advocating for expansive theories within contemporary architectural discourse. In the introduction to his book *Convergence: An Architectural Agenda For Energy*, Kiel Moe (2013) challenges the normative view of architecture (or building) as an object, and considers critical implications of vast spatial and temporal modes of architecture. He argues,

> "The multifarious obligations of the architect – from building to city, from human comfort to planetary dynamics, from the molecular to the territorial – compel an agenda that is at once thermodynamically accurate and ecologically productive, yet simultaneously amplifies the ambitions and capacities of architecture." (p. 2)

Moe later writes,

> "A building, in reality, is a vortex of much larger material and energy flows. ...Buildings are anything but sustainable. In actuality, they are fundamentally dependent on environments of large-scale, nested material and energy systems that far exceed the boundary of a building. In terms of energy, buildings -- and their associeated disciplines -- must be placed in this larger context of matter and energy flux." (p. 21.)

This position fundamentally expands the paradigm of contemporary architecture toward a practice that responds, adapts, and anticipates multiscalar energy and material dynamics. It is a radical approach asserting that buildings are fluid agglomerations of processes and nested systems, which operate within extensive ecological conditions. Moe's theories urge architects to acknowledge their role in shaping material and energy flows, and to more powerfully maximize these opportunities to sustain and regenerate essential ecosystem services. This perspective underlies the hypotheses within this thesis to consider practical approaches for architecture, landscape design, and planning in the urban context of Seattle.

Maibritt Pedersen Zari (2018) similarily articulates broader systems approaches to the application of regenerative design in architecture and urban planning in her book *Regenerative Urban Design and Ecosystem Biomimicry*. Her text argues for designers to make intentional systems optimizations that go beyond the boundary of a singular built form in order to mitigate the harms of climate change and improve global biodiversity. She writes,

> "A benefit of mimicking the functions of ecosystems is that, through careful urban planning and an integrated and multidisciplinary design method, buildings as part of a larger system, able to mimic ecosystem processes and/or functions in their creation, use, and eventual end of life, may have the potential to adapt more readily to climate change. Whole-system adaptation of built environments using an understanding of ecosystems may have the potential to address climate change impacts and biodiversity changes concurrently, but the concept needs to be better understood and further developed." (p. 62)

Expanding on Moe and Zari's paradigm-shifting arguments, the goal of this thesis is to precipitate an approach to contemporary architecture theory that prioritizes ecological optimization within the practices of developing urban housing settlements. Essential in the development of this work is the interdisciplinary considerations of multiscalar spatial and temporal realities. To work toward contextualizing architecture within the climate adaptation agenda means we can reveal more effective optimizations of material and energy flows and improve the habitat conditions for humans and all life forms. The needs of biodiversity and housing are known, and it is time to use our methods of development to benefit both agendas in order to improve living conditions on earth for all species.

References:

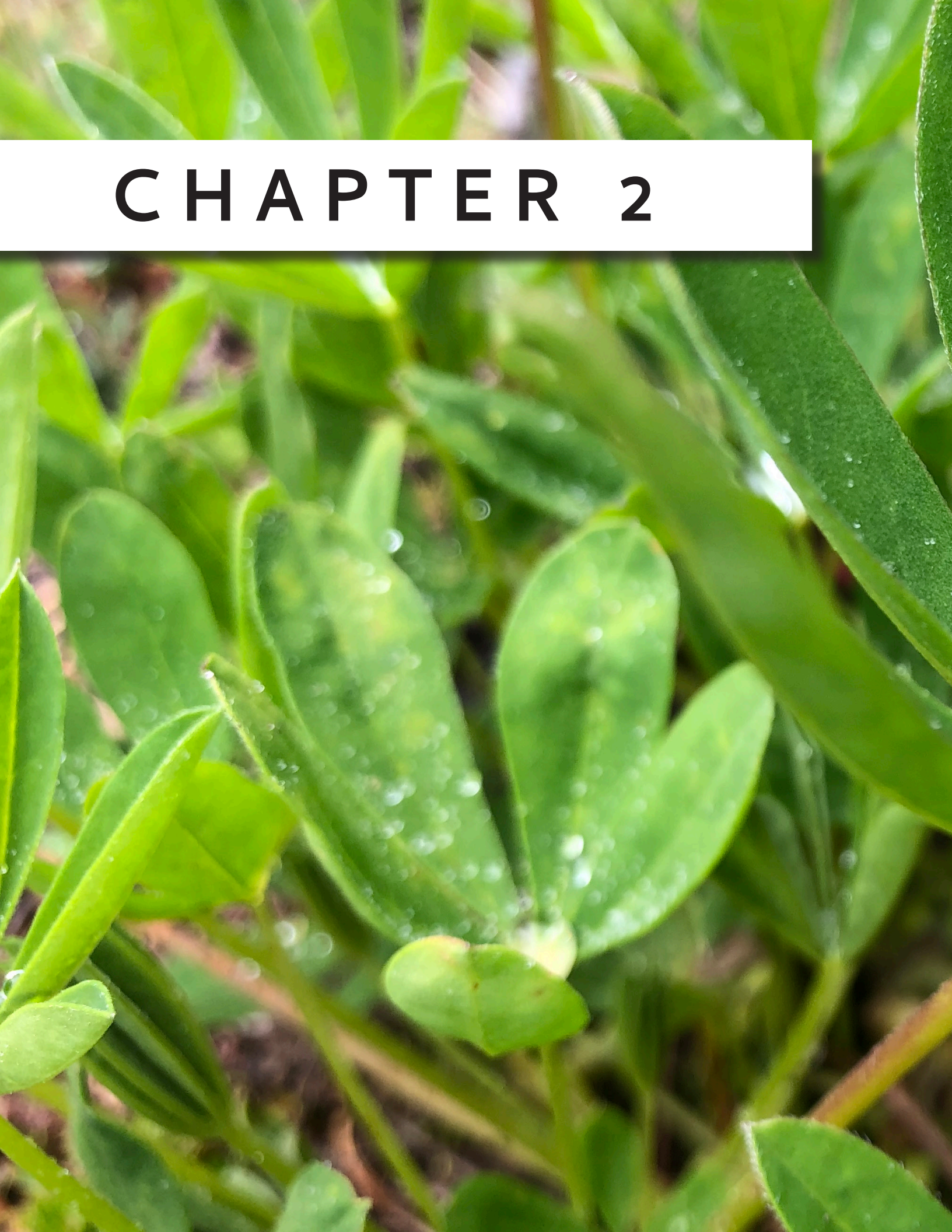
Pierce, et. al. 2022. "Operationalizing urban biodiversity: a guide for integrated action." In *The Routledge Handbook of Sustainable Cities and Landscapes in The Pacific Rim*. Yang, Yizhao, and Anne Taufen. Editors.

Moe, Kiel. 2013. *Convergence: An Architectural Agenda For Energy.* Routledge.

Zari, Maibritt Pedersen. 2018. *Regenerative Urban Design and Ecosystem Biomimicry*. Routledge.

"You are the carbon cycle lifted into song, outrageously beautiful and wild. The importance of carbon to life extends well beyond our own budgetary makeup. ***It is both material and energy, and it drives the economy of nature.*** *The cycles of water and fertility equilibrate with carbon cycle. One cannot imagine one without the other. There is no beginning or end -* ***the cycles of life and emergence of complex ecosystems are so intimately wound together that no single lens of truth seeking can see the system as a whole.*** *We need poetry, science, history, fiction, art and other disciplines to discover our place in the carbon cycle.* ***A collective exploration is needed to clarify our inescapable bonds to nature.****"*

- Philip Taylor, from "A Way of Healing,"
in *The Mad Agriculture Journal* (2019)



CHAPTER 2

Figure 2.1. Image Credits: Peter Essick, from *Aerials of the American Dream*

THE HABITAT CRISIS

> *"The dilemma is this: Development is necessary to provide habitat and sustenance for our society, but development inevitably alters natural systems, usually for the worse."*
>
> (John Lyle, 1996, p. 19)

In his collection titled *Aerials of the American Dream*, Peter Essick photographs ongoing construction sites across the US to illustrate the exploitative land transformations that occur in building projects of all kinds. The colorful and textural richness of the images captures a seemingly violent exposé of landscape degradation due to the construction of human settlements. In these images, the landscape is a casualty of an anthropogenic war waged upon the planet. The subject of these collected works is often a palpable absence of biodiversity within the landscape. By contrasting this absence of life with banal building forms and gestures of heavy machinery or ubiquitous construction debris, Essick articulates the tragic discrepancy between our hubristic habitat destruction and the wasteful building methods of contemporary society. The series evokes a repulsive dissonance between society's built environment and the ecological conditions in which they exist. Such provocations force us to ask, at what cost are we creating these conditioned settlements? What are the ecological tradeoffs we make to fulfill today's standards of human comfort? Has the role of biodiversity in urban settings been reduced to ornament, superfluous to the integral functions of survival?

This thesis presupposes the **habitat crisis** as a confluence of two inextricable disasters that have emerged over the last half century: a global human housing scarcity paired with extensive habitat destruction and biodiversity loss. Since the Enlightenment, dominant Western philosophies of dualism have segregated the human habitat from the greater ecological processes that our species is dependent upon for survival (Robinson, 2020, section 1.2.) As a result, abstracted cultural constructions of subject and object have isolated nature from its integral role in human life (Zari, 2018.) Unfortunately, this has led to a tragically over-consumptive globalized civilization that fails to meet human needs within the carrying capacity of Earth's natural resources (McDonough and Braungart, 2002.)

Over the last century, the issues underlying this convergent habitat crisis have been addressed in academic and political silos – the majority of economists, planners, and developers were consumed with building booms and busts, while biologists, ecologists, and conservation groups were sounding alarms about habitat and biodiversity loss. Yet, it has become increasingly clear that the two crises are inextricably linked, and that through addressing the demands of increased urbanization we can actively adapt to and mitigate the effects of climate change (Kelbaugh, 2019.) Over recent decades, interdisciplinary research has emerged across fields such as design, economics, climate, living sciences, and technology to better articulate the human interdependence within ecological preconditions (ICLEI, 2010; Pierce. et. al, 2022.) Investments in research and programs from universities, businesses, governments, and non-governmental organizations globally are continuing to investigate how our human settlements can be optimally designed, indivisible from the greater ecological context in which they exist. It is essential now more than ever that we exercise these ideals to invent, implement, analyze and iterate the practical solutions for restoring biodiversity while providing adequate shelter to eight billion humans.

For context, Earth's terrestrial and aquatic habitats have been severely degraded for hundreds of years, resulting in enormous declines in species population and diversity (ICLEI, 2010; World Wildlife Fund, 2022.) In tact ecological habitats, both on land and in marine environments, are essential for the survival of biodiverse species. Unfortunately, human development and the extractive consumption of resources has irreparably destroyed habitats and destabilized the vitality of global biodiversity (ICLEI, 2010.) Recent findings from the WWF's Living Planet Index estimate that seventy percent of Earth's wildlife populations have been lost over the last fifty years (WWF, 2022.) As a result of degradation to complex ecological systems, enormous populations of species across all kingdoms of life have been lost and are continually at risk for disturbance or extinction (Ibid.) The WWF utilizes four indicator categories to illustrate the complexity of earth's natural systems within the parameters of available data analysis: abundance, extinction risk, composition, and distribution. These categories help articulate the crisis of biodiversity loss, and are expressive of the inextricable relationships between species prevalence and in tact ecological habitats. However, to maintain arguments that fit within scope of this thesis, I will refrain from extensive elaboration around the intricacies of floristics and faunistics, and rather will refer to issues of biodiversity loss broadly within the framework of these categories as a whole as it relates to habitat loss.

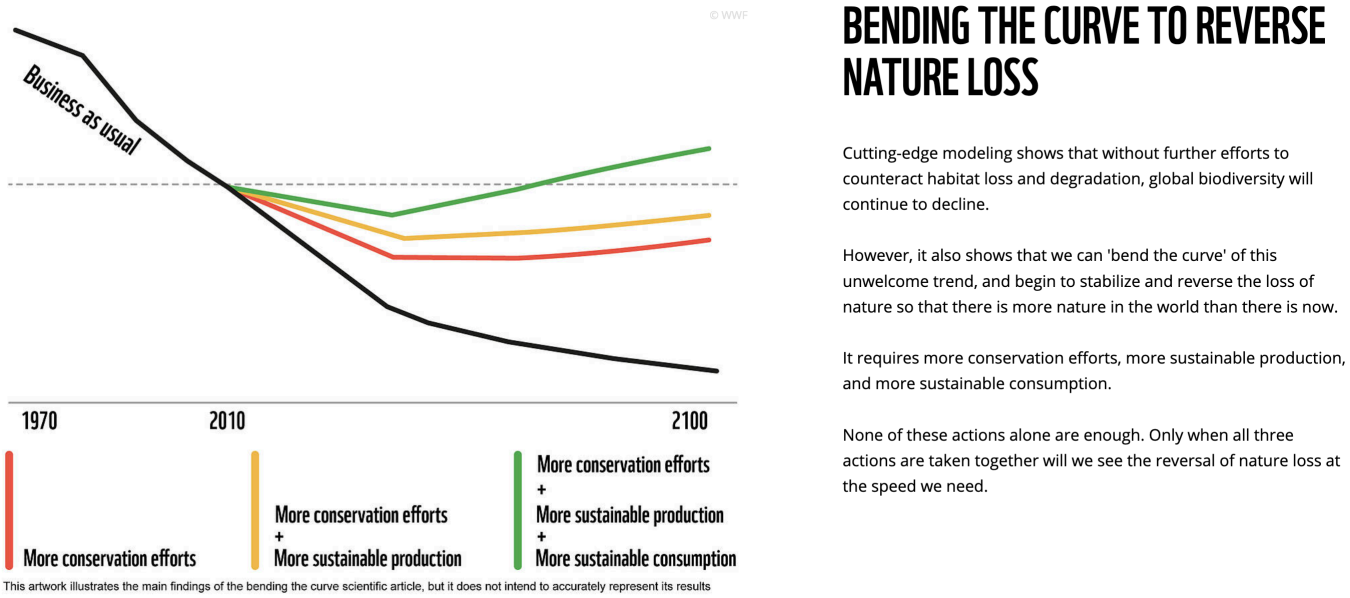


Figure 2.2. The World Wildlife Fund advocates for more than conservation, for nature-positive transformations across sectors to reverse biodiversity loss. Image Credits: WWF, from *Living Planet Report 2022*

Research suggests there are five **primary drivers** of global biodiversity loss: land uses (habitat degradation/loss), species overexploitation, invasive species and disease, pollution, and climate change (ICLEI, 2010; WWF, 2020.) WWF's analysis reveals that across the world, the driver above all others is the transformation of land uses, resulting in habitat degradation and loss (Ibid.) For centuries this has been a result of development, resource and energy extraction, and traditional agriculture. Therefore, the designers of the built environment must urgently transform practices for development and resource procurement toward strategies that are inherently regenerative rather than extractive (Marchetti and Pastore, 2022.) Figure 2.2, borrowed from the WWF *Living Planet Report*, calls on all sectors, governments, and citizens to transform practices of conservation, production, and consumption globally to reverse the trends of biodiversity loss and foster a more healthy and sustainable future.

It is also well understood that the burgeoning crises of climate challenges facing humanity include flooding, drought, erosion, atmospheric instability, increased extreme weather events, wildfire, and ocean acidification, among others. However, arguably most essential is that our civilization recognize the horrific reality of **mass species extinction** and the threats to biodiverse populations in across life kingdoms. According to the United

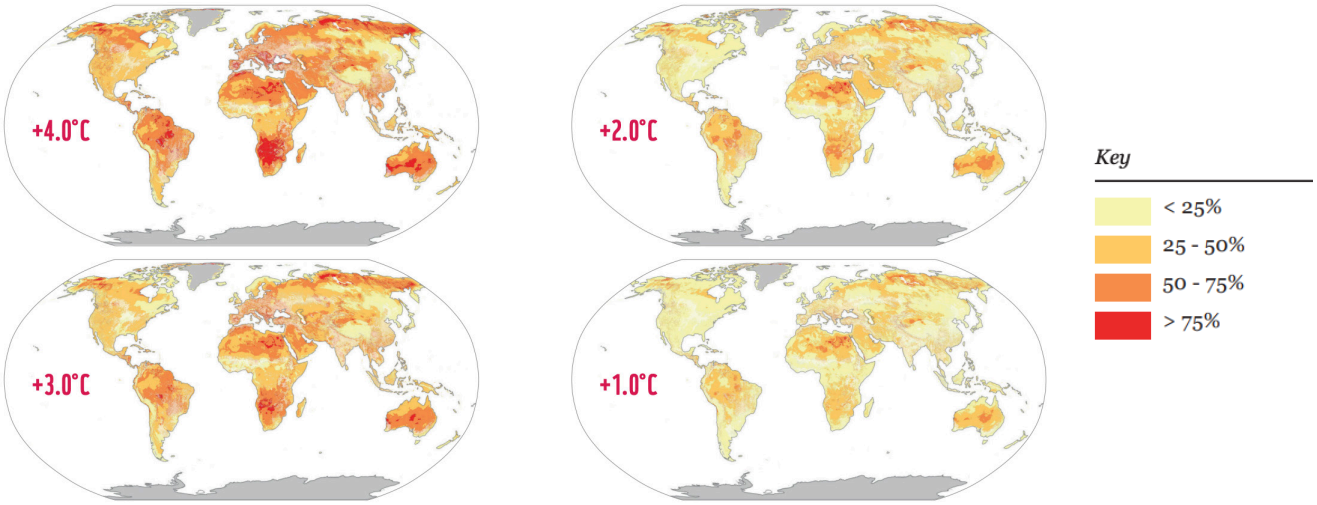


Figure 2.3. Research from the Intergovernmental Panel on Climate Change shows for every degree of temperature (Celsius) increase, a greater percentage of species loss will occur. Image Credits: WWF, from *Living Planet Report 2022*.

Nations, the rate at which animal extinction is happening due to habitat loss is continually accelerating (IPBES, 2019.) As of 2023, an estimated 1,000,000 plant and animal species globally are threatened with extinction (WWF, 2023.) Not only does the dramatic loss of habitat and biodiversity affect human food, water and resource access, but devastating declines in predatory species allows for parasites and disease-carrying species such as mosquitoes to proliferate, increasing the threat of zooanthroponotic pathogens (FAO, 2019.) The integral threats of biodiversity loss is an existential threat to human survival.

The implications of broader global warming and climate change on the issue of biodiversity loss are naturally complex. For the purposes of this thesis, however, it is important to consider the correlation between excess atmospheric carbon dioxide (CO_2) and relative biodiversity loss across terrestrial and aquatic ecosystems (Pierce et. al., 2022, p. 231.) Averting existential biodiversity loss is a massive, multidisciplinary and international issue that requires transformations in economy, industry, and lifestyle to meet indicator requirements. Analysis of these complexities is beyond the scope of this project, yet it is critical to convey the relevance of reversing global warming and the need for urgent sequestration of excess atmospheric carbon to maintain vital global ecosystems and the biodiverse populations which comprise them (see Figure 2.3.)

In an essay titled “An Environmental and Climate Crisis: An Overview,” Simone Marchetti and Maria Chiara Pastore (2021) reverberate the conservation alarm for fellow architects and planners, urging them to consider “the fact that biodiversity and the climate crisis are strictly related, and that together, loss of biodiversity and ecosystem collapse are one of the biggest threats facing humanity” (p. 27.) Overall, the crisis of biodiversity loss is a complex narrative that requires new design paradigms that reimagines our globalized resource extraction economies around urgent and long term climate adaptation. This thesis primarily attends to the threat of species extinction and habitat loss across the kingdoms of plantae and animalia, which compose the majority of terrestrial biomass and play critically integral roles in the life processes that sustain humans and our well-being. Addressing this is an opportunity for architects, planners, and landscape architects to transform cities in a way that leverages biodiversity conservation while mitigating climate impacts. This thesis will demonstrate how this effort is essential in the urgent need to house growing urban populations.

In addition to the intergenerational crisis of climate change and global biodiversity loss is an ongoing human rights disaster of housing accessibility. Despite huge population influx into urban areas and development booms around the globe, housing stock world-wide is still falling drastically short of demand (Bowman et al., 2021.) Inefficient methods of planning and construction have led to a shortage of quality housing that fails to keep up with urban population surges. At the same time, the status quo development practices of contemporary urban and peri-urban areas continues to create negative health impacts on humans and other living organisms by degrading critical ecosystems and irreparably damaging wildlife habitats (Kelbaugh, 2019; WWF 2023.) Such development methods which are failing to protect biodiversity around the world, generating health crises such as air and water pollution, soil erosion, and urban heat island effect. However, in response to harmful design and planning orthodoxies, growing fields of study have emerged that aim to understand how employing biomimicry of ecological processes within the built environment can help cities adapt to the challenges of climate change and mitigate biodiversity loss (Lyle, 1996; McDonough and Braungart, 2002; Zari, 2018.)

The succeeding sections of this thesis will investigate the relationship between developing optimized habitats, where dense human settlements are developed harmoniously within the context of conserving and restoring biodiverse habitats. The project examines

multiscalar aspects of biodiversity as an architectural opportunity, and reveals how evolving architectural and urban design practices can improve the conditions of biodiversity across scales. Ultimately, I argue the role of architects in the 21st century ought to be to bring human development back within the bounds of earth's carrying capacity, so that we may restore biodiversity to maintain vitality for all species, and in doing so evolve our own human condition toward a reconciliation with the creation of life that sustains us. The first task is to investigate what role urban land use, one of the primary drivers in biodiversity loss, plays in developing adaptation and mitigation strategies to this habitat crisis.

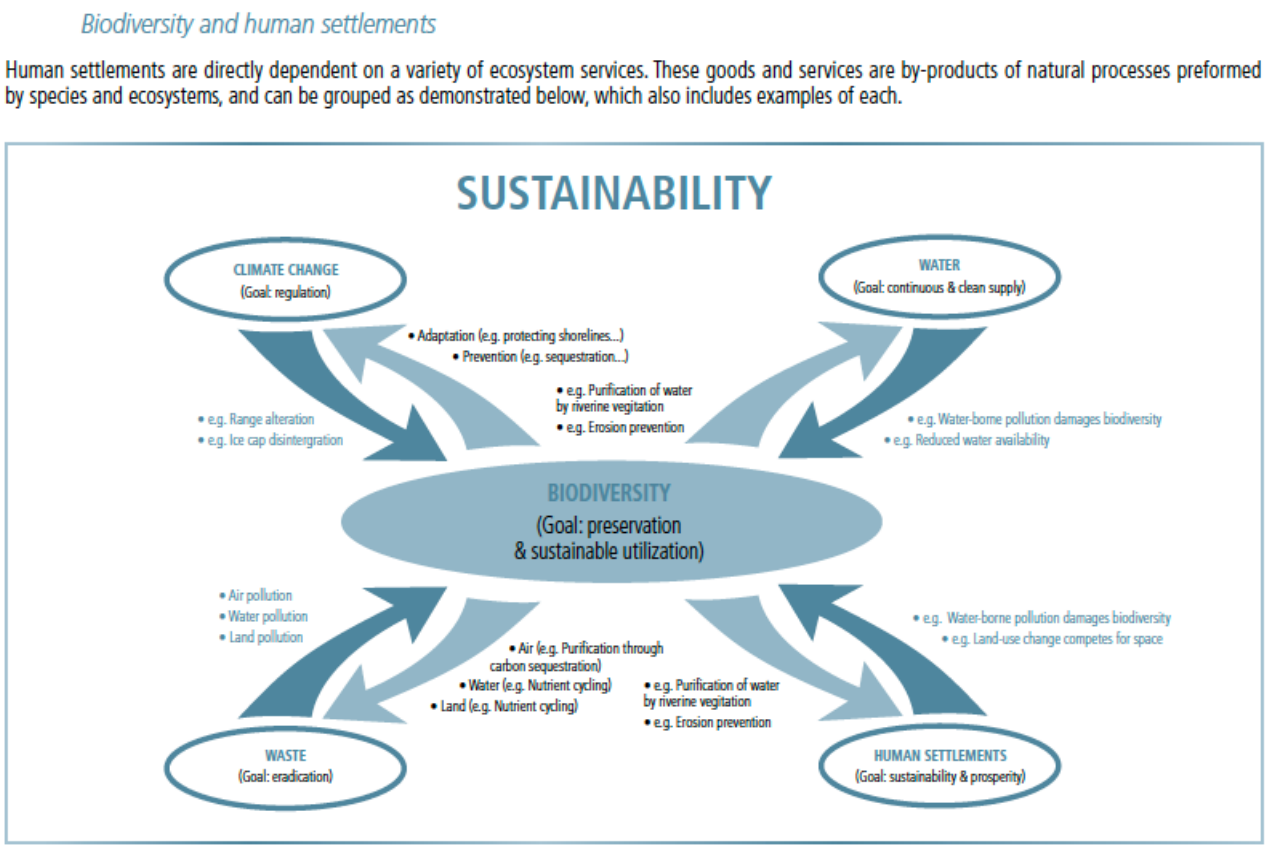


Figure 2.4. This diagram from ICLEI illustrates the inextricable realities of human settlement, climate change, waste, and water, positioning the role of biodiversity centrally as the node of all connectivity. Image Credits: ICLEI, from *Local Action for Biodiversity Guidebook*, 2010.

The Function of Density

> *"The design and operation of cities are essential to the success of any initiative designed to promote carbon-free economic growth. To have a measurable effect on global production of atmospheric CO_2, substantial changes will need to occur not only in lifestyle, but also in urban form."*
>
> (Erell, Pearlmutter, and Williamson, 2011, p. 74)

Land use and habitat transformation is by far the most critical driver in ecological degradation in the 21 century (WWF, 2022.) However, adequately supplying the world with food, water, energy, and resources requires consumption of natural capital to keep the flow of goods and services functioning for human flourishing (TEEB, 2010.) It is essential, then, for paradigm shifts in land use practices that actively conserve and restore biodiverse landscapes. The interfacing of cities and wilderness areas is a broadly researched subject that implicates issues of social justice and equity, as well as conservation and global health (Boeri, 2021; Way and Yocom 2022.) As such, urbanization is an essential factor in the development of burgeoning human populations across various regions of the world. The simple function of urban land use relative to wilderness and habitat availability reveals opportunity to balance what is described in this thesis as the habitat crisis. To best conserve and regenerate valuable resources and biodiverse habitats, we must continue evolving the human habitat by embracing optimal urban densification.

While populations continue to urbanize, it is important to that we consider how development of Earth's remaining open landscapes best serve biodiversity and human needs simultaneously. By adequately densifying human populations in urban areas, ideally we are conserving open space that can be reserved for biodiverse habitats. This conservation and restoration can happen through various methods including protected wildnerness, regenerative agriculture, or maintaining valuable timberlands, as will be discussed later in this paper. By optimizing terrestrial land uses, **regenerative urbanization** gives us an opportunity to provide adequate habitat for humans, while conserving biodiverse landscapes upon which we depend.

As such, injecting large American cities with an increase in housing density may mitigate some of the challenges of the growing housing scarcity and climate change. While

a dearth of housing stock and increased income inequality have crippled American renters and homebuyers, cities have largely failed to build density into their growth plans (Scruggs, 2019.) At the same time, the existing global paradigm for urban construction methods have led to cities that are contributing to dangerous levels of mortality from extreme heat and air pollution (Kelbaugh, 2019, Chapter 1.) For generations, subsidized automobile-centric urban development have concretized our human habitat and have severely affected the health of humans and the quality of social flourishing in cities (Kelbaugh, 2019; Jacobs, 1961.) Additionally, housing density is clearly correlated with lower carbon emissions per capita (Kelbaugh, 2019; Bowman, 2021.) This means that increased urban density is not only essential in ameliorating housing scarcity, but also in reducing carbon emissions to combat climate change. Both reducing atmospheric carbon and optimizing terrestrial land uses (i.e. developing dense housing settlements) play a pivotal role in the stewardship of healthy biodiversity.

Figure 2.5 illustrates Seattle's trending disparity between population growth and net new units. The widening gap articulates the drastic housing shortage, regardless of the issues of affordability or accessibility. This is the issue of the human habitat crisis in Seattle. Adopting more dense urbanization through land use and rezoning efforts will help to ameliorate these conditions, and has been underway through various planning efforts (City of Seattle, 2022.) However, these immense changes take significant time. While meeting these housing demands is the essential task of the city, designers ought to carefully consider the implications of this urban land transformation.

A critical component of increasing the density and accessibility to housing in Seattle is the expansion of zoning designations that are designed to unlock more space for inhabitants in an otherwise land-constrained city. Extensive studies have already been carried out to examine how upzoning Seattle neighborhoods can contribute to diversity, equity and inclusion while lowering carbon footprints of residents and making healthier and more walkable districts (Argerious, 2022; Seattle Planning Commission, 2022.) Design solutions such as the Urban Centers and Villages (Figure 2.6) strategies encourage a density of mixed residential and commercial uses near transit hubs, which will continue to bring maximal land use opportunities to various areas of the city.

Keep in mind, also, that the city's Comprehensive Plan articulates long term needs to add equitable access to open green space and urban canopy restoration, which, in the status

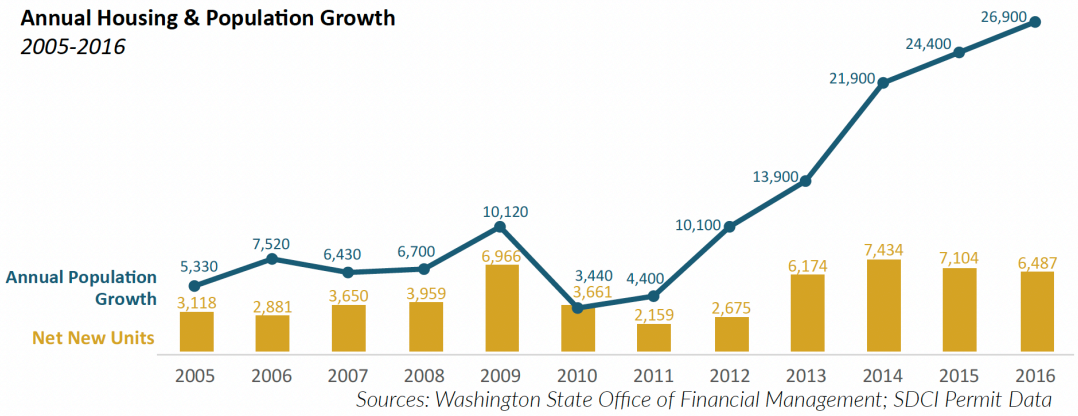


Figure 2.5 Source: *Neighborhoods For All.* Seattle Planning Commission. (2018.)

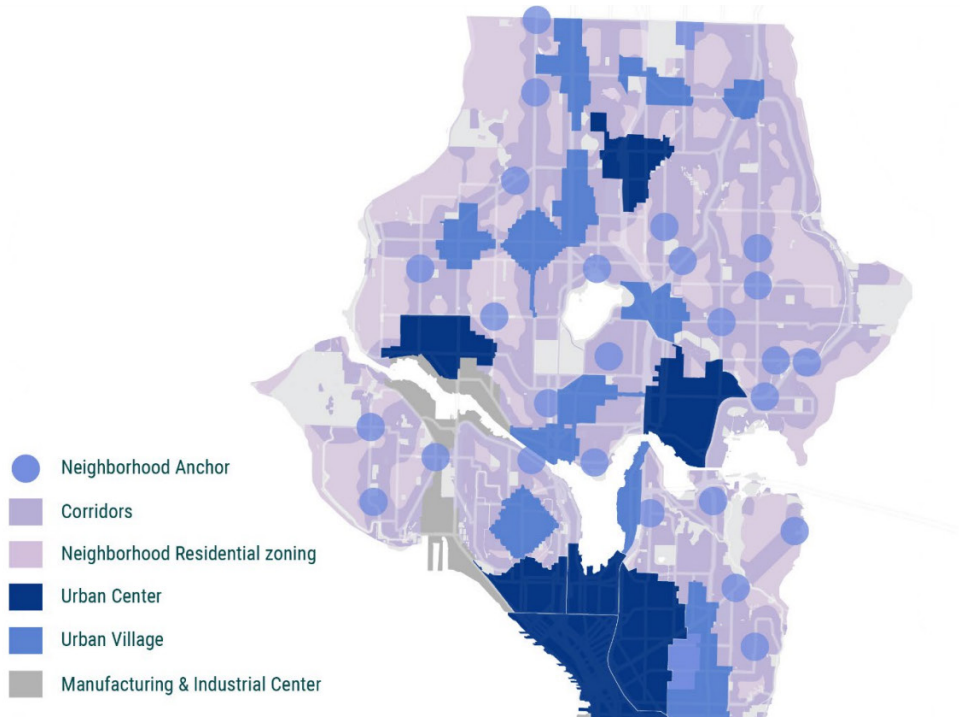


Figure 2.6 Seattle urban zones and uses. Seattle Planning Commission. (2018.)

quo of development practices seemingly competes with the demand for housing creation. Most opinions see upzoning swaths of the city and transforming the urban fabric toward a more dense human habitat as a tradeoff for canopy cover and ecosystem services at the urban scale. However, this thesis argues that with more holistic design practices, such tradeoffs can be mitigated to bring about a **fertile urban form** that healthfully integrates housing and ecosystems. Existing literature suggests that such opportunities are essential at city and neighborhood planning scales (Zari, 2018; Kelbaugh, 2019; Marchetti and Pastore, 2021.)

This thesis will examine these issues by investigating one of the few remaining privately-owned forest sites in Seattle, which is expected to be sacrificed for single-family housing development. Analysis of the upzone potential of this landscape will illustrate the opportunity to add much needed housing while still prioritizing ecological conservation and forest restoration. Further examination of the housing crisis within Seattle and the opportunity for land use optimization is found in the next chapter of this paper. However, we must first understand the extent to which biodiversity conservation is a priority for the disciplines of the built environment. Is it enough for designers and planners to consider generous landscaping interventions or the preservation of existing urban habitats, or is greater contextualization of the problem and opportunities required for maximal urban biodiversity management?

Urban Biodiversity

In their article "Operationalizing Urban Biodiversity," Pierce et. al. (2022) argue that a key objective for maximizing the effectiveness of biodiversity initiatives is the need to connect biodiversity loss drivers and impacts across spatial boundaries (p. 233.) They advocate for "maintaining and enhancing" biodiversity across spatial scales in the context of urban development for two key reasons: first that it is critical for the health of well being for citizens and communities, and secondly that cities have broad impacts on the richness and conservation of regional and global ecosystems (p. 219.) The quote at the beginning of this chapter (Lyle, 1996) articulates the underlying conundrum that over-consumption of natural capital have devastated urban and regional biodiversity. This is due to the fact that human settlements are typically located near robust natural resources (Pierce et. al., 2022), and that the conservation of **natural capital** is poorly managed, often to the detriment of societal equity (TEEB, 2010.) It is then imperative that urban development prioritizes biodiversity in order to mitigate further degradation and to improve conditions for people and all species

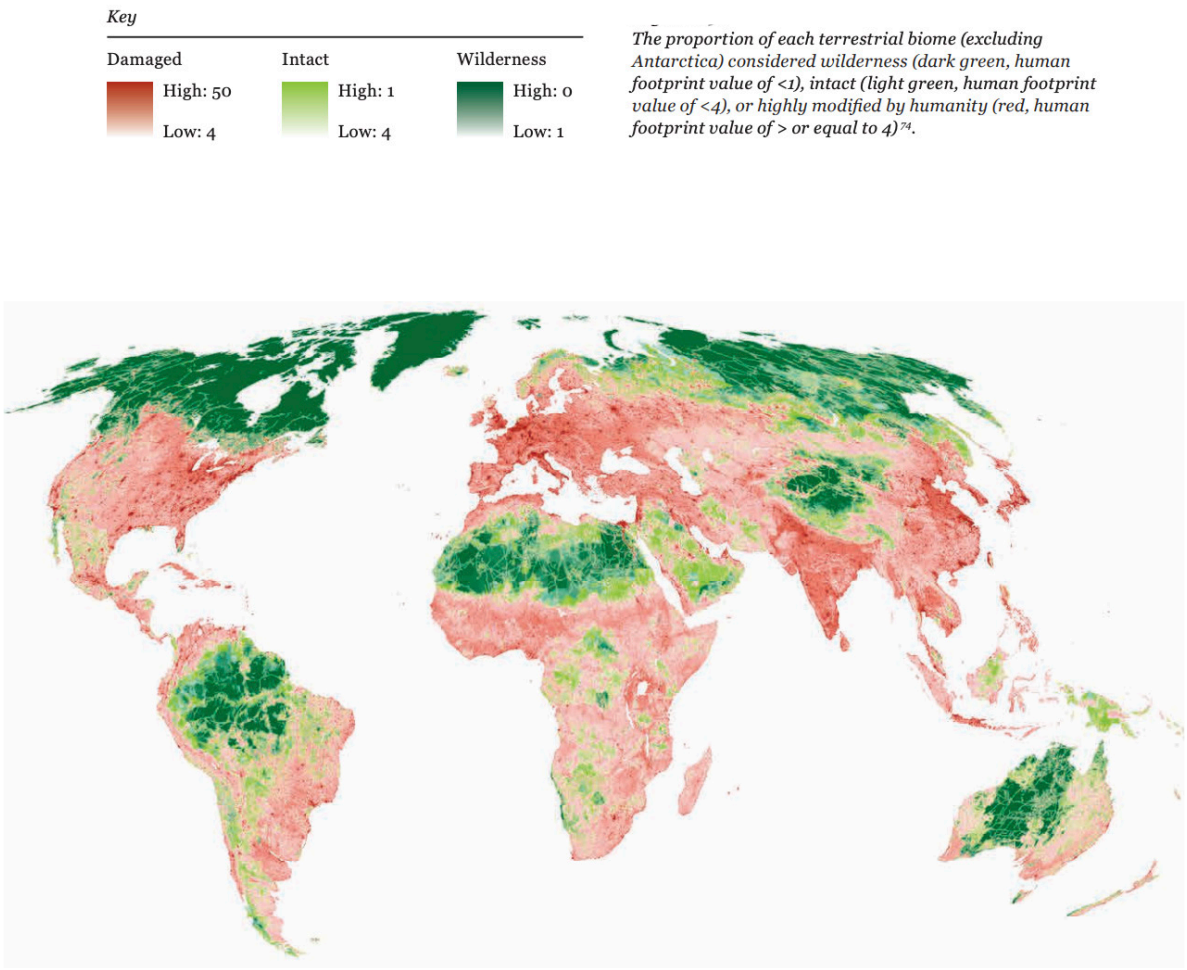


Figure 2.7. The Living Planet Index uses this color illustration to represent the anthropogenic degradation of terrestrial land globally. Research indicates that humans have surpassed the carrying capacity of Earth's resources, and must urgently act to reverse the decline of species biodiversity. Image Credits: WWF, from *Living Planet Report 2022*.

within these areas.

The rationales developed in Pierce's theory include the health and wellness factor of functional biodiversity in cities, the fact that urban biodiversity is a social justice issue that requires careful amelioration, and that urban areas influence species survival at regional and global scales. To help articulate these imperatives, the authors develop two important definitions to guide the evolving practice of socio-political discourse around urban biodiversity conservation:

Urban biodiversity - The variety and richness of organisms and the structures and functions of their ecosystems as they relate to one another under the unique influences of human settlements.

Operational standard for biodiversity management - Prioritized urban biodiversity comprises the organisms and their supporting ecosystem features that enrich and sustain cities and their associated landscapes. (p. 232.)

Prioritizing biodiversity within this framework requires land management and design interventions across ecological planning fields, and invites essential intersectoral action to address these issues. In their argument, the implied spatial scales range as follows: lot, neighborhood, city, regional, and global. This creates a call to action for urban and regional planners to collaborate with biologists, ecologists, landscape architects, engineers, and municipal authorities to interact across various scales and spatial boundaries. A key opportunity to recognize is the role of architects and landscape architects within this constellation of professionals to steward urban habitats and regional resources. By integrating the design of buildings within this framework, we can further advance these principles to provide maximally effective urban biodiversity. To introduce these ideas, we must ask in what ways does the role of architects influence urban biodiversity? And at what scales are we able to identify radical design perspectives that are transforming the "business-as-usual" development practices toward principles that prioritize biodiversity?

Extensive Urban Habitat and Re-Entanglements

> *"Cities are places for living: for individuals and groups, for humans and other species. As habitats, they must provide settings for the biological and social needs of the organisms who dwell there: for reproduction and growth, movement and exchange, communication, making and buildings, teaching and learning, work and play, reflection and worship."*
>
> (Anne Whiston Spirn, 2014, pages 604-605)

As we head further into a critical decade in the global effort to fend off the worst effects of climate change and biodiversity loss, immense focus has been given to cities (ICLEI, 2010; IPCC, 2022.) In this regard, the disciplines of the built environment primarily focus their attention on energy, food, water, waste and transportation. The consumption, production, technologies, and subsequent efficiencies of these challenges are all being reimagined and transformed to meet the demands of our rapidly evolving civilization (Heathecote, 2022.) At present there is opportunity and momentum for the architects and related professionals to steward some of these radical transformations.

In the previous chapter, attention was given to WWF's call to "bend the curve" of biodiversity loss through three primary mechanisms: **more conservation, more sustainable production, and more sustainable consumption**. This is because, as it stands today, the globalized supply chain providing food, energy, and resources for 8 billion people and their buildings have outgrown Earth's carrying capacity (WWF, 2022.) While this thesis will examine localized ecosystem services at the site scale as a function of urban biodiversity, it will also reveal the **extensive habitats** involved in resource extraction and the implicit **material geographies** embodied within architecture. This extensive view frames the boundaries of the urban habitat with expansive, interconnected relationships between cities and the global landscapes upon which the built environment depends. Such interactions across expansive networks of urban biodiversity and adjacent regional landscapes are referred to by researchers as a city's **bioshed** (Pierce et. al., 2022.) To advance architecture toward a discipline that helps radicalize cities in the regeneration of urban biodiversity, we must first examine the context for extensive urban habitats to understand how it fits into the discourse of bioshed conservation.

As noted by Kiel Moe (2013) in *Convergence*, it is critical that the constructors of the built environment recognize fundamental multiscalar flows of energy and materials if we intend to transform our cities into regenerative carbon sinks rather than wasteful emitters. One implication of this framework is that through selective design choices, architects have an opportunity to influence responsible material geographies and stewardship of the extensive urban habitat across biosheds. In her essay titled "Urban Forestry - An Introduction to a Landscape Ecological Approach," architect and researcher Livia Shamir writes,

> "It is of major importance to envision the urban ecology subject on two spatial scales: the regional/metropolitan scale and the urban area scale. Cities lie at the centre of urban regions, areas of active interactions between cities and surroundings. Metropolitan areas, the continuum of a city and its adjacent suburbs, are surrounded by a regionally interdependent ring. These entities are closely tied together by in-and-out flows and movements. This approach involves understanding large-scale systems first and allowing them to inform smaller scale ones, in order to develop schemes able to engage with ecological and social dynamics."
>
> (Livia Shamir, From "Urban Forestry." in *Green Obsession*, 2021. p. 131.)

Limiting our conception of the urban habitat to the boundaries of streets, buildings, and neighborhoods within which we reside is too narrow of a framework to adequately address the decarbonization and biodiversity priorities of our current era. While the conservation and restoration of healthy urban sites is essential, failure to consider the habitat conservation of extensive material geographies makes us lose sight of the interdependence of Earth's wider terrestrial ecologies (ICLEI, 2010.) In the compelling *Wood Urbanism* (2021) compendium, the authors advocate for **"nested" systems** of design organization, where buildings are implicit material storehouses within the expansive metabolic landscapes of metropolitan and international supply chains. This perspective brings awareness to the opportunities for designers to optimize energy and material resources across their life cycles. Such an extensive approach provides the disciplines of the built environment with key strategies for essential **carbon drawdown**, in an effort to sequester as much excess carbon from the atmosphere as possible, and hopefully protect disparate habitats to promote global biodiversity. With such a holistic perspective, architects have the opportunity to contribute to more conservation, more sustainable production, and more sustainable consumption.

This holistic perspective is scalar and multivariate, inviting a complex and imaginative building ecology to emerge. In an essay on the sensible impact of multiscalar heat exchange, Kiel Moe offers a thought-provoking idea,

> "The thermal consideration of timber is but one entry point into the complex, but knowable and practicable, interactions of timber, bodies, forests, urbanization, and civilization. Small-scale molecular movements and behaviors are directly connected to these much larger scales of material movements and solar flux. When the entirety is properly grasped, it becomes impossible to think about wood without thinking about the carbon dioxide and light absorbed in a leaf that is then "printed" as a carbohydrate in the trunk of a tree; how that trunk becomes a timber, comprised of many molecules vibrating from the sun's insolation to warm and adjacent body; and how those timbers are but one of many in a building, each the product of a forestry practice that will either amplify or construct life in the forest and its adjacent societies."
>
> (From "R-Values are not Our Values," in *Wood Urbanism,* 2021. p. 193.)

Choosing to view the extensive framework of multiscalar material and energy optimization necessitates architects to start thinking like foresters, farmers, ecologists, and conservationists. The choices that architects and developers make collectively add up to substantial consequences with regards to the value of the built environment in the global fight against climate change. For this reason, architects ought to participate in advocacy and activism to promote biodiversity through their decision making. As Jana VanderGoot writes in *Architecture and The Forest Aesthetic*, it is imperative for architects to seek counsel from adjacent disciplines such as landscape architecture, forestry, and atmospheric sciences (2018, p. 2.) In this way, architects need not become masters of all knowledge but composers who effectively harmonize disparate disciplines to advance the optimization and stewardship of essential material and energy flows.

Fundamentally, a more holistic approach to the habitat crisis requires survival of biodiverse-rich ecosystems, of which we are inextricably dependent upon (Wilson, 2002; TEEB, 2010; WWF, 2022.) The last half century has seen an evolution in design methodologies from Ian McHarg and the adoption of comprehensive ecological planning, to the multiplicity of urban-isms designed to prioritize human well-being and resource efficiency within architecture, landscape, and urban development. As scales, scopes, methodologies, and

language have continued to evolve, trends continue to promote **nature-based solutions** that respond to both urgent and long term planning challenges around shared natural capital (Zari, 2018; Shamir, 2021.)

Explorations into these theoretical areas have generated diverse attempts at regenerative urban design strategies across the globe, utilizing both natural and technological processes to emulate cyclical and productive urban forms (Zari, 2018; Yudina, 2019.) In the context of building architecture, strategies such as water harvesting, renewable energy production, passive heating and cooling systems, and low-carbon materials have proliferated. At the scale of site interventions, evidence from the literature around regenerative design and landscape urbanism make clear that nature-based solutions are effective strategies for minimizing externalities and in many ways optimizing biodiverse ecosystems (Zari, 2018; Watson, 2019; Pastore and Marchetti, 2021.)

However, the shortcoming of such biomimetic urban systems is that they have yet to systematically align architecture with the extensive material and energy flows, and fail to anticipate or adapt to the emergent context of the crisis of biodiversity loss (Zari, 2018.) The following quote from architect Indy Johar provokes a radical understanding of extensive habitats and pressures a shift in consciousness around inextricable relationships between buildings, cities, and their biosheds.

> "We've been living in a 400-year-old vision of our world based around Newtonian physics and Cartesian logics, based on separation of object and subject. Now we're starting to see the world in terms of entanglements, interdependencies, externalities, a re-entangling of the world at a philosophical, material, social, liabilities and cost level."
>
> (Indy Johar, interview 2022)

The argument presented in this thesis utilizes Indy Johar's notion of **re-entanglement** to broaden the scope of regenerative design to more accurately incorporate the complex interactions among species and ecosystems across spatial and temporal scales, advancing an **Architecture of Biodiversity** that becomes more resilient in the face of urgent climate mitigation and adaptation. Taking this expanded, re-entangled perspective on the urban habitat allows us to consider the inextricable relationships between cities and their hinterlands. Using Way and Yocom's (2022) idea of **infrastructural wilderness**, we can articulate the dynamic

and integral interactions between the functions of urban development and the resources that regional landscapes provide. They argue that such interdependent landscapes are crafting radically new ecologies, ones that ought to be critically understood and maintained with regenerative optimization in mind. The authors write,

> "In Seattle, and more broadly within Cascadia, there emerges a distinct relationship between the flows of urbanization informed by the equally powerful forces and flows of wilderness. Seattle's development suggests how the far reaches of the region have and continue to be informed by the city while revealing significant agency of the wilderness landscape in the perception and experience of the urban nature of Cascadia." (p. 86.)

Confronting the myriad of morbid challenges facing cities in the third millennium requires a structured broadening of regenerative design strategies that is now coming to define the current era of architecture and landscape design. Existing literature clearly promotes increased biodiversity in cities to combat both ecological degradation and human health challenges (Kellert, et al. 2008; Kelbaugh, 2019; Boeri, 2021.) As we begin to deliberately re-entangle our built reality within appropriate ecological preconditions, constructing a self-awareness of our indivisible habitat is an effort that will help us address a multitude of urban challenges that affect all living organisms within cities and their biosheds. The pyramid constructed in figure 2.7 articulates this entanglement of biodiversity at a sequence of scales that affect and are affected by architectural decisions. From building, to site, to city, to region, the role of architecture ought to be to steward resources and promote vitality for humans and all species across scales of space and time.

How do we move toward a more holistic approach to design and planning that is contextualized within the crisis of biodiversity loss? Aligning the built environment with the relative material and energy flows required for its construction requires evolving the architectural design process toward a process of re-entanglement that prioritizes biodiversity within the context of constructing human habitats. Threading together the essential processes of material extraction, manufacturing, site development, and landscape maintenance, allow for the extensive view of the urban habitat to effectively steward Earth's resources. In this way, we can develop an Architecture of Biodiversity that celebrates the ingenuity of the human social fabric and more responsibly imagines humanity's place within the ecological conditions that we inhabit.

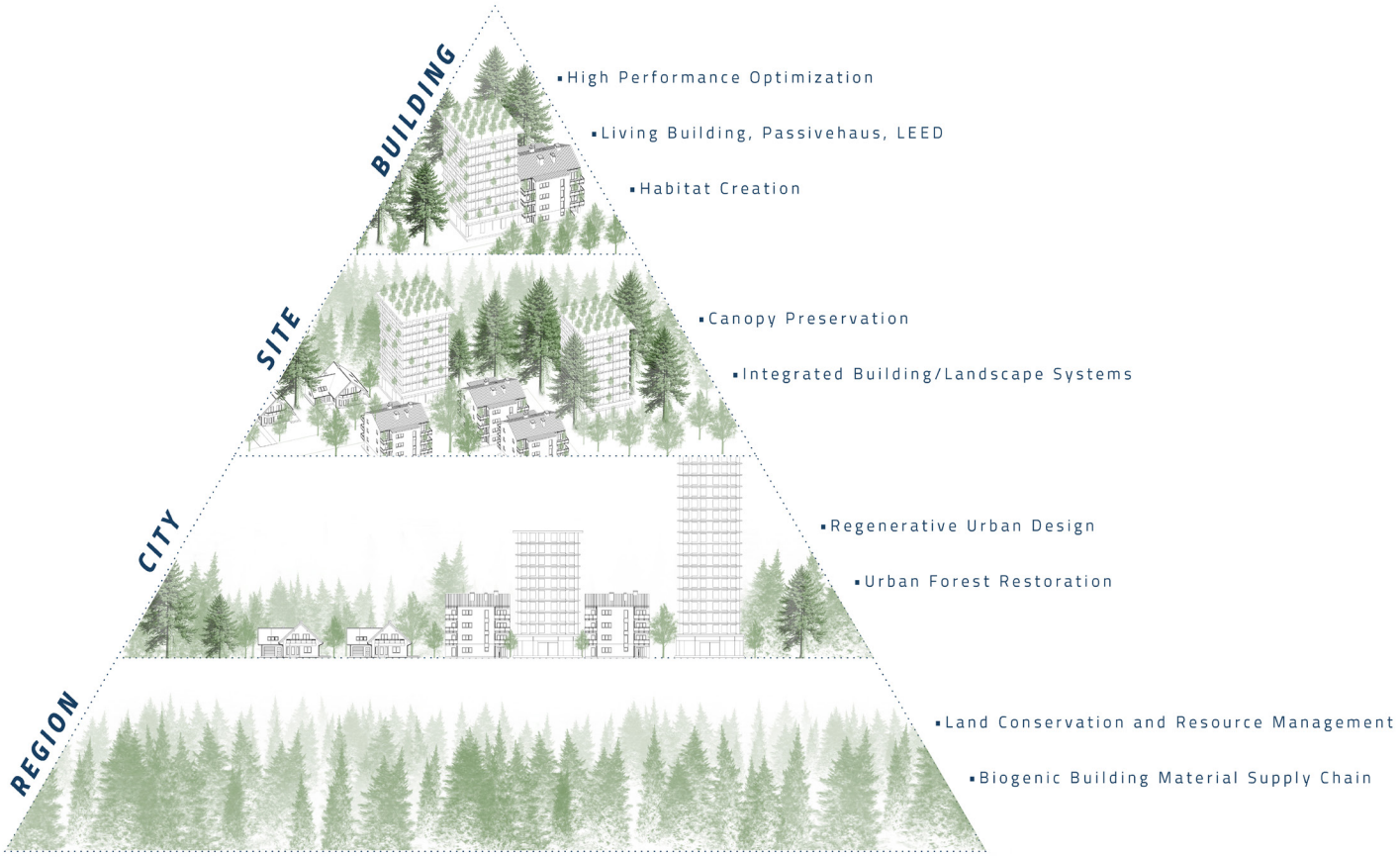


Figure 2.7 The pyramid of multiscalar values for an Architecture of Biodiversity.

Establishing An Architecture of Biodiversity

> *"Our obsession with greenery is not just stubborn desire to create greener architecture. It is, rather, the stubborn search for a different point of view in architecture. It is the idea of an architecture of biodiversity which supports a variety of living species, not just the human one."*
>
> (Stefano Boeri. From "Questions and Introduction," in *Green Obsession*. 2021.)

There have been countless inquiries into the role of vegetation in architecture that we can see from Milan to Singapore, from Melbourne to Seattle. The articulation of green surfaces, either by aesthetic demand, municipal codes or otherwise, have evolved over the last several decades revealing opportunities and errors in the execution of such ideals. However, this thesis provides a critical perspective on the agenda of this verdant architecture, to compile a more holistic understanding of the implications of architecture and biodiversity. After all, biodiversity expands beyond the bounds of plants and trees to encompass all organisms that interact and exchange resources within a **system boundary**. The previous section examined the extensive perspectives of such boundaries, and now it is time to discuss the sensible implications for architectural design.

The objective here is to integrate the fundemental principles of landscape architecture, ecological planning, resource stewardship, and regenerative systems thinking with the holistic frameworks of urban design and building architecture. The accumulation of the following theories reveals an integral reciprocity that attunes architectural decision-making to the urgent needs of biological conservation and regeneration. This interdisciplinary framework advocates for scrupulous reconciliation of the built environment with the ecological conditions upon which our societies urgently depend. Inviting these critical perspectives into the discourse of contemporary architecture offers hope for the transformations necessary to build an integral human habitat, symbiotic to the ecologies upon which it exists.

Borrowing once more from Maibritt Pedersen Zari, the goals of this work is to "Aid in the creation or evolution of human habitats that are able to integrate with and contribute to, rather than damage, ecosystems as a means of concurrently addressing climate change and biodiversity loss" (Zari 2018, p. 71.) Developing this Architecture of Biodiversity answers the call of Stefano Boeri et. al., imagining an indivisible habitat that expresses the needs and

values of humans within self-sustaining bounds of Earth's carrying capacity. Fundementally, this is the task of survival, not only for our species but for all.

I. ADVANCING REGENERATIVE PRINCIPLES

> *"Our economy is a system of extraction. We are basically stealing the future and selling it in the present, and calling it gross domestic product. That is degeneration. You are degenerating all forms of life, whether it is the ocean, lands, forests, or people. Regeneration is the opposite. You are basically investing in the future, you are restoring life and increasing resources, and that can be GDP too, that is better economics."*
> (Paul Hawken. From "Regeneration Vs Extraction," in *Green Obsession*. 2021.)

In order to reverse the trends of global warming and to build climate-resilient cities, the design and planning of our human habitat must continue to become further attuned with the natural processes of our global ecological habitat. As previously discussed, the architecture of our urban habitats are deeply entangled within the spatial and temporal fields of our landscapes. Material and energy resources that construct our built habitats are inextricable from the ecosystems from where the raw sources are derived. They are also causally related to anthropogenic global warming. A key methodological frontier that has framed today's discussion in climate-responsive architectural values and landscape planning has evolved from an ethic of **regeneration** (Lyle 1996.)

With a similar understanding of the operational dynamics that preceded Kiel Moe, John Lyle first introduced his arguments for a regenerative approach to holistic architecture and design practices by offering two principle optimizations: materials and energy. He writes,

> "In supporting its population, the developed landscape has to provide ongoing supplies of energy and materials for habitat, daily living, and economic activity. The first law of thermodynamics makes it clear that the one-way throughput system in unsustainable energy and materials cannot be created or destroyed. This means that, in order to be sustainable, the supply systems for energy and materials must be continually self-renewing, or regenerative, in their operation."
>
> (Lyle, 1996, Page 10.)

It is essential that we consider the implications of regenerative language, and occurances in architectural practice. Challenging the mechanisms of exploitation and resource degeneration is the principal focus of the regenerative design ethos, and must continually be examined to maximize impact. Broad theories and related principles have emerged such as biomimicry that intend to utilize the processes of nature as a regenerative design framework. Yet, it is critical that these architectural formulations are grounded in holistic landscape understanding. Zari (2018) argues,

> "Emulating what ecosystems actually do (functional biomimicry at the ecosystem scale), however, could mean that an in-depth understanding of ecology drives the design of a built environment so that it is able to participate in the major biogeochemical material cycles of the planet (hydrological, carbon, nitrogen) in a reinforcing rather than damaging way. If the living world is to give designers insights into architectural design that improves the sustainability of the built environment or moves into regenerative paradigms, buildings should be considered as parts of a living system and an understanding of ecosystems could be used to set goals for a project, drive design solutions and evaluate successes or failures of the design." (p 35.)

Within this greater purview of material and energy regeneration, urban design processes ought to prioritize the proliferation of biodiversity. Varying degrees of architectural interventions that provide ecosystem biomimicry include water and waste recycling, renewable energy and food production, and energy efficient buildings. Such principles have led to important movements toward green stormwater infrastructure, renewable energy microgrids, and other large system strategies that allow our built environment to embody the processes of nature-based solutions and ecosystem functions. While such strategies are essential for minimizing the normative harm that exploitative building standards have on ecosystems and climate, it is crtical to expand the boundaries of design interventions beyond the site boundaries. A broader view of ecosystem implications introduced in the last section argues to transform the construction of housing from extractive harm-reduction strategies toward truly holistically regenerative practices across vast spatial and temporal bounds.

> "Ecosystems and the biodiversity within them can affect climate through interacting terrestrial feedback mechanisms such as CO_2 fertilisation, carbon storage in vegetation and soils, vegetation albedo, evapotranspiration, structural change in biological communities

> and peat-land methane emissions... It is important to consider the built environment in its wider ecological context and to understand and respond to the social and economic context that also impacts on the built environment."
>
> (Zari, 2018 Pg. 11)

Research demonstrates that maximizing biomass in urban areas is an essential component of cooling urban environments amidst rising global temperatures (Erell et. al. 2011.) Vegetating the horizontal and vertical surfaces of our constructed environment will continue to bring us closer in tune with the material and energy transformations upon which we depend, and will provide countless opportunities for improving the well-being of our cities. Additionally, advancing canopy restoration goals and preserving mature urban trees are essential factors in site planning and must be accounted for in larger urban design if we want to build cities that meet the needs of future generations. Investigating these opportunities to optimize the regeneration of biomass in urban environments is why biodiversity must become a generative principle within the disciplines of architecture, landscape, and urban design.

II. BEYOND ZERO: TOWARD CARBON-SMART DESIGN

According to the WWF *Living Planet Report* (2022), the supply chains upon which our built environment depend are critically important drivers of biodiversity and habitat loss (p. 74.) Within the field of architecture, advancements in **biogenic materials**, or products sourced from biological sources, is gaining more global attention for its opportunities to reverse this issue. Advocacy and research through academic publications, professional associations, trade organizations, and builders groups have garnered momentum over decades to precipitate scalable influences around these practices. While construction with bio-based products such as wood, straw, hemp, bamboo, perennial grasses, and earth have existed across the world for as long as humans have built structures, the scale of these products has been limited in the construction of modern cities. Reliance on concrete, steel, and other highly carbon intense products that are easily standardized and manufactured have been the status quo for development, especially in large multistory buildings (King and Magwood, 2022.) However, advancements in technologies, manufacturing processes, and building codes is slowly revolutionizing the opportunities for architects to build with such materials at scale. This thesis advocates that an essential component to developing an Architecture of Biodiversity is prioritizing the use of biogenic materials in the construction of midrise housing settlements.

Architects Bruce King and Chris Magwood (2022) argue in *Building Beyond Zero: New Ideas For Carbon-Smart Architecture* that building with plants is a time-tested, well-loved method of construction that, at scale, can leverage the construction industry to mitigate further global warming and actually be a part of the **carbon drawdown** solution. They make the case for a "biological architecture" that values **photosynthesis** as the primary energy conversion process for manufacturing building materials. In this way, the authors are propagating Moe's argument that solar radiation is the boundary limit by which we can establish material and energy dynamics. In growing plant matter, Mother Nature uses sunlight, water, and carbon dioxide to make free and abundantly renewable sources of biogenic materials (see figure 2.8.) While these sources of biomass have long been used by humans to construct shelter, they also serve other critical functions by nature of their physiology. They produce oxygen that we breathe, essential food and habitat for wildlife, and have the capacity to store enormous quantities of excess atmospheric carbon in their material composition. Today, with evolving access to advanced processing and chemical technologies, the utilization of these regenerative biological resources should be escalated at magnitudes of scale to rapidly reduce global warming and mitigate the worst outcomes of anthropogenic climate change (King and Magwood, 2022.)

The authors, along with many contemporary voices in the green building movement, advocate for the urgent withdrawal from our profligate use of steel, concrete, and other high-energy sources of carbon emissions. A primary failure of the green building movement for the last several decades has been the lopsided focus on operational carbon, failing to give due attention to the criminally high embodied emissions in typical and even "high-efficiency" buildings (Ibid. chapter 1.) Such unfortunate tradeoffs have resulted in business as usual building practices that fail to attend to accurate life cycle assessments of building materials, perhaps worsening the problems of global warming and biodiversity loss. Recognizing **embodied carbon** as a primary factor in the life cycle of building's emissions, they argue that biogenic building materials must become essential substitutes for many building components, including cladding, insulation, and structure, where embodied carbon sources are currently creating much higher than necessary volumes of emissions (Echenagucia, Moroseo, and Meek, 2022.)

Extensive literature points to the role of reducing emboddied carbon in the construction of the built environment in order to mitigate further global warming (Magwood, 2019; Echenagucia, et. al. 2022 ; AIA n.d.) Building with biogenic materials means growing

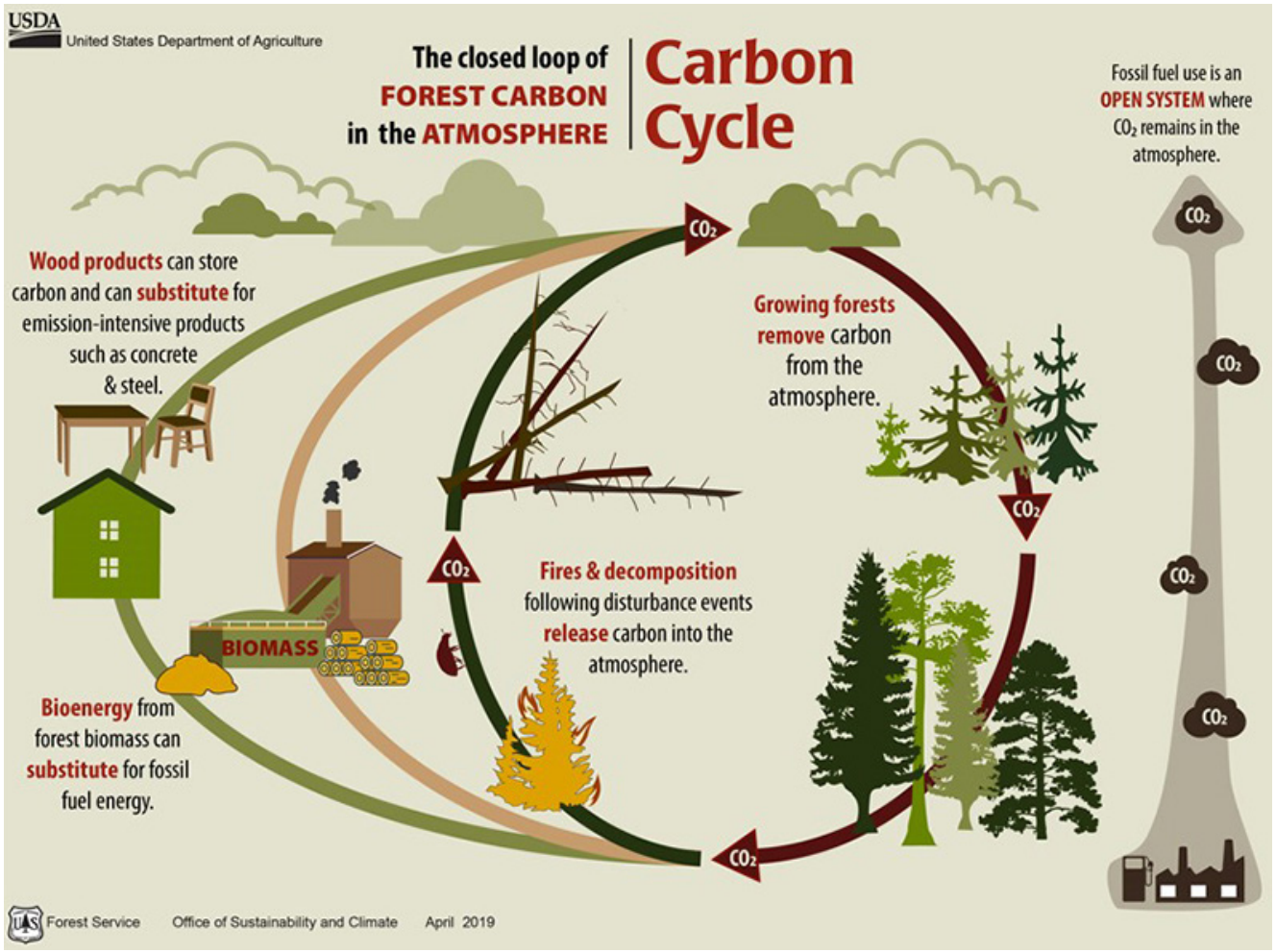


Figure 2.8. Source: Office of Sustainability and Climate, US Forest Service (USDA, 2019)

autotrophic, carboniferous products that, when used as building materials, effectively lock up excess carbon dioxide and prevent it from returning to the atmosphere through decomposition. Momentum is gaining in the Architecture, Engineering, and Construction (AEC) sector to address embodied carbon through material selection for both structure and other building systems (AIA, n.d.) The 2021 International Building Code adoption of mass timber for structures taller than six stories was a milestone for the architecture, engineering and construction industries' transition toward reducing embodied carbon via using biogenic structural materials. The opportunity to substitute timber, which sequesters carbon across its lifecycle as a building product, for concrete and steel is a huge opportunity for transform

buildings into carbon sinks, rather than emitters. However, just as it is critical to distinguish the role of embodied carbon emissions from operational emissions, it is key that we are targeting embodied emissions from all building components and systems beyond just the structure (Timurbanga, et. al. 2023.) This thesis will examine the role of embodied impact of both building envelope and structural components, focusing on carbon and other externalities of extraction, primarily habitat degradation.

This brings up another critical externality within this equation which is the harmful extraction processes of materials that are devastating to biodiverse ecosystems out of sight from their final site assemblies. Shifting the attention toward a holistically sustainable approach requires a re-entangling of our building design process with the inextricable stewardship of the landscapes required to produce them. This provides an exciting opportunity to bring awareness to architects to utilize biogenic building materials that allow projects to lower greenhouse gas emissions, provide more stewardship over distant landscapes of extraction, and connect people's dwellings with natural materials that are safer and more sensually rich in experience. The pyramid in Figure 2.7 illustrates the opportunity for re-entangling our buildings with the habitats in which they are situated and from where their materials are grown. A more holistic and effective approach to architecture requires design values that align strategically with landscape optimization, ecological urbanism and planning, and larger **regional resource conservation**. In this way, an Architecture of Biodiversity articulates a symbiosis of building design with extensive habitat stewardship. Architects and foresters, planners and farmers, have a critical opportunity to cooperate over resource optimization and carbon sequestration efforts. Further, these strategies offer integral conservation and soil restoration opportunities for practices of regenerative agroforestry and product procurement in ways that promote biodiversity and health of regional biosheds.

III. THERMAL AND HYDROLOGICAL EFFECT OF MATERIALS

Mapping and planning for urban microclimates can be successful when factoring in the thermal and hydrological properties of building materials. As urban heat islands continue to threaten populations across the globe, architects and landscape architects can play a huge role in designing urban oases for residents to find shelter from sweltering summertime heatwaves. Various strategies including building orientation, evaporative cooling, and material emissivity all influence the opportunities for favorable microclimate conditions in urban spaces

(Shamir 2021; Mannuccio and Gatti 2021.) It is important for architects, landscape architects, and planners to understand the dynamics of urban climatology, in order to best grasp the influences that architectural decisions have on urban spaces. While architecture, and the codes that regulate the production of buildings, pay special attention to the internal climate of buildings, it is critical that we bring attention to the outside climate of our built spaces. Providing optimal urban-scale climates is essential to address global heat warming and the impact that urban heat island effect has on humans and biodiversity (Erell, Pearlmutter, and Williamson 2011.)

Beyond their carbon-sequestering potential discussed in the previous section, building materials have an essential opportunity to help physically cool cities, improve urban habitats, and generate architectural expression. According to Erell, et. al., "The materials that make up the urban surface have a great influence on its thermal and hydrological balance. The absorptivity and thermal admittance of a surface affect its temperature in changing conditions, and in turn influence air temperature" (2011, p. 159.) This means that at the building scale, intentional material considerations offer a multitude of improved outcomes for lowering urban heat island effect, enhancing stormwater control, and providing optimal microclimates for humans and wildlife.

One aspect of appropriate material selection is the consideration of the albedo effect on the surfaces and roofs of buildings and hardscapes. Combatting unintentional warming from thermal heat gains due to dark surfaces is a strategy that can be applied to roads, roofs, walls, terraces and any other vertical or horizontal surfaces where vegetation is not otherwise present. Prioritizing materials with low absporptive properties is a strategy that can help mitigate urban heat islands and provide appropriate temperatures for biodiverse species to thrive (Erell et. al. 2011; Kelbaugh 2019.) Choosing biogenic material sources can be a way in which designers include low-thermal emissivity materials in the urban environment (Ibid; Moe 2021.)

Additionally, the proliferation of vegetation on urban surfaces including streets, walls, and roofs of buildings can have significant benefits to the thermal and hydrological impacts of urban areas. Due to the physical properties of latent heat flux, evapotranspiration, and the thermostat effect, situating biomass onto surfaces in the urban environment helps to keep temperatures down in cities (Erell, et. al.) Shading from street trees and surrounding urban

form also helps maintain thermal comfort for humans and wildlife. Extensive literature also points to the proliferation of biomass as a key component in green stormwater infrastructure (Erell, et. al. 2011; Shamir 2021; Mannuccio and Gatti 2021.) The use of nature-based solutions and ecosystem services are premier strategies that underlie the site and city scales within the framework of an Architecture of Biodiversity. These methods can be synchronized to provide optimal habitat conditions for humans, plants, and wildlife that inhabit the site's urban boundary.

IV. BIOCLIMATIC EXPRESSION

Evolving the morphology of our urban environments to better align human shelter with sustainable utilization of material and energy sources inevitably transforms architectural expression. Voices in the modernist era such as Victor and Aladar Olgyay argued extensively for contextual attention to bioclimatic architectural strategies, celebrating the opportunity for authentic vernacular building expression (Barber, 2020.) In some cases, these ideals successfully proliferated across various regions of the world throughout the modernist movement of the 20th Century. Unfortunately, a status quo of "energy profligacy" and the ubiqutous creation of air-conditioned spaces generated what has now become an unconscionable hubris of building approaches, leaving 20th-Century cities with enormous embodied energy sinks and dreadful lifetime carbon footprints (Ibid.) It is widely understood that bioclimatic architecture and cultural expression of vernacular place-making is as ancient as civilization (Lyle, 1996; Ingersoll, 2016.) Attention to vernacular and indigenous architecture for environmental adaptation has trended among practicioners in recent years, in part thanks to advocacy from high-profile designers and researchers such as Bjarke Ingels Group (2015) and Julia Watson (2019.)

Today's renaissance in climate-oriented building design has roots in Vitruvius' treatises on architecture and urban planning, where biophysical factors of the environment were primary influences for building and development considerations. Atavistic design practices dating back thousands of years that attend to solar geometry, prevailing winds, altitude, temperature, water, and soil are being repopularized with the context of contemporary computational methods for architecture as a reaction to increased temperatures and rapid climate change. Some of these ancient principles intrinsically respond to the elements,

geography, ecology and biophysical site conditions that offer idiosyncratic architectural form. Propagating a contemporary Architecture of Biodiversity offers the opportunity to further accentuate localized climates and biota through careful planning of plants, trees, and other landscape elements. Such intentional considerations for developing human habitat offer positive outcomes with respect to thermal and visual comfort, zooanthroponotic disease mitigation, and multisensory biophilia (Pastore and Marchetti, et. al. 2021)

Extensive architectural and landscape theories developed around E.O. Wilson's concept of **biophilia** (1984) have revealed an intrinsic relationship between humans and the built environment (Dutton and Mann, 1997.) To advance the function of biophilia beyond ornament toward systems of regeneration, an Architecture of Biodiversity advocates for the integral creation of human habitat as indivible from that of the building's ecological conditions. In arguing for an approach to architecture that synthesized such values, Kenneth Frampton (1983) developed **critical regionalism** as a framework of principles by which climate-appropriate forms could emerge. This thesis will examine the role of both site interventions and biogenic material use as primary drivers of an Architecture of Biodiversity that yields valuable bioclimatic expression.

V. FERTILE URBAN FORM

Extensive literature describes the benefits of integrating functional vegetation systems into urban settings, i.e. **ecosystem services**. The proliferation of plants and trees in cities adds a huge range of values including cooler temperatures, cleaner air, oxygen and food, stormwater mitigation, soil stability, water treatment, multisensory biophilia, and even real estate values (Erell et. al. 2011; Hawken 2017; Zari 2018; Kelbaugh 2019; Boeri 2021.) Recognizing biotic matter as an essential material in our construction of space allows us to articulate architectural values that are ecologically, spatially, and temporally dynamic.

Maximizing the volume of biomass and species diversity within cities is a core principle for an Architecture of Biodiversity that realizes plants and trees as essential architectural components of the urban fabric. These plants are simultaneously sequestering excess CO_2 from the atmosphere while producing more habitat and food for fauna and for humans. In this way, regenerative design practices that employ ecosystem services as elements of urban design become authentic and reliable sources for urban biodiversity. Orienting urban

developments with these methods will foster a **fertile urban form**, where our habitat returns to its natural role of providing wellsprings of life and prosperity, not just for humans but for all species.

As opposed to static inanimate construction materials, the fertile urban form is a living civic architecture that is in constant flux across space, time, and scale. The dynamic processes of photosynthesis, decay, and regeneration of plants transforms such an architecture across diurnal, seasonal, and annual time scales. The dynamic spatial complexity of plants also allows for an intimate architecture that is responsive to human needs and site-specific conditions through cutting, pruning, propagating, and planting. This provides an embodied biophilic experience that offers tremendous health benefits, which are well-documented with regards to health, mental wellness, and life satisfaction (Kellert, 2008; Beatley, 2010; Cooper Marcus and Sachs, 2014; Boeri, 2021.) In this way, the architecture itself becomes a truly regenerative living system that reinforces our perceptions of spacetime and re-entangles our human rhythms within the greater ecological context.

An Architecture of Biodiversity also fosters relational identities through climate, geography, floristics, and faunistics. Landscape architects advocate for the acclimation of plants and trees in an urban environment that respond to localized weather patterns, hydrology, and soil conditions with maintenance requirements inherently expressing the morphology of the site's ecological conditions. The fertile urban form derived from these values animates our perceptions of reality and shared embodied memories. This context allows humans to cultivate ideals of land ethics, and helps us discover who we are (Pallasmaa, 1996.) Similarly, architects can adapt built form that integrate such living processes to reveal the underlying biomimicry at organism, behavioral, and ecosystem level (Zari, 2018.) By expressing integral human-ecological relationships, design and architecture have abundant opportunities to promote biodiversity and usher in a fertile urban form.

Conclusion

> "If there is a purpose for our innate connection with nature, perhaps it is to help humans find our place on earth and in the universe. When we experience elements of nature, many express a greater sense of wholeness and an innate recognition of the interdependence of all things. Perhaps if we more deeply experience this connection, we will be less abusive of nature and treat the earth more responsibly. Developing biophilic buildings and communities is a step along the restorative pathways."
>
> (J. Rose, "Green Urbanism: Developing Restorative Urban Biophilia," p. 305,)

Multidisciplinary investigations into the habitat crisis from both the human housing aspects and from habitat and biodiversity loss are becoming more clear in its research: we need to develop dense, healthy urban forms, that effectively utilize materials and energy in ways that actively promote resource conservation and carbon sequestration. Through developing the framework within this thesis described as an Architecture of Biodiversity, designers can widen their perspective on the impacts of their design decisions to promote biodiversity through multiscalar interventions.

Critical to this thesis is understanding the extensive boundaries of what is conceived as urban biodiversity and urban habitats. Establishing expansive frameworks for identifying goals and outcomes of promoting biodiversity is an essential step in planning for continued urbanization. Site specific interventions as well as larger material geographies are equally important considerations in the design of the built environment when we foster an understanding of species interdependence and the role of ecosystem services and biosheds. Finally, these principles invite new formulations of architecture that can repair broken relationships within urban habitat boundaries, and can help humans remember the value of prioritizing integral biodiversity.

Ultimately, the synthesis of these theories relies on contextualization in the design process. The remaining chapters of this thesis will investigate these theories within a Seattle context local to the author, provide a design process that explores such ideals, and evaluate the product of such synthesis. The intention overall is to provide a new perspective on design within the built environment, illustrating at once the priority of biodiversity conservation and the need to house our current population and the next generation of humans.

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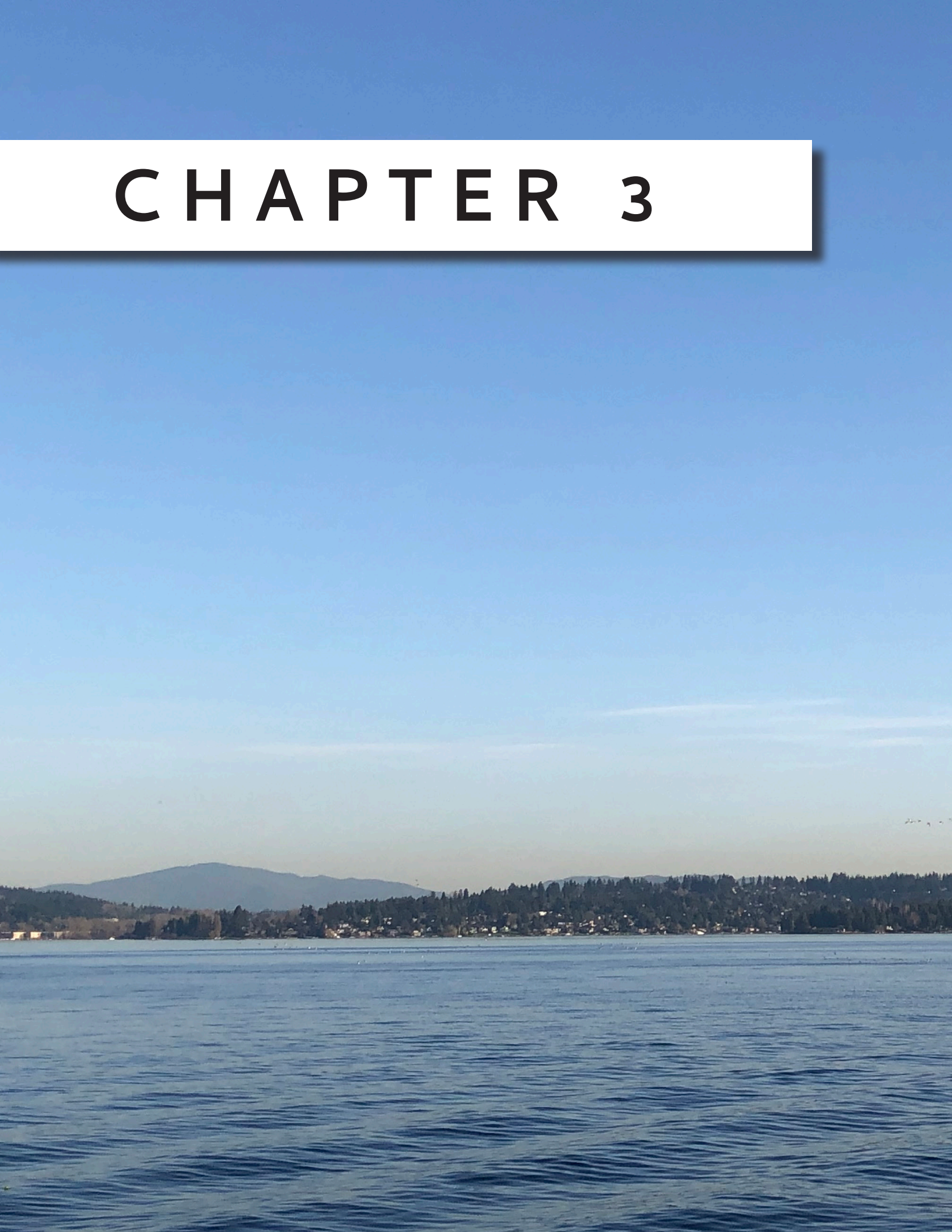
CHAPTER 3



CONTEXT OF SEATTLE'S HABITAT CRISIS

> *"We need to open up the opportunities and options for low-income households to live in Seattle. Increasing the overall supply of housing so that it keeps pace with demand is an important strategy for promoting affordability."*
>
> (Seattle Planning Commission, *Affordable Housing Issue Brief 2022*, p. 9.)

Currently, housing access and affordability in Seattle is more competetive than ever. Data shows that household incomes are not adequately keeping up with the cost of either purchasing a house or renting in the region because of the shortage of housing stock (SPC, 2022). Additionally, a close look by the Seattle Planning Commission suggests that the problem has worsened for extremely low-income households and continues to disproportionately affect BIPOC communities as a result of intergenerational systemic exclusion (Ibid. p. 8.) Addressing these issues requires extensive development planning across local and regional scales in ways that unite municipal, private, and non-profit sectors. While solutions to this crisis are complex and expand well beyond the scope of this project, the evidence is clear that our land use strategies are pivotal in addressing housing opportunity and affordability in Seattle and the Puget Sound region.

In response to Washington state's 1990 Growth Management Act, the City of Seattle created a Comprehensive Plan that facilitates a strategic framework for sustainable urban development. A component of the housing strategies within the Comprehensive Plan help to focus economic and residential growth patterns in specific urban areas in Seattle that have modeled capacity for taking on higher density. A key to the housing growth strategy in the Comprehensive Plan is the Urban Villages, which are areas of the city that have been identified with the capacity for anticipated growth and meet the standards of citywide and regional development guidelines (Citywide Plan, 2021.) Urban Villages and Centers are designed to densify transit- and opportunity-centric development for building more diverse and resilient communities. Over the last couple decades, these Urban Village designations have been successful in their potential for added growth, accounting for 75% of the city's residential and job growth in an area that constitutes 17% of the city's land. According to the Comprehensive Plan, the Urban Village strategy maintains the following goals:

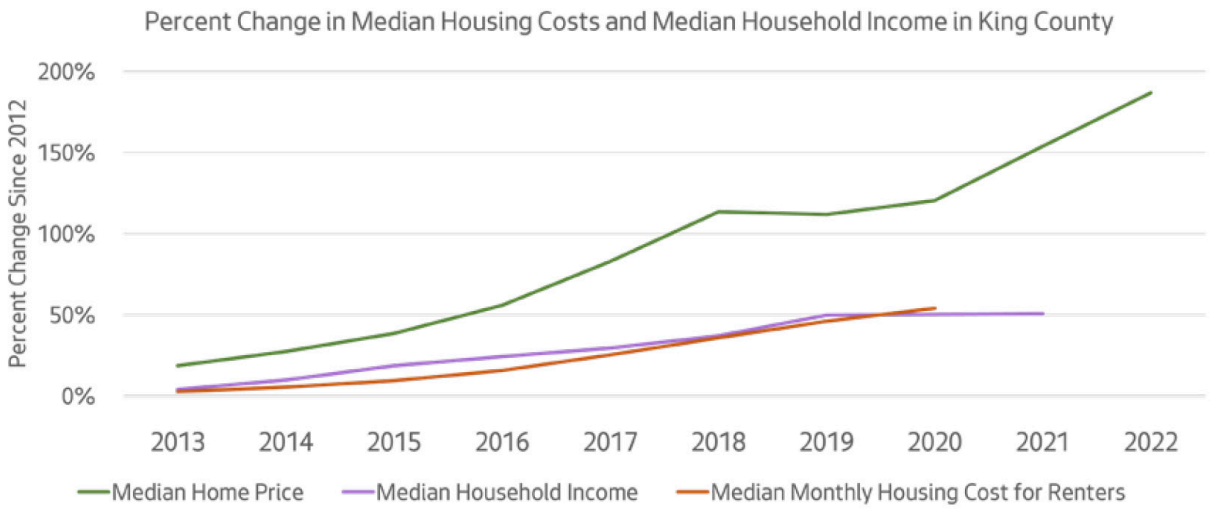


Figure 3.1 The cost of homes and rental affordability is not keeping pace with median household incomes in King County. Source: Seattle Comprehensive Plan (2021.)

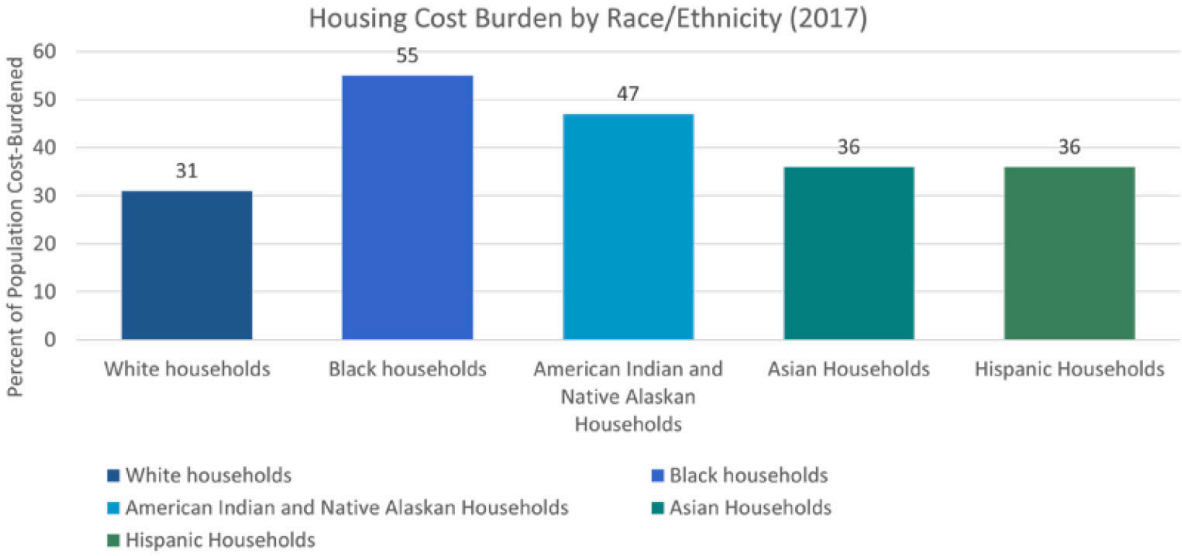


Figure 3.2 Seattle's housing cost burden, broken down by race and ethnicity, illustrates that the intergenerational exclusion of wealth creation via redlining and restrictive covenants, and single family zoning still disproportionally affects BIPOC communities. Source: Seattle Comprehensive Plan (2021.)

- accommodate Seattle's expected growth in an orderly and predictable way;
- strengthen existing business districts;
- promote the most efficient use of public investments, now and in the future;
- encourage more walking, bicycling, and transit use; and
- retain the character of less dense residential neighborhoods outside of urban villages.

In order to achieve these goals, the city utilizes comprehensive research and planning methodologies to advance development goals toward their vision for an equitable future. And while the framework works cooperatively with Seattle's Climate Action Plan in an effort to make Seattle a carbon neutral city by 2050, its ecological implications are sometimes developed to the contrary to the economic and residential development needs of the plan. For example, the plan argues that by "concentrating growth in urban villages, we help preserve the existing green areas in the city, including the areas that now contain low-density development" (Citywide Plan, 2021, p. 7.) This effort does preserve greenspace and has made a notable impact on the greater regional landscapes around King County by shouldering a large portion of the region's residential growth. In this way, Seattle's densification helped substitute land use for housing with rural farm and forest land protection (Ibid.) However, a critical area of missed opportunity that must be addressed in future amendments to the city's housing development goals is the need for **integrating biodiversity conservation and regeneration** within the city while maintaining equitable access to housing and biodiversity.

Land use is a critical consideration for housing growth in the coming decades in Seattle. To advance the city's goals for equity, diversity and inclusion, the development of housing should not be a mechanism by which wealth segregation can be perpetuated. According to the Seattle Planning Commission, "When 75 percent of residential area in the city does not allow multi-family housing, housing overall is more expensive and opportunities for placing affordable housing are restricted" (SPC, 2022, p. 9.) Moreover, by limiting green space to "low-density" areas, this plan appears complicit in environmental injustices and discrimination by favoring biodiversity goals in the low-density, more affluent areas. A more radical approach is necessary to precipitate biodiversity conservation within areas of medium and high-density, through strategic design and planning efforts. Converting existing single-family housing stock into mixed, biodiverse density can be a method for improving access to green space and expanding urban ecosystem services while adding essential housing stock.

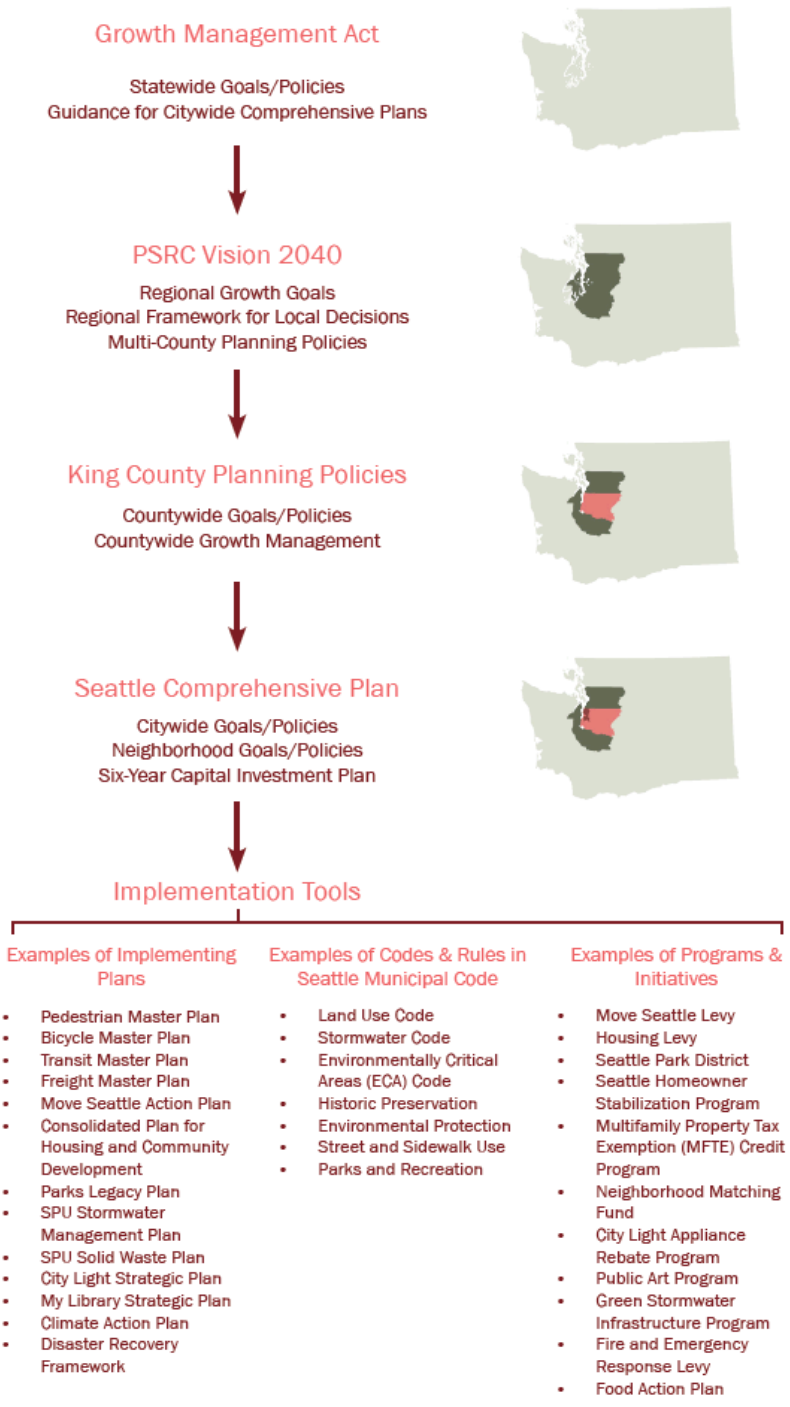


Figure 3.3 Seattle's Comprehensive Plan is itself an example of a nested system of planning, organizing and aligning city, county and regional goals for development. Source: Seattle Comprehensive Plan (2021.)

Within the "Environment" chapter of the Comprehensive Plan, the City expresses general goals to "improve human health, make vibrant green spaces, create habitat for wildlife, generate jobs, and reduce the burdens on the environment" (Citywide Plan, 2021, p. 131.) They aim to meet these goals through Land, Water, Climate, and Environmental Justice strategies that each contain broadstroke initiatives and vague policy guidelines for reform. The Urban Village strategy, however, is measured with a list of indicators (below) that paint a limited, anthropocentric perspective on development, and fails to acknowledge the urgency of biodiversity optimization in urban areas:

- the number of new housing units;
- the number of demolished housing units;
- the number of jobs;
- the number of income- and rent-restricted affordable housing units;
- access to frequent transit service;
- presence of sidewalks;
- the number of households with access to open space;
- city infrastructure investment; and
- housing costs.

While these indicators are essential to planning and achieving an equitable future for a diverse urban population, a critical aspect of growth that is left out is that of biomass and biological diversity within the city boundaries. As expressed in the previous chapter, added **biodiversity in urban areas is critical** for a multitude of reasons, including urban heat island mitigation, optimized wildlife habitat, stormwater management, erosion and flood control, human health and biophilia, and increased land value. Additionally, growth strategies that encompass this union of population and biodiversity growth will surely make 21st century cities more appealing and habitable for all species (Boeri, 2021; WWF, 2022.) Seattle's Citywide Plan for urban development urgently needs to align its goals with county and regional strategies for biodiversity conservation. The opportunity to integrate solutions is available through principled efforts on behalf of planners, developers, architects, landscape designers, and communities.

This thesis argues that the Urban Village growth strategy ought to incorporate a more holistic approach with regards to environmental externalities, and set forth guidelines for architects and landscape architects to address while engaging with the city's development

strategies. The city's Comprehensive Plan already describes key policy goals such as reforesting the urban canopy and utilizing low-impact development strategies to foster healthy environs for people and wildlife. However, at the present moment, these programs, codes, policy guidelines, and action plans appear to have competing goals. These initiatives are at odds with one another in the case of expanding housing development and promoting ecological habitat in ways that prioritize equitable development. Unless the priorities of the Land, Water, Climate, and Environmental Justice guidelines are intentionally woven into the architectural process for developing these Urban Villages, the environmental indicators will only appear in the peripheries of these areas where diversity and equitable development are already a major challenge.

The work of this thesis is to articulate strategies for healing this fractured paradigm. While the Urban Village strategy outlines a vision for low-carbon emission development, it fails to incorporate critical compositions of the complex web of life. By strategically planning opportunities for restoring tree canopy, improving pedestrian quality of life, and mixing essential ecological systems into the urban fabric, Seattle can hope to meet the goals of a net zero city by 2050 without sacrificing critical ecological habitat or housing availability. The integral nature of our life on earth requires a union with the natural environment, and the density goals of Seattle do not necessarily need to sacrifice this outcome. Opportunities to bring people together within the historic richness of Puget Sound's vital landscapes can continue to be a beacon of urban development that illustrates the harmonious possibilities of urban ecological habitats in the 21st century.

Seattle Neighborhood Density Comparison

Seattle's crippling housing crisis is primarily a function of low density, which is a result of stubborn and historically discriminatory zoning policies that came into being in the 1920s (Honig, 2021; SPC 2022.) Since then, single-family zoning restrictions, now called Neighborhood Residential zones, have come to account for 3/4 of the designated residential land use within Seattle (Seattle Geodata, n.d.) Much of the challenge to creating equitable opportunities in Seattle comes down to land use, which urgently must be addressed through rezoning efforts to promote urban density. The city currently hosts over 165,000 detached homes, encompassing over 30 square miles of its 84 square mile land area (DiRaimo, 2021.) This means only a quarter of the land area dedicated to housing legally supports dense

multifamily housing types. Even with the recent legislation that has encouraged an uptick in ADU developments on detached single-family lots, this inefficient housing typology results in astronomical land values, making the cost of Seattle rentals and mortgages over twice the national average (Ibid; Rentcafé, n.d.)

The graphics on this page illustrate the inefficiency in land use and urban density in Seattle. Figure 3.4 visualizes the amount of land area required to house the population per housing type. Where 75 percent of our residential land area is currently dedicated to single family housing typologies, with an average bedroom number of 3.2, it would take 65 square miles to house our entire population (nearly twice our available housing land area.) Figure 3.5 describes the discrepancy between new unit construction of some density to available land area for that type of development. It is clear that our land use practices have squandered huge swaths of our city to promote inequitable, low density that is now oppressing a generation of homebuyers and renters. To address these issues we must capitalize on the opportunity to rezone areas of our city to promote density and add value to our urban conditions.

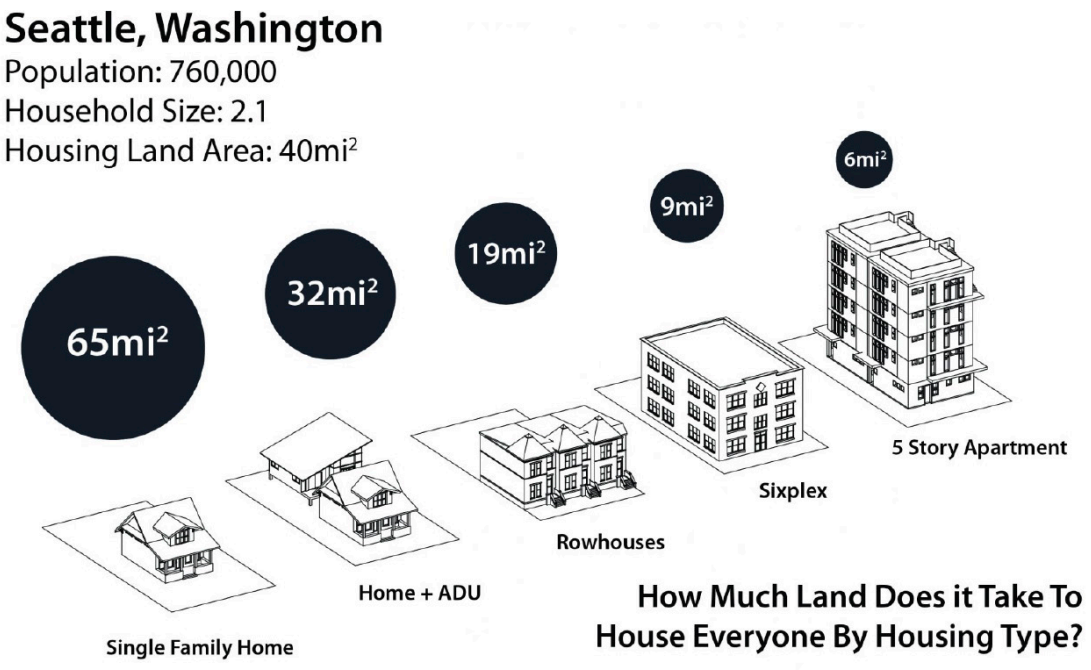
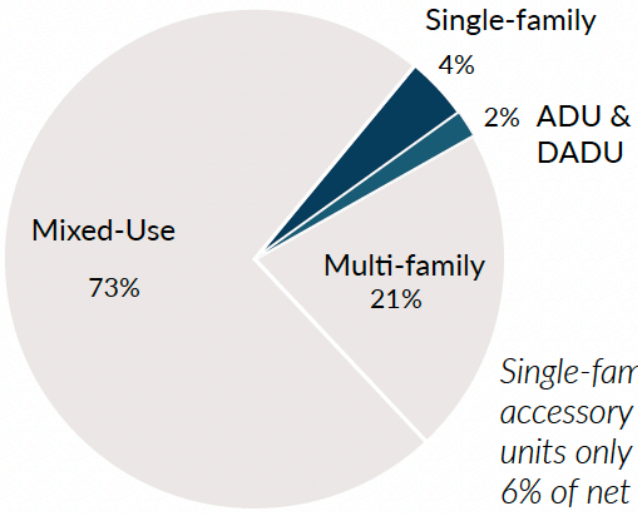


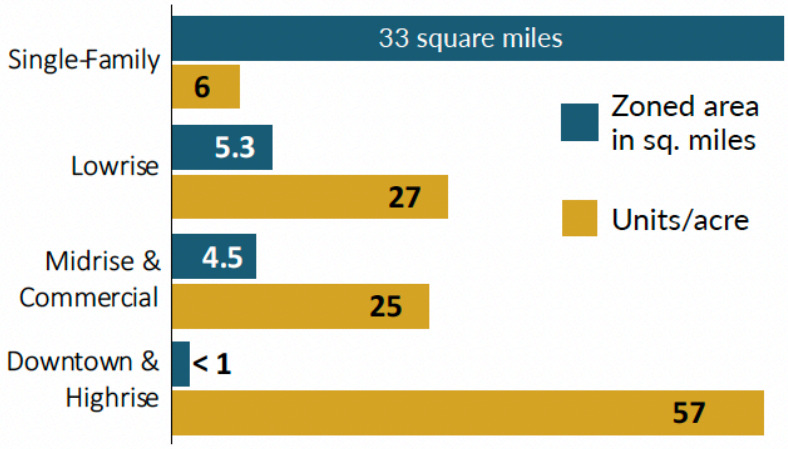
Figure 3.4 Housing efficiency by housing type. Image Credits: @pushtheneedle, via The Urbanist, 2021

Net New Units by Type 2006-2017
Source: SDCI Permit Data 7/14/2017



Single-family units and accessory dwelling units only account for 6% of net new units from 2006-2017.[26]

Density by Zoning Designation
Source: City of Seattle, SDCI



The number of units per acre in single-family zones is much lower than other zones, meaning that fewer people live on more land in a significant portion of the city. Even if an ADU was built on every single-family lot, the density per acre would still be half that of lowrise zones.

Figure 3.5 Source: *Neighborhoods For All.* Seattle Planning Commission (2018)

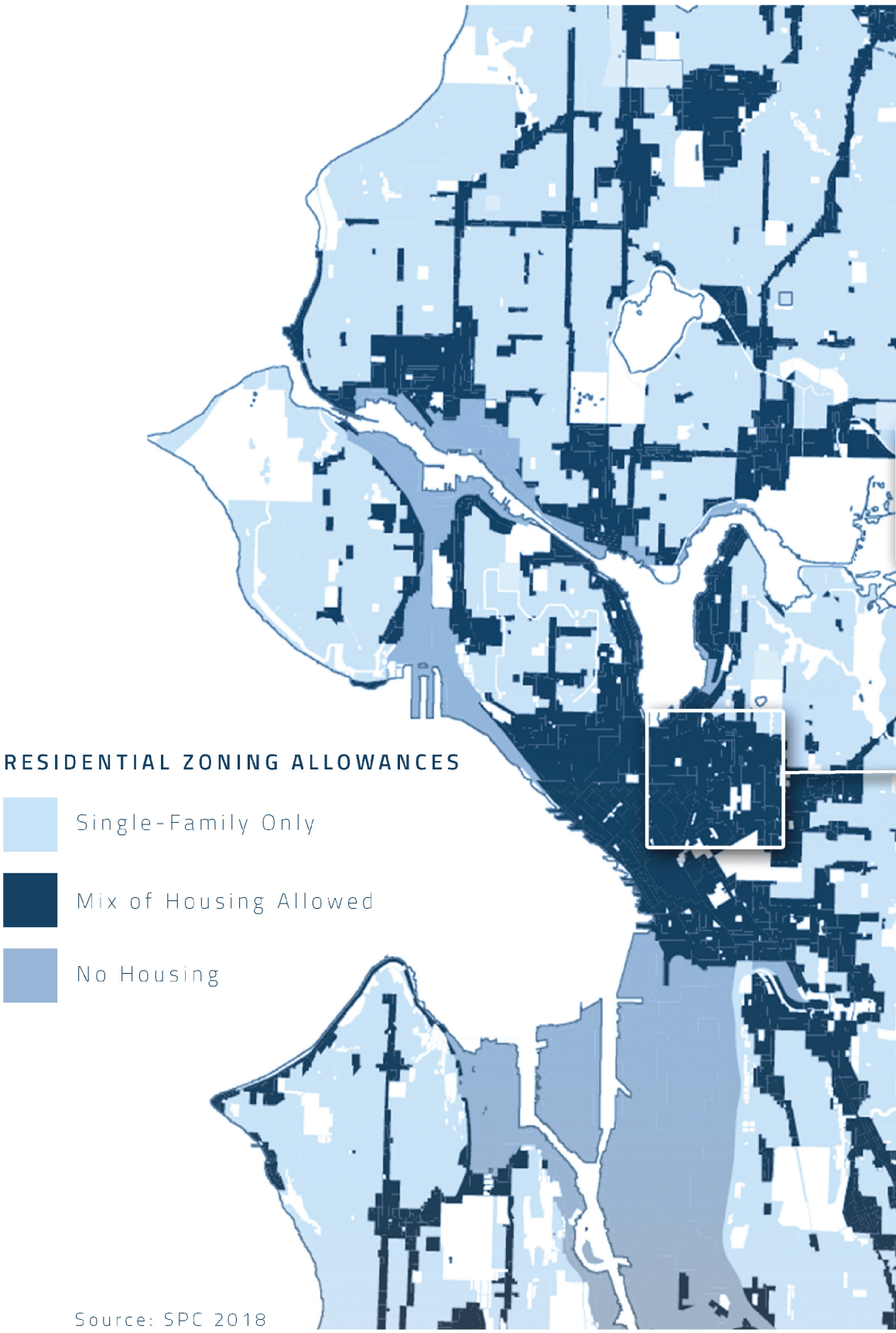


Figure 3.6 Comparing the function of density in Seattle across various residential land use designations.

THE FUNCTION OF DENSITY:
UNDERSTANDING REZONE POTENTIAL

LAURELHURST/BRYANT

RESIDENTS: 12,510
DENSITY per sq mi: 7,140
AVG. RENT: $2,154/Mo
MEDIAN AGE: 40
AVG WALK SCORE: 36
AVG BIKE SCORE: 51

Sources: Seattle Geodata; 2020 US Census, Point2Homes, Walkscore.com, Movoto

Seattle Neighborhoods Density Comparison:
1.75 SQ. MILES

CAPITOL HILL/SOUTH LAKE UNION

RESIDENTS: 63,470
DENSITY per sq mi: 36,270
AVG. RENT: $2,300/Mo
MEDIAN AGE: 34
AVG WALK SCORE: 90
AVG BIKE SCORE: 87

Sources: Seattle Geodata; 2020 US Census, Point2Homes, Walkscore.com, letsgoslu.com

In order to better visualize the spatial inequity in the planning and development of single family neighborhoods in Seattle consider the map in Figure 3.6 comparing two vastly different neighborhoods within minutes of each other. The variations of blue colors in the map indicate the zoning allowances for residential development in Seattle. Dark blue represents areas in the city where housing developers can build mixed multifamily housing, which ranges in size but generally provides far greater density than a stand alone 1 or 2 story house. The remaining areas in light blue indicate all the land in the city where single family residential, or "Neighborhood Residential," is allowed and has historically been built. These swaths of light blue indicate vast acreage of land that has the potential to house thousands more people than are currently there if renovated appopriately. This thesis builds upon the premise that strategically upzoning some of these areas can contribute to more economic and racial diversity across the city (SPC, 2018; DiRaimo, 2021.)

The map compares two 1.75 square mile areas within the city, featuring two extremes of zoning policy. The first area is the neighborhood of Laurelhurst and its surrounds, which is the location at hand for the site examination of this thesis. Laurelhurst is a waterfront community on Lake Washington, which has historically been segregated via racially restrictive land covenants and currently houses many of the city's most sizable and valuable residential properties (Rochester, 2001.) Its Neighborhood Residential zoning code means that only single detached houses are built on each lot within the area. Aside from a small strip of mixed use zoning on Sand Point Way and institutional use of Seattle Children's Hospital, this zoning designation puts the 1.75 sq. mile area, which are majority residential lots, at a density of 7,140 people/sq. mile. Compare this with some of Seattle's densest neighborhoods and we can recognize vastly underutilized land occupancy. South of the Montlake Cut is Seattle's historic Capitol Hill neighborhood and its rapidly densifying neighbor South Lake Union. This area of the map that is called out on the left has a density of over 36,000 people/sq. mile. It is essential here to keep in mind that this zone also includes many commercial and institutional uses, and reflect a robust economic engine, not just residential lots like Laurelhurst. The opportunity to resolve some of the land use inequity in the city comes down to rezoning opportune areas with appropriate housing typologies that do not overcrowd neighborhoods but provide greater access, opportunity, and affordability for more people.

Addressing Urgent Rezoning Opportunities

The Seattle metropolitan area is one of the fastest growing areas in the nation. Since 2010, population influx has skyrocketed, and though housing development in Urban Villages has boomed, overall stock still falls far short of units necessary to house the city's burgeoning population (SPC, 2022.) This failure to keep up with demand has perpetuated a long history of exclusionary housing practices in the city, and is partly responsible for astronomical rent hikes (SPC, 2018; SPC, 2022.) To combat these erroneous practices, urgent moves must be made to upzone swaths of the city beyond the Urban Villages to provide more housing access in a greater variety of neighborhoods. Recognizing this need, this thesis proposes that the city consider upzoning the developable area of parcel 1125049017 in the Laurelhurst neighborhood of NE Seattle, which is examined in depth in the next chapter.

The forested parcel is currently appraised at over $46 million, making it one of the most valuable tracts of privately owned undeveloped land in the city (King County GIS Center, n.d.) It is a highly unique property within the city, featuring 15 acres of second growth deciduous forest sloping down toward Lake Washington. For various market and geographical factors, the economic development potential of this site is high. It is also why the land owners, the Missionary Sisters of the Sacred Heart of Jesus, seek to sell the property to consolidate their global assets. Unfortunately, the parcel is legally zoned for Neighborhood Residential (single-family) development, meaning any developer who purchases the land will intend to build detached residential units on approximately 5,000 sq. ft. (minimum) lots. This scenario would perpetuate exclusionary housing practices in the neighborhood and decimate important habitat and tree canopy. Given the urgency surrounding Seattle's housing crisis and the inefficient practices of detached housing units, if the land is to be developed, the city ought to change its zoning designation to accommodate mid-rise multifamily apartments, providing a much greater access to housing while conserving a mature forested area.

While the county appraisal approximates the site's economic potential, it is also essential to consider the value of ecosystem services that the existing site conditions provide. These values are harder to discern financially, but ought to be integral to the land valuation, economic opportunity, and strategic development plans of the site. That is why this thesis proposes to simultaneously address urgent housing needs with ecological preservation, and intends to demonstrate an architectural typology that responds to Seattle's existing strategic

development plans that prioritize both housing and forest restoration. Balancing ecological habitat for as many life forms as possible while supporting human housing needs can be a promising approach to design and development practices in the coming decades.

Local Environmental Regulations

The simultaneous challenges of biodiversity conservation and the development of human settlements are issues addressed at the highest level by intergovernmental agencies and non profits such as the International Council for Local Environmental Initiatives (ICLEI) - Local Governments for Sustainability. This German-headquartered network has developed research and cross-continental partnerships to advocate for and develop countless sustainable development strategies related to this habitat crisis. In the publication *Local Action For Biodiversity Guidebook,* they outline strategies for managing biodiversity along side urban development while advocating for localized approaches that follow the adage: **think global, act local**. In considering these implications of our habitat crisis, outlined in this thesis, the authors argue,

> "Biodiversity cannot be adequately and effectively conserved through the creation of reserves and through regulations alone, since local governments often lack either capacity and/or resources to extend their biodiversity networks or to enforce regulations. In addition, in urban contexts local **governments are often faced with the challenge of increasing demands for new housing areas, infrastructure, business and industrial areas whilst at the same time ensuring conservation of sufficient biodiversity to guarantee a sustainable city. Therefore, innovative and progressive mechanisms for conserving and managing biodiversity must be adapted to fit the needs of local authorities, developed appropriately and applied.**"
>
> (*LAB Guidebook*, p. 86)

Their argument sets in motion the opportunity for local governments, in alignment with regional and federal goals, to incentivize cities, industries, and communities to prioritize harmonious development alongside biodiversity conservation. In Seattle, actionable components of city, county, state, and federal legislation all affect development practices, especially in environmentally sensitive areas such as the project site in this thesis. In the Seattle Comprehensive Plan, **Environmentally Critical Areas** are regarded as vulnerable

sites that must be specially cared for because of intrinsic ecological value. Whether it be preserving water quality, species habitat, native vegetation cover, or other circumstantial qualifier, these areas have key limitations when it comes to considering urban development. Other aspects of the Plan such as the Shoreline Master Program address the issues of urbanization alongside critical ecological conditions. These guidelines limit actions and dictate how developers, planners, and land owners optimize city land use. These governance and development strategies also fall in line with King County's regulatory framework which include Critical Areas, Stormwater, and Clearing and Grading Ordinances. By constraining urban development to data-informed parameters for sustainability, the regulatory controls that affect development are already operating to some degree in nested, regionally-attuned ways that affect biodiversity (King County Biodiversity Report, 2008; ICLEI, 2010.)

It is important to understand these ways in which development regulations are influenced by such regional goals of resource conservation and other environmental issues. The Central Puget Lowland ecoregion, where Seattle is located, has undergrone the greatest urban development and landscape transformation in the region since the establishment of colonial land uses (King County, 2008, p. 31.) The destruction of ancient coniferous forests and wetlands of exceptionally rich biodiversity for urban and suburban development has raised regional concern for the conservation of ecosystem services since the 1970s (Ibid.) Historically, King County pioneered some methods in prioritizing the richness of these landscapes, while aiming to meet the demands of urban population growth (Sims and Bissonnette, 2000; ICLEI, 2010.)

It is clear, then, that the richness of Western Washington's ecoregions are critical to conserve for future generations, requiring multiscalar and intersectoral solutions. This thesis aims to imagine Seattle's housing development goals as opportunities to engage with these greater landscape and conservation concerns. What if "wildlife corridors" went beyond parks and vacant sites of overgrown vegetation, and instead included cultivated, biodiverse habitats for people and wildlife together? What if environmentally critical areas were symbiotic opportunities for robust habitat enrichment, rather than a hinderance to urban development? What if Urban Village designations imagined a **fertile urban form** that boasted lush vegetation and wildlife habitat while fulfilling the urgent housing needs of Seattle's growing population? Such speculative methods disrupt the harmful duality of people from nature, and instead offers a vision for a completeness of the human condition, where our connectedness with nature is an integral part of everyday interactions. In this way

we can return our Westernized values of inhabiting this land back to the ones shared by the Coast Salish peoples who were and still are the original caretakers. By thinking globally and acting locally, we can promote biodiversity in our own backyard, spurring healthy human development in line with the international goals for biodiversity conservation.

Regional Resource Stewardship

Greater Puget Sound is a mosaic of diverse ecosystems ranging from temperate lowland and alpine forests to grasslands, to riparian corridors of wetlands and salt marshes. The region's unique confluence of freshwater aquatic systems and oceanic habitats provides a rich harmony of life at the interface of marine and terrestrial biodiversity. However, as is the case with the global biodiversity crisis, our region's biodiversity is threatened by the effects of increased human populations and climate change (King County, 2008; ICLEI, 2010, p. 70.) The drivers of global biodiversity loss discussed in Chapter 2 are also at play in our region, and King County's goals for stewardship are twofold: **(1) protect existing elements of biodiversity, and (2) restore and recover elements that have been unduly harmed by human interference** (Ibid, p. 74.) This thesis argues that designers of the built environment have an essential role to play in these mutually supportive goals through appropriate project planning and design.

Protecting our regional biodiversity through optimal land use is among the top priorities for state, regional, and county jurisdictional authorities. By increasing density in metropolitan areas such as Seattle, the regional development plans, informed by the Growth Management Act, are successfully encouraging conservation of natural landscapes, which are key for hosting biodiverse ecology and wildlife populations (Citywide Plan, 2021) (see Figure 3.3.) However, as the design project in the next chapter will demonstrate, successful densification also does not need to be mutually exclusive from urban habitat conservation and regeneration within the city.

Furthermore, beyond traditional conservation of undeveloped terrestrial and aquatic landscapes, the **sustainable management of agricultural and productive timberlands is essential in coordinating regional resources stewardship**. In her book *Fibershed* (2019) Rebecca Burgess argues for a deep ecological approach to the production and cultivation of regional landscapes within a renewable textile industry, which shares theoretical

synergies with the concepts here. In her call to action for a regenerative approach to material consumption, she writes,

> "...When we empower our communities to ground their livelihoods in material culture that is grown, processed, and utilized from their regional soils and in honor of existing human cultural heritage, the strategies for how we design and implement solutions for many of our most pressing global challenges -- including climate change and wealth inequality -- become more precise and effective."
>
> (p. 13.)

The arguments presented here and in the following chapter are in support of regional, place-based approaches to sourcing and producing building materials that can ameliorate the impacts of climate change and biodiversity loss. As Burgess suggests, such practice are "... required to rebuild our soils, heal our climate, and strengthen our regional economies" (pg. 13.) Advancing our region's already robust silviculture and agricultural landscapes in ways that support regenerative land practices is essential for improving soil and ground water quality, as well as restoring optimal biodiversity.

The state and tribal authorities already work toward improving the vitality of our regional landscapes through educational and governmental programs aimed to strengthen community engagement over important resource management. Existing momentum around regional resource stewardship provides important socioeconomic value to the state. Washington's Department of Natural Resources estimates the economic benefit of ecosystem services:

> "Ecosystem services provided by designated natural areas include greenhouse gas and climate regulation, water regulation, nutrient filtration, habitat for pollinators, fish, and other wildlife, and opportunities for recreation and aesthetic appreciation. ... The open spaces in the Central Puget Sound region have been estimated to provide $11.4 to $25.2 billion in economic benefits to the regional economy."
>
> (*DNR Natural Heritage Plan* p. 17)

However, threats from development and climate change impacts including extreme weather events, disease, fire are continually pressuring regional communities and resources (DNR

Heritage Plan, 2022, p. 65.) To address these issues, the DNR operates a Forest Action Plan that maintains efforts to improve forest ecologies across the state. The collaboration between state authorities, the U.S. Forest Service, and the Washington Department of Fish and Wildlife focuses on eight priority actions:

- Landscape resilience
- Community wildfire preparedness and wildfire suppression
- Keeping forests as forests
- Urban and community forest resilience
- Uural economic development
- Stewardship of family and working forests
- Wildlife and salmon recovery
- Water quality and quantity

These actions are used to promote the health of renewable landscapes and to "ensure sustainable food and timber production by conserving working farms and forests, securing water resources, and protecting high-productivity soils in the face of population growth." (p. 31.) In the context of forest conservation, the aimed measurable impacts of this work include "one million acres of forest health restored; one million acres of working and natural forest conserved; and one million acres replanted by 2040" (p. 32.) Yet, at a greater regional scale, robust landscape stewardship of this kind requires collaborative effort beyond political boundaries. The complex nature of resource management in the Northwest is addressed through strategic partnerships such as the Cascadia Climate Adaptation Strategy to improve cross-regional coordination. The importance of such alliances is to ensure that our regional landscapes are performing at optimal levels to provide robust species habitat for promoting biodiversity, sequestering carbon dioxide, and maintaining air and water quality. Advancing these goals in forestry is something that the Architecture, Engineering, and Construction sector can influence through product demand that directs capital into the agroforestry sector to best maintain and cultivate these regenerative landscapes.

Moreover, regenerative agricultural practices have emerged in response to generations of heinous industrial farming methods that have degraded soils, poisoned waterways, and stripped biodiverse species from indigenous habitats (Taylor, 2019.) By rejecting these destructive land practices in industrial agriculture such as pesticides, synthetic fertilizers,

and heavy till in favor of no-till rotational and cover crops, regenerative farmers are already transforming the status quo of American farmland toward land management that improves soil health and promotes biodiversity. This is a shared vision for reconciliation between our consumption methods and our ecological boundaries. Such a vision requires intersectorial action and collective attention, as is demonstrated in the following chapter of this thesis.

This radical approach offers a vision of balancing the cycles of carbon within our planetary boundaries described as **"carbon farming."** In an essay on the subject, author and founder of Mad Agriculture, a regenerative agroecology publication, Philip Taylor writes,

> "It fundamentally disrupts the industrial economy by shifting it from principles of extraction to regeneration, quality over quantity, diversity in place of monoculture, community instead of conquest, circularity over linear design, and invites us into a wholesale re-grounding of the economy in the virtues of stewardship, love, and reciprocity." (2019.)

Such approaches to regenerative agriculture are **extremely valuable in promoting biodiversity on regional farmland** (Olimpi et. al, 2021.) Research suggets vastly improved species richness and biodiversity improvements on farmlands that use less intensive agricultural practices and instead prioritize landscape heterogeneity (Velickovic, et. al., 2016; Mad Agriculture 2023.) A common focus within the literature is around bird biodiversity on farmlands, which serve as megafauna indicator species of more diverse landscape composition. By observing robust bird diversity on farms, researchers argue that regenerative agriculture that includes **spatially variable habitat conditions** can promote farm multifunctionality, including ecosystem services and biodiversity support. Improving the ecosystem services of multifunctional farmland provides habitat for micro- and macrofauna species within the soil, aiding in overall soil health and crop quality, while providing food and habitat for species at higher trophic levels (Mad Agriculture, 2023; Olimpi, et. al, 2021.) Advancing industry synergies over the cultivation of agriculture-based products can be a key way in which our society uses mechanisms of consumption and construction to in fact regenerate these important habitats.

The state's Department of Fish and Wildlife prioritizes twenty habitat types for conservation of regional species, based on native landscape typology. However, since 36% of the state's land area is utilized for agriculture and ranchland, the opportunity to steward biodiverse species populations needs to include regenerative farmland. The next

chapter demonstrates opportunities by which the AEC sector can and should align its product procurements with regenerative agroecology initiatives that are urgently needed to support vital habitats. Protecting and promoting biodiversity is a regional imperative that can positively coincide with opportunities for constructing our built environment and producing much needed housing in the region.

Aspects of Government Intervention

> *"Under the Biden-Harris Administration, USDA is engaged in a whole-of-government effort to combat the climate crisis and conserve and protect our nation's lands, biodiversity and natural resources including our soil, air and water. Through conservation practices and partnerships, USDA aims to enhance economic growth and create new streams of income for farmers, ranchers, producers and private foresters. Successfully meeting these challenges will require USDA and our agencies to pursue a coordinated approach alongside USDA stakeholders, including State, local and Tribal governments."*
>
> (U.S.D.A., 2021)

Earlier sections of this chapter summarized the role of city and regional governmental interventions for planning equitable growth strategies into the future. However, to address broader regional implications of biodiversity requires state, tribal, and federal efforts that seek to align values and policy measures to ensure holistic, well-intentioned solutions. Federal agencies and non-profit organizations such as the U.S.D.A Forest Service, the Sustainable Forest Initiative, and Forest Stewardship Council are actively charting pathways toward a future of sustainable land use practices and the manufacture of biogenic building materials. Valuable economic and population resiliency has been identified through investment in sustainable agroforestry practices. The Wood Innovations Program is one comprehensive grant program being employed to fund enterprises that foster a healthy forest products industry. On April 6, 2023, the White House announced plans to invest $33.7 million from the Bipartisan Infrastructure Law to "strengthen the wood products economy and promote sustainable forest management" (USDA, 2023.)

According to Agriculture Secretary Tom Vilsack, "These investments will reduce the risk of catastrophic wildfires, support existing jobs, and create new economic opportunities

in Tribal and economically disadvantaged communities" (Ibid.) Investing in these programs means that there is progress to be made in the development of forestry products for use in the construction sector. The transformation of the built environment toward a more sustainable model requires material and energy optimizations that start with the sourcing of materials. Architects and designers within the built environment ought to advocate for and foster the growth of this renewable economy for the principles of regenerative material sourcing. It is a matter of time before supply chains produce regenerative sources of forestry and agriculture products at a scale that is comparable with traditional construction processes. There is immense opportunity for the AEC sector to create radical methodologies for advancing construction standards toward innovative regenerative possibilities. Nested within these methods can be socioecological ideals for supporting rural economies, sequestering CO_2, providing habitat, and mitigating threats like wildfires and invasive pests.

The Wood Handbook created by the U.S.D.A. Forest Service argues that the greatest threat to forest and woodlands in the country are wildfires, insects, and disease. Additionally, the publication illustrates the need for active cultivation of our Nation's forests to protect ecosystem health, promote biodiversity, and improve economic opportunities. Despite the low volume of wood extracted from national forests, average annual net growth (calculated as gross growth minus mortality) declined while average annual mortality nearly doubled from 2006 to 2016. These patterns reflect aging forests and combinations of wildfire, drought, and insect infestations" (USDA, 2021.)

Beyond the focus on forests and woodland management, the U.S.D.A. is also actively promoting the improvement of agricultural lands and grasslands. As of February 7, 2022, the Department committed its administration to providing $1 Billion toward a program called Partnership For Climate-Smart Commodities, which is designed to advance innovation and the cultivation of agriculture, ranch, farm, and forest lands (USDA, 2022.) The goals of the partnership include:

- Implement climate-smart production practices, activities, and systems on working lands
- Measure/quantify, monitor and verify the carbon and greenhouse gas (GHG) benefits associated with those practices
- Develop markets and promote the resulting climate-smart commodities.

While these goals are admirable in their effort to advance domestic awareness and productivity in these areas, the message from the current administration flies in the face of the Conference on Biological Diversity COP 15 Montreal agreements, which the US did not sign (Einhorn, 2022.) In 2022, the Montreal Conference of the Parties on Biodiversity initiated globalized policy efforts with the intention to halt biodiversity loss and protect 30 percent of the land and seas from exploitation. U.S. conservatives, in their aversion to such international treaties, have squandered a collective effort to unify around this crisis and employ opporunities to further the U.S.'s domestic and global leadership in conserving biodiversity. To be sure, rejecting this effort at a global policy scale is a setback for North America and the world's biodiversity, and it provokes more energized bottom-up efforts that can be realized through other mechanisms, some of which are outlined in this thesis.

Conclusion

Ultimately, the habitat crisis is an affliction of poor land use and resource management that is damaging to both our society and environment. The setbacks we have seen in biodiversity metrics over the last century are startling and tragic. Globally, it is a crisis that threatens water and food supplies, species viability, and climate regulation. Meanwhile, our society is urgently focused on the housing crisis, where affordability and access are also at crisis levels, creating complex challenges for all systems of government and resource management. These issues are inextricable; while we continue plundering resources for extractive consumption practices, we are degrading our regional and global landscapes for materials to build our housing developments. Yet, reversing the demand is seemingly impossible as we need to provide housing for eight billion people on Earth. However, any effort to address these crises is an opportunity to envision a future where we can choose to live more harmoniously within the bounds of the material and energy flows upon which we depend.

Here in Seattle, the need to reimagine our land use practices to develop more affordable and accesible housing opportunities is clear. How we do this, however, can be met with opportunistic imagination for conserving and promoting biodiversity. At the scale of the urban form, this is key for not only preserving critical urban biodiversity, but also for creating equitable access to green space in the city. A future of equitable housing ought to ensure all citizens have access to tree canopy, as well as healthy rivers, streams, creeks, lakes, wetlands,

and parks. Interwoven biodiversity within the architecture and urban form of our cities does not necessarily compete with the need for more housing development, as is demonstrated in the next chapter. Additionally, at the regional scale, biodiversity can be a priority of the AEC sector through strategic partnership with agroforestry, government, and tribal interventions that aim to advance regenerative land use practices. Together, these efforts must employ top down governmental incentives, bottom-up advocacy and engagement, and unilateral commitment to advancing the goals of an equitable and biodiverse future.

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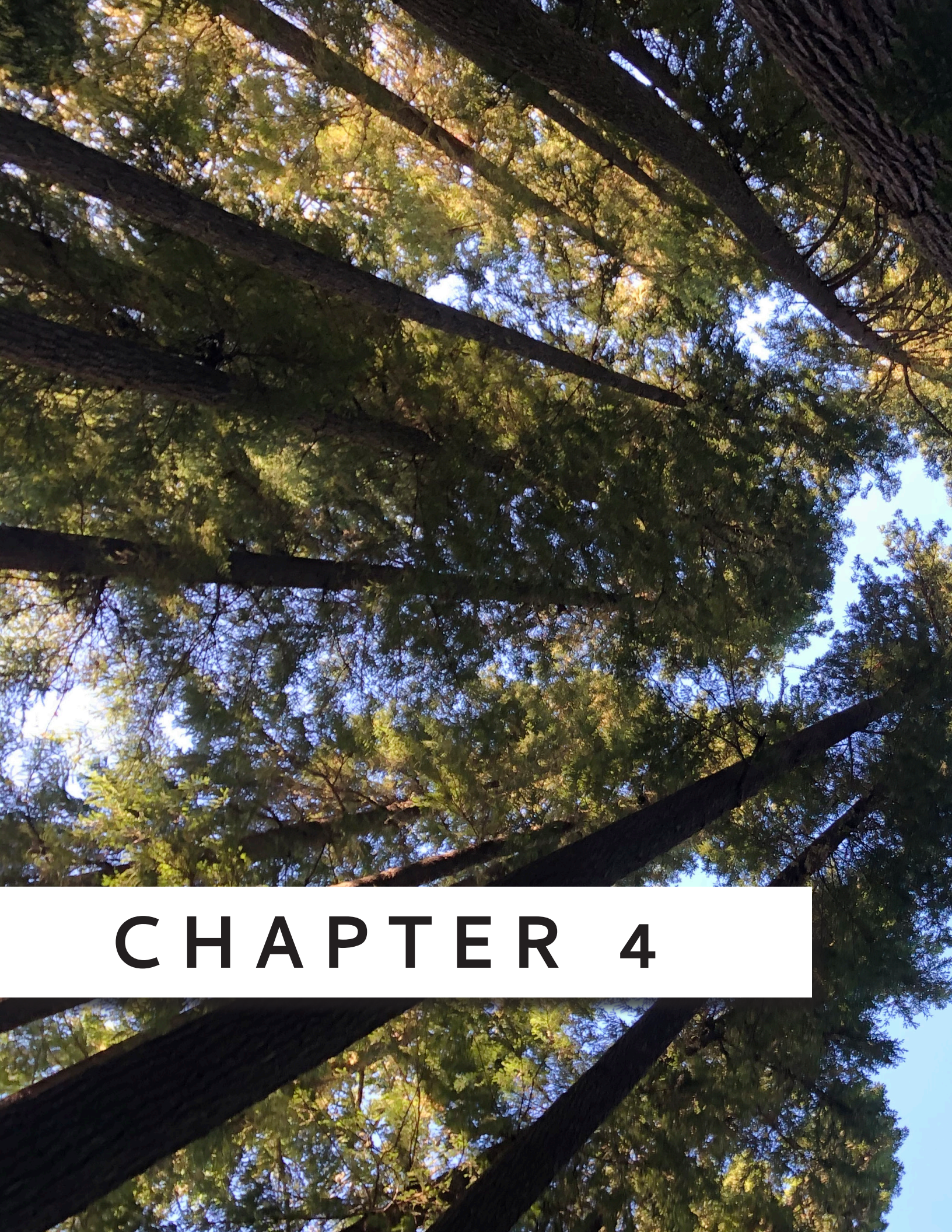


CHAPTER 4

Figure 4.1. Parcel 1125049017 aerial view. Credits: Washington Shoreline Viewer GIS, 7/29/16.

Site Analysis

ANTHROPOLOGICAL HISTORY

This area of Puget Sound was originally inhabited by the Duwamish people, an indigenous group whose ancestors have inhabitated and cared for these lands and waters since time immemorial. Before the American settlers arrived in the 1800s and transformed this area into the urban metropolis of today's Seattle, indigenous settlements were built with a vernacular timber frame construction using almost exclusively timber from western redcedar trees. Villages were built along waterways and near abundant food resources, often consisting of plank longhouses that were sometimes occupied by up to hundreds of individuals (Ott, 2014; Stewart, 1995). It is hard to say with any certainty whether this specific project site was ever a permanently occupied dwelling, but we know from anthropological research that it did have a significance as a named place by the city's original inhabitants (Sheikh et. al. 2014.)

In the 1850s, American pioneers came to settle in the land that is Seattle and quickly transformed the region's forests and wetlands to fit Eurocentric expectations for diet, agriculture, and commercial activity. By the turn of the 20th Century, colonizers from American expeditions were settled in the area, clearcutting oldgrowth conifer forests to extract valuable timber for commercial operations. Forests along the water's edge such as this project site were cut first for easy access to water transportation methods.

In 1914, Mother Cabrini, a Catholic missionary worker and the first American canonized saint purchased a 24 acre lot from Charles T. Conover in hopes of moving her orphanage from Beacon Hill (Rochester, 2001.) In 1924, Seattle architect John Graham Sr. began construction on the large brick buildings at the top of the hill to house the orphanage. In 1950, the facilities were transformed into a school operated by the Missionary called Sacred Heart Villa. The adjacent building operated as St. Paul's Infant Home. In 1977, ownership of the school properties transferred to a private Catholic

organization, and the school became known as Villa Academy (Stoner, 2000.) The Missionary Sisters of the Sacred Heart of Jesus have retained ownership of the larger estate to this day.

The 21.7 acre hillside parcel has remained undeveloped ever since the Cabrini land acquisition, and the only permitted structure built on the wooded site is a small sheltered deck for use as an outdoor classroom by the school. Access roads stop at the top of the hill behind the school, and only small trails are cleared for navigating by foot down to the water. In February 2022, the Sisters announced that they would sell the 21.7 acres of undeveloped land, which has stirred controversy within the community and amongst the greater discussion of housing and land use in Seattle (Grover, 2022.)

Figure 4.2. Site analysis collage reveals longtime occupancy by a diversity of peoples, plants, and wildlife.

Figure 4.3. Parcel information overview.

GEOLOGICAL HISTORY

During the last ice age, until about 10,000 years ago, Seattle and its surrounds were enveloped in a giant 3,000 ft. glacier referred to as the Puget Lobe of the Cordilleran Ice Sheet. As the ice sheet retreated, the hydrological forces left behind the area's distinctive geographical features including the freshwater in Lake Washington and Seattle's valleys and ridges (Williams, 2017.) The soils that were deposited hundreds of feet deep across the region were the silty Lawton clay and advance outwash called Esperance sand. On top of these stratifications was Vashon till, which consisted of sand, boulders, gravel and silty materials. The site's soil composition at the surface is silty and gravelly, with sand making it similar in composition to nearby areas of advance outwash and Vashon Till (Kruckeberg, 1991.) The site's adjacency to Lake Washington means that a shoreline of lake deposit soil rich in organic matter was exposed in 1916 when the Montlake Cut was created and the lake's water levels dropped nine feet (Ott, 2012.) With the site's slope and silty soils, soil stabilization considerations are imperative for erosion control and landslide hazard mitigation. Presently, a robust forest ecosystem serves to stabilize the hillside from sliding into Lake Washington.

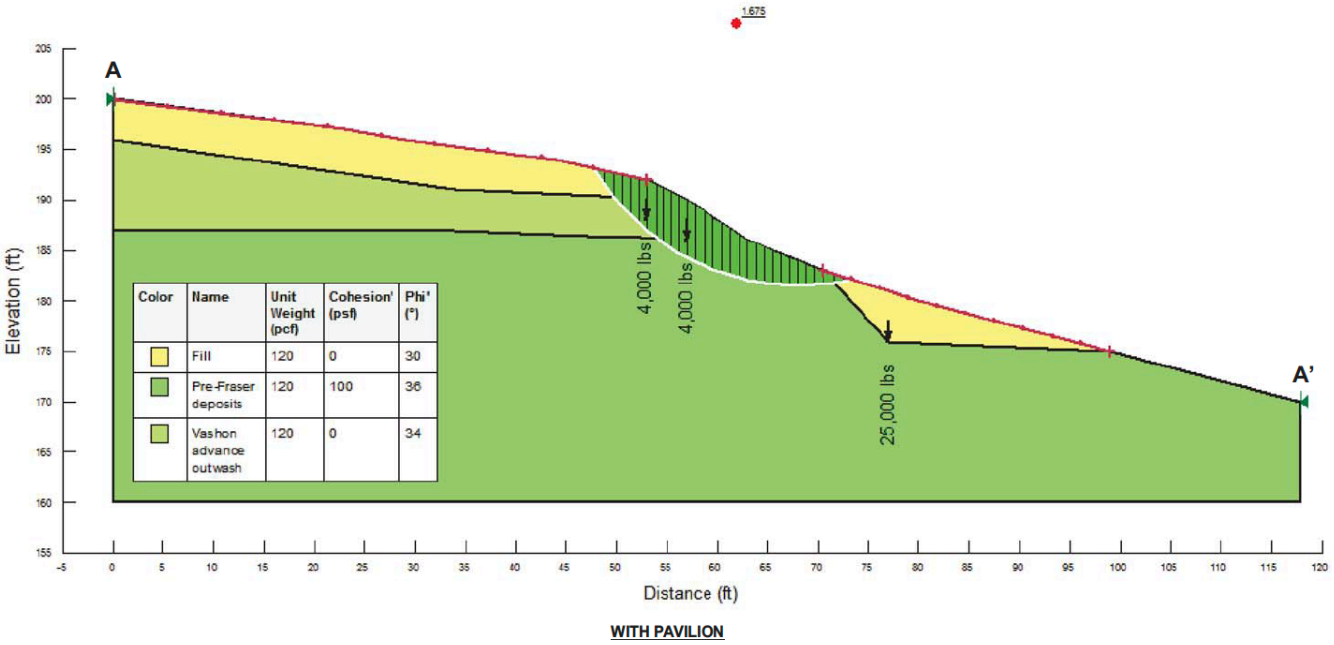
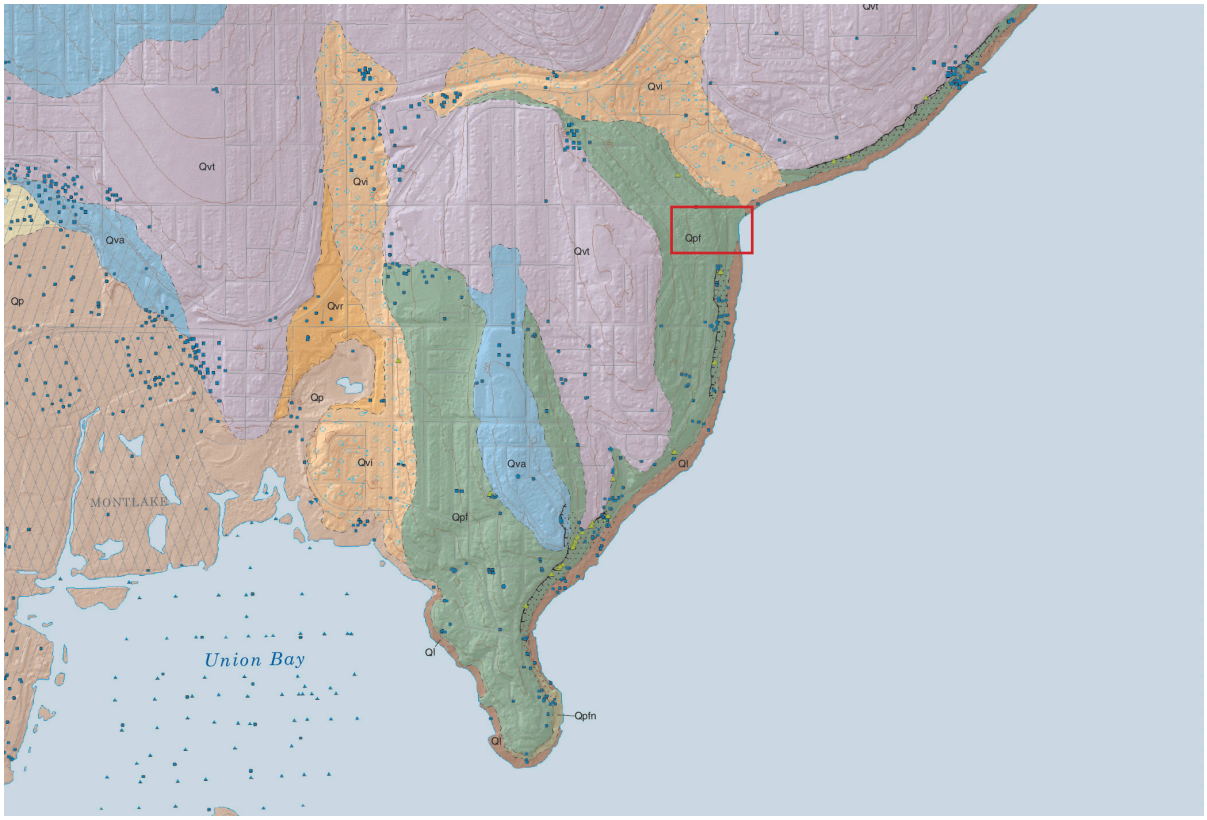


Figure 4.4. Geotechnical slope stability analysis for Villa Academy outdoor learning pavilion.
Credits: Associated Earth Sciences Incorporated.



Qvr

Deposits of Vashon stade of Fraser glaciation of Armstrong and others (1965) (Pleistocene)—Consists of:

Recessional outwash deposits—Stratified sand, moderately sorted to well sorted; less common silty sand, silt, and gravel; locally may include plastic swelling clay. Deposited in broad outwash channels that carried south-draining glacial meltwater during ice retreat away from the ice margin. Also includes deposits that accumulated in or adjacent to recessional lakes. Deposits less than about 1 m (3.2 ft) thick not shown on map; locally more than 6 m (20 ft) thick.

OLDER GLACIAL AND NONGLACIAL DEPOSITS

Qpf

Deposits of pre-Fraser glaciation age (Pleistocene)—Interbedded silt, sand, gravel, and diamicts of indeterminate age and mostly indeterminate origin; lightly to heavily oxidized. Discriminated from texturally similar younger deposits, particularly unit Qva, on the basis of stratigraphic position, oxidation, and commonly heterogeneous grain size. Above coastline of Puget Sound, mainly thinly laminated gray silt with neither organics nor drop-stones overlying and interbedded with oxidized sand and sandy gravel; granular layers more common below 60' altitude. Above shoreline of Lake Washington north of Thornton Creek, oxidized sand and gravel common above 50' altitude; laminated silt present throughout but particularly in lower part of unit, with scattered plant debris and local peat beds (all of infinite radiocarbon age). On Capitol Hill, primarily laminated silt overlying finite-dated organic material of unit Qob. Some parts of unit as mapped are probably equivalent to dated deposits of unit Qob or to overlying Qvlc but are mapped as Qpf where neither age control nor lithology allow definitive discrimination. Maximum elevation of pre-Fraser deposits as high 65 m (213 ft) on Capitol Hill but more commonly about 40 m (131 ft); base of unit not exposed in map area. Landslides commonly associated with groundwater emergence within and immediately above

Figure 4.5. Geological composition map of area. Credits: USGS 2009.

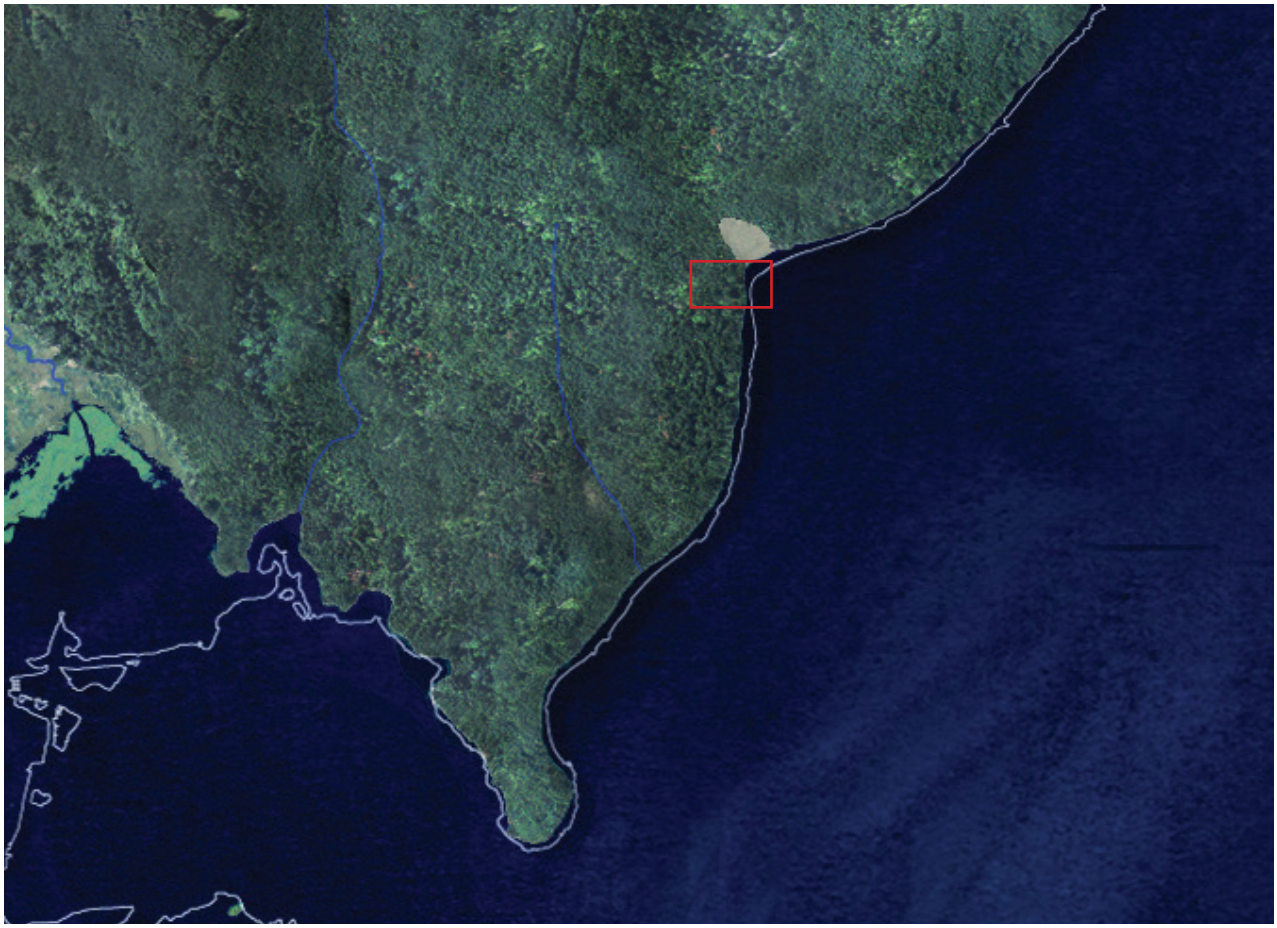


Figure 4.6. Waterlines Map of the historic canopy cover in the site's vicinity. Source: Waterlines Project, Burke Natural History Museum.

BIOLOGICAL HISTORY

" ...Between 1972 and 1996, Seattle lost 46% of its heavy tree cover and 67% of its medium tree cover. That loss costs Seattle an estimated $1.3 million per year in rainwater storage and management capacity and $226,000 per year in air pollution-related health care costs."

(Green Seattle Partnership 20-Year Plan, 2006)

Seattle's history as a forested city comes from its dominant ecosystem called the Western Hemlock Zone. In this region, the historical old growth canopy condition constituted the conifer species of *Tsuga heterophylla* (Western Hemlock) and *Thuja*

Figure 4.7. Parcel aerial view in winter, courtesy of Washington Shoreline Viewer GIS. 2/2/07

Figure 4.8. Site analysis illustrating canopy, slope, geological hazards, and shoreline management areas.

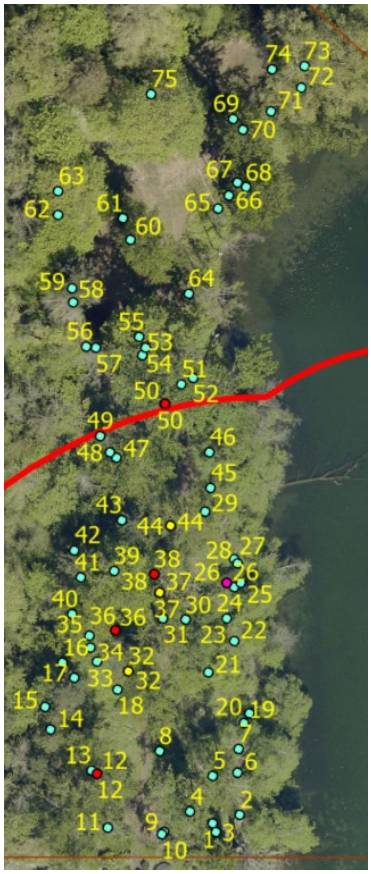
plicata (Western Redcedar.) In the succession of this forest type, *Pseudotsuga menziesii* (Douglas Fir) also proliferates as an opportunistic species in clearings and degraded areas. In these conditions, Douglas Fir can reach climax conditions (Kruckeberg, 1991.) However, in the towering shade of these trees, the Douglas Fir seedlings ultimately fail to thrive, and are out performed by the shade tolerant Hemlock-Cedar dominants. The project site's east-facing slope condition suggests it was originally inhabited by the Hemlock-Cedar condition, until clear-cut by loggers in the 1800s. Upon clearing, the planting and natural dominance of deciduous hardwoods such as *Alnus rubra* (Alder,)

Figure 4.9. Site photos by author. January 2023.

Populus trichocarpus (Black Cottonwood,) *Acer macrophyllum* (Bigleaf Maple,) as well as Douglas Fir populated the forest, as is typical for more second-growth sites in Seattle (Buchner, 2016.)

Under the shade of these historic mixed canopies, a huge diversity of temperate plants thrive in cool, moist ecotopes (Kruckeberg, 1991.) Vegetation ranges from thick carpets of *Gaultheria shallon* (Salal,) to vast colonies of *Polystichum munitum* (Swordfern,) to mixed communities of many other shrubs and herbaceous plants. Epiphytes such as *Polypodium glycyrrhiza* (licorice fern) and mosses adorn the trees of deciduous giants. Such a range of plant life provided a huge variety of edible and medicinal plants that are essential sources of sustenence for indigenous people and wildlife inhabitants. Although landscape transformations such as deforestation, hardwood replanting, and urban development have altered the site from historic ecological conditions, the parameters of hydrology, climate, sun and elevation remain ripe for restoration of this endemic ecosystem type.

Historically, diverse plant communities in lowland sites such as this also hosted a rich abundance of wildlife. Megafauna including wolves, coyotes, cougars, bears, deer and other large mammals would have roamed the area around this site. Smaller forest dwelling animals as well as semi-aquatic mammals like beavers and otters would have also been key inhabitants. Salmon and a variety of other large fish were and are still critical keystone species of the aquatic aspects of the site. The fish and small game are prey for the area's bald eagles, hawks, falcons and other birds of prey, which continue to exist in the area. The site is currently host to a bald eagle's nest. Seattle's iconic great blue heron and other waterfowl also have long been present here. Today, many omnivorous mammals including coyote, deer, bobcat, rabbit, racoon, river otter, and others still make this landscape home (Kreling, 2021; Amaral and Garcia, 2021.)



NORTH

Key Map

Green: Wildlife Corridor ECA9
Blue: Steep Slope ECA1
Red: Project area

Size of Area:
115,000 sq feet
Existing vegetation covers:
107,000 sq feet

Existing ecological functions:
- Habitat (eagle)
- Stormwater filtering, detention, infiltration (foliage and dense twigs)

Tree ID	*Botanical Name*	DBH	Health / Structure	Canopy	Proposed Action
12	*Populus trichocarpa*	60	Fair/Fair	30	Reduce to snag
26	*Prunus lusitanica*	9	Good/Good	9.5	Remove
32	*Populus trichocarpa*	40	Fair/Fair	25	Canopy reduction
36	*Populus trichocarpa*	50	Fair/Poor	28	Reduce to snag
37	*Populus trichocarpa*	28	Fair/Fair	20	Reduce to snag
38	*Populus trichocarpa*	35	Fair/Fair	32	Reduce to snag
44	*Populus trichocarpa*	39	Good/Fair	35	Canopy reduction
50	*Populus trichocarpa*	50	Fair/Fair	35	Reduce to snag

Refer to provided table of trees for complete list of existing trees

Tree Solutions Inc
Consulting Arborists
2940 Westlake Ave N #200
Seattle, WA 98109
www.treesolutions.net
206-528-4670

Katie Hogan
ISA #PN-8078A
ISA Qualified Tree Risk Assessor

Villa Academy Shoreline
5001 NE 50th St
Seattle, WA
Parcel #1125049017

February 4, 2021

Existing Conditions

Sheet #

L-1

Figure 4.10. Existing conditions canopy survey. Credits: Tree Solutions Inc. 2021.

Figure 4.11. Lake view from upper hill. Image Credits: Villa Academy.

Figure 4.12. Photo of invasives barrier prohibiting pedestrian street access on Laurel Dr. NE. January 2023.

City Intervention

NEIGHBORHOOD CONTEXT

The area known today as Laurelhurst was originally a seasonal settlement called "Sahlouwil" for members of the Duwamish tribe, where hunting and fishing were widely available. In the mid 1800s, these inhabitants were forcibly displaced by the signing of the Treaty of Elliot Point, and moved to reservations on the Kitsap Peninsula. In the 1860s, white settlers in the area made claims to these properties north of Union Bay for hunting and leisure activities. Ultimately, Henry Yesler built his second lumber mill on what is today the site of UW Urban Horticulture Center, and in 1888 established a community plat called the Town of Yesler, built for the workers of the mill. A railroad was created to connect the lumber supply to the city of Seattle, which ultimately became the Burke-Gilman trail, and over a decade the community blossomed into a small suburban population. The twelve blocks of Yesler drew in families and businesses, and although the original mill burned down in 1895, development continued in the nearby communities. Ultimately, the mill was rebuilt and the population spurred, and in 1906 real estate developers established Laurelhurst to lure Seattle residents across the water for the land's spacious properties, prosperous hunting grounds, and breathtaking vistas. The 1909 Alaska-Yukon-Pacific Exposition at the University of Washington campus increased developer attention in the area, and in 1910, the small towns of Yesler and Laurelhurst were together annexed by the city of Seattle (Rochester, 2001.) Over time, development of the neighborhood transformed into a suburban enclave for Seattle's most affluent, and today it remains one of the most exclusive neighborhoods in the city (Rentcafé, n.d.)

Laurelhurst specifically shoulders an ugly history of racially divisive policies through Racial Restrictive Covenants, which were forms of legally-bound land use discrimination that were effective until as recently as 1968. Research from the University of Washington into county property records indicate over 200 parcels in Laurelhurst contained such covenants, prohibiting non-white individuals from occupying or owning homes (Seattle Civil Rights & Labor History Project, n.d.) Today, inaccessible housing policies and aggressive community advocacy rebuffs inclusion and accessibility in the neighborhood. In an article arguing for an equitable land access development at the

Talaris site, also in Laurelhurst, Laura Loe and her colleagues repudiated some of the neighborhood's historically racist policies as a charge against perpetuating inequity today, stating:

> "The current zoning and land use restrictions — laws the LCC [Laurelhurst Community Club] have lobbied to preserve — dictate what can and cannot be built in Laurelhurst, and who can and cannot afford access to the neighborhood. It may not be conscious, but the LCC is perpetuating past land use injustices through their fight to remain exclusive today."
>
> (Loe, et. al. 2018.)

The fight for racial equity and environmental justice in such development projects is a community responsibility, and organizers such as the Laurelhurst Community Club ought to uphold values that support fair and equitable housing opportunity. Outrageous land valuations in the neighborhood mean that a small fraction of the city's inhabitants occupy some of the city's most valuable property, in carelessly inefficient and inequitable ways. The zoning laws and development strategies for the neighborhood should change if the city intends to meet its Comprehensive Plan goals, especially due to its proximity to the University of Washington and the U-District Urban Center.

Today, the estimated average home value in Laurelhurst is $2.5 million (Zillow, n.d.) making it one of the most exclusive residential communities in the United States. Real estate here is valued well over double the average of Seattle homes, and with living areas around 3,000 sq. ft., homes in this neighborhood fetch somewhere between $800-900/sq.ft. (King County Department of Assessors, n.d.) That value metric does not include parcel size, some of which range up to 50,000 sq.ft (King County GIS Center, n.d.) There are a total of 1,691 parcels accommodating over 4,500 residents, indicating a low population density that is concerningly disparate from other urban areas of Seattle.

Typical new detached residential developments in Seattle allocate 5,000 s.f. lots, which means that the cost of a new house in the anticipated development of this site would be somewhere around $2.5 million. Evidence illustrated in the previous chapter describes why the rezoning of this parcel would bring urgent opportunity for access and affordability in the neighborhood. Currently, Laurelhurst's median household

income is around $180k, which is over twice the city's average. While property values and income inequality continue to grow, the opportunity to develop a more accessible neighborhood is shrinking. Decisions must be made with regards to zoning laws and development procedures to curtail extreme class divides in the city, and to provide more options for more people in this housing disaster.

As ordinary Seattleites face a disastrous housing affordability reality, the city urgently needs to prioritize equitable development zones. Areas with the opportunity to expand housing to accommodate access and affordability must be identified. This site has potential to provide brand new housing stock, offering up hundreds of new units while engaging in a neighborhood that has historically been a place of segregation and racial inequity. Constructing dense housing stock in this area would help reduce costs of living in this area, and hopefully expand access to Northeast Seattle to a greater diversity of people. This is an essential consideration in the city's efforts to foster an inclusive, anti-racist approach to residential land use.

ZONING ANALYSIS

Perhaps challenging the zoning policy through targeted transformations would help jumpstart the dispersion of Urban Village neighborhood pattern across Neighborhood Residential areas of the city. Broader scale evolutions of Seattle's zoning policy and the need for radical transformations in density are outside the scope of this project. The goal, rather, is to demonstrate the opportunity of this project to elicit **alternative urban form typologies** in the Neighborhood Residential areas of the city. Shifting the site's current NR-1 and NR-3 designations to a mixed residential code would allow for taller buildings, more commercial activity, and the opportunity to create improved pedestrian experiences as they intersect with ecological conservation and reforestation opportunities. It is understood that robust housing density can avoid promote diversity, avoid overcrowding, and create optimal urban pedestrian experiences at a scale of 4-8 story buildings, with 100 dwelling units/acre (Manzo, 2018.) The imagined zoning alternate in Figure 4.13 illustrates the potential for a development like this to expand out toward nearby commercial and institutional uses, transforming the potential of this neighborhood to house more Seattle residents.

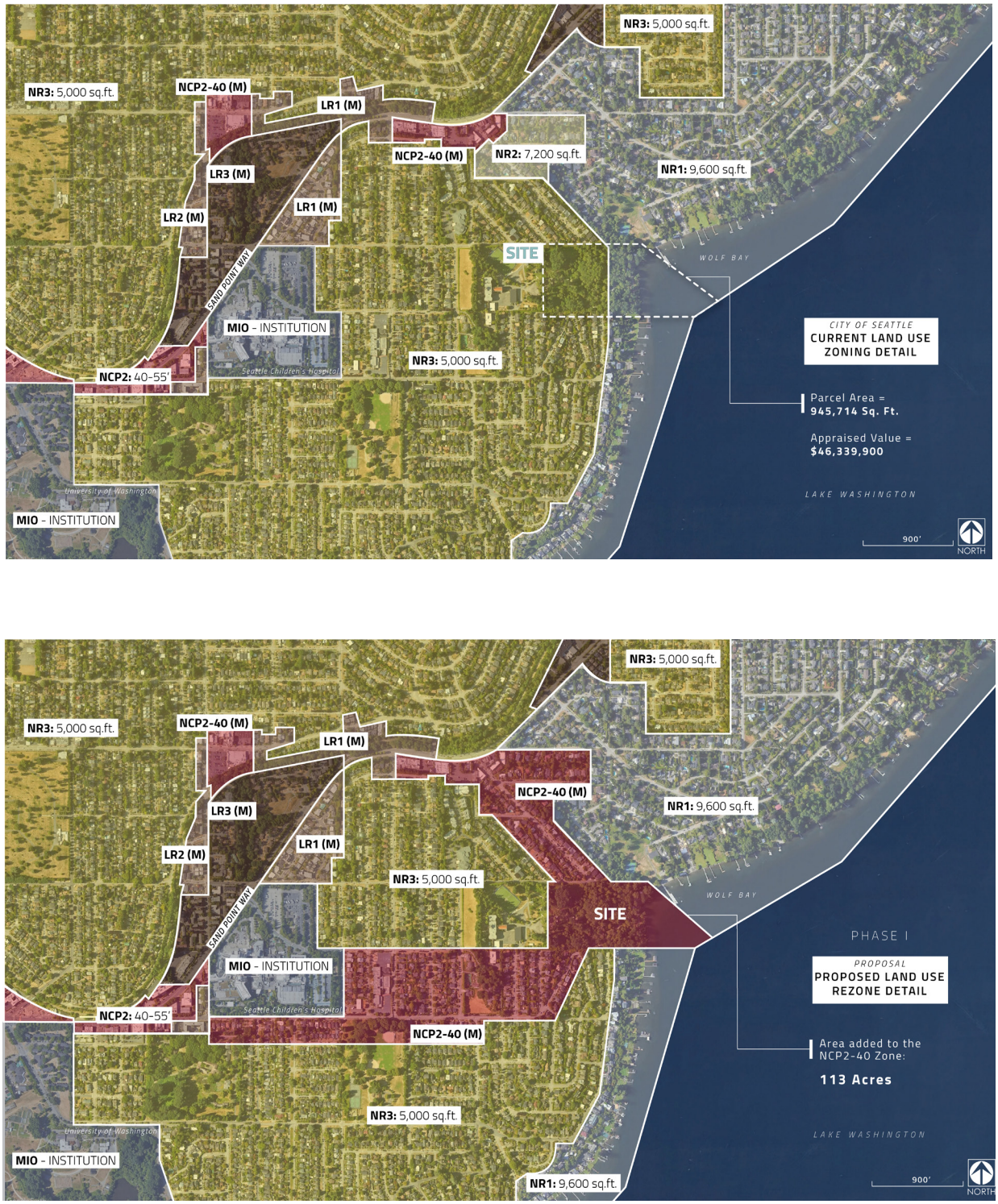


Figure 4.13. Current vs proposed neighborhood land use zoning detail.

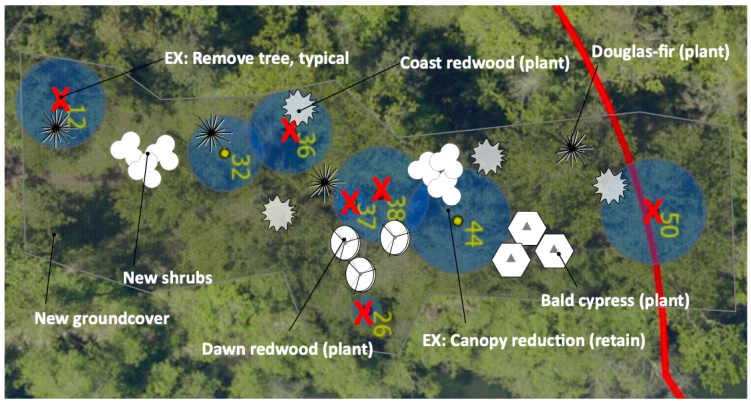
FOREST CONSERVATION AND RESTORATION

> *"**Urban Forestry** is an integrated, interdisciplinary, participatory and strategic process approach to planning and managing forests and trees within cities and in their surrounding areas. It includes assessment, planning, planting, maintenance, conservation and monitoring of urban forests and can operate at different scales [...]."*
>
> (Livia Shamir, pg. 137 *Green Obsession*.)

Efforts are underway in the City of Seattle to reforest the urban canopy to 30% land coverage by 2030 (Engelson, 2023.) In spite of this goal, development for housing, commercial, and industrial development all compromise these restoration efforts. Additionally, the age and lifespan of the existing canopy means that mature specimens across the city are being lost to development, disease, old age, and climate change (Beekman, 2023.) In recent years, the debate over canopy protection and housing creation has reflected the challenges of participatory urban forestry management, development goals, and citizen advocacy (Ibid; Don't Clearcut Seattle, 2023.) It is essential, however, to remain committed to high reforestation goals because climate impacts are certain to raise temperatures and challenges from urban heat island effect. A robust urban canopy is essential in combating rising summer temperatures, and to maintaining a healthy populations of local wildlife. Support for the compromise of these inextricable goals is making headway in local legislature, which would add regulatory friction but may help to protect canopy and promote restoration efforts (Engelson, 2023.)

Concurrently with reforestation goals, **forest restoration** efforts are employed to ensure the existing urban canopy maintains a healthy longevity. Maintenence by hundreds of community organizations is critical in these restoration efforst across the city. The Green Seattle Partnership oversees largescale planning efforts around this initiatives, which are primarily undertaken in the public realm at parks, greenways, and other city-owned parcels in Seattle and adjacent metro areas. Supporting community and civic efforts such as these are critical for architects, landscape architects, and developers to cooperate with for maintenance and stewardship of our urban forest ecosystems.

This project site has been maintained by the property owners and Villa Academy, employing private arborist consulting firm Tree Solutions Inc. and one-off volunteer labor



SYM	QTY	NAME	SCIENTIFIC NAME	SIZE	SPACING
Trees					
	4	Douglas-fir	*Pseudotsuga menziesii*	5-7 ft	10’ o.c.
	4	Coast redwood	*Sequoia sempervirens*	5-7ft	10’ o.c.
	3	Dawn redwood	*Metasequoia gliptostroboides*	5-7ft	10’ o.c.
	3	Bald cypress	*Taxodium distichum*	5-7ft	10’ o.c.
Shrubs/Groundcover					
	20	Oregon grape	*Mahonia nervosa*	1 gal	2’ o.c.
	20	Sword fern	*Polystichum munitum*	1 gal	2’ o.c.
	10	Ocean Spray	*Holodiscus discolor*	1 gal	4’ o.c.
	10	Vine maple	*Acer circinatum*	1 gal	4’ o.c.

New planting locations are approximate and should be determined in the field

NORTH

NOTES:

- Area of disturbance / area to be replanted is approx. **16,900 sq ft.** of wildlife corridor area
- Project proposes total canopy replacement of **28,588 sq ft.**
- Project proposes a 2:1 tree replacement for all trees removed or reduced to snag
  6 trees X 2 replacement = 12 replacement trees
- Project proposes a 1:1 tree replacement for all trees to be pruned
  2 trees X 1 replacement = 2 replacement trees
- Project proposes groundcover/shrub plantings for approx. 1000 sq ft.
  1000 sq ft. = 60 new shrubs/groundcover
- Project proposes replacing deciduous trees with evergreen tree plantings to improve stormwater mitigation function of the site
- Leave existing native vegetation to regenerate where possible
- Leave large logs in contact with the ground to act as nurse logs, if any are felled during this process.
- Use smaller pieces of wood as wattles for planting pockets and soil/moisture retention
- Remove all invasive weeds using best management practices.
- Plant sizes listed are ideal but based on availability. Larger quality plant material is acceptable but will require additional temporary irrigation. Smaller quality plant material acceptable if quantity is increased.

Plan must be consistent with standard tree and vegetation plan and BMP’s and conform to all Federal, State, and Local agency management requirements.

Tree Solutions Inc
Consulting Arborists
2940 Westlake Ave N #200
Seattle, WA 98109
www.treesolutions.net
206-528-4670

Katie Hogan
ISA #PN-8078A
ISA Qualified Tree Risk Assessor

Villa Academy Shoreline
5001 NE 50th St
Seattle, WA
Parcel #1125049017

February 4, 2021

Mitigation Plan

Sheet #

L-2

Figure 4.14. Existing invasives and hazard mitigation strategy on site. Credits: Tree Solutions Inc. 2021.

from Green Seattle Partnership. Advancing these efforts are key in performing optimal site-scale interventions within an Architecture of Biodiversity. The purposes of forest restoration efforts include essential stormwater mitigation, soil erosion control, slope stabilization, invasives removal, and hazard mitigation. Cultivating robust native and native-adapted ecological conditions within the site is an imperative for promoting biodiversity and creating climate-resilient human settlements.

Currently, the condition of this forest is threatened by the proposed development of detached Neighborhood Residential units. The priority of biodiversity at the site scale of course requires a more holistic approach to the habitat crisis. In this instance, the goals for creating housing units and the conservation of essential mature forestland do not need to be mutually exlusive. At risk is the health of a robust second-growth forest ecology that is home to a diversity of plant and animal species that help foster a biodiverse mosaic within the urban waterfront conditions of Lake Washington. Sacrificing this landscape for the construction of single family houses would be a squandered land use and wasteful of resources and opportunity. By applying the principles of an Architecture of Biodiversity as outlined in this paper, developers and planners ought to consider the rezoning of this parcel to accomodate a more dense housing scheme. A density of units in a low or mid-rise construction approach would provide adequate housing equal to or greater than that proposed in detached single family houses, while preserving majority of the canopy.

To examine this scenario, Figures 4.14 and 4.15 evaluate the estimated tradeoffs. Prioritizing effective land use and human occupancy amongst essential urban forestry needs is essential in advancing the opportunities of an Architecture of Biodiversity. Thorough analysis of the site is taken into consideration to understand slope hazards, forest maturity, shoreline setbacks, and habitat management. Extensive planning efforts ought to be made to protect as much of the existing habitat while providing adequeate housing units. Forest restoration efforts are also key to employing effective land use and planning practices, for improvement of the existing conditions to produce the most habitable landscape possible for humans and wildlife. As discussed, these priorities are in line with the city's comprehensive planning goals, and should not be admonished by shortsighted developers. Rather, this extensive view of the existing site conditions and landscape potential should articulate biodiversity as an effective architectural priority.

Figure 4.15. Land use scenario comparison.

PROPOSED DEVELOPMENT COMPARISON

Advocating for and optimizing biodiversity at both the city and site scale requires critical land use analysis. In the case of this development, consideration of canopy conservation and housing units are both addressed within a framework of upzone potential. The status quo or business as usual zoning in this neighborhood permits NR-3 and NR-1, which allow for 5,000s.f. lots and 9,600s.f. minimums respectively. Various land uses are factored into the canopy loss calculation including 50% lot coverage averages, shoreline setback, right of way, and room for construction logistics such as earth moving equipment and utilities. The result of this detached single-family residential construction approach yields approximately

37 houses, providing around 111 bedrooms (3bd/house city average,) and a canopy loss of over eight acres.

The alternative case for more strategic land use to protect and enhance biodiversity would be a more dense multifamily apartment building. Such a building at midrise scale could provide over twice as many units, with a fraction of the canopy loss. Provided the right of way occupies existing forest clearing and the appropriate shoreline setback distance is maintained, one multifamily building doubles the available bedrooms and leaves 90% of the forest intact. Seeing land use and rezoning opportunities as strategies for addressing both housing access and biodiversity conservation is key to addressing the habitat crisis.

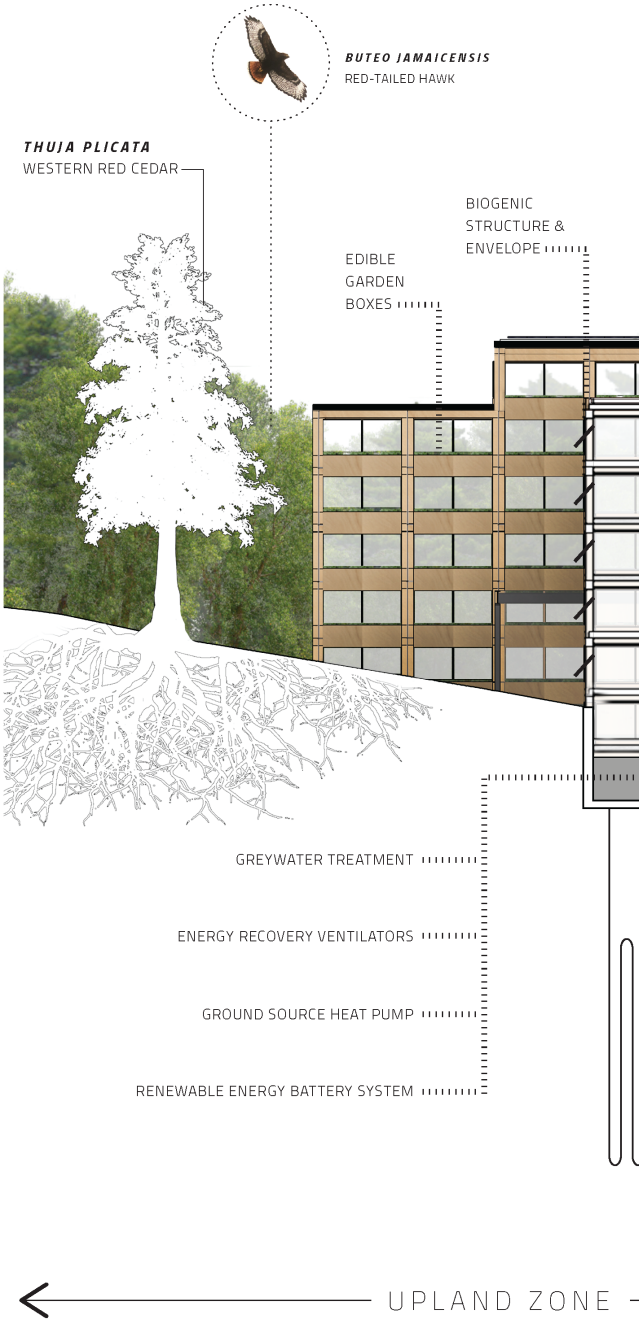
Figure 4.16. Canopy conservation and forest restoration of the mixed second growth deciduous/conifer forest would allow for a healthy mix of native and native-adapted plants to foster rich local biodiversity.

Figure 4.17. Native lowland forest vegetation provides essential food and habitat for many wildlife species, as well as year-round and seasonal beauty for inhabitants.

INTEGRATED HABITAT

Extensive work and literature produced in the fields of architecture and landscape architecture articulate the opportunities for buildings to perform integrally within the immediate ecological conditions of the site. Various systems approaches from water and waste recycling to energy and food production offer numerous methods by which architects can reduce building systems consumption and offer salubrious design solutions that optimize living systems. Theories and design methods going back to Lyle (1996) provide tacit principles of regenerative building performances that can be applied here. These methods typically aim to utilize passive and active systems for reducing energy and water consumption, and provide habitat and food for people and wildlife.

In-depth analysis and calculations of these systems are beyond the scope of this project, yet the value of some of these principles are illustrated in this section diagram (Figure 4.18), which describes the integral relationships between the building and its site ecology. First, water systems, from stormwater collection and reuse to the acquatic shoreline buffer, highlight the critical imperative of water control in such a hydrophyllic landscape. Secondly, energy systems that utilize renewable sources and heat recovery ventilators aim to maximize the solar and geothermal collection potential for the overall site. Thirdly, the use of raised floor construction over pilons minimize



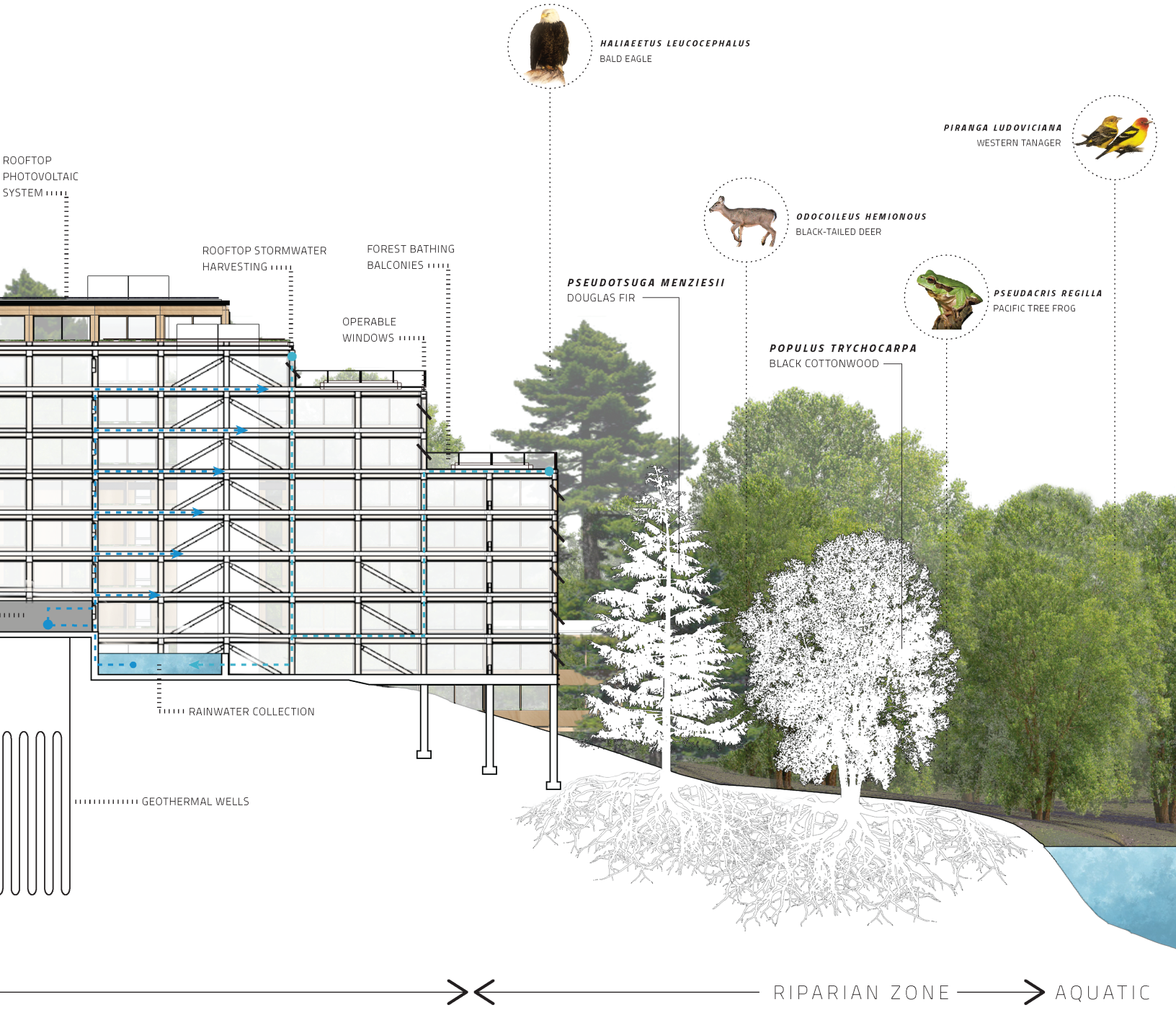


Figure 4.18. The integrated urban habitat fosters biodiversity and human wellness through the propagation of healthy ecological conditions and optimized high performance building systems.

building footprint and allow for vegetation to grow robustly around the building. These systems and the project siting strategies, along with the land use optimization techniques, work to reduce the building's impact on the soil and existing vegetation and canopy. Such methods provide a more sensitive occupation of the land and preserve vital site conditions and resources into the future.

Also essential to the principles of an Architecture of Biodiversity is the expressive relationships between human inhabitants and the diversity of organisms within the site's ecosystem. Edible garden boxes, balconies, and rooftop farming all invite social opportunities for the occupants to engage with nature and cultivate a biodiverse habitat. Large spans of glazing and operable windows within units allow inhabitants to experience a flood of forest biophilia and control thermal conditions with natural ventilation. These multisensory opportunities promote "forest bathing," known as *shinrin-yoku*, a Japanese wellness tradition that reduces stress and celebrates the human connection to nature. Incorporating these design strategies invites inhabitants to recognize their role within the immediate ecological conditions and fosters a sense of land ethic and stewardship among residents.

MASS TIMBER AND PREFABRICATED CONSTRUCTION

Recent trends toward mass timber construction in North America are accelerating due to advancing technologies in engineered products, as well as advocacy and market demand for more carbon-friendly building methods (WoodWorks, n.d.) Much research has been published arguing that substituting mass timber for concrete can reduce emboddied emissions in large structures, and is critical in the effort to decarbonize the construction industry (Gensler, 2023.) Replacing concrete and steel structural grids, typical of mid-rise buildings, with mass timber provides the opportunity for lower emboddied carbon construction of the built environment. These carbon savings are essential in reversing global warming and phasing out superfluous use of high-carbon materials. Further discussion of the advantages of biologically sourced building materials, including mass timber, will be made in a later section of this chapter (see "Biogenesis".)

Beyond reducing global warming potential of the structural frame, construction with mass timber offers several discrete advantages that should be considered for projects of this scale. First, the use of mass timber as a structural element provides the opportunity to

expose the wooden columns and beams within interior spaces to add warmth and biophilia to inhabitants' experiences. This architectural strategy expresses material integrity and offers a tactile relationship between the end users and the extensive habitat from which the structure derives. Creating emotional connections like this is a powerful way by which architects can draw awareness to the re-entanglement of the spatial and temporal realities of our housing settlements.

Secondly, the use of prefabricated engineered wood components means less waste, faster construction times, and less intrusive jobsite conditions. By manufacturing mass timber columns, beams, and floor assemblies in a factory prior to construction, it means assembly of the structural grid is faster and more material efficient than concrete (Robertson, 2012.) Studies show that overall greenhouse gas emission levels per sq. ft. of floor area are much lower in mass timber structures than cast-in-place concrete or steel frame assemblies (Ibid, 2012.) Prefabricated components removes the need for weeks of onsite concrete framing and curing periods, saving time and materials and removing unecessary jobsite hazards. Creating more streamlined construction schedules also means less intrusion of jobsite logistics and pollutants on the surrounding ecology. Removing the need for heavy concrete and steel working equipment also reduces noise pollution, which could otherwise disturb the health of exisiting wildlife habitat.

Thirdly, the mass timber structural frame allows for easy program transformations over the lifecycle of the building. The accessible workability of timber building components means that renovations can be made easily when different occupancy uses are introduced over time. Additionally, the use of prefabricated facade assemblies means more room for adaptive architectural features. Figure 4.21 illustrates a module that hosts a hanging planter box accessible by operable window walls. Modularity in the facade assemblies means that other components can be included that optimize architectural strategies depending on building orientation, microclimate needs, habitat creation, or specific occupancy uses. In these ways, material and energy optimizations can be accounted for throughout the scales of design, from product selection to fabrication to installation and use.

Finally, another advantage to the use of a mass timber structural grid is the opportuntity for material reuse over the lifecycle of the product. At the end of their use within the building, upon demolition glulam girders and columns can be reprocessed and milled

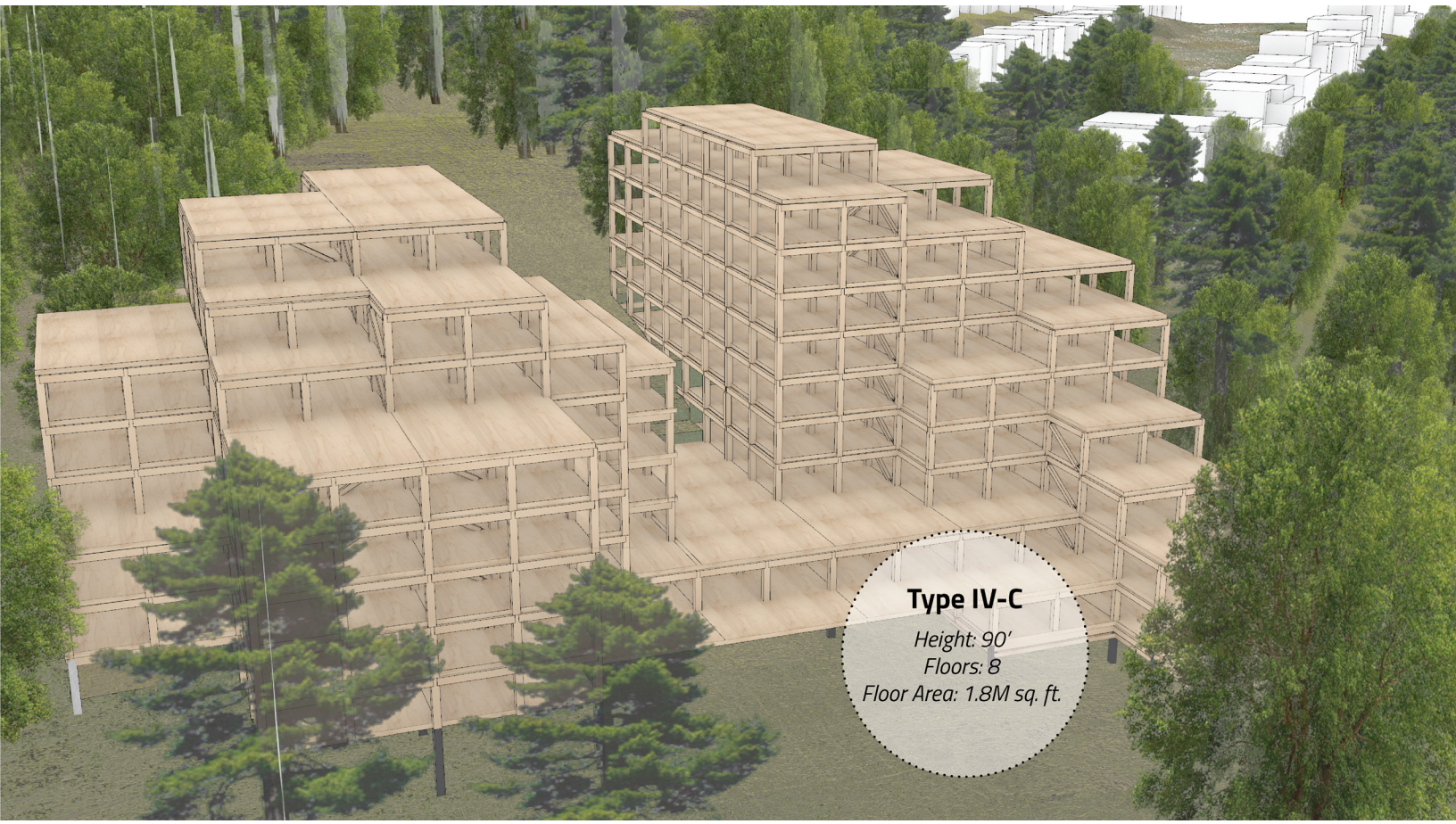


Figure 4.20. Utilizing construction type IV-C allows for building with a mass timber structural grid, allowing for efficient construction times and modular uses over time.

into other configurations for use in other wood products. Smaller structural applications can be utilized in this scenario, as well as furniture, millwork, or other interior elements. These upcycled assemblages are essential in the holistic life cycle approach to material and energy optimizations. To transform such materials into effective applications for generations to come means that the carbon stored in the materials stays out of the atmosphere and can be calculated as a net positive in regards to our longterm efforts to decarbonize the economy and drawdown carbon from the atmosphere.

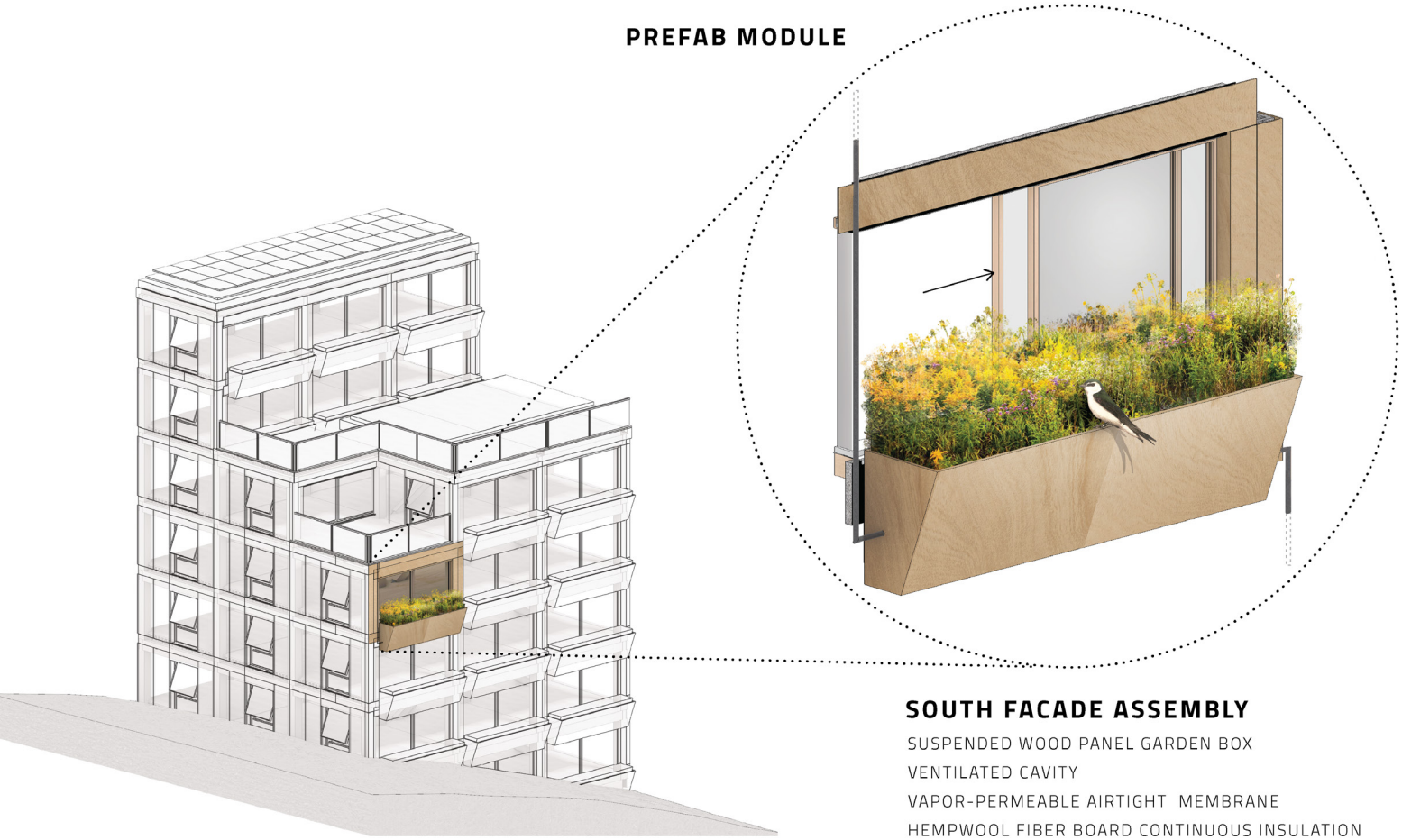


Figure 4.21. Utilizing prefabricated modules allows for effective use of biogenic building materials in ways that reduce waste and streamline construction schedules.

Figure 4.22. The living facade strategies imagine multiple methods for forming and cultivating vegetation among the surfaces of the building. Edible, medicinal, and aesthetic value of the species for residents allow for the creation of a mosaic of organisms that reflects the diversity of human residents. The building then becomes a scaffold for the spontaneous inhabitation of wildlife and volunteer plants who can create a harmonious environment of rich biodiversity.

WINDOW GARDEN BOXES

HERBAL, MEDICINAL, EDIBLE, POLLINATOR

Calendula officinalis

Ribes sanguineum

Echinacea purpurea

Lobelia cardinalis

Vaccinium ovalifolium

Matricaria chamomilla

Daphne odora

Penstemon kunthii

LIVING FACADE STRATEGIES

Utilizing the surfaces of buildings is an optimal way in which architects, engineers, botanists, and landscape architects can collaborate to cultivate biodiversity within cities. The challenge, however, is to create biodiversity that is site and scale appropriate and does not come at the cost of other externalities, such as in the case of high carbon-embodied structures that require RC cantilevers and other excessive structural systems. This brings up the issue of carbon tradeoff. While incorporating maximal amounts of biomass into buildings has excellent intentions from improving air quality to providing wildlife habitat, we have to consider critically the implications of the added structure required to meet structural loads. Trying to incorporate trees or large woody shrubs into the facades of buildings typically requires more concrete and steel to support the soils and weight of the plants. This project demonstrates that creating an more optimized approach to biophilic living facades requires careful consideration around the pragmatics and functionality of such a facade, including factoring in its purposes and externalities.

First, the primary plant choices that compose such a facade should come from some level of agency of the users of the space. To promote cultural inclusion, the built environment should be a commons of free expression. This includes cultivatable spaces such as a unit garden box, where daily encounters with tendering a plant community connects one with their greater surroundings and puts them in touch with the life force of their natural co-inhabitants. This provides

residents an opportunity to sow the plants and vegetation that is important to them, whether it have edible, medicinal, or aesthetic value. By rendering our living facades in this way, we can encourage the curation of a building mosaic, where many individual organisms and their inherent value add up toward a holistic living community that supports humans and wildlife in restorative and beneficial ways.

Secondly, the living facade provides important habitat to birds and pollinators, meaning that the value of this site is shared in community with neighboring ecosystems that are linked through the web of pollination and migration networks. The foliage from the vegetation will create valuable surface area for stormwater mitigation and water uptake, and its shade will provide important coolth to the inhabitants and exterior walls of the building in summer. With these strategies, the building becomes a seasonally advantageous habitat that can affect microclimate changes and hopefully mitigate natural effects of global warming and climate change.

By integrating MEP, energy, and water systems with the composition of the terraces, roofs, planter boxes, and downspouts, the facade becomes a holistic integration of the ecosystem services that privilege a multifamily building like this to maintain its operation. Connecting these systems within the form of the building allows the site to function in dynamic and resource efficient ways that promotes biodiversity and elevates the ecosystem functions of the larger site.

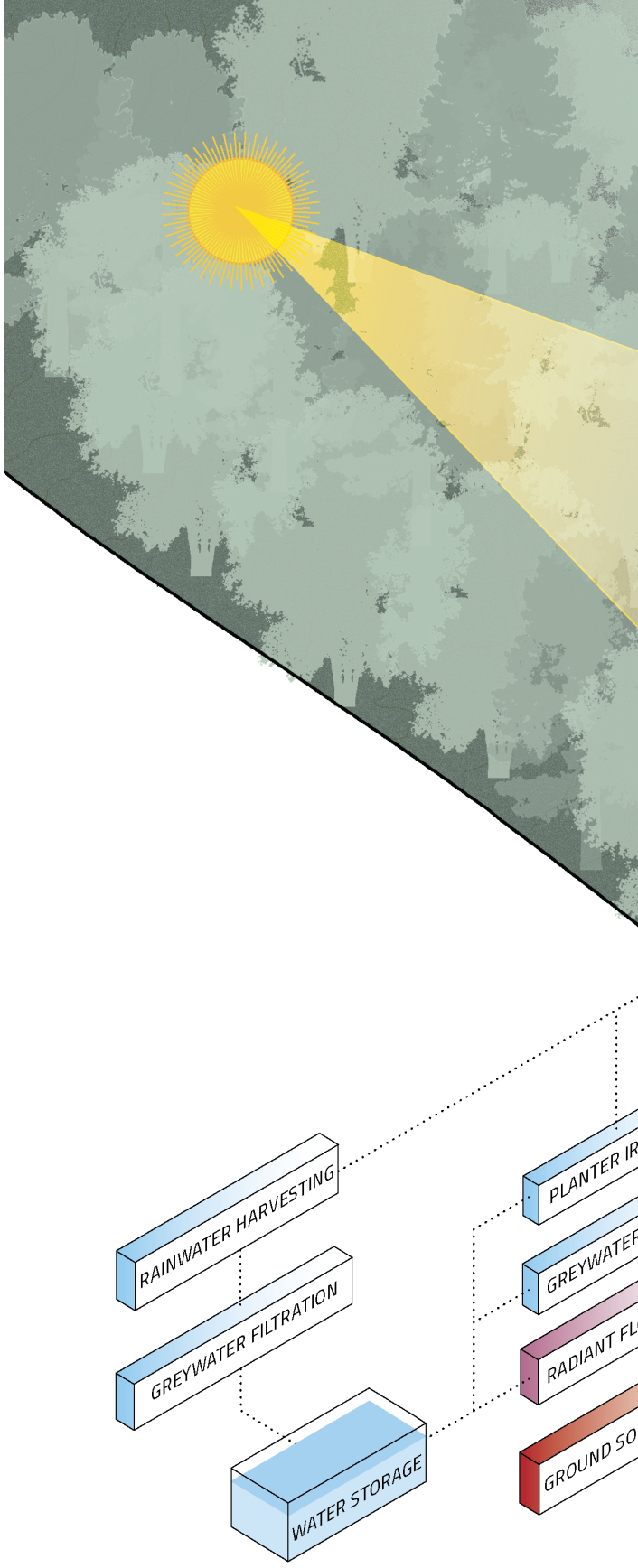


Figure 4.27.


PHOTOVOLTAIC
ELECTRICITY
SOLARIUM
ATRIUM
RIGATION
R FIXTURES
OOR HEATING
URCE HEAT PUMP
GEOTHERMAL HEAT WELLS


EQUINOX
ALITUDE
42°
WINTER
ALTITUDE
22.5°
SOUT

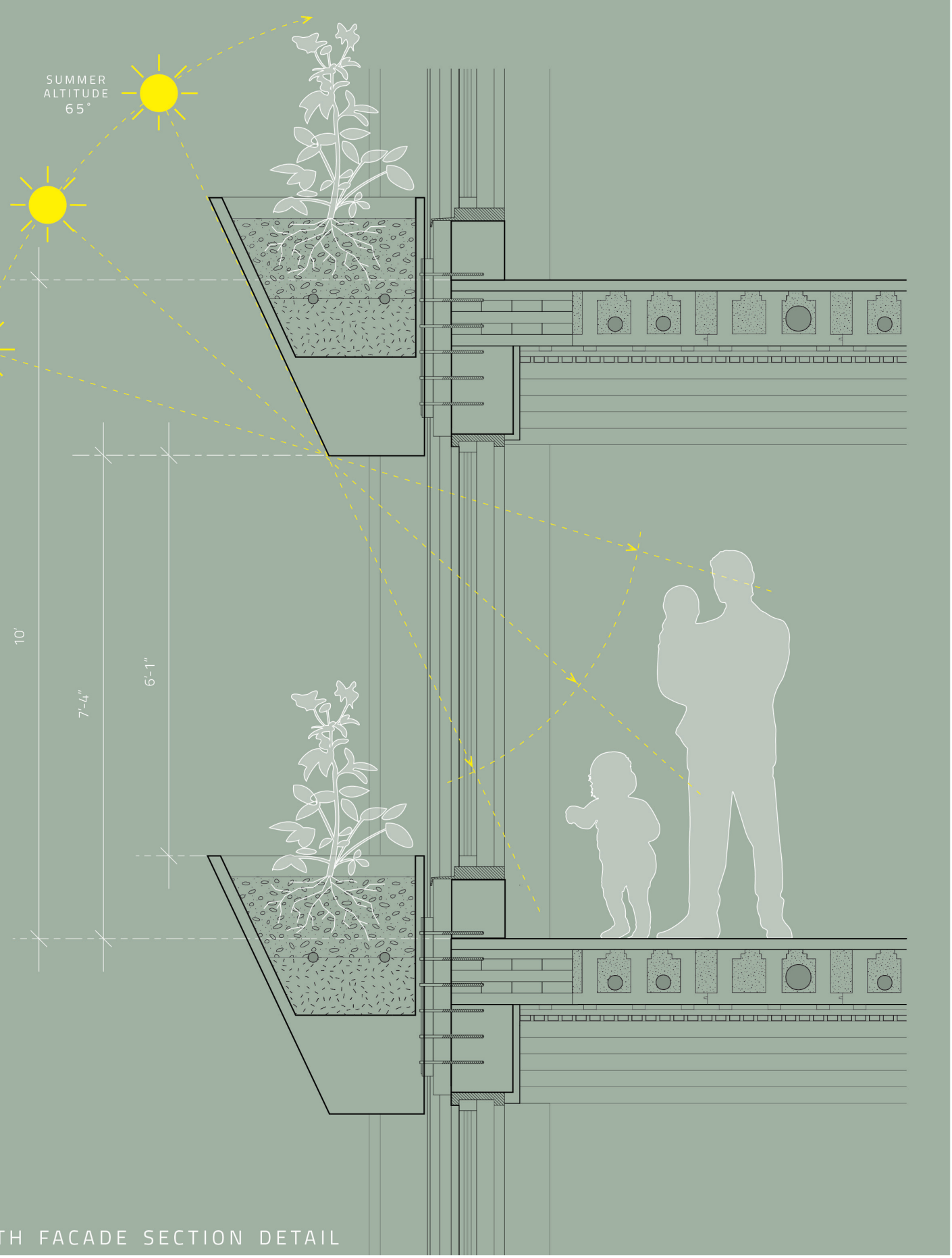


Figure 4.23. The unit interior offers accessible gardening boxes that also act as shading devices.

Figure 4.24. Rich colors and textures from the canopy pour light into units, which are designed with large glazing and operable windows to maximize natural daylighting within the shade of the mature forest canopy. This strategy celebrates the concept of forest bathing, known as *shinrin-yoku,* a Japanese practice for improving physiological and psychological wellness. Extensive garden boxes on the facade allow residents

to interface with the site's ecology and wildlife by cultivating their own small garden plot from within their apartments. Bountiful garden boxes and terraces provide accessible conditions to produce food, medicine, herbs, or simply attracting pollinators.

Figure 4.25 Accessible terraces are oriented to provide community gardening and wildlife habitat opportunities.

Figure 4.26. Integral landscape planning is an opportunity to provide forest restoration and biodiversity.


WA Biodiversity At Risk
20 Priority Habitat Types
117 Endangered, Threatened, and Sensitive Species and Candidates
Source: Department of Fish and Wildlife
WOLF BAY
PROJECT SITE
King County Critical Wildlife Habitat
LAKE WASHINGTON
UNION BAY
1000'
LONGITUDE: 122°16'9"W
LATITUDE: 47°39'50"N
OLYMPIC PENINSULA
CASCADE MOUNTAINS
SEATTLE
CEDAR RIVER WATERSHED
PUGET SOUND
MT. RAINIER
NORTH
20 MILES

Region

BIOSHED

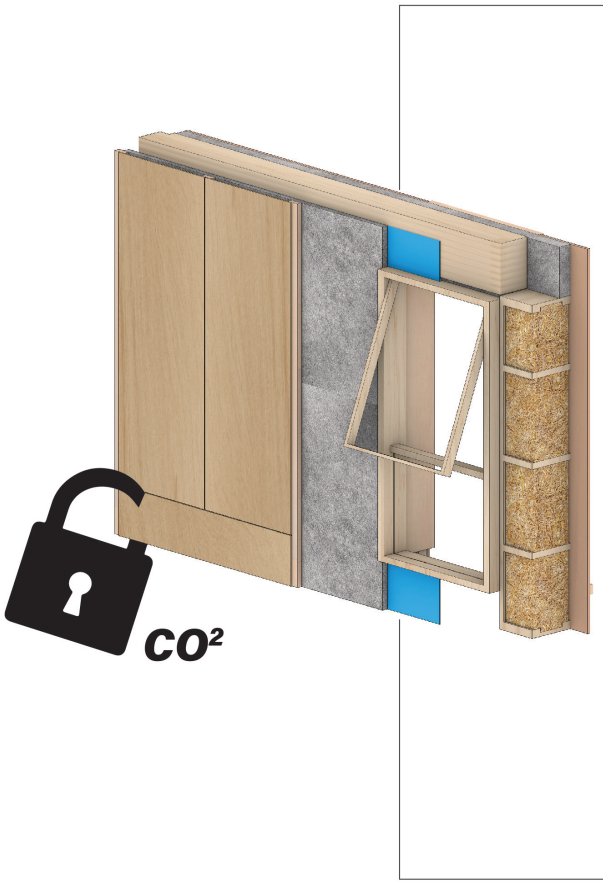
Addressing climate change and the crisis of biodiversity loss requires paradigm shifting attitudes around material consumption, carbon and resource life cycles. It is imperative for all industry, but especially the construction sector, to transition urgently away from extractive material resource practices toward renewable processes that provide much more sustainable and ecologically beneficial solutions to urban biosheds. This section will explore the interdependent relationships of people, cities, and regional landscapes by interpretting expansive system boundaries of material resource streams. As Pierce (2022) writes, "By recognizing and reconciling these relationships, **cities can become allies for biodiversity** -- and not just biodiversity found within cities but also in rural and remote lands, and at regional and global scales" (p. 212.) In this way, biosheds offer abundant potential as "the wide and varied landscapes that are directly and indirectly either harmed or protected from harm by the city" (Ibid.) According to the author, three areas of impact are key considerations for contextualizing and evaluating theories around the **urban bioshed**: (1) Land use, conservation, and restoration, (2) consumption and production, and (3) societal influence. It is important to understand these three equally valid impact areas when assessing the complications and opportunities for shifting material resource paradigms in the construction industry.

One major implication of architecture on the health of the urban bioshed is biophysical relationships within the extensive system boundary. As described in Chapter 2, the extensive urban biodiversity entangled within and beyond cities is a mosaic of inextricable resources, habitats, and life forms. Integrating the prosperity of these entanglements with the society development goals is essential for sustaining the vitality of the bioshed (Pierce, et al. 2022, p. 221.) A narrow view of a project's system boundaries which only considers the limits of the project site is a shortsighted perspective that fails to adequately address holistic needs of extensive urban ecologies. It is important instead to consider the site as one node within a nested system of greater ecological complexity. This understanding reveals how immediate site conditions are influenced by upstream hydrological cycles, wildlife migrations, and the viability and availability of regionally produced building products. It also critical

(Opposite) Figure 4.28. Aligning regional biodiversity goals at the scale of the building site requires deep ecological perspectives that considers the nested implications of local ecological conditions.

to investigate how interventions can affect downstream conditions of creeks, rivers, estuaries, and other waterways that provide critical wildlife habitat. By nesting these ideas of the site within greater hydrological and ecological systems, designers have the opportunity to steward the landscape and ecosystem services of the site and the extensive habitat on which it depends.

This design project site is located on the western shoreline of Lake Washington, in what is called Wolf Bay, north of the Laurelhurst peninsula known as Webster Point ("Sahlouwil") (Figure 4.28.) This area of the regional shoreline management plans calls out regulations for both conservation and urban residential uses. The site's proximity to the water's edge makes this parcel a hybrid landscape of terrestrial and aquatic ecologies. This means that the opportunity to steward the health of the local ecosystem is not limited to the bounds of the hillside forest, but must consider the multidude of ecological conditions between lake and forest. Maintenance of this landscape requires attention to stormwater runoff to ensure safe water discharge into the Lake Washington. Applying these methods prioritize biodiversity both on shore and within the lake's greater ecosystems. Collective stewardship of these shoreline landscapes ultimately implicates the holistic health of the lake and its surrounding waterways. In the context of Puget Sound's hydrophyllic geography, it is important to consider these multiscalar issues of aquatic stewardship to promote the health of marine biodiversity within both freshwater and ocean contexts. Additionally, the density of mature trees in the site's forest is home to bald eagle habitat as well as a range of migratory bird species, making it an important node in the extensive view of urban biodiversity.



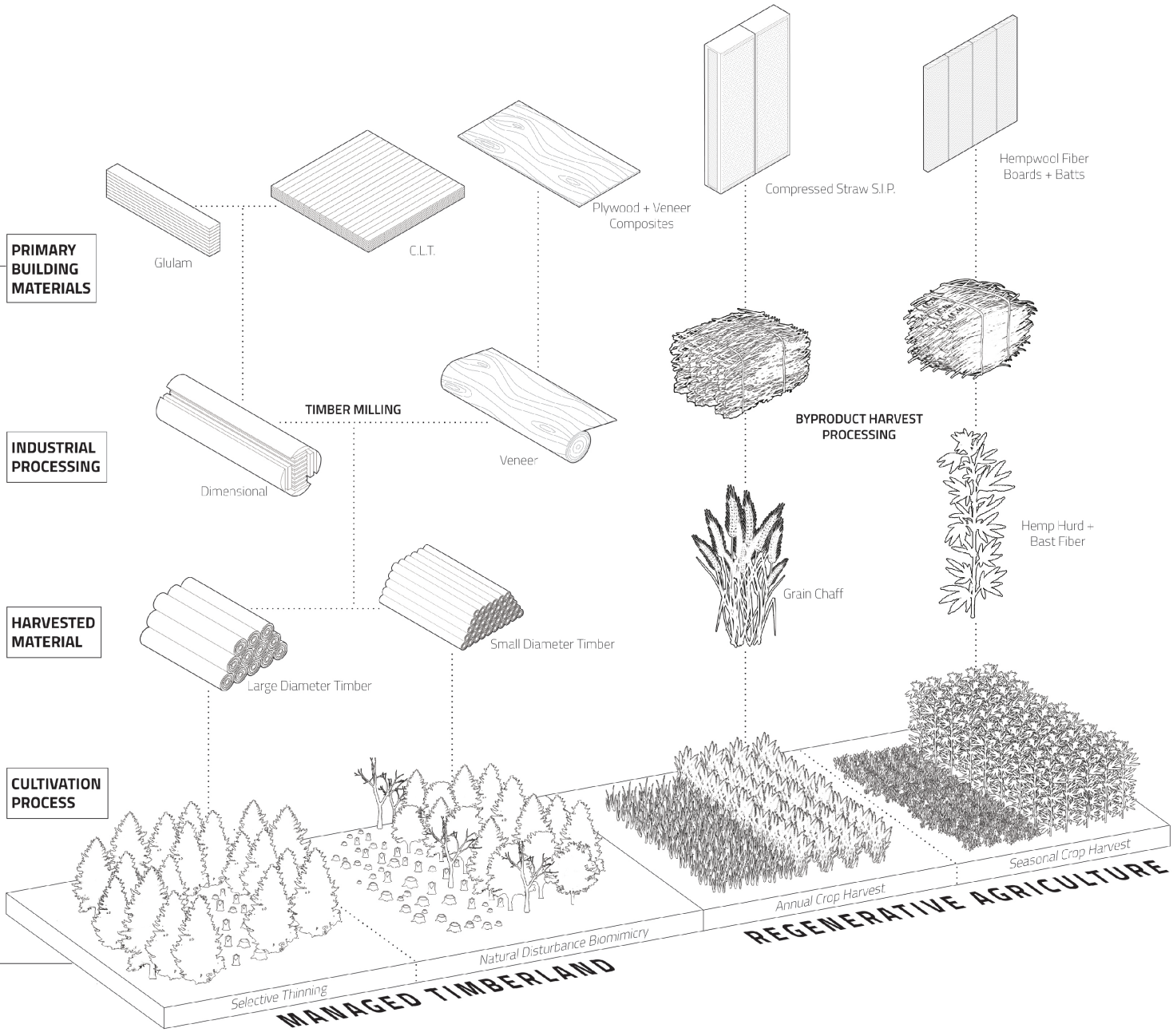


Figure 4.29. Prioritizing materials from biogenic sources is a key mechanism for architecture to produce building practices that actively sequester carbon and promote biodiversity.

The second major implication of architecture on the vitality of urban biosheds is in regards to material and resource consumption. Appropriately contextualizing a building's composition within these regional system boundaries allows designers the opportunity to participate in greater bioshed resource stewardship through regionally appropriate biogenic material selection. The relationship and opportunities of these material implications will be explored in the remainder of this chapter. In order to advance holistic stewardship of resources and regional ecological conditions, architects and designers must understand the deep ecological perspective that considers how materials grown organically from the earth can contribute to carbon sequestration and promote extensive urban biodiversity.

BIOGENESIS: GROWING BUILDING MATERIALS, DRAWING DOWN CARBON, AND CONSERVING SPECIES DIVERSITY

Aligning the region and building scales of specific project requires the holistic consideration of material and energy optimization outlined in Chapter 1. Fundamental to the practice of an Architecture of Biodiversity is employing material resource streams that advance goals of extensive habitat stewardship. This requires advocating for and utilizing local supply chains to source building products from regional producers. The primary advantages of this methodology is two-fold: to drastically lower embodied carbon emissions in the built environment, and to improve conditions of regional habitats and biodiversity.

Extensive research in the development of renewable, **biogenic building materials** has been published to help advance the mass production of such products (ISOBIO, 2019; Magwood and King, 2021) The major advantage revealed through the existing research and development of biogenic materials is the enormously lower embodied carbon emissions when used as substitutes for typical industry-standard building materials (Ibid.) The substitution of biologically-based, or biogenic, building materials for more traditional carbon-intensive materials is an essential component of advancing a regenerative agenda of material and energy use in architecture. Trees, woody plants, and perennial grasses, through the process of photosynthesis, sequester enormous amounts of carbon dioxide from the atmosphere during their growth cycle, converting them into sugars and storing them in their cells and generating their physical structure. When these kinds of plants are grown and cultivated for use in material manufacturing, they essentially transform from carbon-capturing living organisms into biogenic building products, effectively becoming material storehouses that

turn buildings into carbon sinks. This process allows architects and builders to employ renewable material sources in the construction of buildings, offering enormous opportunity for carbon drawdown to mitigate climate change and reverse global warming (Mayo, 2015; Magwood and King, 2021.)

However, the burgeoning momentum for architecture to promote rapid carbon drawndown has sparked important conversation about sustainable harvest practices of such materials to ensure that the consumption of forest products and other material sources do not outstrip the natural growth cycle of those ecosystems. While decarbonization of the built environment is essential reversing global warming and mitigating the worst impacts of climate change, it is critical to give due attention to sustainable forestry and other renewable

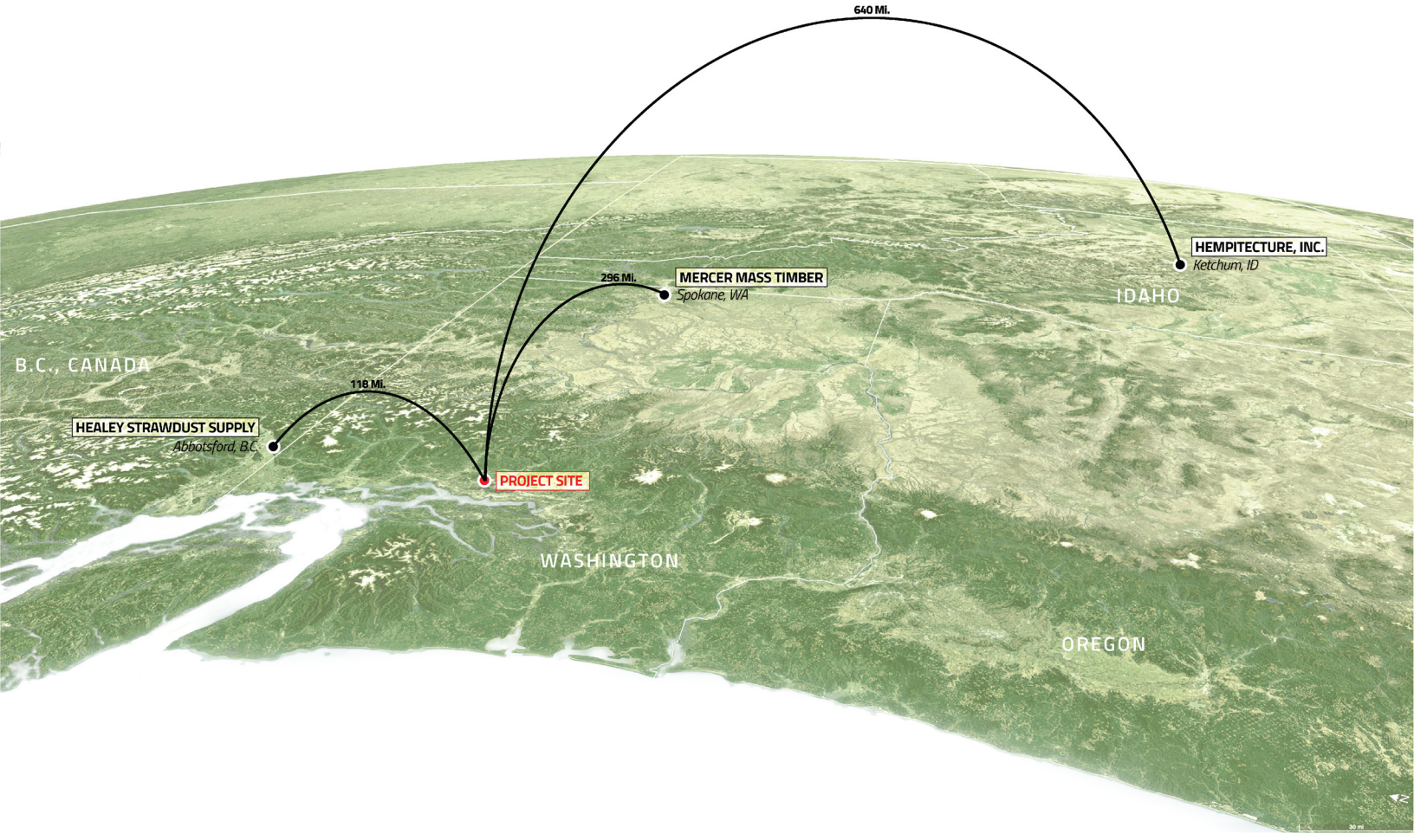


Figure 4.30. Sourcing regionally appropriate biogenic materials creates an integrated supply chain that can drawdown carbon, align diverse stakeholders, and optimize material geographies.

product harvesting. Additionally, it is essential not to overlook the impact on global biodiversity in such material procurement practices. Stewarding and regenerating biodiversity on the regional scales of which these products are harvested offers massive opportunity in the reversal of habitat loss and the conservation of species. The opportunity for these products to have salubrious impacts on regional ecosystems and landscapes is also important to consider when investigating the theoretical and measurable advantages to building with biogenic materials. Conceptually, these strategies are relevant to regional context and local material geographies. This chapter illustrates these contextual opportunities at the regional scale of the Pacific Northwest, where forestry and agriculture are already essential economic drivers.

Finally, the consideration of biogenic products building assemblies lends itself to the question of durability and longevity with regards to embodied emissions. A prefabricated envelope assembly module, such as the ones proposed in Figures 4.26 and 4.34, can be nearly entirely composed of rapidly renewable materials. Using such a modular construction method means over the lifespan of the building components can be exchanged as needed on a timescale that is compatible with the relative maintenance needs. The argument here is not for ultimate durability in our construction materials, rather for a more maximally effective approach to the energy and material optimizations required for a re-entangled approach to architectural design (Moe, 2013). In evaluating these tradeoffs it is important to apply **deep carbon accounting** that provides regenerative solutions to our climate adaptations. Selecting biogenic materials expresses multiscalar principles of architecture that value biodiversity, land stewardship, and carbon drawdown as essential factors for advancing the effectiveness of design in the built environment.

MATERIAL GEOGRAPHIES

Further re-entangling of the spatial and temporal realities of material and energy systems requires deep ecological perspectives, which reveal opportunities to steward extensive habitats. Architects have the opportunity to integrally compose material geopgraphies that support regional land stewardship, promote local economic growth, and streamline effective energy consumption. The opportunity for biogenic building materials as a mechanism for regional land stewardship is essential to the principles of re-entangling extensive habitat cultivation. Understanding the growth and production of biologically-based products is a

primary solution for diverse sectors to align in land stewardship efforts. Architects, planners, and designers can influence the advocacy and demand for these products, and in turn boost the economic engine that transform these niche markets into larger scale producers that compete with, and eventually outvalue, more typical building materials. In this way, the diversity of professionals who interface with natural resources and cultivate essential acreages of regional landscapes can come together around shared goals and means of production.

By prioritizing local materials in the construction of building structures and assemblies, architects can reduce logistics complications and lower costs to developers and contractors. This provides opportunity to simultaneously lower transportation emissions and pollution across whole building life cycles, while promoting green jobs within the region. Together, these outcomes create a valuable opportunity to bring online more regional producers and stimulate regional economies.

Expressing this value within design, the built environment has the potential not only to steward regional landscapes, but to employ a variety of producers and tradespeople in burgeoning industries that rely on agricultural and forestry products. While the opportunties and examples of biogenic building materials are extensive, it is important to recognize that for their appropriate use they must be contextualized with respect to regional material geographies. Although there are abundant opportunities for biogenic material applications from bamboo to stone to cork to timber and earth, this thesis will primarily focus on four materials ideal for our regional conditions: timber, straw, clay, and hemp.

HARVESTED WOOD PRODUCTS

Timber, or harvested wood products (HWP), are considered an essential solution in the advancement of low-carbon building sectors (Boeri, 2021.) Yet, beyond the benefit of lowered global warming potential and the exceptional performance of natural carbon sequestration, the transformations within these landscapes of production has critical implications for biodiversity. Through practices of sustainable forestry, efforts can be made to improve the robustness of ecosystems at a scale that prioritizes regional biodiversity. Methods illustrated in Figure 4. include selective thinning and natural disturbance biomimicry. These strategies are articulated by research within the disciplines of forestry and ecological conservation as methods to effectively sequester carbon and produce more healthy forest habitats.

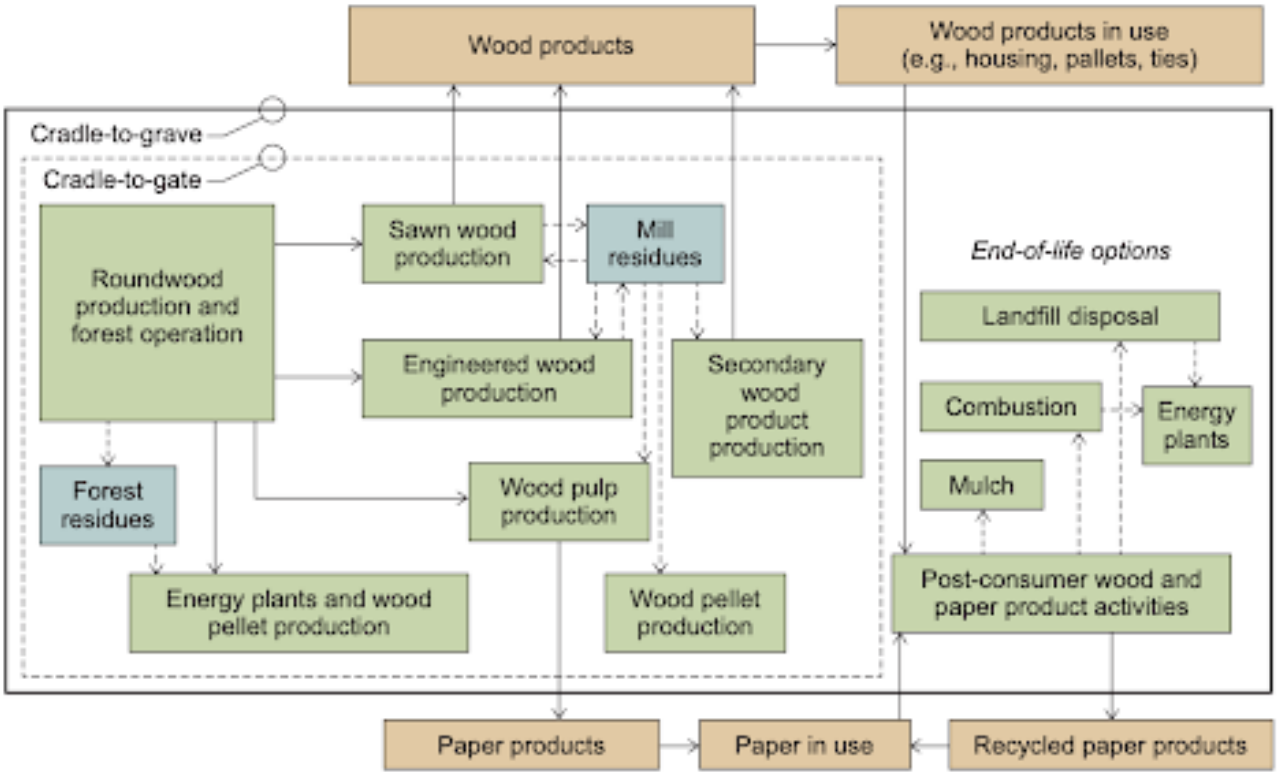


Figure 4.31. Sustainable practices in producing harvested wood products are essential for creating a low-carbon building sector and improving the quality of biodiversity and habitat restoration. Image Source: Branshaw and Bergman, 2021.)

Selective thinning has multitude of benefits stemming from healthier forest interventions. By removing trees intentionally to maintain ecosystem richness fosters competition among diverse species and prevents overdominance by monocrop tree species. This in turn leads to healthier, more resilient ecosystems that recycle important nutrients and fight of pests and diseases. By clearing the canopy of mature timber, sunlight can better penetrate forest floors and allow for the growth of seedlings and species diversity. This can be an advantage in longterm forest management in regards to the production of future valuable timber. Overall this process maintains healthy forests and optimizes habitat for beneficial species.

The second method for effective forest stewardship is through natural disturbance biomimicry. According to Olmsted (2022,) “Disturbances act to disrupt stable ecosystems

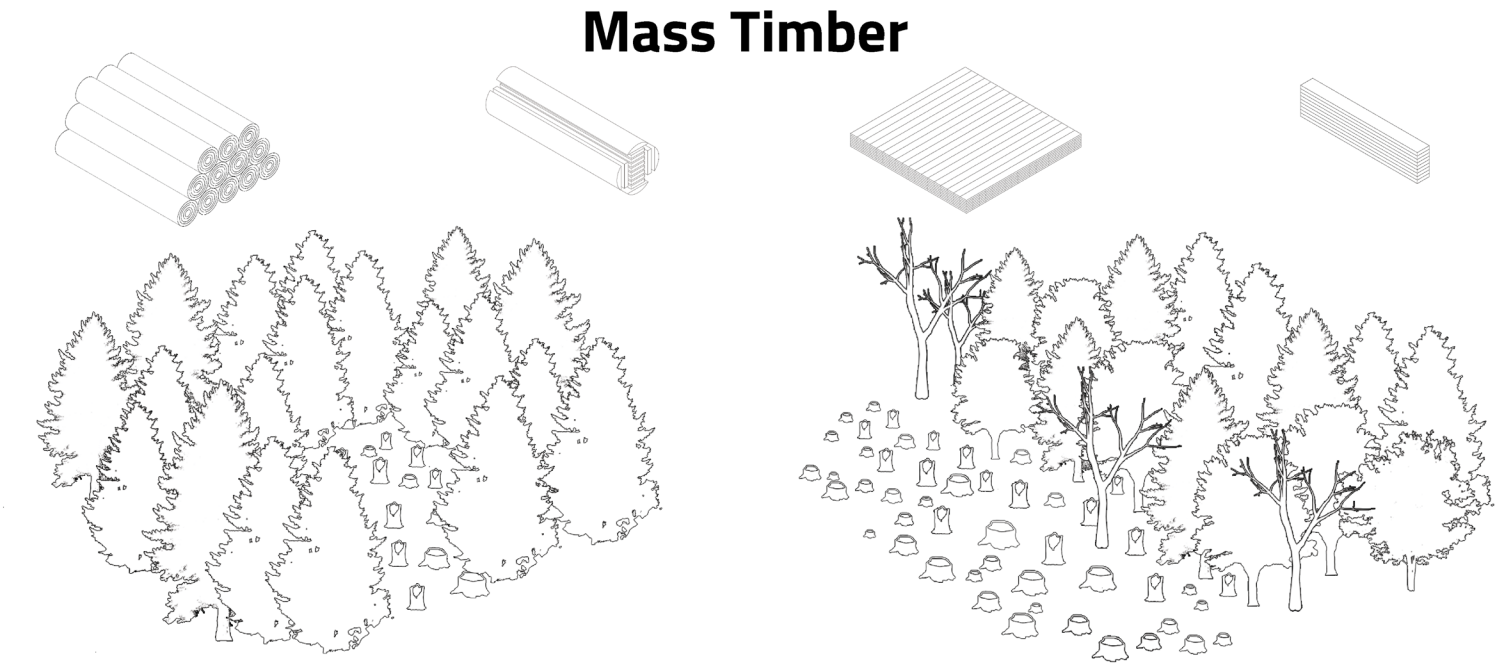
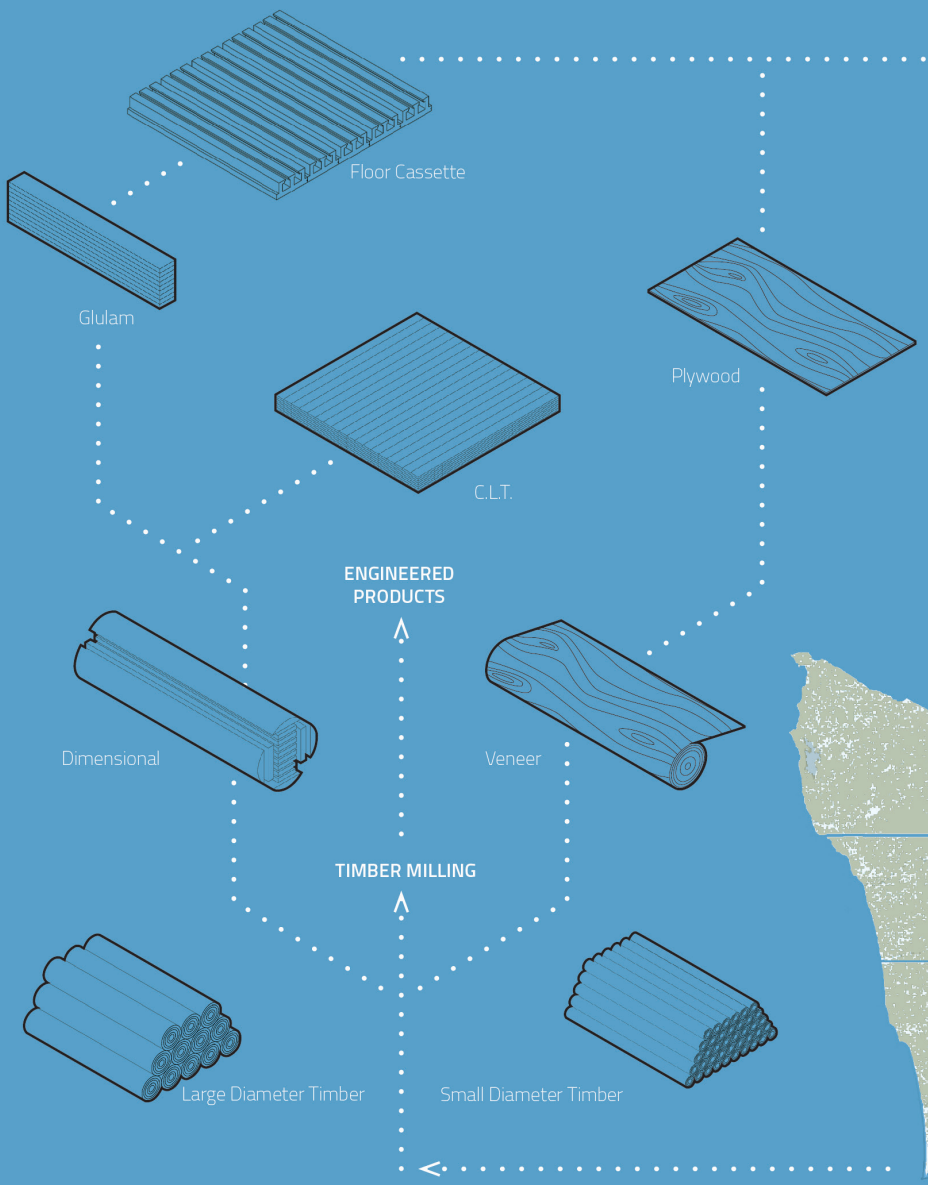


Figure 4.32. Mass timber products integral components of supporting demand for healthier, sustainably managed renewable forests.

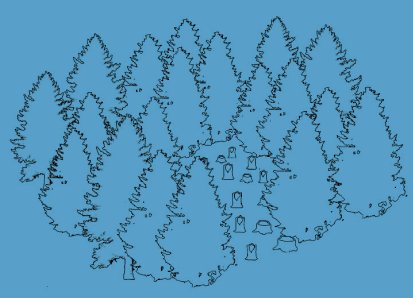
and clear species' habitat. As a result, disturbances lead to species movement into the newly cleared area (secondary succession.) Once an area is cleared there is a progressive increase in species richness and competition between species takes place." This means that in the conditons of northwest forests the health and progression of successional species can improve biodiversity and reach optimal levels of competition within ecosystems. Olmsted also notes, that fire-adapted species such as those in some of Washington's regional forests, depend on disturbance in ecosystems. Together, these methods can make forests more resistant to catastrophic wildfires and increase the resilience of wildlife habitats. In this way, the demand for renewable bio-based materials creates a critical economic mechanism for maintaining healhy, sustainable forestry in the region.

WASHINGTON TIMBERLANDS

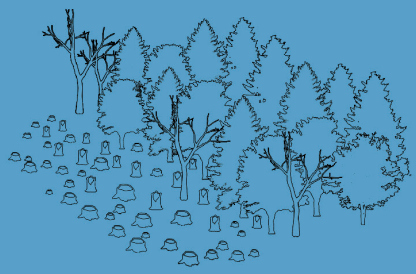


Timber CO_2 Sequestration

742 kG CO_2e/m^3



SELECTIVE THINNING



NATURAL DISTURBANCE BIOMIMICRY

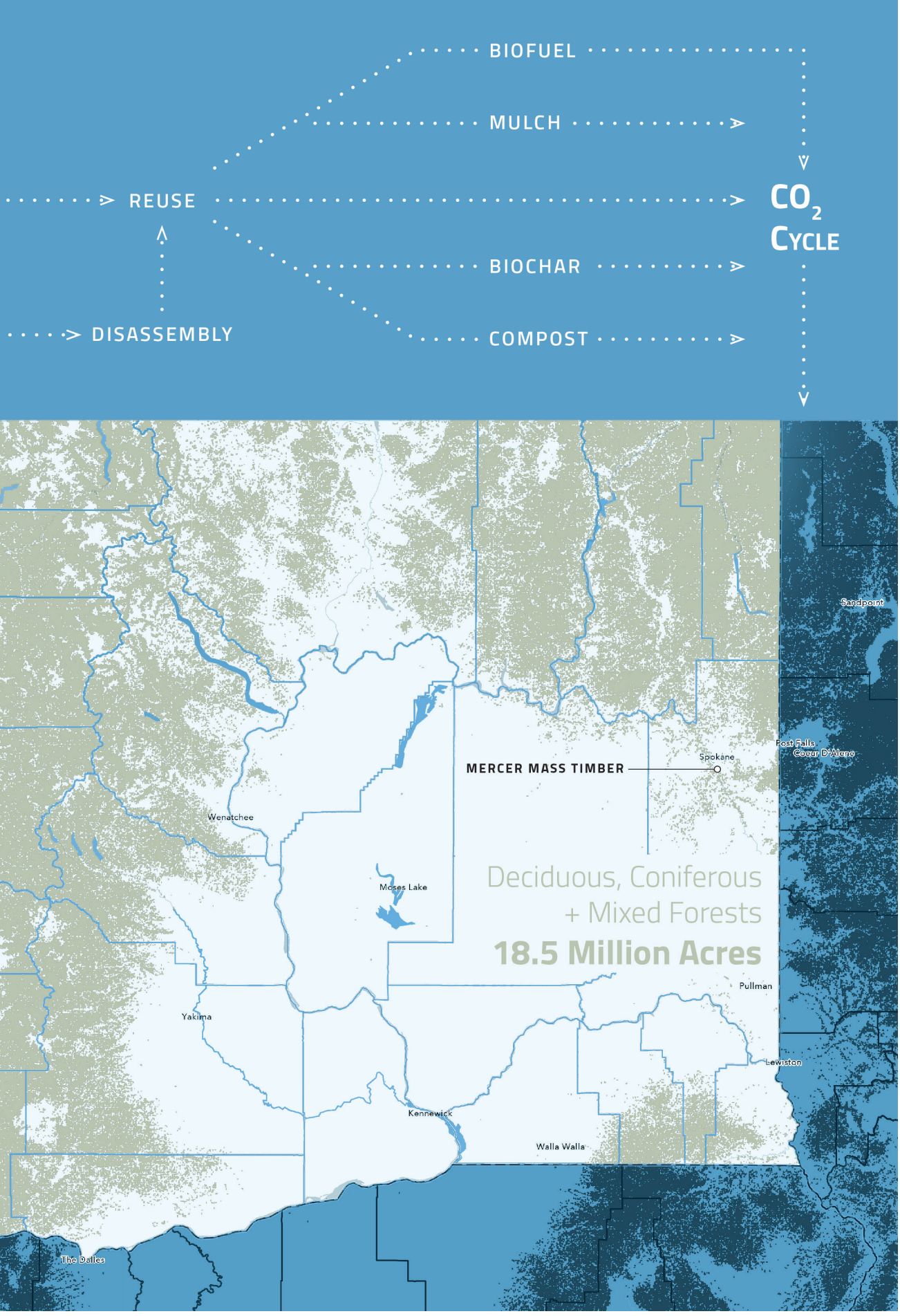

BIOFUEL
MULCH
REUSE
BIOCHAR
DISASSEMBLY
COMPOST
CO_2 CYCLE
MERCER MASS TIMBER
Spokane
Sandpoint
Post Falls
Coeur D'Alene
Wenatchee
Moses Lake
Deciduous, Coniferous
+ Mixed Forests
18.5 Million Acres
Pullman
Yakima
Lewiston
Kennewick
Walla Walla
The Dalles

Figure 4.36

Regenerative Agriculture

STRAW

Straw is a rapidly renewable agricultural byproduct of the grain industry. With no nutritional value, straw is the left over biomass from food cultivation in products such as wheat, oats, barley, and rice, and is often left to decompose back into the earth releasing carbon back into the atomsphere. Therefore, wherever grain is grown as a food commodity, straw is present as an inherent output. Rather than seeing this byproduct as a waste material to decay and emit carbon, manufacturers can transform this excess biomass into a cheap, high-performing insulation material. By building off **cradle-to-cradle** principles, manufacturers can close the waste loop and use straw as a valuable material input for insulation products.

Generations of builders have experimented with straw-based construction, primarily through stacked bales. However, recent developments in research and industry have positioned straw as a critical component of 21st century pre-fabrication wall panels for constructing well-insulated, non-toxic building enclosures (ISOBIO, 2019; Ecococon, n.d.; Magwood, 2019.) There exists enormous opportunity to develop regional producers of such products in locations where agricultural grain is produced. Again, aligning the AEC sector with manufacturers and farmers of bio-based materials creates room for advocacy around regenerative farming practices that promote healthy soils, farm biodiversity, and keep excess carbon out of the atmosphere by locking it up in building mass.

Washington state grows over 2.5million acres worth of diverse grain crops every year, making it the fifth most competitive state in grain production (USDA, n.d.) With abundant quantities of this agricultural byproduct, the opportunity for manufacturers of pre-fabricated straw structurally insulated panels (S.I.P.s) is promising. The advantages for aligning the sectors of construction, manufacturing, and farming here are numerous:

- Carbon drawdown and longterm storage
- Income incentivization for regenerative agricultural practices
- Cover crop and rotational harvests to improve soil health and farm biodiversity
- More resilient farmland are better for biodiversity, food security, and farm workers

Figure 4.33. Pesticide use on farmland is one of the biggest threats to migratory *Danaus plexippus* (monarch butterfly) populations in North America. Image Source: Adobe Stock

- Cheap material inputs for high-performance, prefabricated building products likely yields reduced building costs

CLAY

Straw-clay is a critical wall surface composition in the interiors of biogenic building methods. While clay itself is not a biologically based material, (rather, geogenic), it is an important resource to mitigate exploitative consumption patterns in building material supply chains. Additionally, the composition of clay plaster typically includes biogenic materials to provide fiber and binding strength. Substituting natural clay products in interior applications can have a huge impact on resource consumption and carbon emissions if applied at scale. Strategic substitution of gypsum board and other extractive interior products such as latex primers and paints can be a mechanism by which architects and building engineers employ healthier, and more economic and energy efficient dwellings. Advantages of clay interiors are multifold.

First is the undeniable biophilic qualities and warmth of clay plasters. The wellbeing attributed to textures, colors, vibrancy, and thermal effusivity of clay applications is well documented in natural home building across the world (Minke, 2006.) However, the scale at which these applications are made are typically small and limited to residential buildings due to limited research and development of standardized clay products. Advances in research and advocacy toward such practices may change this because the use of clay is both cost effective and materially efficient when building with straw S.I.P.s. Straw-clay surfaces bind together effectively due to the molecular characteristics of the two materials, and has positive health outcomes for inhabitants (Ibid; King and Magwood, 2021.)

Secondly, research shows that due to these physiological properties, the application of clay plasters can have positive impacts on indoor air quality (Ibid.) The hygroscopic qualities of clay creates ideal conditions for effective air and moisture exchange. The humidity asborption potential of clay relative to other materials such as gypsum, lime-cement plaster, brick, or planed wood makes it more significantly more advantageous in regulating indoor air comfort with less mechanical ventilation and heating requirements (Ibid.) This supports the argument for introducing clay/straw composite S.I.P.s into larger scale residential living.

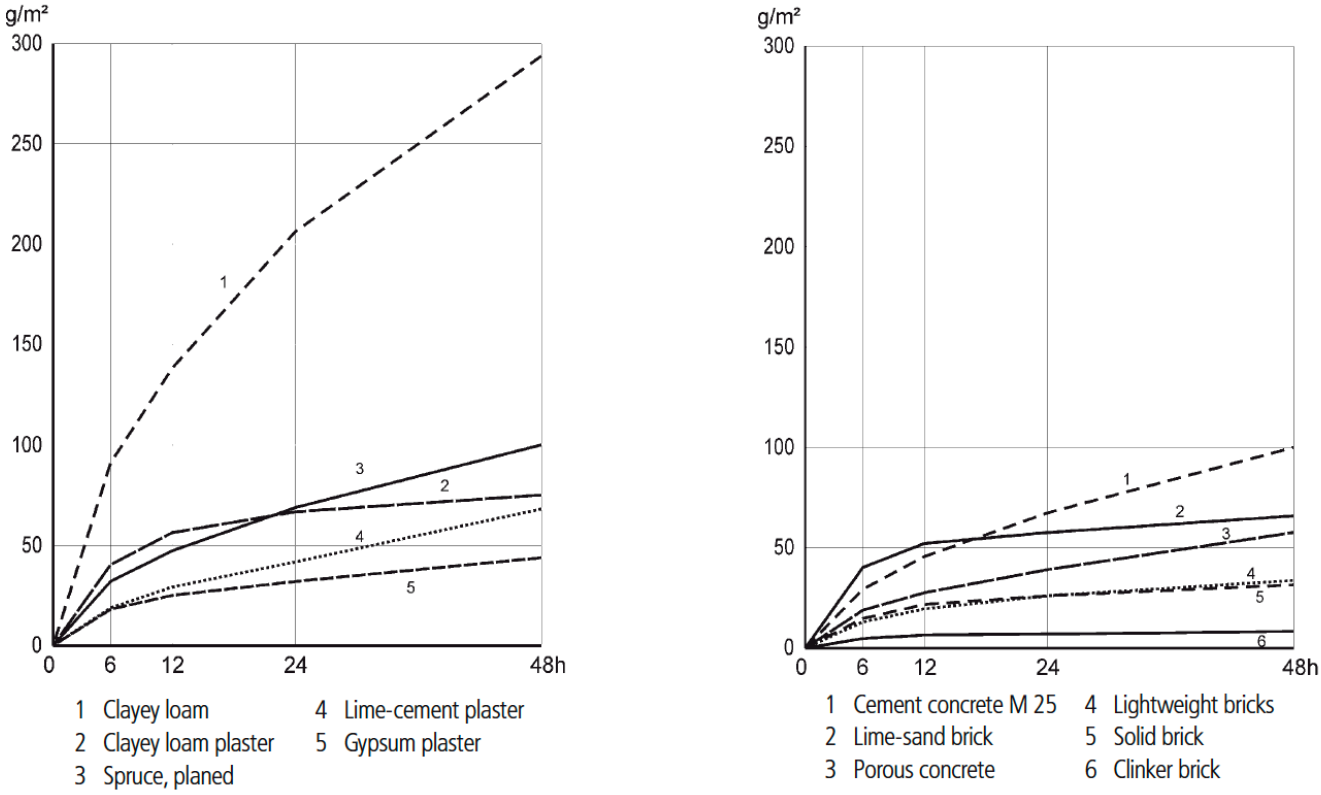
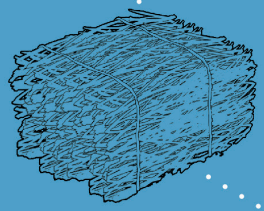


Figure 4.35. Relative humidity absorptivity of clay plasters as compared to other typical interior building materials.

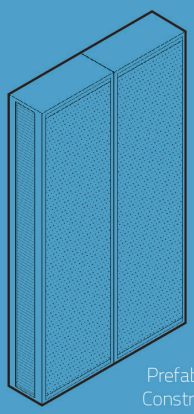
WASHINGTON STRAW PRODUCTION

AGRICULTURAL PRODUCTS:

Wheat
Barley
Rye
Oats



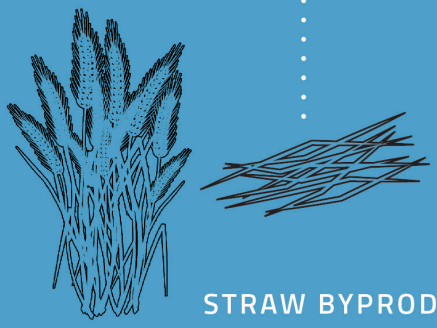
Bale Process



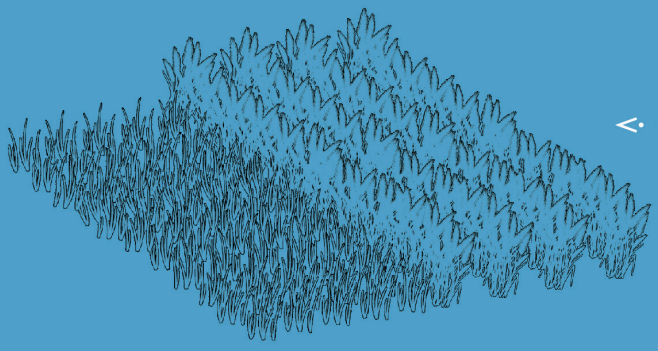
Prefab S.I.P. Construction

Straw CO_2 Sequestration

400 kG CO_2e/Acre Per Year



STRAW BYPRODUCT



GRAIN PRODUCTION WITH REGENERATIVE COVER CROP PRACTICES

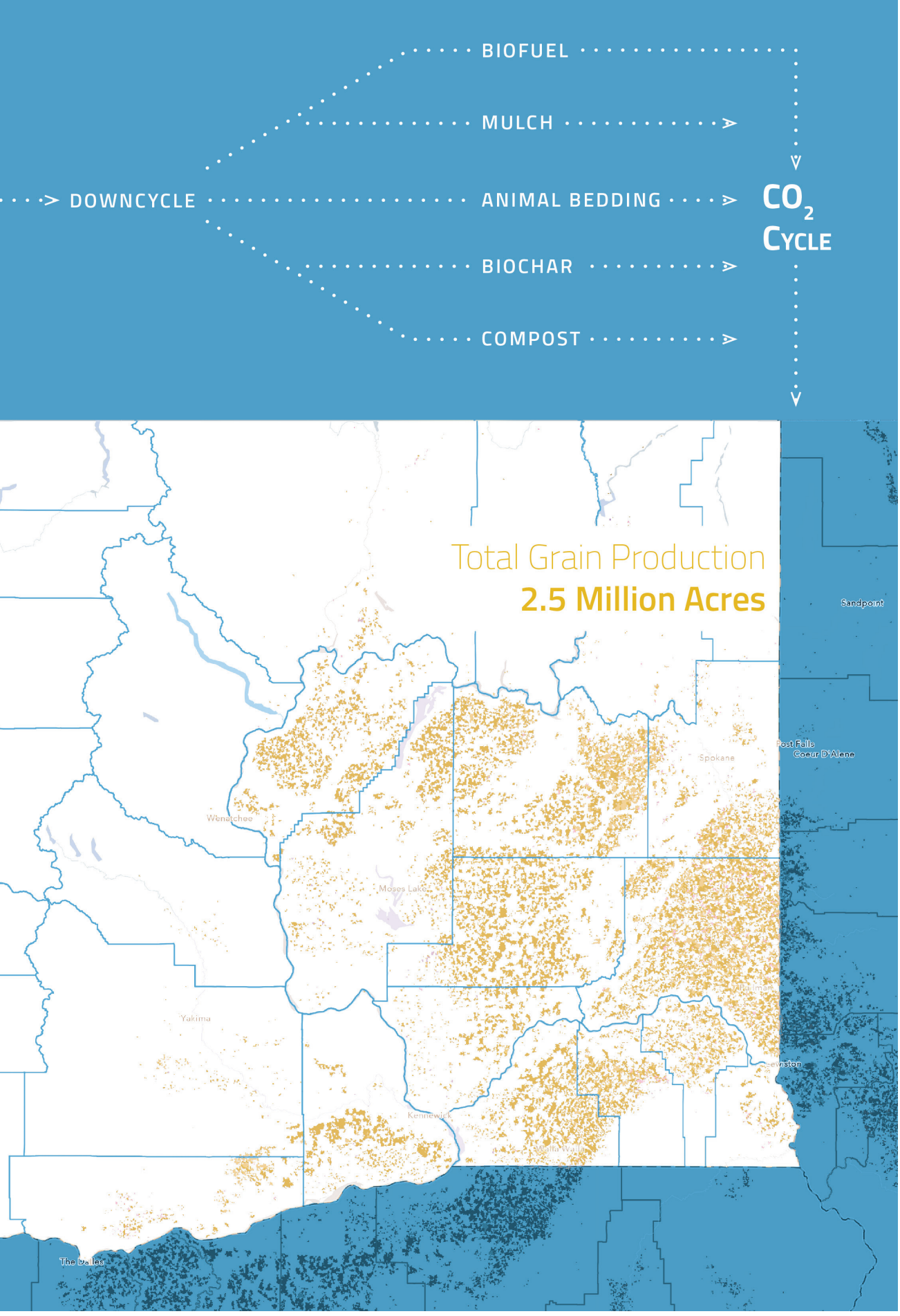

BIOFUEL
MULCH
DOWNCYCLE
ANIMAL BEDDING
BIOCHAR
COMPOST
CO_2 Cycle
Total Grain Production
2.5 Million Acres
Sandpoint
Spokane
Coeur D'Alene
Wenatchee
Moses Lake
Yakima
Kennewick
The Dalles

Figure 4.37

Figure 4.34. Image Source: The Hempcrete Book (2014.)

HEMP

Similarly to straw, hemp is a crop with enormous potential for simultaneous opportunities to sequester carbon and promote biodiversity on agricultural lands. Legalized federally only as recently as 2018, agricultural production of *cannabis sativa*, or hemp, is slowly burgeoning as the next enormous cash crop for its function in various industries from construction to textiles to nutrition and skin products (Industrial Hemp Association of Washington, n.d.) While the development of the hemp industry is still in its infancy in North America, other parts of the world have proven for millenia that hemp is a widely popular and exceptionally functional material for countless products. As a building product, hemp-based insulations such as hempcrete and hemp fiber boards and batts are extrememly promising, with existing large-scale regional producers as near to us as Ketchum, Idaho.

Ongoing research and development is happening around hemp insulation products and their performance across various building metrics such as hygroscopy, thermal performance, fire rating, non-toxicity, and more. Evidence strongly suggests that hemp-based insulation products perform on par or better than traditional insulation materials such as fiberglass and extruded polystyrene (Stanwicx and Sparrow, 2014; Hempitecture, 2022.) However, since hemp was federally illegal to cultivate in the United States until very recently, industrial hemp production has economies of scales to anticipate for competing at a necessary scale with traditional products. However, this need is essential, because sourcing insulation materials from hemp will be a boon to biodiversity on regenerative hemp farms and will be a key carbon sequestration strategy. Hemp's profuse growth of biomass and biannual cultivation cycle makes cannabis sativa a very valuable CO_2 sink (King and Magwood, 2021.) Drawing down excess CO_2 on hemp farms and storing it in buildings will be a valuable way for cities to avert further carbon squandering.

Additionally, hemp is a key component of cover crop regenerative agriculture practices. Its rapid growth other physiological properties help keep weeds at bay and help to retain moisture and nutrients in the soil across grow season. This mitigates the need for pesticides, herbicides, insecticides, fungicides, synthetic fertilizers, and more (Groff, 2017.) By supporting farms that utilize hemp in cover and rotational practices, we are helping promote soil health, thereby steward healthier habitats to promote species biodiversity and CO_2 sequestration.

WASHINGTON HEMP PRODUCTION

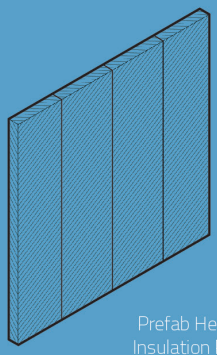
AGRICULTURAL PRODUCTS:

SEED
Oil + Food + Fuel

LEAF
Medicine + Mulch

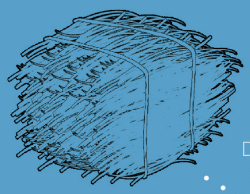
FLOWER
Medicine

STALK
Paper + Textiles

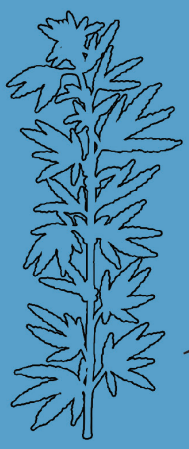


Prefab Hempwool Insulation Products

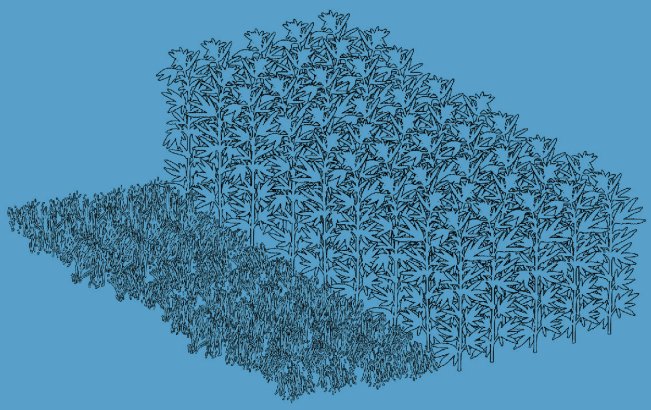
Hemp CO_2 Sequestration
110 kG CO_2e/m^3



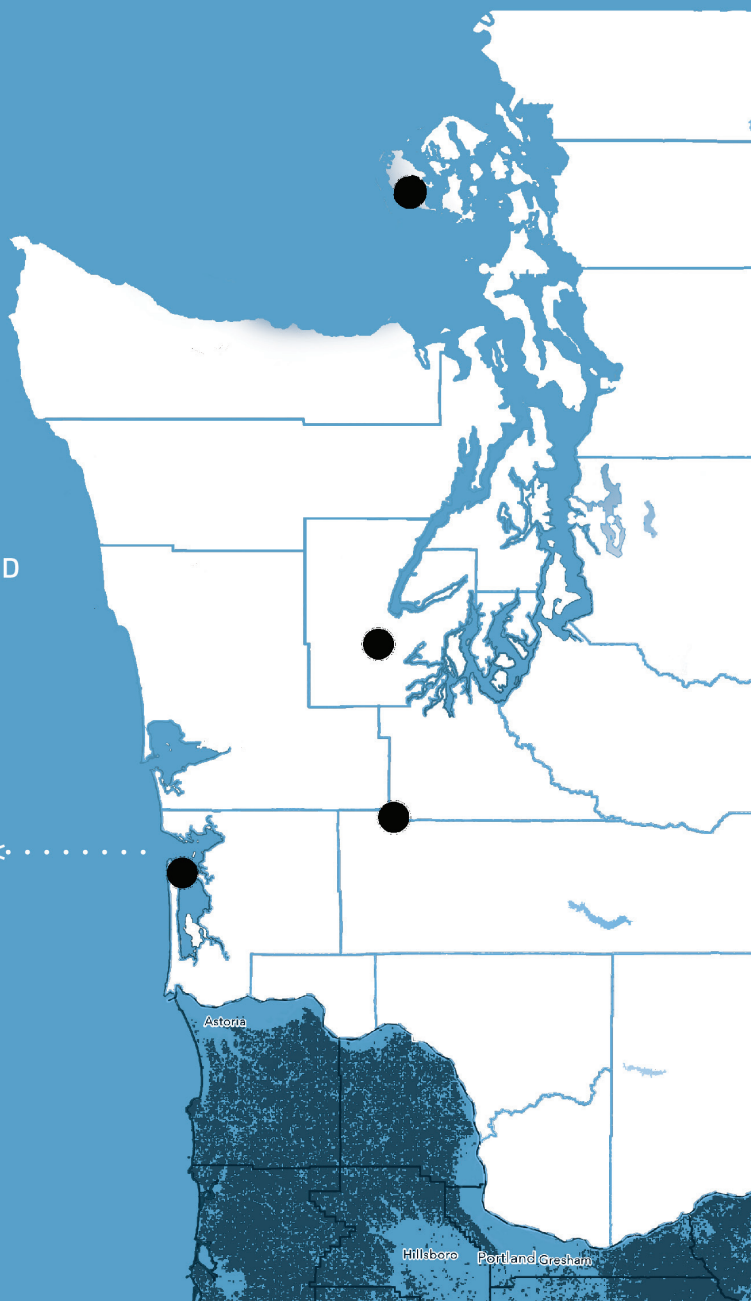
Decorticating + Bale Process



BAST FIBER + HURD BYPRODUCT



HEMP ROTATIONAL + REGENERATIVE COVER CROP PRACTICES



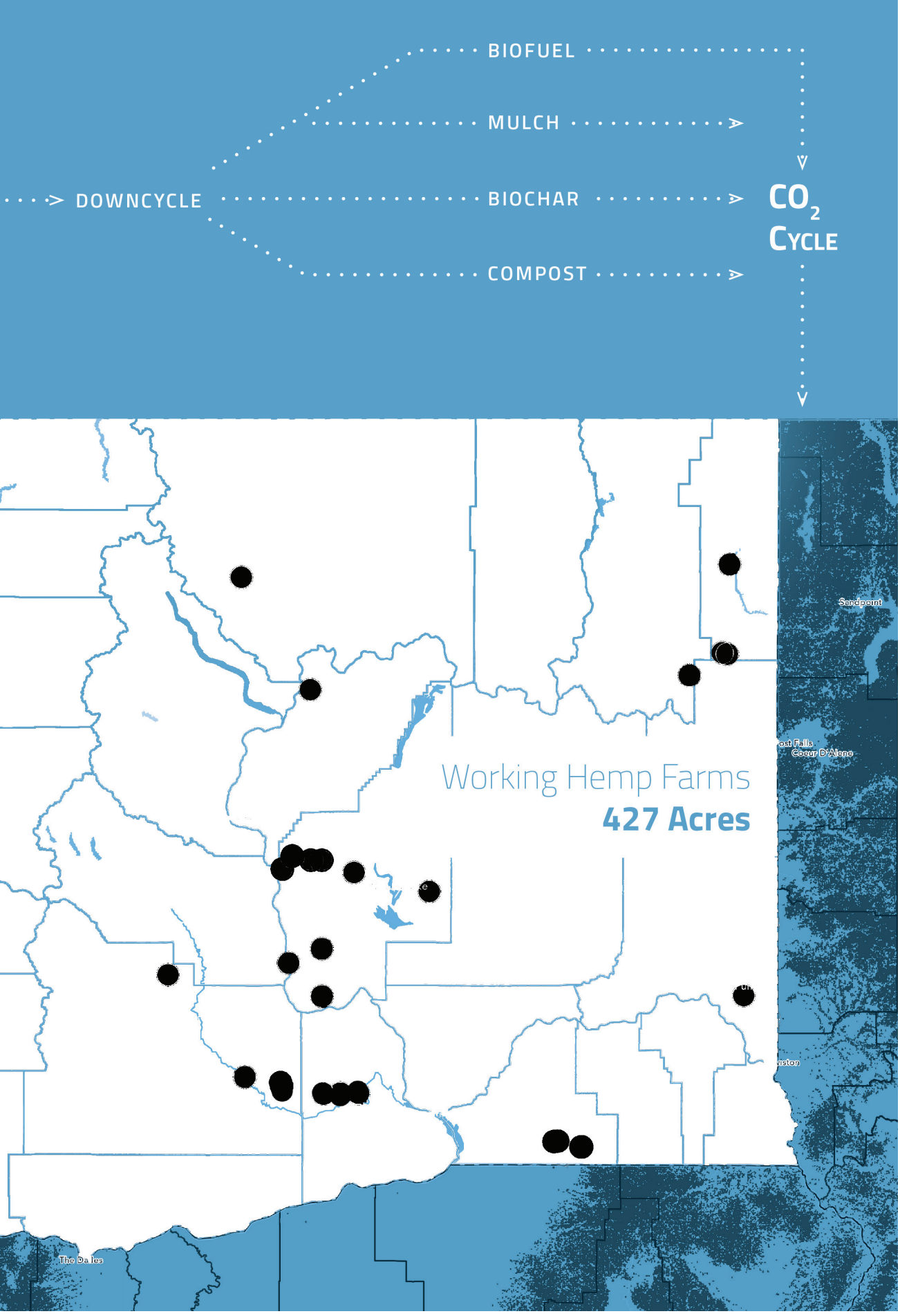

BIOFUEL
MULCH
DOWNCYCLE
BIOCHAR
COMPOST
CO_2 Cycle
Working Hemp Farms
427 Acres
Sandpoint
Coeur D'Alene
The Dalles

Figure 4.38

R - 46 PASSIVHAUS ASSEMBLY

East/West Facades

Laminated Wood Panel Rainscreen
Vertical Battens
Hempwool Fiberboard Continous Insulation
Vapor-Permeable Airtight Membrane
Prefab Straw S.I.P.
3 Coats Natural Clay Plaster
Operable Passivhaus Triple Glaze Window

LIGNOTREND FLOOR ASSEMBLY

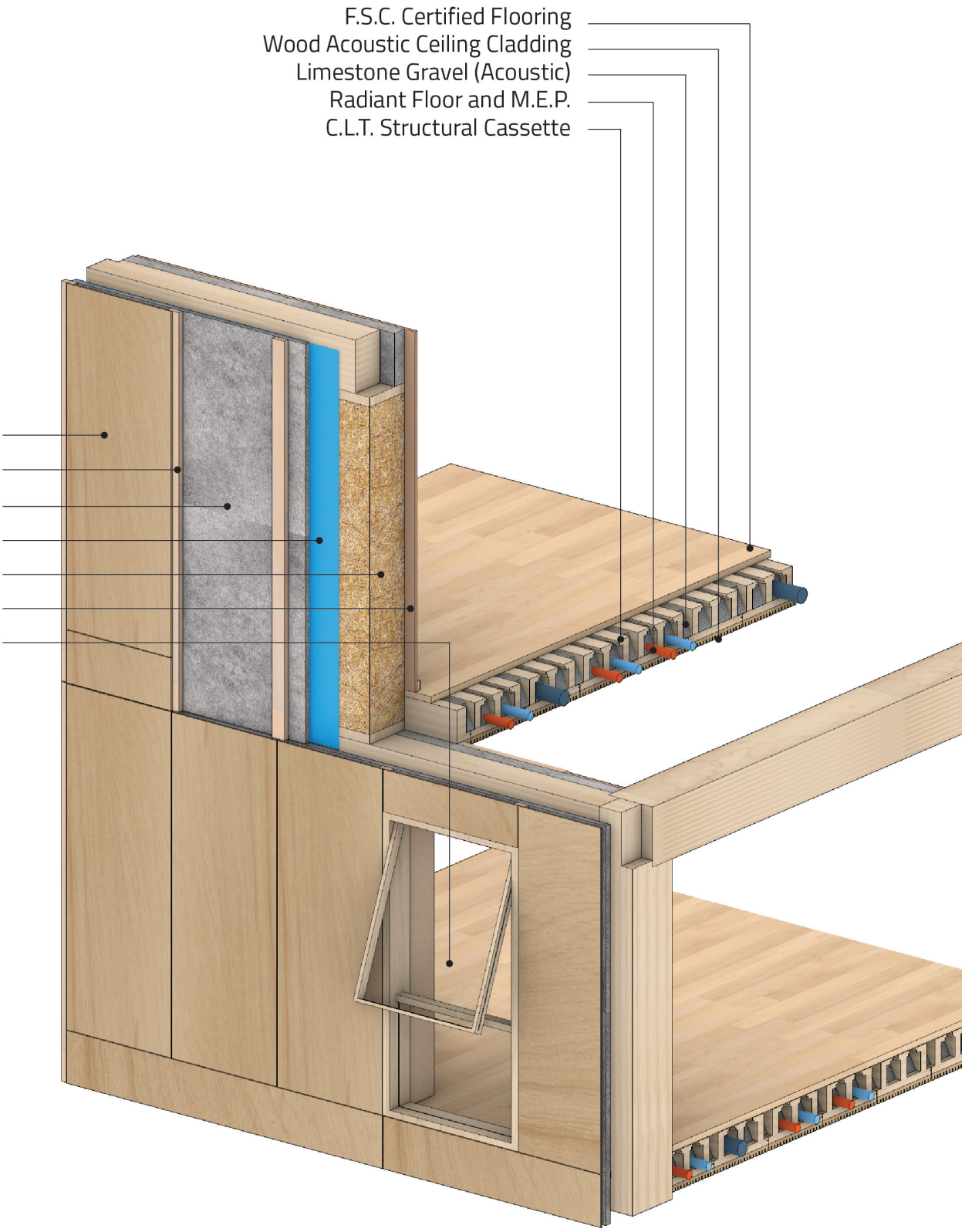


Figure 4.39. Utilizing prefabricated modules allows for effective use of biogenic building materials in ways that reduce waste and streamline construction schedules.

Figure 4.40. Imagining a **re-entangling** of the habitats that we depend on. The intersection of agroforestry, architecture, and landscape design and planning offer abundant opportunity for the built environment to address the biodiversity crisis while supporting the development goals of our growing urban populations.


C
O
P
Ca
Mg
K
N

Conclusion

With global temperatures continuing to rise, the urgency at which we reverse the anthropogenic causes of climate change is becoming increasingly critical for our survival and the survival of all species on our planet. The biosphere is an extraordinarily complex habitat teeming with the novelty and life. As robust as this thin membrane of planet Earth is, its systems are seemingly out of homeostasis, at the hands of our hubristic homo sapien race. The coming decades are critical for the vitality of life on Earth, and the values with which we steward the biosphere is going to become a defining legacy of our human civilization.

At once, our species' sophisticated consciousness allows us to communicate with symbols and language, shaping culture and transfering knowledge across time. This profound capacity has, perhaps fatally, equipped us with the ability to transform the biosphere to the liking of an elite percentage of humans across time. The development of industry and globalization has ontologically segregated our human experience from the resources upon which we depend, and in turn has led to anthropogenic global warming and ecosystem collapse. However, it is this same capacity for knowledge sharing and technological innovation that gives us the immense opportunity to solve these crises. We know that our gross overconsumption of resources and burning of fossil fuels is leading to the destruction of our habitable biosphere. If we transform the paradigms for which we live through degrowth economic mechanisms, we can reverse these crises while providing the values upon which we urgently depend: love instead of fruitless consumption, respect instead of capitalistic competition, and hope over insatiable poverty of the spirit.

To shift these paradigms is the radical and necessary action we must strive toward in this decade if we want to avert the worst outcomes of climate change within our lifetime. Critical in this value shift is the survival of more-than-human species, from which the beauty and well-springs of life emerge. There is no other task than to protect and regenerate this beauty for the coming generations and their offspring, to maintain the harmony of life on Earth. These efforts will take collective action. As the development of knowledge and technological procedures advance, we must act together in unified ways that bring together various sectors to promote these positive transformation. Together we must align our efforts to advocate for and advance the vitality of biodiversity on Earth and to bring about justice to its people.

All images, diagrams, and illustrations in this document are by the author unless otherwise indicated.

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