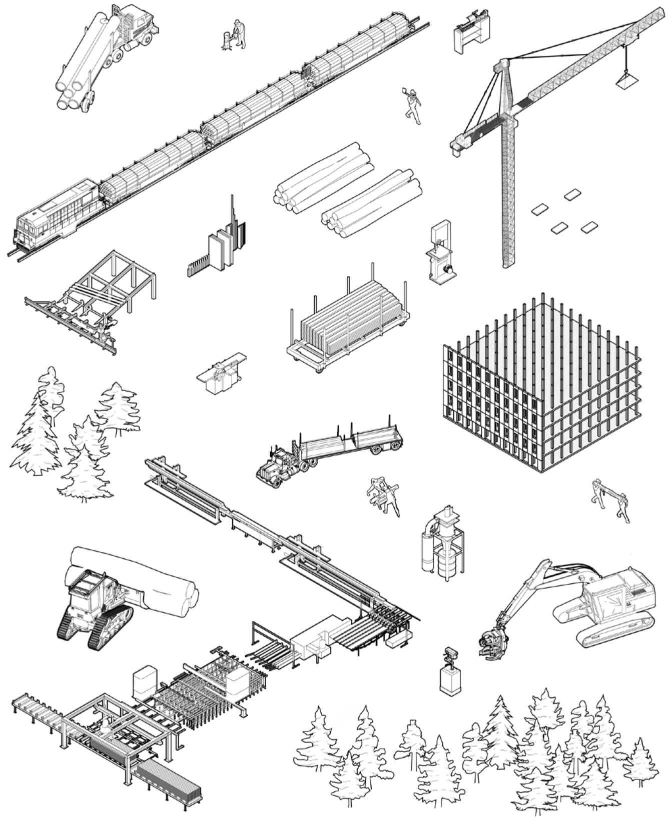
Places of Production: Forest and Factory

DANIELS

[Studio Series]



U OF T

John H. Daniels Faculty
of Architecture,
Landscape, and Design,
University of Toronto,
in Collaboration with the
Canadian Wood Council and
the Woodsmart Program

DANIELS

wood SMART building for tomorrow

Canadian Wood Council
Conseil canadien du bois

Editorial Team
Curtis Ho, Dylan Johnston, Niko McGlashan, Alexandra Ntoukas, Sidney Tsao

Faculty Advisors
Brigitte Shim, Robert Wright

Cover Design
Jennifer Chau Tran

Editorial Assistance
Craig Rodmore

Printed By
Astley Gilbert

Publisher
John H. Daniels Faculty of Architecture, Landscape, and Design

LAND ACKNOWLEDGEMENT

James Bird
John H. Daniels Faculty of Architecture, Landscape, and Design, University of Toronto, MArch
The Dene Nation, Knowledge Keeper
RAIC Indigenous Task Force, Member
Indigenous Initiatives, University of Toronto, Council Member

Niko McGlashan
John H. Daniels Faculty of Architecture, Landscape and Design
MArch

An Exercise in Reconciliation.

This publication exists at the intersection of the Forest and the Factory, seemingly two opposed forces that reside within the industry of Mass Timber. Both of these systems are enriched with their own histories and cultural perspectives, which are explored throughout this publication. Despite their natural opposition, a clear hierarchy exists where the Factory could not exist without the Forest; neither could this publication or its academic discourse.

This hierarchy prompts us to consider the Land required to formulate this knowledge, give thanks to the past and present environmental stewards, and recognize the impacts of colonialism. Stating this Land acknowledgement has become a fairly regular practice at the University of Toronto:

We wish to acknowledge this Land on which the University of Toronto operates. For thousands of years it has been the traditional Land of the Huron-Wendat, the Seneca, and most recently, the Mississaugas of the Credit River. Today, this meeting place is still the home to many Indigenous people from across Turtle Island and we are grateful to have the opportunity to work on this Land.

For this Land acknowledgement to better serve as a prelude to this publication, it is necessary to extend this recognition to the myriad of First Nation communities, geographies, and territories explored in this text. As we quickly realized, such a broad scope of content made this task particularly challenging and contradicted the site-specific nature of the Land acknowledgement. The question became: how can one pay tribute to the continuous Forest? Two Master of Architecture students, James Bird, a knowledge keeper of the Dene Nation and member of both the RAIC Indigenous Task Force and the Indigenous Initiative Council at U of T, and Niko McGlashan, the publication coordinator, worked together to investigate this question through conversation. Through this engagement, the publication aligned with the University's Call to Action for reconciliation in the report titled "Answering the Call: Wecheehetowin" (2017). To that end, we combined the pedagogy of both Indigenous and Western cultures. The following amendment was a product of this pedagogical collaboration:

We wish to specifically honour the spirit of all the Trees, Land, Flora, and Fauna that combine to define the Forest. Without the sacrifice of the Forest, this publication would not be possible.

This text reflects an attitude that was deeply embedded in the framework of the initial studio at the John H. Daniels Faculty of Architecture, Landscape, and Design where much of this content was produced and disseminated. With hope, this land acknowledgement will carry more relevance to the reader after gaining the knowledge and wisdom that resides in this publication.

FOREWORD

Robert Wright
John H. Daniels Faculty of Architecture, Landscape, and Design, University of Toronto
Interim Dean

When I was Dean of Forestry and worked on amalgamating the Faculty of Forestry with the Daniels Faculty, I met with two opposed responses:

1. How was Forestry relevant to a Design School? What possible connection was there between a Design Focused Faculty and Science Focused Forestry Program?

2. This was a unique opportunity to further bring science, conservation, and ecology into a design school, particularly as they relate to sustainability and construction.

When the Faculty of Forestry joined Daniels in 2019, the discussion focused on the exploration and manifestation of the second point. Professor Brigitte Shim and I felt it was incumbent on the faculty to make use of the opportunity and conceived a design studio directed at exploring the dimensions and intersections forestry and design.

This journey begins by understanding that Canada has often been described as a forest nation. For our First Peoples, the forest was central to survival as well as a central representation of their spiritual connection to the land. Later, in a colonized Canada, the forest has figured strongly in our national mythology first as an economic resource and later as our ecological responsibility to conserve and sustain. Looking at Canada's early settlement maps, we realize we were born in small islands of development in an enormous sea of forests. Most historical descriptions of Canada contrasted our rural roots against a vast wilderness. More recently, we have added an "Urban Fringe" that, for the most part, hugs our southern border. To understand our relationship to the forest is to understand the history of Canada.

Canada has approximately 9% of the world's forests but 25% of its most pristine forests. Forests make up around a third of all of Canada, and 95% of these forests are publicly owned and subject to sustainable forestry management. Less than 5% of Canada's forests are harvested, and Canada has the world's highest sustainable forestry certification. But all these statistics are still contingent on our continued responsibility to steward the forests far into the future.[1]

As designers and builders, we must understand the importance of forests across several dimensions related to forestry practice and design and construction itself. Do we know forests and wood's potential as the most sustainable building material in the long term? How can we integrate ecological thinking from the forests into the design and back again to ensure sustainable forests in the future? These were some of the questions we confronted, but by no means resolved.

The purpose of this book is to take the reader along on this journey, one that will hopefully begin to open the imagination to the possibilities of one of Canada's most abundant and sustainable resources. This is a journey that this faculty will continue to support.

Note

1. The State of Canadian Forests annual report, 2020 edition, https://www.nrcan.gc.ca/our-natural-resources/forests-forestry/state-canadas-forests-report/16496.

Kevin McKinley

Canada Wood Council
President and CEO

Building with wood is a practical way to mitigate carbon. In Canada, we are fortunate to have robust regulations and sustainable management practices to guide how our forests are harvested and regenerated. Yearly, less than 0.2% of Canada's 347 million hectares of forests are harvested, significantly less than the 5% of forest lands lost each year to insect attack and fire—naturally occurring issues perpetuated by climate change. In fact, wood products from sustainably managed Canadian forests play an integral role in mitigating climate change, creating a natural and continuous cycle of carbon absorption and long-term storage.

Since 1959, the Canadian Wood Council (CWC) has represented the wood products industry in Canada, championing the use of wood in Canadian construction. Our leadership led to the adoption of six-storey wood construction in Canada's 2015 National Building Code. And now, up to twelve-storey mass timber construction will be permitted in the 2020 National Code. CWC's stewardship, expertise, and passion have made today's love of mass timber and other innovative wood construction possible.

Industrial wood buildings are not a new concept. From the mid-1800s to 1940 many brick and beam buildings were constructed across Canada, consisting of a masonry exterior and a heavy timber post and beam interior structure. These buildings, many between five and nine storeys tall, began their service life as tractor factories and textile mills. In Toronto, there are more than forty mid-rise brick and beam buildings that, despite their initial heavy industrial use, have served beautifully for over a hundred years and are now some of the most sought-after real estate in the city. It's no surprise that we see a renaissance of industrial wood buildings. Given advances in engineered wood products like glulam and CLT, coupled with sophisticated digital fabrication technologies, modern wood construction is reshaping the way buildings are designed, manufactured, and assembled. This systems approach represents a new opportunity in construction, which for decades has lagged behind other industries in terms of productivity. However, we now have a major positive disruptor in construction—one the exploits new wood product systems, ease of manufacturing, and efficiency of assembly to provide timely, resource-efficient, automated, and controlled construction.

Challenges to the increased use of wood in construction include the large industry dominance of concrete and steel, as well as the tradition of greater focus on these structural materials in Canada's post-secondary curricula. CWC's woodSMART program is now leading the effort to expand wood design and construction education. As a result, when students—our future architects, engineers, and other building professionals—enter the workforce, they will have the required skillsets to plan, design, fabricate, and assemble advanced wood structures. Supporting these future practitioners will increase the use of wood in construction and in turn help to mitigate climate change through carbon sequestration and substitution.

The Daniels design studio Places of Production: Forest to Factory presented a valuable opportunity to engage the future architects of our built environment. The studio challenged students to harness the strength and sustainability of wood to reimagine what a factory could be in a low-carbon future. The five schemes developed in it exemplify CWC's vision to be a passionate champion of wood construction for an advanced and sustainable wood culture. We applaud the incredible efforts of the studio and encourage these emerging and innovative designers to be our future voices and advocates of wood construction across Canada, and around the world.

INTRODUCTION

01

INTRODUCTION

Brigitte Shim
John H. Daniels Faculty of Architecture, Landscape, and Design, University of Toronto
Professor

Robert Wright
John H. Daniels Faculty of Architecture, Landscape, and Design, University of Toronto
Interim Dean

The joint advanced research design studio Places of Production: Forest and Factory explored the intersection between the disciplines of forestry, architecture, landscape architecture, and urbanism, enabling our graduate students to explore relevant and pressing issues in an in-depth and immersive way. Architecture and landscape architecture students worked collaboratively, realizing a comprehensive project to design an industrial building and its landscape. It also enabled the Daniels design faculty to develop a specific studio curriculum facilitating intense and focused design exploration near the conclusion of each student's graduate education.

This studio was the second collaboration between architecture and landscape architecture faculty members to provide an opportunity for our students to work in interdisciplinary teams co-mingling architecture students and landscape architecture students engaged in a complex and challenging semester-long design project. Our first collaboration, Building Health (2018), was a partnership between the Daniels Faculty and the North York General Hospital and Foundation.

The forest and the factory are both examples of constructed nature that speak to our contemporary attitudes towards nature and production. Each studio group provided an integrated design response to the studio brief, considering the role of the landscape and built form to develop a bold design solution that explored the role of forestry and design simultaneously.

A large portion of the world's population spends much of its time in places of production such as factories and industrial facilities. In most cases, industrial facilities are built with only economic performance in mind; the welfare of those who work in these buildings has not been a major concern. But the definition of industry is changing rapidly, and the modes of production are transforming.

Canada is a country that still relies on primary resources as a central part of its economy. The shift to a value-added economy is an essential part of our collective future, and the role of advanced sustainable industrial buildings is part of that. Our forest is a constructed landscape that has been used as a natural resource; our image of nature is often that of an organized nature that is human-made. The factory as a building type and its surrounding landscape needs to be rethought and reconsidered. Innovative industrial spaces using cross laminated timber (CLT) construction has the potential to create humane and sustainable spaces, reinventing the workplace of the future.

During a time of environmental crisis, we need to rethink the design of our forest in Southern Ontario and explore its re-integration into the production of value-added wood products. We need to act sustainably to provide exemplary models for reforestation and building with one of our most renewable resources—wood. Mass timber and CLT engineered wood are an excellent source for sequestering carbon contributing to a sustainable future that inextricably links forestry and design. This studio was an opportunity for Daniels students to explore the critical and relatively untapped relationship between forestry and design. The invaluable links between our use of Canadian natural resources, the increasing role of prefabrication, and the critical role of the designer in adding value to this process were all interrogated and explored during the semester.

02

"... Indigenous People protected and honoured the forests. This doesn't mean that we didn't modify the forest to our liking but we did this in a sustainable way."

FOREST AND OTHER FRIENDS

Dr. Henry Lickers

Haudenosaunee Elder of the Seneca Nation, Turtle Clan
International Joint Commission, Canadian Commissioner
Retired Environmental Science Officer for Mohawk Council of Akwesasne

Shekon

I hope this narrative finds you and your families in good health and spirits.

In the Thanksgiving Address of the Haudenosaunee People, the trees of the world have a special place along with all of the other things in creation like the sun, moon and stars. The home of the trees, the forests were special places to the Indigenous Peoples. The Forests were our groceries, pharmacies, hardware stores and energy providers. They provide shelter and food to many other animals that we depended upon and the trees gave of themselves. Lumber and fiber that we could use to make our lives more comfortable. It is no wonder that Indigenous People protected and honoured the forests. This doesn't mean that we didn't modify the forest to our liking but we did this in a sustainable way.

Indigenous Peoples believe we have been here "in time out of memory" that is to say a very long time. My Great Grandmother told me that my people, the Haudenosaunee People, have existed for 100,000 years but we lived far to the south because we couldn't live on the great ice sheets that cover Turtle Island. At that time, we lived with the "people of stone", cruel people who were cannibals but we were saved by building their great houses of stone. The climate changed and the power of stone people vanished leaving the Haudenosaunee Peoples free. Taking the three sisters, corn beans, and squash we moved northward. We promised ourselves that we would never build our homes of stone for fear that we would become like the "stone people". The Forest became the suppliers of materials for our homes and villages. As we built our homes and villages, we cleared the land and planted the three sisters. The Haudenosaunee prospered and our villages grew. In 600 AD, the Haudenosaunee Village near Syracuse NY had over 60,000 people living in it and it was considered the capital city of the Haudenosaunee. We noticed that as we lived in an area and cleared the forest and the land for crops that we depleted the resources and the land. A plan was established that saw our village divide into smaller groups of 20,000 people and move seven days run by our young men to a new area. Where the land would be cleared and a new village built. The old village was abandoned and the fields allowed to return to the wild. Trees and bushes that we may need in the future were replanted in the old site. We moved our villages in great circles that would take hundreds

Elm tree bark used as shingles in longhouse construction

Prescribed burning of the Black Oak Savannah

of years to return to the old village sites. By that time the forest would have matured and been ready to receive us again. In this way, we managed the forest and the lands.

There are many stories of diseases that swept through the forest as "evil winds" or "plagues of insects" that destroyed species and tracts of land. In each of these cases, our people looked for trees that could resist these invaders and they became our "Grandfather" tree revered for the strength and resilience. Their seeds were spread throughout our territories and shared with the neighbouring nations. Refugia were established in the secluded mountain dales to preserve some of the original stock for reintroduction once the pests had passed. These refugia are said to be protected by spells and wards that only the medicine people know, even Google Maps may not be able to find them.

Fire was used by men to burn specific areas of forest so that they remain the same for many centuries. Women used water and a helper (the beaver) to flood valleys and create beaver meadows. Each of the created ecosystems provide different medicines and trees that we needed.

As the ice receded, the Haudenosaunee followed the retreating ice front and planted trees as far north as they could go, in this way butternut and black walnut were moved from the Carolinas, as far north as the St. Lawrence River and beyond. It wasn't enough to just plant the nuts of these trees but you also had to bring along the tree's companions as well. Soils containing bacteria and fungus from the parent soils were transported northward with the tree. These parent soils seemed to allow the trees to grow better. Similarly, some trees and herbaceous plants seemed to need each other in order to thrive (e.g. American Ginseng and Butternut). All of these things were known and could be used to help the trees walk north with the Haudenosaunee.

As we continued to plant our way north, our neighbours, the Anishinabek peoples, saw the things we planted and they too liked the nuts and berry bushes and so continue to plant these along the travel routes through their northern area. In this manner the Carolinian forest of the south moved northward. It is not fate or squirrels that established these southern species in Canada but Indigenous peoples. Today we see the climate changing again and are very concerned that the trees can not move north fast enough as the globe warms. Many projects are now being designed and implemented to help the trees walk north and the academics call this assisted migration. Climate change is impacting many different ecosystems and the forest most of all. As the world warms, invasive species begin to thrive in areas that once were too harsh from them and threaten to destroy the very existence of the forest. Emerald Ash Borer threatens the Black Ash Trees that are the basis of a $7 million dollar basket making industry in our villages. Dutch Elm disease eradicated the elm tree that was the "shingles" on our longhouses. The White Birch trees that once grew to such a great girth that a birch bark canoe skin could be made from one tree are fast disappearing. These changes to the forest and the trees hurt not only our bodies due to lack of medicines but also damage our spirits and souls.

In this modern world, it seems that our warnings about destroying the forests and the trees have gone unnoticed, however non-native and native foresters are working together to integrate our knowledge systems into a powerful new force to save the forests. My Grandfather likened the knowledge of Indigenous peoples to the song of the drum or the heartbeat of the Mother Earth and the knowledge of science to the dance of numbers or the movements of the earth. Each has their place in the World but it is very hard to dance without a song and the song must be powerful enough to move our feet. By bringing them together can we create the beauty and the power to save us and the world.

I have hope that some of you will create the song and other's the dance.

I know the forest and trees will celebrate with you.

Naiwa Gowa (A Big Thank You)

And Skennen (In Peace)

Henry Lickers

CURIOUS IMPORT

Dan Handel
Department of Interior, Building, and Environment Design, Shenkar College of Engineering, Design, and Art
Professor

"The forest is not a thing in the world, but has always been a human construct. In other words, we need to remake the story of our environment in order to redesign our survival."

In 1970, a curious import from the forests of British Columbia found its way to the fantasy grounds of Expo '70 in Osaka. This was the province's pavilion, designed for the occasion by architect Barclay McLeod, assisted by Cunningham Design Consultants, sourced and realized in collaboration with forest products giant Macmillan Bloedel.

The pavilion was a rather exceptional affair, whose signature appearance was created by a hyperbolic wood mass assembled from a large number of Douglas Fir trees. The unstripped trunks were shipped from Vancouver Island and put in place with great effort: the highest modules were 192 feet long and had to be felled is such a way so they wouldn't break and so that the bark would show no cracks or missing parts. With the biggest "sticks" it was necessary to use two trucks, carrying the logs in tandem and communicating via radio to avoid sharp turning and possible breakage of the valuable cargo. The entire bulk of wood material had to be extracted and shipped from different sites and coordinated to arrive to Vancouver at the same time for the journey to Japan. Thus 250,000 board feet of logs—an amount of wood equivalent to what is required for the construction of two hundred houses, according to the propaganda film produced for the project—were removed from Canadian Forests to be shown as mummies on display across the pacific.

The pavilion was meant to be the tallest wooden structure in the world, but apparently its designers did not go as far as to consider the Japanese building code, which demanded a steel structure for such tall buildings as a measure against earthquakes and typhoons. And so, the logs were attached to a conventional structure to "give the appearance of a gigantic sculpture in wood"—and "give an appearance" is precisely the term to be used, since on its way to Japan the pavilion was transformed from a potentially innovative structure to a cladding operation more fitting to a frontier-era balloon-frame house or a Las Vegas hotel facade.

Illustration for the British Columbia Pavilion for Expo '70 in Osaka

Construction: Assembling the British Columbia Pavilion

Construction: Assembling the British Columbia Pavilion

The designers and industrialists sponsoring this operation may have had innovation in mind, but it's clear that against the background of the futuristic, ephemeral, techno-optimist architecture of Expo '70 the British Columbia Pavilion appeared as an archaeological relic, which indeed it was: a building conceived and designed by the standards and mindset of industrial production, which the Expo organizers must have considered anachronous with their forward-looking ambitions.

This building is perhaps not much more than a footnote in North American wood architecture, but it is quite telling in regard to the potential interactions between forests and architecture, as mediated by an industrial economy. Rarely does this expose itself with such brute force in a built project: normally architecture would be there to envelop greed in aesthetic preferences and at least a pinch of ideology. But in the British Columbia Pavilion these etiquettes were cast aside in favour of a display of the capitalist reinvention of the province. John Cunningham, of the company who consulted on the design, said that "British Columbia cannot be expressed in terms of a building—it is an environment . . . that makes us what we are." The piece of BC forest making an appearance in Osaka was a very selective version of this environment, presented as a monocultural, Indigenous-free resource wonderland of eternal promise, ripe for the taking. This snapshot might as well have been taken in 1871. The tout was channelled by the idiosyncratic architecture of the pavilion, which unintentionally exposed the fact that spatial design and forests, at least in Western cultures, were often at odds with one another.

This relationship was never easy, partly since architecture has its beginnings in the eradication of vegetal life. Architectural theorist Sylvia Lavin reminded us in a recent article that plants and plans (in the architectural sense) share etymological homology as planta and pianta, while resonating a historical cleavage: at that moment in the fifteenth century, "new buildings and living organisms, like young trees and seedlings, were implanted in the Earth because that was where they were understood to grow and propagate . . . architecture was itself a plant." But as the modern discipline of architecture was enshrined in the writings of Leon Battista Alberti, the abstractions of plans that were to become buildings, often drawn directly on the ground, pushed actual plants off the site and out of mind. Six hundred years later, this fundamental resentment is safely in place, with the mainstream of architecture still struggling to figure out whether trees are friends or enemies.

Fifty years after Osaka, the British Columbia Pavilion seems even farther removed from our age of ecological consciousness, in which the architecturally cultivated consider the sourcing and life expectancy of materials in their designs. But we may want to ask whether stacking trees on buildings as vertical forests or shipping CLT panels across borders really challenge our cultural preconceptions about the forest and the role it may play in our societies. Before we can alter the disastrous course of exploitation, expulsion, and extinction that is taking its toll on the well-being of the humans, plants, and animals that live in and around woodlands, we need to change our own projections. The forest is not a thing in the world, but has always been a human construct. In other words, we need to remake the story of our environment in order to redesign our survival.

NOMINAL VERSUS ACTUAL: A HISTORY OF THE 2x4

Originally published in Harvard Design Magazine 45.

Oliver J. Curtis
Boston Architectural College, Faculty of Landscape Architecture
Instructor, Information Design

"The ubiquitous lumber product known as the 2x4 does not, in fact, measure two inches thick by four inches wide. The naming of this building material is the result of compromise between forestry technology, species' properties, forest composition, transportation efficiency, construction speed, and price competition."

Part of uncleared land on farm, Boundary County, Idaho, 1939.

The ubiquitous lumber product known as the 2x4 does not, in fact, measure two inches thick by four inches wide. The naming of this building material is the result of compromise between forestry technology, species' properties, forest composition, transportation efficiency, construction speed, and price competition. To accurately reflect its dimensions, the 2x4 should be renamed the 1½ x 3½.

An obsessive concern for material efficiency in the United States, the dominant global user of light-stick framing (also known as 2x4 stud construction), has driven the use of the 2x4 and its resultant commodity homogenization. Before industrialized wood production, which began around 1870, trees were felled, skidded, sized, and made to order for carpenters. Sizing tolerances varied, thus leaving final measurements to site construction. Trees were grown and used locally. North American forests seemed an unlimited resource for almost everything. As trees were harvested, however, human ecology transformed forestland into farmland with landscapes deforested for many generations to come.

Available forestland, therefore, moved toward the hinterlands as nearby areas were cut over. Supply and demand concentrated around the major port cities of New York, Baltimore, Boston, and Philadelphia. Prime forestland—determined by tree size, species type (originally and exclusively white pine), and access to transportation—was changing. Trees were floated out of their watershed, breaking the link between lumberman and carpenter. Rivers, canals, and lakes, made Bangor, Albany, and Chicago wholesale timber capitals. With the advent of the railroad in the nineteenth century, transportation options and demand for wood increased. Lumbermen purchased vast areas of forestland in the north, south, and west of the country. A new phenomenon was born: species intermingling at market.

Competition occurred among regions, or more fundamentally, among species. For example, southern pine forests called "pineries"—consisting of shortleaf pine, slash pine, longleaf pine, loblolly pine, and other less common species (collectively known as southern yellow pine, SYP)—were pitted against western Douglas fir, western hemlock, and spruce forests. Buyers needed convincing to purchase lumber from unfamiliar species, and hence marketing focused on differentiating attributes such as ease of use, workability, strength, load capacity, and grain movement. The phenological and physiological variability among species was influencing purchase economics.

At the turn of the twentieth century, lumber was commonly sold FOB—free on board, with the purchaser responsible for shipping—as it is today. According to the US Department of Agriculture's "History of Yard Lumber Size Standards," shipping charges, determined by distance traveled and weight, doubled the cost of lumber. Thus, the physiological variables of density and moisture began to have an outsized impact on forestry economics. Lumbermen favored thinner, lighter sizes for longer hauls. They produced optimal finished sizes of preferred species by kiln drying to control moisture content. And they influenced manufacturers' associations to prescribe commercially advantageous sizing rules. The 1909 textbook Construction Superintendence acknowledged that lumber classification was "a matter of judgment" and cited lumber inspection rules for three areas that they considered to be major centres: Saginaw (west), Maine (east), and Baltimore (south).

Defense houses under construction. Wheeler Dam Village, Alabama, USA, 1941.

Other factors also drove the market toward smaller sizes. The same steam engine technology that powered the railroad, for instance, enabled the newly invented circular saw to achieve faster, continuous cuts in the sawmill. This development coincided with the mid-nineteenth-century evolution of building framing—from timber-braced to light-stick balloon and its derivatives—which progressively utilized greater amounts of "small dimension stock," like 2x4s. And the differences in how lumber was sized, surfaced, and dried became apparent in the lumberyard, where a medley of species in various dimensions claimed to be 2x4s. Lumberyards demanded uniformity so that builders could compare cost and quality. As retailers clamored for more regulated measurements and standards, trade associations were formed.

In April 1919, attendees of the first American Lumber Congress called for size and terminology standardization. However, disagreement about specific considerations persisted for decades. In the meantime, demand for ammunition pallets and crates during World War II created lumber shortages. Postwar housing required even more lumber. Foresters and economists faced pressure for maximum utilization. Engineers promoted light-stick framed construction with plywood sheets (and later oriented-strand boards) because it used smaller sticks efficiently. The limited availability of lumber and the rapid pace of housing construction made other methods like concrete-block housing viable. This pressured further compromise because thinner 2x4s were a way to compete in price with wood alternatives. Size standards, maximum moisture content, and nomenclature were agreed upon only as recently as 1964. The nominal 2x4 thus became the actual 1½ x 3½ imperceptibly, a fraction of an inch at a time. It was a 34 percent reduction in actual volume; as those in the trade would say, it's "selling air."

Today, everyone in the construction industry knows that nominal size is not actual size—despite the fact that the 2x4 designation persists in the marketplace. So, why does awareness of the "slimming" of its actual size matter? For one, we must dispel any notion that the current size is a perfect utility equation of structural performance in terms of strength-to-size ratio. Instead, let's recognize that the evolution of the 2x4 resulted from economic compromise based on simplifying differences and creating a nationwide standard for customers. It is utility optimized for construction speed—speed in shooting together the single-family light-stick stud homes that represent more than 90 percent of the residential housing market.

As we search for alternatives to this construction logic, such as timber stacking, hybrid wood-concrete composites, and cross-laminated timber, we should also challenge our adherence to the actual 1½ x 3½ and its shelf-space edge. To recognize this constraint is one way to discover ecologically motivated systems with better impacts on society. Perhaps we should return to a species-based synthesis of growth, harvest, usage, and aesthetics. This type of approach unifies forestry and architectural practices toward a new coherence of words and actions.

Stacks of lumber from the sawmill that will be converted into dimensional pieces in the mill. Dailey, West Virginia, USA,1941.

THE REFORESTATION IMPERATIVE

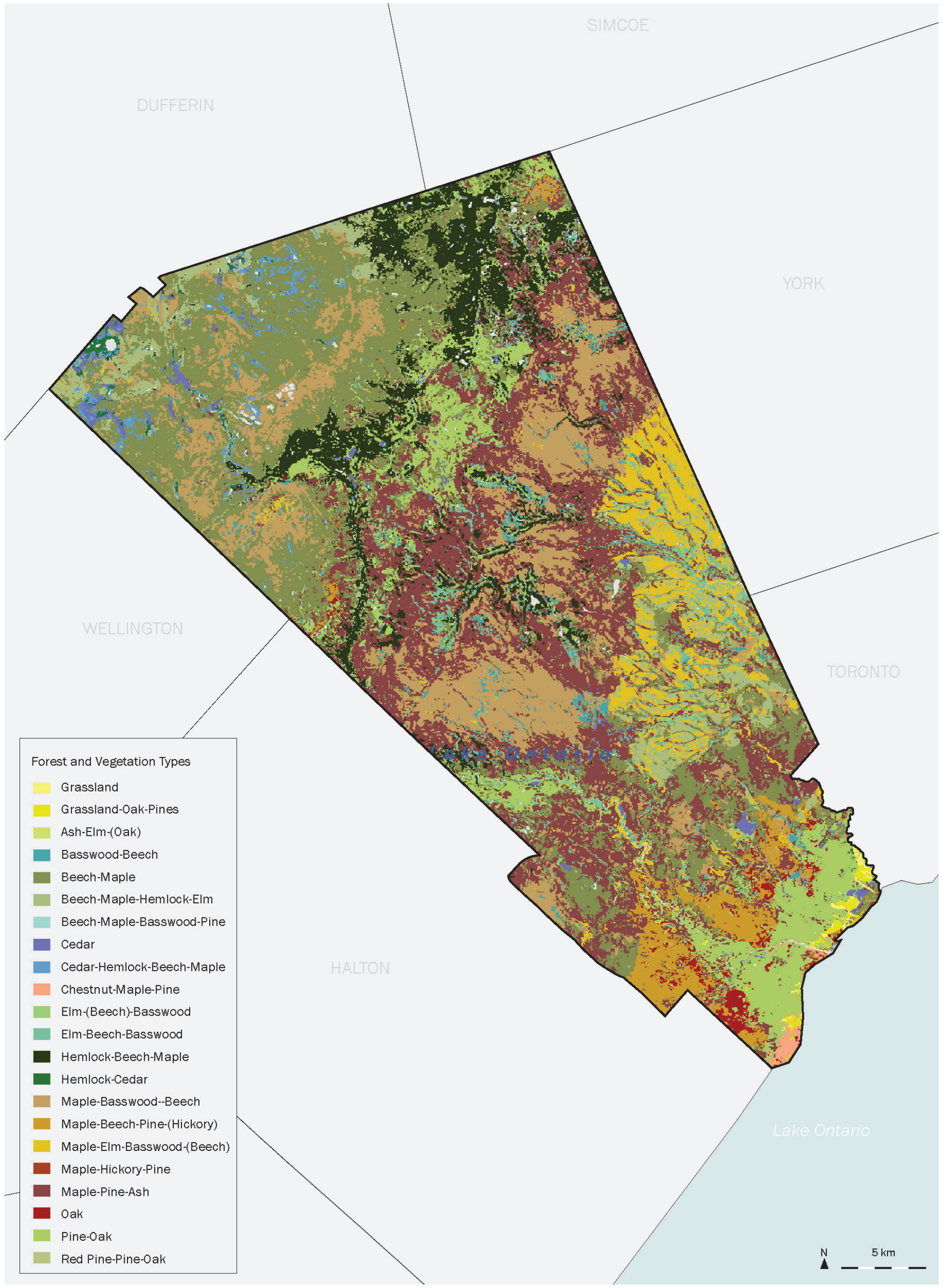
Dr. Danijela Puric-Mladenovic
Institute of Forestry and Conservation, University of Toronto
Professor

“Every woodland patch in Southern Ontario is shaped by the natural environment and two centuries of intensive land degradation, and various anthropogenic and biological impacts.”

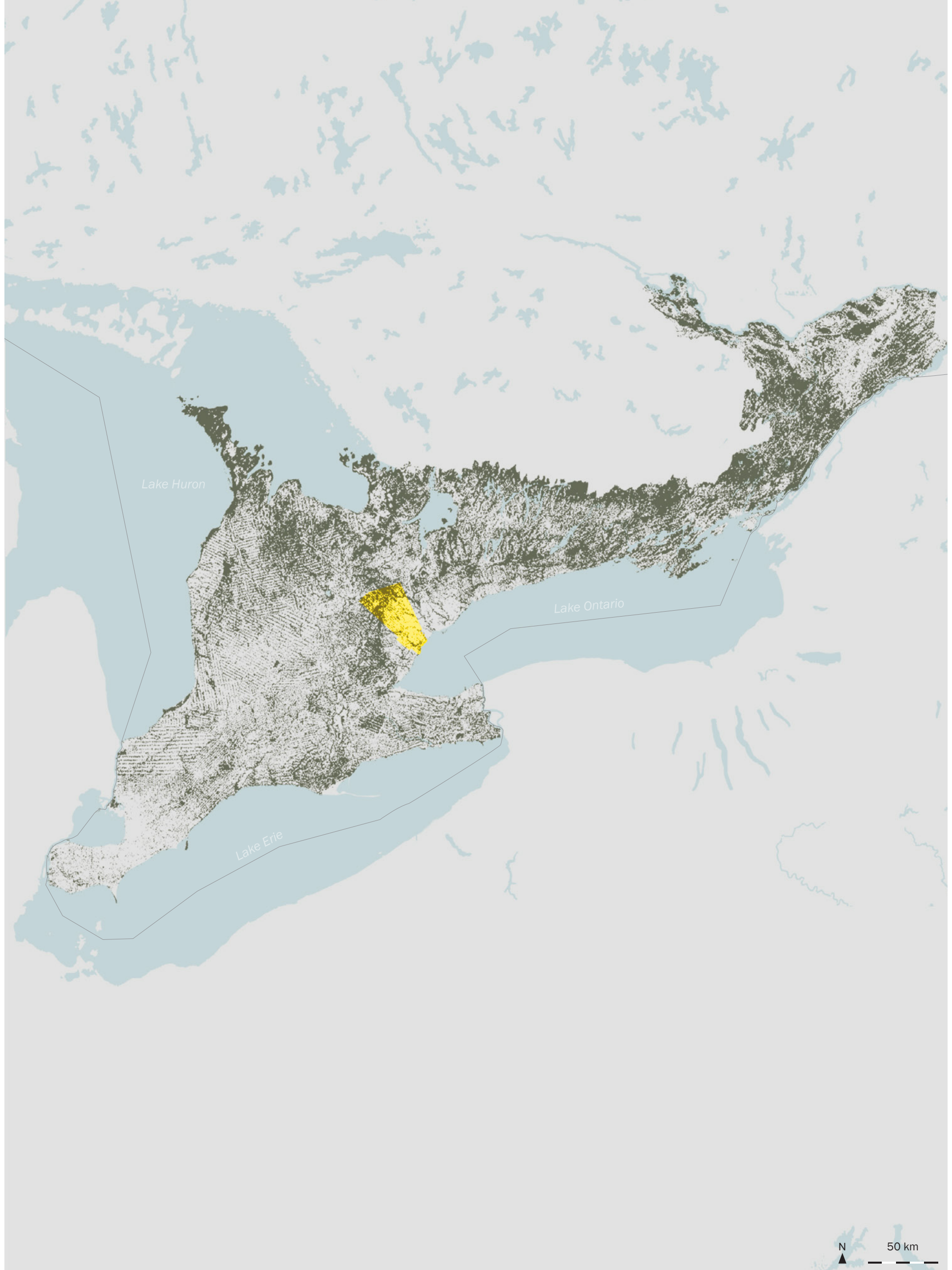
As the most southern tip of Canada, Southern Ontario, with its milder climate and productive soils, has the most diverse flora and fauna in the country. The region is situated where the northern edge of the Carolinian forest and the mixed forest region meet, resulting in diverse natural vegetation and forest types. These favourable natural conditions, proximity to Lakes Ontario, Huron, and Erie, and accessibility to waterways have made this region attractive to human settlement for thousands of years.

In this region, the Indigenous peoples practiced agriculture, tended, and managed the forests and lands using fire. Their activities promoted oak and pine forests, while successional forests were quickly taking over their abandoned fields. Despite their developed agriculture, most of the land was forested, and the First Nations' influence on the land and forests was recoverable. After the first contact with Europeans, the Indigenous populations declined, their impact on forests diminished, the land recovered, and by the late eighteenth and early nineteenth century the forest canopy had closed. Before the European settlers' massive land clearing, Southern Ontario was blanketed by continuous forest cover that ranged from 80 to 90 percent, depending on the area. Natural forest cover was ample and diverse. Within the mosaic of upland, lowland, and swamp forest types, the early successional forest made up about 5 to 8 percent of forest cover. Within this treed, diverse landscape marshes were interwoven in lower, slow draining sites and areas bordering water bodies, where it was too wet for trees to grow. Prairie savanna openings, indicating past fire disturbance, occurred on sandy soils and closer to the lake shores.

The first settlers cleared the rich and diverse forests to make room for farming. The initial deforestation included tree cutting, burning, and girdling conducted first to clear the land along roads, around the home, and for agriculture. Trees, as additional readily available revenue, were cut down for timber. The most valued tree species for squared timber were pine (Pinus spp.) and oak (Quercus spp.), and to a lesser degree species such as rock elm (Ulmus thomasii), ash (Fraxinus spp.), basswood (Tilia americana), butternut (Juglans cinerea), eastern white cedar (Thuja occidentalis), and birch (Betula spp.). Trees were also cut down to produce potash, tannin, heating wood, fencing, building plank, and corduroy roads (cedar and elm). To meet the demand for wood, many mills were operating in Southern Ontario at



Vegetation of the Region of Peel in the 1800s prior to European settlement



Present-day forest cover in Southern Ontario. The area highlighted in yellow is Peel Region, where extensive forest loss has occurred since European settlement.

the time. However, within a few decades, as the original forest declined, they were closed.

Due to ferocious deforestation, the land was cleared of trees by the mid- to late 1800s, and the once forested landscape became agricultural. While this enabled food production and extra revenue for farmers, deforestation's negative consequences soon became apparent. Deforestation exposed vulnerable soils to wind and hydrological erosion, which resulted in floods, loss of topsoil, drought, the formation of erosion gullies, and stream sedimentation. The disappearance of vegetation and uncontrolled hunting decimated populations of small and large wildlife, bird, and fish populations.

The land was cleared within less than one human generation (or one-sixth to one-eighth of a tree's life span). As a result of evident degradation and signs of biodiversity loss, by the 1880s the first conservation efforts started to emerge, and tree planting was perceived as a solution to environmental problems. However, despite the severe ecological degradation, forest cover loss continued until the early 1920s, at which point massive tree-planting started. At that time, forest cover reached its lowest point, with forest cover across Southern Ontario counties ranging from 5 to 25 percent as about 90 percent of the forest encountered by the first European settlers vanished.

Environmental and forest degradation resulted in farm abandonment and had economic consequences. Growing ecological and economic crises finally prompted the establishment of the large-scale tree planting program of "agreement forests" in the 1920s. Besides being the first forest restoration and conservation effort, the Agreement Forest Program was also a foundation of forest stewardship and of the conservation-minded forestry profession in Southern Ontario. As a legacy of afforestation efforts that lasted from the 1920s to 1990s, forest plantations make a considerable component (7 percent) of forest cover. The program's legacy, tree plantations, fulfilled their function of saving the land and stopping erosion. Properly managed pine plantations (such as Simcoe County and York Regional Forests) have provided habitat for native flora to return and have been succeeded by deciduous forest. They also offer various ecological and recreational services as well as wood forest products.

The government-led afforestation effort and natural forest succession on abandoned and nonproductive agricultural soils enabled Southern Ontario's forest cover to increase after the 1920s. However, the expansion of forest cover from about 10 to 12 percent in the 1920s to the present 26 percent took a century. The existing forest of Southern Ontario is comprised of numerous forest fragments spread out across mainly private and minor public lands.

As much as they have been shaped by the natural environment, every woodland patch is also a product of two centuries of intensive deforestation, forest use, and associated anthropogenic and biological impacts. About one-third of the existing forest cover consists of remnant woodlands residing on land that was never cleared of forest. Despite that, they survived land clearing; they were high graded and managed for a specific purpose (e.g. sugar maple tapping, firewood) and have a less diverse species composition and structure. Besides, introduced pathogens decimated valuable and iconic species such as American chestnut (Castanea dentata) and American elm (Ulmus americana). The woodlands have also suffered from the decline in the abundance of mast-producing tree species such as red (Quercus rubra), white (Quercus alba), black (Quercus nigra) and bur (Quercus macrocarpa) oaks and American beech (Fagus americana).

The rest of the existing cover (about two-thirds) consists of secondary growth forests and plantations. These forests were either self-established or planted on abandon agricultural and marginal lands. Suppression and lack of natural disturbances (e.g. fire, passenger pigeons, beaver) have favoured forests dominated by red maple (Acer rubrum), white ash (Fraxinus americana), green ash (Fraxinus americana), eastern white cedar, and trembling aspen (Populus tremuloides). In these early and mid-successional forests, ash trees have been killed by the invasive Emerald Ash Borer. Cumulative combinations of historical, recent, and present impacts are only amplified by climate change and anthropogenic disturbances. Altogether they have made the forests less resilient and turned their compositional and growth dynamic into unknown discretion.

FROM SUPPLY CHAINS TO DISTRIBUTION LOOPS

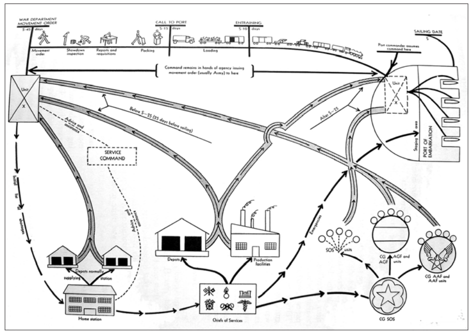
Dr. Jesse LeCavalier
Daniels Faculty of Architecture, Landscape, and Design
Associate Professor

"Recovering a role for an architecture of industrial production requires shifts in values and an assertion that the labour, energy, and material that go into the manufacturing process be recognized and equitably accounted for."

To consider sites of production is to also consider sites of extraction, processing, distribution, and consumption. Indeed, contemporary questions of manufacturing are questions of logistics, in which a comprehensive view of the "supply chain" understands a product as a temporary form along a trajectory from raw material to entropic decomposition. While the phrase has become commonplace, the metaphor of the supply chain was first used in a Booz-Allen report to describe "the sequence of events that occurs from after the procurement of raw material through to delivery to the final customer." By contemporary standards, this definition might seem quaintly circumscribed. With the advent of the so-called "logistics revolution," management of the supply chain has become far more comprehensive as it assesses total life cycle as far upstream and downstream as possible.[1] For some products, this cycle is short—consumer electronics with built-in obsolescence, for example. For more durable elements, including building products, the life cycle might be longer. But regardless of duration, contemporary sites of manufacturing are likely distributed, specialized, and mechanically augmented. Part of this decentralization is connected to a change in paradigm pioneered by Toyota's just-in-time (JIT) production. Rather than manufacturing a given quantity of goods and then "pushing" them on to potential consumers, JIT allows consumer demand to "pull" the process forward. This results in less backstock and less waste but requires careful coordination throughout the process.[2] To understand the spatial implications of this shift, consider the Ford Motor Company's vertically integrated River Rouge plant, in which all aspects of production happened in the vicinity of the complex: raw materials in one door; completed product out another. With JIT production, a factory might be better thought of as an assembly facility as it brings together intact subcomponents and would very rarely be involved with the transformation of raw material.

While the JIT model dis-integrates spatially, it requires an ever more tightly integrated distribution network. Intertwined advances in logistics technologies and in permissive economic policy have made it possible for firms to exploit imbalances in quality of life expectations leading to the distributed and highly uneven and inequitable factory system.[3] Jason Moore has described this tendency through his assessment of the "four cheaps" that make global exploitation possible: food, energy, raw materials, and human life.[4] Images of these distributed areas of production can seem elusive, in part because of a general Global North blindness to sites of labour in the contemporary imagination. Moreover, it is rare for a contemporary factory to receive the design considerations once afforded industrial production. Architectural attention seems to be increasingly evident in sites of control rather than manufacturing sites exactly because there are no longer single sites of production. For example, Foster and Partner's Apple Park offers an easily digestible image when compared to the generic and anonymous forms of any given Foxconn plant even though the latter is more significant in terms of the company's impact.[5]

Recovering a role for an architecture of industrial production requires shifts in values and an assertion that the labour, energy, and material that go into the manufacturing process be recognized and equitably accounted for.[6] One place to start could be to focus on the natures of logistics and on the ways the inequities of logistics are naturalized through the language of material "flow." Likewise, the metaphor of the "supply chain" shifts focus away from issues of distribution and suggests that the process is linear and tidy when in fact it is entangled and excessive. If we thought instead in distribution loops, we might accept the messiness of the process and admit that "leanness" is a myth that perpetuates cruelty. These distribution loops could offer approaches to production informed by a logistical imagination but not governed by one and in the process assert the necessity to reclaim sites of production as worthy of design.[7] By helping to envision these worlds, architects and urbanists can facilitate the enrollment of the policy leadership necessary to change value paradigms in industrial production.



Procedure for Equipping a Typical AGF Unit for Overseas Movement: February 1943—a topological depiction of the space of logistics. Source: James A. Huston, The Sinews of War: Army Logistics 1775–1953 (Washington, D.C.: Office of the Chief of Military History, U.S. Army, 1970), 503.

Notes

1. Keith Oliver, quoted in Arnold Kransdorff, "High Stock Levels—Not the Answer to Volatile Demand" Financial Times, Friday 4 June, 1986.
2. James P. Womack, Daniel T. Jones, and Daniel Roos, The Machine That Changed the World: The Story of Lean Production—Toyota's Secret Weapon in the Global Car Wars That Is Revolutionizing World Industry (1990; repr., New York: Free Press, 2007).
3. Deborah Cowen, The Deadly Life of Logistics: Mapping Violence in Global Trade (Minneapolis: University of Minnesota Press, 2014).
4. Jason Moore, "Anthropocene or Capitalocene? Nature, History, and the Crisis of Capitalism," Sociology Faculty Scholarship (2016), 24.
5. See for example, Stefan Als, ed., with Paul Chu, Alexander Garvin, Claudia Juhre, Casey Wang, Factory Towns of South China: An Illustrated Guidebook (Hong Kong: Hong Kong University Press, 2012). Likewise, Athena Do's treatment of Tesla's operations in Nevada: Athena Do, "Language of Efficiency: A Misreading of the New Industrial Era," Avery Review 46 (April 2020), http://averyreview.com/issues/46/language-of-efficiency.
6. See The Funambulist, no. 33: "Spaces of Labor," January/February 2021.
7. There are examples of work in this area, including Nina Rappaport, Vertical Urban Factory (Barcelona: Actar, 2016) and Robert Lane and Nina Rappaport, eds., The Design of Urban Manufacturing (London: Routledge, 2020).

03

“The Mass Institute believes that more interdisciplinary research is required in the areas of sustainability and society; building science and constructability; Indigenous participation and reconciliation; manufacturing, design and supply chain; trade and export diversification; and analytics and data synthesis.”

WOOD ETHICS

Dr. Anne Koven
Daniels Faculty of Architecture, Landscape, and Design, Adjunct Professor
Mass Timber Institute, Director

The Mass Timber Institute, which is located within the University of Toronto’s John H. Daniels Faculty of Architecture, Landscape, and Design, aims to help position Canada as a global leader in mass timber research and education and in the export of sustainable mass timber products and building systems. These ambitions will succeed only if the nascent Canadian mass timber industry is built on forest sustainability.

In Canada, the forest industry has a complex political, economic, and environmental history. Harold Innis, the great Canadian political economist and historian, was critical of Canada’s historical reliance on natural resource production and export for limiting us to being a country of “hewers of wood.” Canada, however, has prospered from its natural resources for four hundred years; government revenue from forestry built our hospitals, schools, and public buildings, and forestry remains a major exporter, an economic lifeline for northern communities, and a job generator in southern Canada. The forest industry has long attempted to add value to lumber and pulp and paper and it is making headway in this transformation. Mass timber is a test case today for innovating: can Canada manufacture mass timber products from our lumber? The alternative, using cross-laminated timber as an example, is for some of our lumber exports to the United States to be sold back to us as expensive imported products.

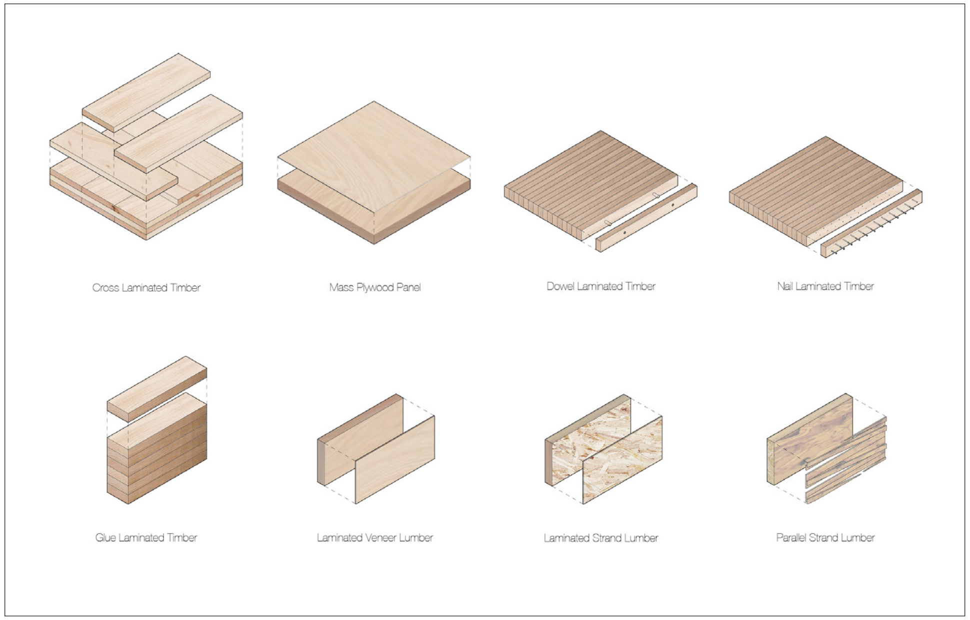
The term sustainability has many meanings: businesses use it to describe their growth, universities to describe their fundraising campaigns, climate scientists to question an uncertain future. Sustainable forestry is concerned with scientific evidence and forest industry practices resulting in healthy, productive, perpetually regenerating forests with protected areas. In Canada there is an argument to be made that there is a surplus of sustainable wood supply available for new mass timber manufacturing.

In Canada over the past thirty years, the broader forest sector, including the industry, government, academic, environmental, and conservation organizations and the professions, have contributed to the development of a unique

BC Passive House Factory by Hemsworth Architecture

sustainable forest management regime supported by legislation. In Ontario, for example, the 1994 Crown Forest Sustainability Act and its associated environmental assessment approval required forest management planning to evolve from a historical focus on timber to a more ecological one that recognizes the importance of biodiversity and non-timber forest values and users. Recent changes by Premier Ford's government to privilege the forest industry over other forest values, such as endangered species, are concerning, but it is too early to understand the implications. A backstop to the political decisions made about forests is that sustainable forest management planning requires the participation and approval of registered professional foresters who are required by law (Professional Foresters Act, 2000) to consider the public interest in Ontario's forests.

What does this have to do with charrettes? Architects, designers, and engineers now need to consider enhanced and public scrutiny of their choice of construction products. The contemporary interest in sustainability and construction is associated with the environmental ethics of the professionals and their clients and global concern about climate change. Building construction and operation, criticized as being among the biggest carbon emitting industries globally, as well as intensive energy and water users, need greener construction materials and processes. Mass timber provides one solution for mid- to high-rise buildings given its low carbon characteristics and structural capacities compared to concrete and iron and steel. Architects need to be informed about mass timber construction and embodied carbon when working with municipal initiatives such as the City of Vancouver's Zero Emissions Building Plan or applying to building code approvers who might be concerned about fire and mass timber. Architects will also be put to the task of responding to the details of the sustainable certification of the mass timber and other wood products they use.



Various mass timber products available on the market

The Canadian Wood Council and its WoodWORKS! program and FPInnovations, funded by government and the forest industry, are two organizations that have been successfully promoting mass timber for more than a decade. The Mass Timber Institute thinks, however, that the pace for growing the Canadian mass timber sector needs to be accelerated. Education of architects, designers, and engineers in mass timber is urgently needed, and this requires more participation by universities and colleges, beginning with our academic partners, as well as government and industry.

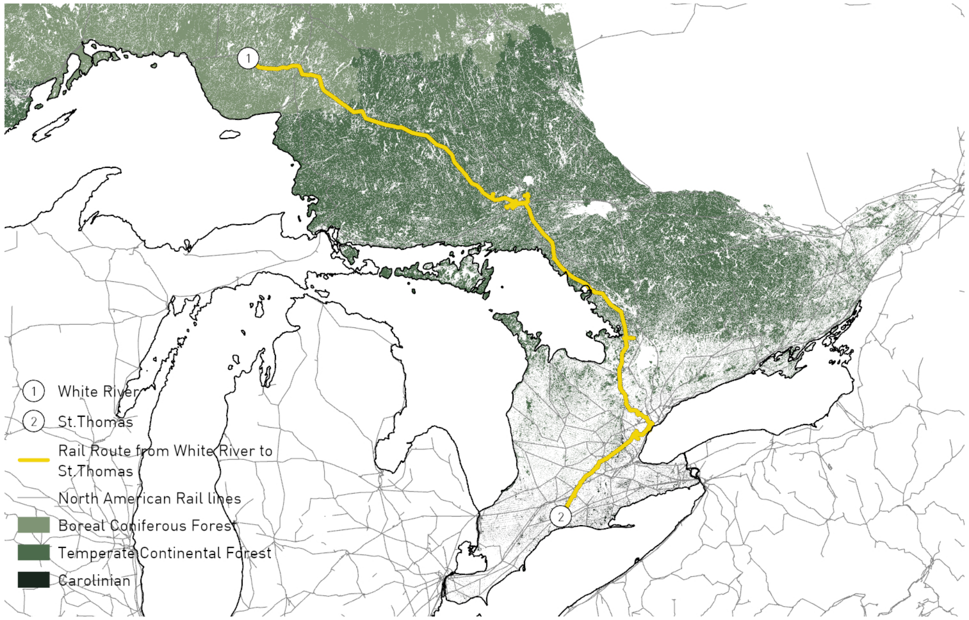
The Mass Timber Institute believes that more interdisciplinary research is required in the areas of sustainability and society; building science and constructability; Indigenous participation and reconciliation; manufacturing, design, and supply chain; trade and export diversification; and analytics and data synthesis. Sustainable forestry engages with Indigenous participation in the Canadian context of Aboriginal and treaty rights and the Truth and Reconciliation Committee's calls to action. One of the Mass Timber Institute's partners, the Whitefeather Forest Initiative, is pursuing a mass timber enterprise with its forest tenure.

The University of Toronto will be reviewing a proposal from the Mass Timber Institute for an interdisciplinary mass timber Institutional Strategic Initiative, which would make it the first North American university to do so. The University of Toronto is exceedingly well-positioned to bring together academic excellence, sustainable forestry, and Canada's largest construction market.

INCITING A MASS TIMBER REVOLUTION

Patrick Chouinard
Element5

"Canadian-owned and operated mass timber fabricators have recently joined the mass timber market. With their introduction comes the opportunity to source mass timber products sustainably and locally, to manufacture high performance wood components and buildings."



The railway route used by Element5 when transporting lumber from White River Forest Products in White River, Ontario, to the CLT factory in St. Thomas, Ontario.

The Mass Timber Revolution

The construction industry is the midst of a revolution with far reaching industry, social, political, and economic implications; it is characterized by buildings that are manufactured off-site and rapidly assembled on-site. In the face of a growing carbon crisis and irrefutable evidence of climate change, we must do everything we can to reduce the carbon footprint of the built environment. In comparison to other building materials, wood has both lower energy consumption and carbon emissions.[1]

A Changing Industry Dynamic

The shift to wood-based off-site manufacturing is potentially as transformative to the construction industry as automation was to the automobile industry. It is an entirely new design, delivery, and construction paradigm accompanied by positive environmental impact. Owners captivated by the increased profit potential of mass timber construction have few options but to contact mass timber manufacturers directly. Such conversations place manufacturers in a powerful position. Manufacturers, who traditionally sat pooled as commodity suppliers at the bottom of the design hierarchy, are now able to orchestrate solutions and in fact hire or influence which architects, engineers and other consultants participate in projects.

No two manufacturers in North America make the same-sized CLT panel. Projects that are designed to make optimal use of a particular manufacturer's product specifications can typically achieve considerable savings by early engagement with the manufacturer. Larger CLT panels, for example, can impact grid sizes and reduce the number of picks during assembly, thereby increasing the speed of construction. Manufacturers are now engaged at the beginning of the design and engineering process. For owners and developers truly committed to pursuing wood, this encourages closer working relationships with vendors. It is these close relationships that help fuel innovation. Manufacturers gain valuable insight into the problems and challenges from the architect's perspective.

Like any material, mass timber has certain inherent limitations. Attempting to span a very long distance between supports with CLT floor panels or glulam beams alone is materially inefficient and can be cost prohibitive. In clear spans beyond nine metres, concrete and steel alternatives are often more cost effective. Few value-added products exist in the industry to complement mass timber solutions, but this challenge can be overcome with innovation. One such mass timber innovation is the hollow core CLT or Boxx Panel. A Boxx Panel is stronger and lighter than CLT. It is composed of engineered joists or glulam beams sandwiched between two thinner CLT panels. This engineered wood panel is able to span longer distances in a way that is materially efficient and cost-competitive with concrete and steel.

Opportunity also exists for products like CLIPs (Element5's Cross Laminated Insulated Panels), which are high performance, primarily plant-based facade panels prefabricated off-site, with an interior CLT layer, ideally wood fibre insulation, paper-based cladding like phenolic panels, and eventually windowpanes made of wood fibre. CLIPs are designed to quickly and cost effectively enclose wood, concrete, and steel buildings.

Success and leadership in the mass timber revolution requires continuous innovation—research, development, testing, certification, the creation of new products that overcome challenges, and solutions that capitalize on opportunity.

Change Is Not without Challenge

The mass timber industry currently faces many challenges. These include common misconceptions like "wood is not strong," "it won't last," and "it burns." Such misperceptions, for example, inflate construction insurance premiums for wood buildings to as much as ten times those of conventionally constructed buildings. Faster construction timelines for wood buildings may shorten the period for which this insurance is required, but the significant and unfounded disparity remains.

White River Forest Products is a community-operated sawmill in White River, Ontario. The local forest pictured here is processed into lumber, some of which is transported to Element5's CLT factory in St. Thomas, Ontario

Few architects, engineers, and contractors know how to design, engineer, and assemble mass timber buildings. To manufacture anything, Element5 had to become both professional service provider and contractor to support projects from early-stage design to assembly. Quantity surveyors and tradespeople unfamiliar with mass timber add a risk factor to their estimates to compensate for the unknown which unnecessarily drives up the comparative cost of wood over concrete and steel. Employees with skills and experience in mass timber must be hired from afar.

In addition to lack of experience and education, the construction industry is resistant to change. The current players resort to existing methods to generate profit. It takes time, energy, and effort to learn new things and most people, most professionals, and most companies are unwilling to make these necessary investments in the short term despite the prospect of higher long-term returns.

Access to local lumber is another obstacle. As mass timber manufacturers, we were unpleasantly surprised to discover that we were unable to buy lumber anywhere in the format necessary to make cross-laminated timber. To overcome this obstacle, Element5 invested millions of dollars in equipment to ensure the use of Ontario wood in our projects. This equipment included a conditioning kiln to dry input materials to the necessary 12 percent moisture content for optimal manufacturing, finger jointing equipment to create lengths of lumber to sixteen metres, and a planer to ensure materials have uniform dimensions.

Locally, the Ontario Building Code is slow to change compared to new technologies for mass timber. In other parts of Canada, building codes permit timber buildings up to twelve storeys. In Ontario, the code limit is six storeys, and even then the use of wood for elevator shafts and stairwells is only permitted through the alternative solutions pathway, which is time-consuming and costly. As long as the Ontario Building Code hinders Ontario's mass timber industry, resources and supplies will continue to be poured elsewhere across Canada and away from Ontario's economy.

Within Canada, key players in the local construction industry would rather source material from out of province or from Europe from established manufacturers than buy locally. Their choice of vendor is strictly a business decision, as there is perceived risk in buying from "the new kid on the block" in Ontario. For the future success of Ontario's manufacturers, industry players must lean into this perceived risk and support local industries.

Ontario Leadership Challenge

Ontario has the potential to be the centre of the mass timber industry in the eastern half of North America. From its central location, Ontario has ready access to the central and eastern United States. St. Thomas is now home to the world's most fully automated mass timber manufacturing plant at 137,000 square feet with an annual capacity to produce 37,000 m3 of CLT and 5,000 m3 of glulam.

Ontario is vertically integrated with strategic ties between the northern forestry industry and southern-based manufacturing. With the devaluation of the Canadian dollar, Americans can purchase Canadian products at an approximate 30 percent discount. The opportunity is at hand for Ontario to incite a revolution and to assume a leadership role in the mass timber industry. However, that requires all key stakeholders—industry, forestry, regulators, government, and educational institutions—to unite.

Fortunately, the education sector in Ontario has taken huge strides toward mass timber leadership in construction. Virtually every major college and University in Ontario has a mass timber building in various stages of design and development. George Brown will build the Arbour, a ten-storey, exposed tall wood structure located on the Toronto waterfront. Centennial College is planning the first zero-carbon six-storey higher-education building at Progress Campus. Humber College is revitalizing their Lakeshore Campus and incorporating mass timber in the creation of a Humber Cultural Hub. Trinity College is building a new mass timber student residence and academic building. The University of Toronto has just tendered its new fourteen-storey Academic Tower.

The Canadian Wood Council is committed to supporting wood-based building education. Their newest program, WoodSMART, supports post-secondary institutions, educators, and students to ensure that future architects, engineers, and construction professionals have up-to-date knowledge and skillsets in the design, manufacture, and assembly of advanced wood buildings.

Individual institutions are also taking it upon themselves to develop new content for their students. This past fall, we were pleased to be part of a new course created by professors Brigitte Shim and Robert Wright for the Master of Architecture and Master of Landscape Architecture programs at the University of Toronto. The design studio called Places of Production: Forest and Factory asked students to design their own landscape and architectural approach to Element5's new plant in St. Thomas. Students were brought right into the heart of what is happening in mass timber, were introduced to numerous industry stakeholders, and gained essential timber design experience. It was a privilege to be part of Brigitte and Robert's design studio, and the students' enthusiasm for wood design and the work they produced was inspiring.

Element5 believes firmly in supporting the education of students and existing practitioners. As mass timber experts, we see it as our role to be ambassadors of mass timber, sharing information and expertise to expand everyone's capacity for wood design. Whether it is a factory tour, cost consulting, design assistance, offering insight on how to efficiently design in mass timber, or speaking about prefabrication and DfMA, we want to help. We believe mass timber construction is the future, and we want as many people as possible to be able to participate in that vision.

Join us. Revolutionize the construction industry. Make a difference. Make a positive contribution to the environment, to communities, and to future generations.

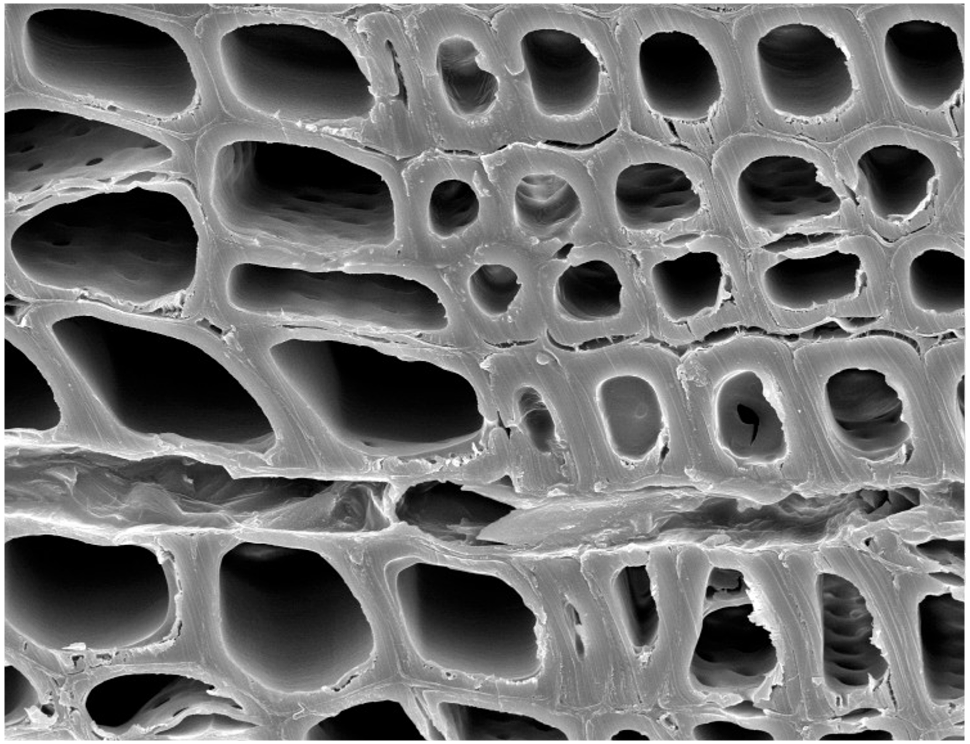
Note

1. Bruce Lippke, Jim Wilson, John Perez-Garcia, Jim Bowyer, and Jamie Meil, "CORRIM: Life-Cycle Environmental Performance of Renewable Building Materials," Forest Products Journal 54, no. 6 (June 2004): 8–19.

GRAND VISIONS & DEVILISH DETAILS: BUILDING A GLOBAL CARBON SINK

Alan Organschi
Regenerative Building Lab, Yale School of Architecture, Director
Gray Organschi Architecture, Principal

"Those same benefits, however, if misapprehended and misapplied, even with benevolent intent, could quickly turn into an alibi for further environmental degradation, transforming a potentially renewable material technology into just one more motive for virgin resource extraction and ecological exploitation, a game-ending scenario for the planet as we know it, for a large share of its human population, and for an array of non-human species."

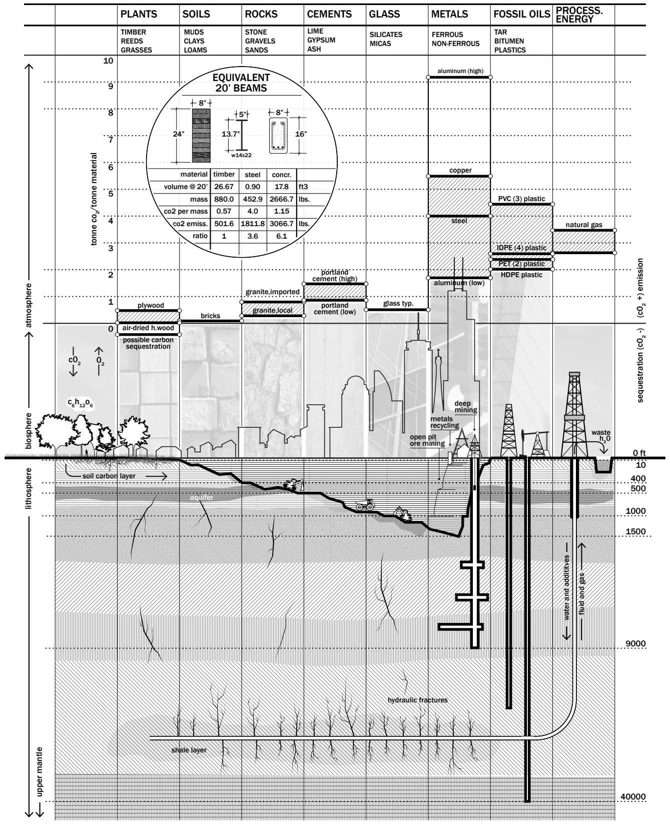


Microscopic view of wood fibre. Tubular cells are responsible for the anisotropic properties of wood

"What is wood, anyway?" my friend and colleague Kiel Moe asked me one day as we were discussing the design and engineering professions' recent fascination with engineered wood and its laser focus on cross-laminated timber as "the product to solve all architectural design challenges" (large and small). Kiel's obviously rhetorical question evinced a concern that some of us who work with bio-based building materials and seek to promote their potential environmental benefits share: we could really mess this up. The trans-scalar character and eco-systemic role of wood (and the forests that are its source) endow this age-old building material with potentially game-changing physical and biological properties that can offer a host of environmental benefits for a planet facing an existential crisis. Those same benefits, however, if misapprehended and misapplied, even with benevolent intent, could quickly turn into an alibi for further environmental degradation, transforming a potentially renewable material technology into just one more motive for virgin resource extraction and ecological exploitation, a game-ending scenario for the planet as we know it, for a large share of its human population, and for an array of non-human species.

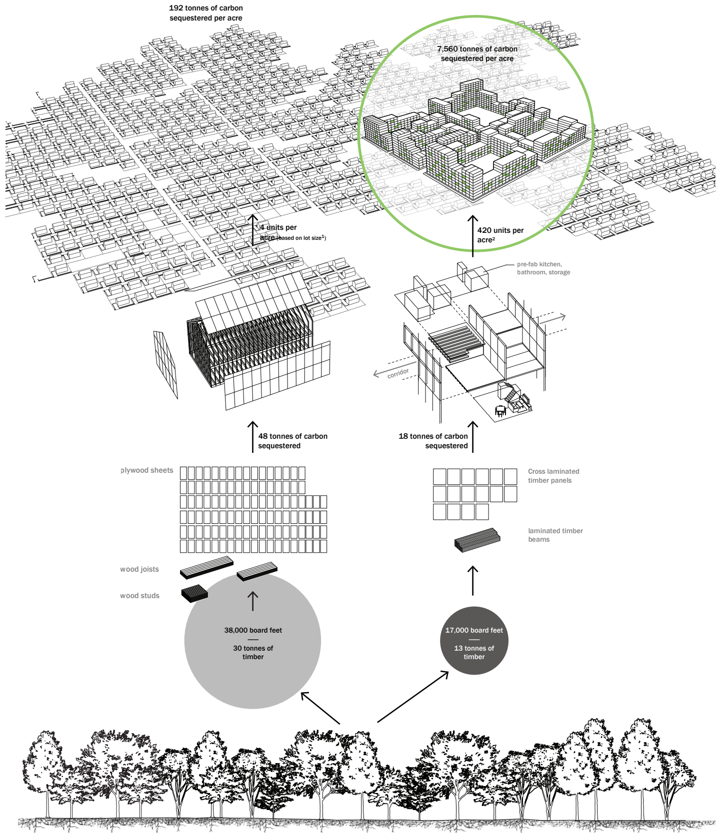
Of course, the question of whether or not we act on the promises of a new, photosynthesized means to materialize human settlement is answered pretty quickly by a glimpse at its more conventional, mineral-based and fossil hydrocarbon–fueled alternative. The convergence of contemporary geo-biological, -chemical, and -physical factors presents a darkening global outlook. Human activity continues to drive greenhouse gas emissions and an ever-steepening climb in atmospheric carbon concentrations. Continental forests, shrunken and degraded by the pressures of land conversion and by climate change itself, are decreasingly biodiverse and generally weakened as a reliable terrestrial carbon sink. In the coming decades, significant population growth and urbanization are anticipated, creating enormous demand for a whole new planet's worth of buildings and infrastructure. Meanwhile the building sector, the very instrument that is needed to meet (and that will potentially profit mightily from) that demand, continues to utilize extractive material, energy, and manufacturing technologies, producing across building life cycles nearly half of all annual anthropogenic GHG emissions. The embodied emissions spike incurred in the production phase of this construction boom will create its own climate forcing, an initial debt that will be amortized only over the course of decades of efficient, "sustainable" operation and that will create an emissions burden at the exact moment that we're attempting to reduce our climatological impacts. Old paradigms of sustainability, adaptation, and resiliency may serve to reduce building sector emissions and avoid some of its most characteristic failures but will fail to reverse the consequences of ongoing and increasing atmospheric disturbance.

Can the confluence of population growth and human consumption be decoupled—at least as a result of our activities as builders—from a corresponding spike in greenhouse gas emissions? What if the physical structure and fibre of the built environment could serve as a repository of atmospheric carbon rather than a significant source of its emission—a storage bank that might offset the impacts of its own production? Buildings are some of the most durable products we make. Cities, and their dense aggregation of large buildings,



Comparing carbon sequestration, emissions, and extractive processes for common building materials

represent the largest global stockpiles of industrialized material that we produce. A recent study conducted by our interdisciplinary team of forest and climate scientists, industrial ecologists, and building designers and engineers suggested that the capacity to store biogenic carbon within the structure of the built environment could potentially be as much as 20 Gt atmospheric carbon while avoiding another 9.7 Gt through the avoidance of fossil hydrocarbon–fueled materials we currently use in buildings (Churkina et al., 2020). A corollary benefit to explore and expand upon is that the scale of wood fibre utilization entailed in such a transition of the building sector could potentially strengthen forest carbon sinks, increasing forest health and resiliency, reinforcing the forest biomes against the vicissitudes of an expanding human footprint and climate change, promoting biodiversity, and offering economic incentives for forest restoration and expansion. The potential benefits to public health are lodged in both the upstream eco-systemic services offered by resilient forests and in the downstream emotional and bio-chemical effects of indoor spaces lined with bio-based materials like wood. An environmentally and industrially synergistic relationship between forest fibre supply and urban building demand is an immediate means of drawing down atmospheric carbon that represents a way to take immediate environmental advantage of what is already, effectively, the sunk cost of materializing new human settlement while avoiding the initial carbon

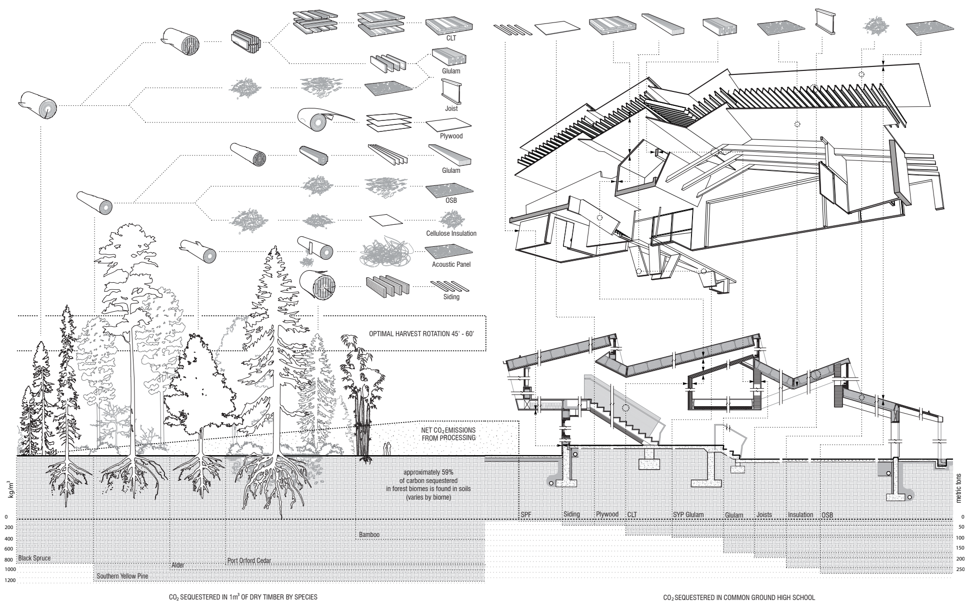


Carbon sequestration potential of mass timber products at scale

spike, significant investment requirements, and unforeseen environmental impacts of nascent mechanical carbon capture technologies.

But the vision of entire urban landscapes constructed out of mass timber functioning as huge storage banks of carbon photosynthesized in regional forests is as simplistic as it is compelling. The mechanisms of that material and molecular exchange are the devil we'll meet in the details: the particularities of varying regional forest ecologies; their proximity to urban demand centres; the species, properties, and processing protocols of wood and cellulose fibre that might be harvested from forests managed regeneratively but with a range of varying objectives—wildfire risk mitigation, soil remediation, increased biodiversity, and disease prevention; and the socioeconomic circumstance of regional forest landownership. These are only some of the challenges to a building industry committed to protecting sunk costs and established practices, a political economy addicted to short-term gain, and a general public suspicious of the motives of big timber and fearful of granting social license to potential agents of deforestation (while ignoring the often remote and unseen impacts of other more conventional forms of raw material extraction and consumption).

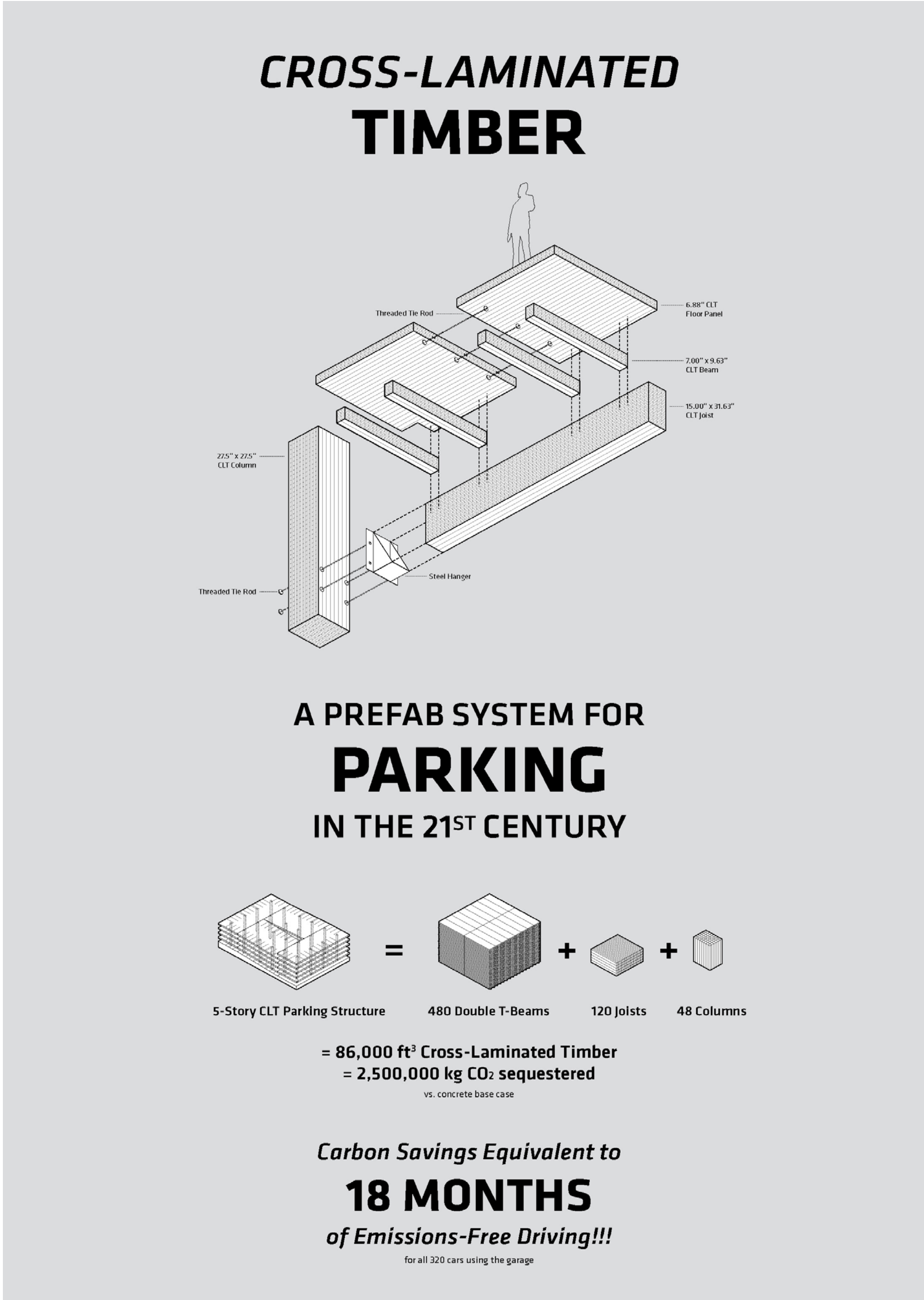
Perhaps most critically, we need to develop system-wide consensus on a reliable method of measuring the true volume of the carbon we



Carbon sequestration strategies in Common Ground high school by Gray Organschi Architecture

aim to manage: carbon remaining in the soils and unharvested stands of working forests; CO_2 emitted during the production phase of new bio-products; carbon successfully transferred into and stored in bio-based building assemblies; carbon emissions avoided in the substitution of biological materials for metallurgical, cementitious, asphaltic, and petroleum plastic ones. Without understanding and agreeing upon the dynamics of those flows, we expose our nascent industry to manipulation and we become the authors of our own misinformation.

With those caveats and cautionary examples firmly established, we can acknowledge that we face a remarkable opportunity. A transition from carbon-emitting building materials and assemblies to ones that can durably capture and hold carbon in reserve over a building life cycle (and, under circular economic policy frameworks, over several building or consumer product life cycles) presents a kind of force multiplier of environmental action: encouraging the use of biologically renewable materials in durable assemblies with policies and economic stimulus that reward it; exploiting the large, monolithic format and prefabricated assembly of mass timber elements in a reversible system amenable to disassembly and material reuse; incentivizing the restoration and expansion of working global forests whose once mighty economic value and the sociocultural measures that once preserved and renewed it have been successively diminished by the remote and omnivorous forces of advanced capitalism and its associated consumer behaviour; revolutionizing a host of bio-based products—nano-cellulose sheets and panels, lignin-based adhesives, rigid insulation formed from wood fibre, transparent and flexible bio-plastics—that will emerge and take their appropriate place in mid- and high-rise urban building assemblies. New economic enterprises and employment opportunities for rural communities disenfranchised by the devaluation of forests and for urban communities locked out of the business-as-usual systems of conventional building delivery would promote social equity and political interdependency. Two global landscapes, the city and the forest, today locked in toxic antagonism, might enjoy a new environmental, as well as economic, symbiosis.



Envisioning carbon sequestration of cross-laminated timber by wood volume

MASS TIMBER PRIMER

Dave Bowick
Blackwell Structural Engineers, Principal
Daniels Faculty of Architecture, Landscape, and Design, University of Toronto, Adjunct Professor

"With mass timber, it seems every project is constructed using a unique structural system. There's an opportunity to go beyond purely pragmatic concerns with mass timber."

Designed by BNKC architecture + urban design with Blackwell as structural engineer, 77 Wade is a seven-storey mass timber office building under construction in Toronto. The building highlights the use of mass timber as a composite construction material.

The most novel architectural material in Canada right now is an old one: wood. But when made into mass timber beams and panels, the age-old material gains structural and fire-resistance qualities that open up new possibilities for construction.

Mass timber construction—which makes use of glue-laminated (glulam) beams and columns with products like cross-laminated timber (CLT), nail-laminated timber (NLT), and dowel-laminated timber (DLT)—is in its early days. With concrete and steel, there are clear templates for commercial construction—the 9 x 9 bay concrete flat slab with 4 metres from floor to floor, and for big box retail, the 9 x 12 bay with steel beams and open-web steel joists.

With mass timber, it seems every project is constructed using a unique structural system. There's an opportunity to go beyond purely pragmatic concerns with mass timber. The uniqueness of the system can become a design goal.

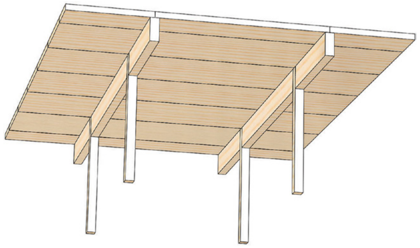
What are the baseline rules of working with this family of materials? Mass timber systems follow inherently different rules than concrete and steel. Square bays are effective when you have a system that has similar strength and stiffness in both directions, but are inefficient with wood, which is necessarily "stick built" with "one-way" elements (elements that are much greater in one dimension than the others, or decks that are much stronger in one direction than the other) stacked on perpendicular one-way elements. Because mass timber systems rely on beams, they are necessarily deeper than slab systems, requiring greater floor-to-floor heights. The beauty of wood, and the cost premium in constructing with mass timber, means that architects and owners often want to expose and express the structure. Fire-protecting exposed wood structures and protecting them from the elements during construction creates design challenges and can be costly.

One also needs to consider construction economics. With mass timber construction, the cost of fibre represents roughly two-thirds of the cost of the structure. Mass timber elements are manufactured off-site in large pieces, often taking advantage of CNC milling, which minimizes both factory and site labour. The impact is that systems that minimize material use may prove economical, even if they result in increased complexity in the system.

As the use of mass timber becomes more widespread, it may become more affordable. For many years in North America, the cost of construction has been dominated by the cost of labour. Current estimates place labour at more than 50 percent of the overall construction costs. When other contributing costs are considered, such as equipment and general conditions, the cost of material in construction represents a relatively small part of the overall budget for a building.

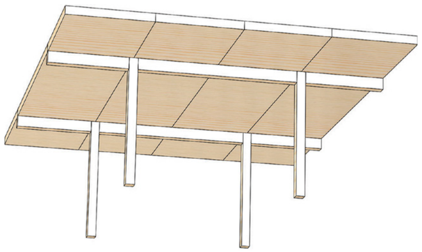
Moreover, the inevitable shift to a low-carbon economy means that those technologies that have the lowest contribution to greenhouse gas emissions will ultimately prove to be the most economical. Wood is a renewable resource that encapsulates carbon. It is part of the solution, rather than part of the problem. The only question is how long this shift will take, and how bad the climate crisis will get first.

In the meantime, opportunities and challenges await the architects and engineers working with mass timber. At the conception of this article, I planned to present the relative merits of a half dozen ways one might assemble a mass timber floor. I quickly realized that there are many, many more than that. Here are a few.



Long Beam Short Deck

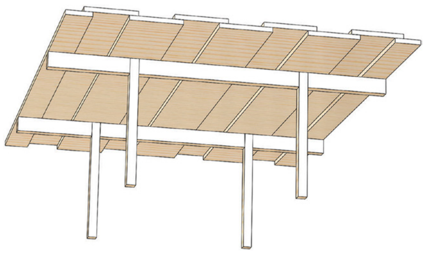
If there were such a thing as a “normal” system in mass timber, this would be it. If you are using a beam and deck system, it makes sense to orient the beams in the long direction and the deck in the short direction, since the beams, being deeper, resist bending more efficiently, resulting in a structural system with less fibre overall. However, this also results in a deep system, so it might not be right if floor-to-floor heights are critical.



Short Beam Long Deck

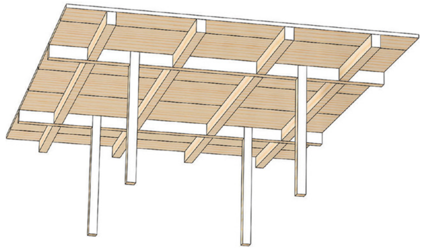
In cases where the floor-to-floor height is critical, it may make sense to orient the beams in the short direction, since this will result in a shallower overall floor system.

Beam and deck systems can minimize beam shadowing in largely glazed buildings if beams are oriented perpendicular to the perimeter walls.



Staggered Deck

The staggered deck system has been used by Michael Green Architects and advanced by Equilibrium Consulting. It consists of two parallel layers of deck—a top deck and a bottom deck—gapped and offset, with a relatively small overlap between the two. The overlap is fastened with diagonal screws in a way that develops longitudinal shear. The impact is that the deck may be thin, as the structural performance reflects the overall thickness, similar to corrugated metal deck or cardboard. It is a means of achieving long spans with minimal material.

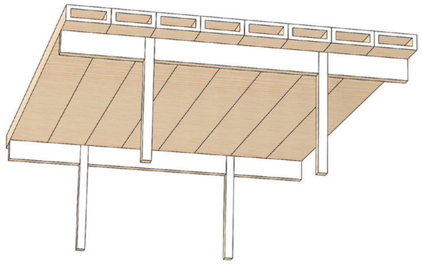


Beams and Girders

A system of beams and girders is a strategy for ensuring minimum cost by keeping the deck as thin as possible. Beams are spaced at the maximum span of the most economical deck. Girders must then be provided to support the beams and transfer load to the columns.

Any system with beams has an impact on the distribution of services and potentially, as a result, on floor-to-floor heights. Providing beams and perpendicular girders further reduces flexibility, although it may generate the most economical structural scheme.

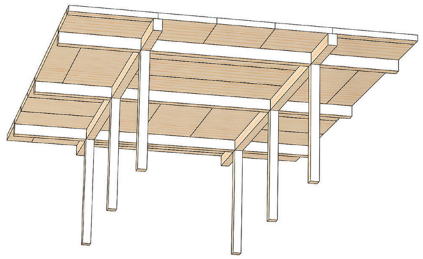
Beam and girder systems result in a greater amount of beam shadowing relative to beam and deck systems.



Cassette

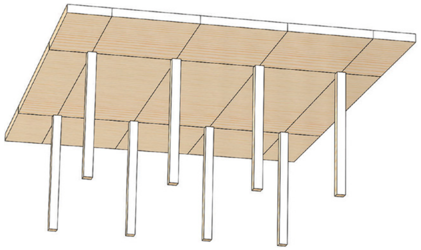
The term “cassette”—literally a box—is used in mass timber construction to describe manufactured assemblies of beams and deck. These are optimized to crane capacity, minimizing the number of pieces to be erected and accelerating construction.

The void may be left open for distribution of services, or may need to be filled to prevent a cavity which can spread fire.



Two-Way Beams

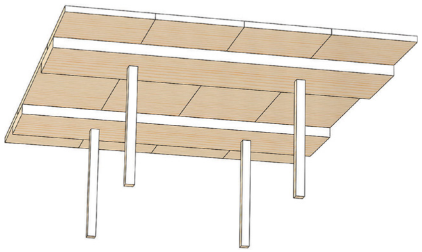
Two-way beam systems are particularly interesting to consider when bay sizes are equal in both directions. By alternating the deck orientation in a basket-weave pattern, the beams in both directions are loaded equally. Each beam receives half the load that it would see in a unidirectional beam system, and as a result, the beams can be smaller and lighter. An advantage of a two-way beam system is that there is no dominant orientation, which may have a beneficial impact on space planning.



Point-Supported CLT

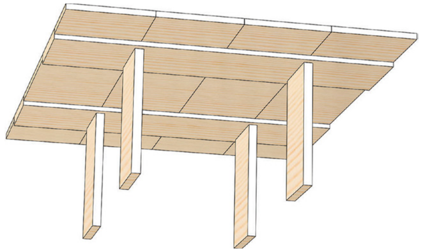
A two-way, point-supported CLT framing system takes advantage of the two-way bending strength of CLT to eliminate beams altogether, creating an extremely thin floor system. In particular applications, this can be a tremendous benefit.

Fire is also particularly challenging. After about 1½ hours, you have burned through two laminations of the CLT in a five-ply panel. This leaves only two laminations in the strong direction and one lamination in the weak direction, which may not sustain the fire load case. Thus, CLT used in this manner will often have to be encapsulated in drywall for fire protection, concealing it from view.



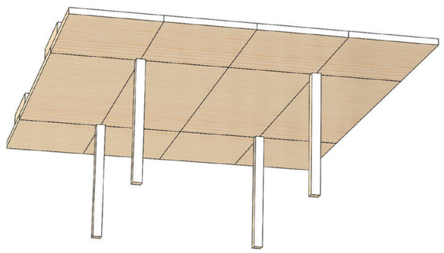
Wide Flat Beams—Beams on the Bottom

When an objective is to achieve long spans coupled with thin structural depth, wide flat beams made from glulam or CLT can be used. Bending capacity is proportional to width, but varies with the square of the depth, so wide flat beams are less efficient than narrow deep ones. As a result, the structure will be less economical.



Wide Flat Beams—Beams Flush

It is possible to use wide flat beams in a system where they are flush with the deck. This will provide a very thin system overall, and potentially an economical one, because in this case, the deck span is only the distance between beams, not centre to centre. If conventional columns are used, the system is unstable and the beams will topple under unbalanced loads. To resist this, the columns must be made to be wide—almost as wide as the wide flat beam—so that unbalanced moments are resisted by the column. It also presents other challenges for the designer, who must develop a flush hanging system for the deck and prove the torsional strength and stiffness of the beam—these properties are not well understood or documented.

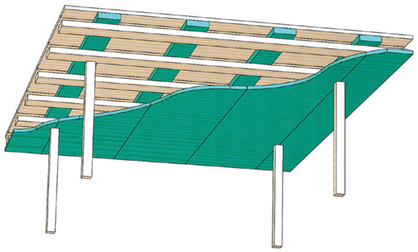


Wide Flat Beam—Beams on Top

With a wide flat beam system, there is an opportunity to hang the deck from the beams, as opposed to supporting it from below. It makes no difference to the deck, which has to span to the middle of the beam regardless, although it adds the complication of designing hangers (or possibly long screws) and fire-protecting those hangers.

On top of the deck, the floor can be made flush with a raised floor system, or the cavity between beams can be filled with EPS foam billets, and the whole made flush with a concrete topping.

This system can be helpful in space planning and may have aesthetic benefits by eliminating beam shadowing.

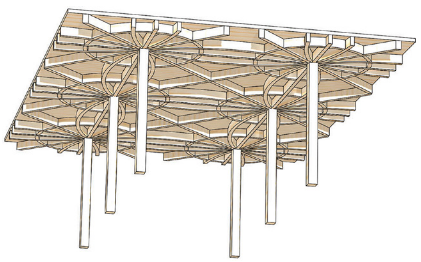


Stressed-Skin Lattice

“Stressed skin” is an expression used in wood construction to describe a system where the deck contributes to the flexural strength of the system by carrying compressive and tensile forces and doesn’t merely transfer load to the beams.

A stressed-skin lattice is a system which attempts to gain the benefits of a stressed-skin system in a two-way system. Since wood is inherently a one-way material, strong only parallel to its fibres, the “skins” (CLT panels) are used in opposite orientations: the top skin in one direction and the bottom skin in the other. The web must work in both directions as well. One layer transfers shear across its width, and the other carries the axial chord force, balancing the skin.

The diagram shows, in colour, the upper lattice which acts composite with the bottom skin, forming a shallow vierendeel truss oriented into the page. The lower lattice, which acts composite with the upper skin spanning parallel to the page, is shown in tan.

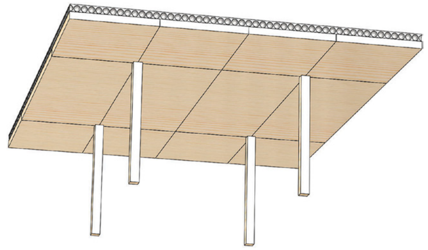


Nervi

With material cost high relative to labour costs, Italian architect and engineer Pier Luigi Nervi developed structural forms in concrete that optimized the use of material and minimized weight.

The mass timber industry is in a similar situation today. The cost of the raw material is high (at roughly two-thirds of the overall cost) and CNC fabrication allows complex forms and assemblies to be constructed relatively economically.

The structural strategy used by Nervi for the Palace of Labour in Turin could be adapted to a mass timber solution. In this proposal, sixteen radial beams span directly to each column support, eliminating the need for a girder—another example of using wood in a two-way system.

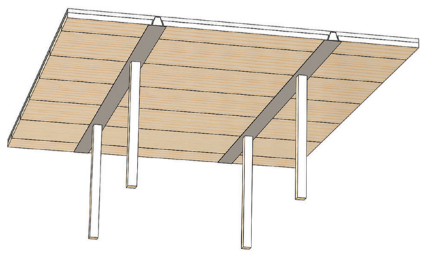


VCTC

Voided concrete timber composite (VCTC) is a timber concrete composite (TCC) system with a thick topping, roughly equal to the thickness of the mass timber. The “voided” part is about removing the concrete where it is least effective, closest to the neutral axis, saving weight and reducing the carbon footprint of the system.

The significant advantages of a VCTC system are the elimination of beams and the ability to achieve long spans. The direction perpendicular to the wood fibre is carried by the concrete alone, which acts as a wide flat beam within the thickness of the topping. The elimination of beams results in a thinner structural system overall. In addition, space planning is simplified and beam shadowing is eliminated.

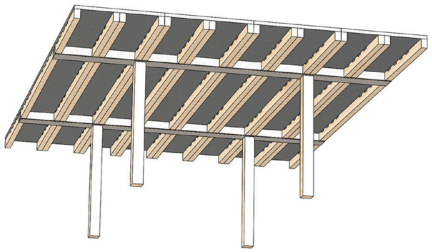
A VCTC system presents the minimum surface to fire, making it extremely fire-safe. By adding rebar to the bottom of the topping, just above the wood, the system can be made to sustain fire load in the complete absence of the wood.



DELTABEAM

The Peikko Deltabeam system is an extremely effective solution to the challenge of achieving both long spans and a shallow depth.

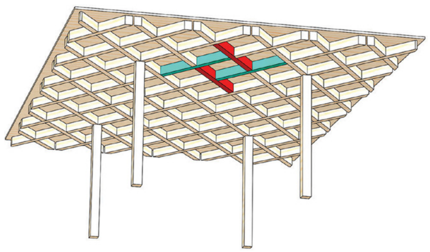
The Deltabeam is a flush steel beam, consisting of a tapered box with a wide bottom flange that serves as a seat. The webs of the box are perforated with large holes that allow the beam to fill with concrete from the topping. The concrete topping is fully composite, with both the deck and the steel beam contributing to the bending strength and stiffness of the overall system. Reinforcing steel may be placed inside the box, and made capable of sustaining load in the case of fire without the contribution of the bottom flange—so the bottom flange may not need to be fire protected.



Cree by Rhomberg

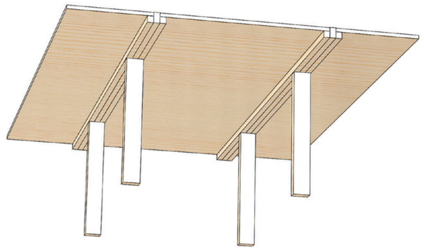
As mass timber matures, many proprietary and non-proprietary systems have appeared in the marketplace—and between writing and publishing this article, there will no doubt be a few more. Some will have legs and endure, while others will not. Many are composites, combining wood with steel and concrete to maximum benefit.

Cree by Rhomberg is one proprietary, modular system that has gained some traction in Europe. It consists of mass timber beams with a composite formed-concrete deck, pre-manufactured in panels of 2.5 to 3 metres in width by one full bay long. At the exterior edges, the concrete is turned down to form an edge beam. The exterior may be supported on columns or modular wall panels. In the interior, the panels are supported on a steel box beam, with a wide bottom flange which acts as a seat.



Zollinger Lamella

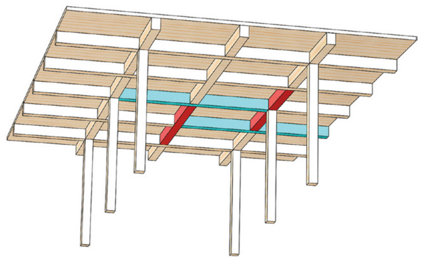
When German architect and engineer Friederich Zollinger invented the lamella roof in the 1920s, it was to respond to a severe shortage of housing and building materials following the First World War. The system uses simple, standard segments of timber in a rhomboid pattern. The Zollinger Lamella is a reciprocal framing system, where the beams are oriented in the fashion of a diagrid. One of the great benefits of the Zollinger Lamella comes from the arched form of the roof, but the system has benefits when on the flat as well. The high density of the lamella means that individual pieces can be made small and the deck panels may be made as thin as possible. Orienting the deck orthogonally on a diagrid of beams creates a very strong diaphragm, which is a benefit for resisting wind and seismic loads.



Triple Beam

The triple-beam system is one of a number of all-wood, shallow-beam systems. With a triple-beam system, the middle beam is discontinuous, allowing the column to pass through to support the column above. This configuration prevents the problem of crushing perpendicular to the wood grain, and of large shrinkage perpendicular to the grain. The two side beams may be continuous past the column, adding significant strength and stiffness benefits.

By assembling the beam out of multiple pieces, a designer is able to push past the limiting width of 365 mm usually linked to glulam beams. While wide shallow beams are less efficient, there is a benefit from a fire safety perspective, as they present less surface relative to volume; in addition, the side beams provide fire protection to the connection of the middle beam. The savings in depth with this system can be critical as timber buildings get taller.



Reciprocal Frames

A reciprocal frame is an apparently whimsical system that, nevertheless, offers some distinct structural advantages. The colours red and cyan in the diagram above represent the warp and weft directions of the frame, and highlight the reciprocal nature of their support.

As with a beam and girder system, the density of the reciprocal frame can be set to optimize the deck, offering economic advantages. Unlike a beam and girder system, though, it is a democratic framing arrangement without a dominant orientation.

Another benefit is that in a reciprocal framing system, all members simultaneously contribute to the support of the load, which helps mitigate floor vibration. While the total static deflection under load may be the same, optimized to the design criteria, the single point load deflection—which is an indicator of vibration performance—is much less.

FORESTS AND CARBON

Dr. Sean Thomas
Institute of Forestry and Conservation, University of Toronto
Professor

"In 1862 Liebig made the first calculation of the global capacity of plants to take up CO_2 from the atmosphere, estimating that plants could in theory remove all CO_2 from the atmosphere in only twenty-one to twenty-two years."

It was common knowledge up until the early 1800s that soils held all the vital elements necessary for plant growth—more specifically, that the carbon making up much of plant materials was taken up from the soil. This fit with the experience of farmers and foresters, and with a prevailing "humus theory" of soils in scientific circles that traced back to Aristotle.[1] Soils in forests were dark in colour and provided a medium good for plant growth when cleared. Depleted agricultural soils, on the other hand, were lighter in colour. The dark forest soils were self-evidently alive with macro-organisms, and with a world of micro-organisms that was just beginning to be recognized and described. This view also fit with the idea that an essential life-force was present in soils, particularly the soils of the untouched forests or "Urwald" that figured prominently in the Central European imagination and mythology. Along with carbon, this life-force was thought to be taken up into plants and ultimately into animals, including humans.

Of course, "common knowledge" is often mistaken, and carbon in plants is not taken up from the soil; it comes instead from the atmosphere. This was first definitively shown in the 1840s by the German scientist Justus von Liebig, best known as the scientist who showed that the main nutrients needed by plants were nitrogen, phosphorus, and potassium. Building on a tradition of bell jar experiments of prior scientists (in particular Priestley, Ingen-Housz, and de Saussure), Liebig grew plants in charcoal, knowing the carbon therein was highly stable and could not be taken up by plants.[2] Taking advantage of new methods to quantify carbon in organic materials, Liebig observed that

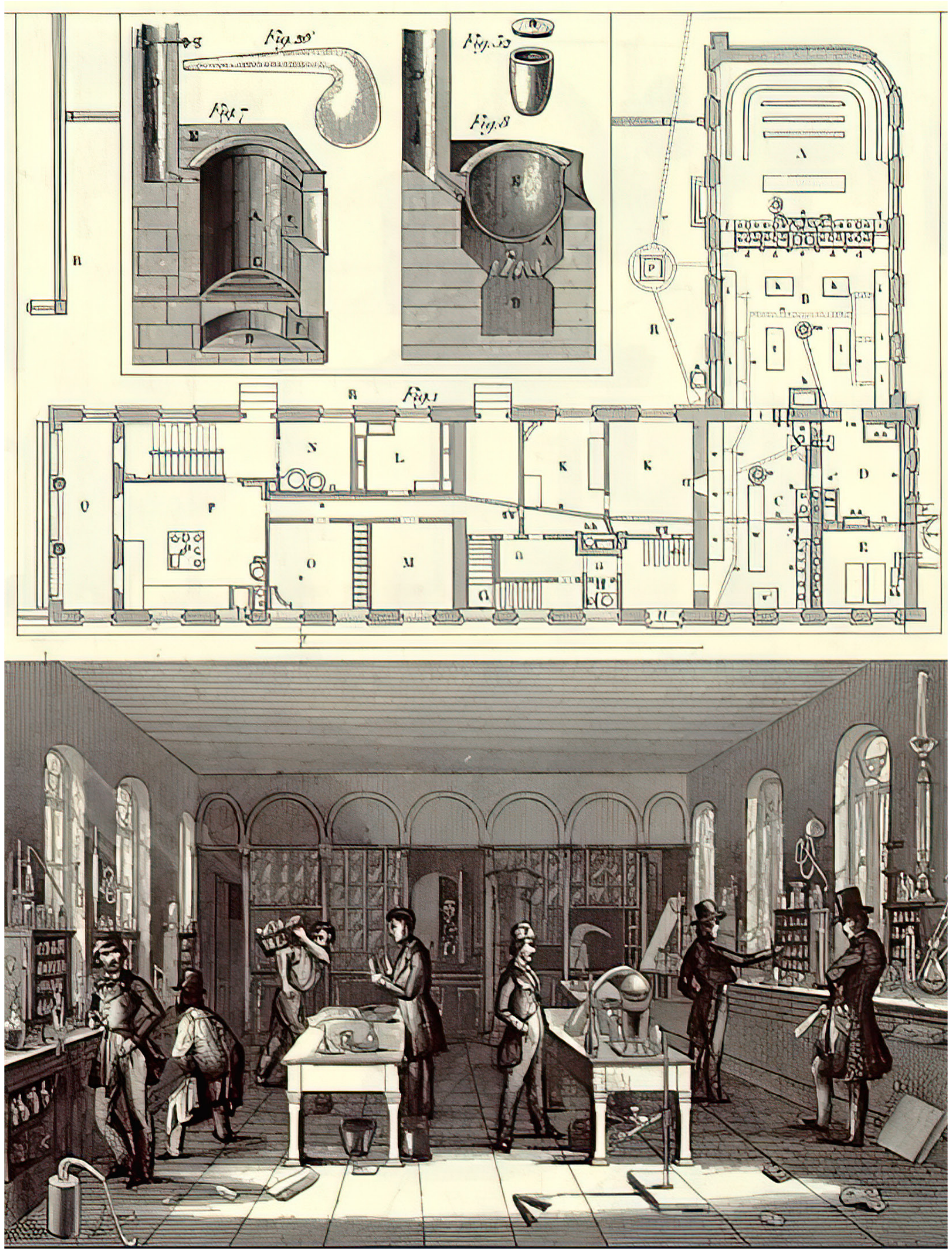


Fig. 1. Floor plan and drawing of Justus von Liebigís laboratory in Giessen, Germany, where experiments were first conducted demonstrating that plants take up carbon from the atmosphere. Designed in 1839 by architect Paul Hoffman, Liebigís laboratory became the model that largely holds to this day. (Illustration: Liebig's laboratory at Giessen, by Wilhelm Trautschold, 1841).

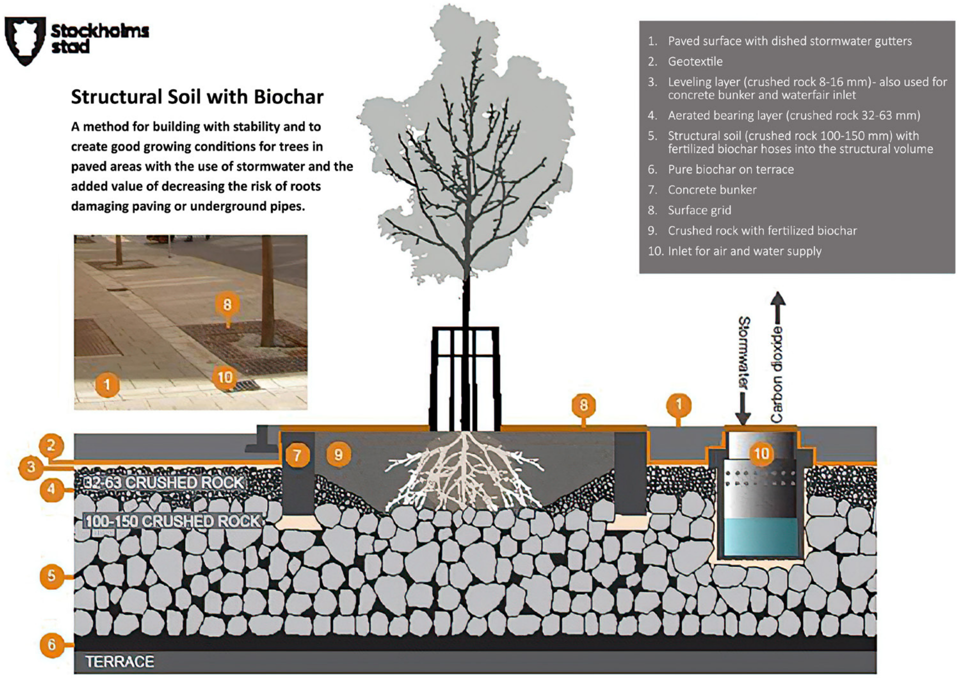


Fig. 2. City of Stockholm design for urban tree planting involving mix of structural soil with biochar generated from urban waste wood. From [6].

there was no loss of carbon from the charcoal as the plants grew. Moreover, plants would quickly cease growth in an enclosed space without access to carbon dioxide (CO_2). These observations fit with Liebig's main intellectual effort to overthrow the humus theory and other forms of "vitalism." In 1862, Liebig made the first calculation of the global capacity of plants to take up CO_2 from the atmosphere, estimating that plants could in theory remove all CO_2 from the atmosphere in only twenty-one to twenty-two years.[3] It was only about three decades later (in 1896) that the Swedish scientist Svante Arrhenius, making use of the recent discovery of the heat-trapping properties of CO_2, calculated the effect of CO_2 in the atmosphere on the Earth's temperature that is now known as the "natural greenhouse effect." In this same work, Arrhenius predicted that emissions of CO_2 into the atmosphere from the burning of fossil fuels would inevitably warm the planet.

There are a few remarkable points that emerge from this thumbnail sketch of the earliest scientific work on forests and carbon. First, there is a long history of viewing forests (and particularly forest soils) as having mysterious and even magical properties, and a main scientific accomplishment that led to an understanding of how forests actually "work" was based on casting this idea aside and looking for interactions between plants and the abiotic environment. Second, by 1900 it was known that atmospheric CO_2 had profound effects on the Earth's climate. Third, even before the heat-trapping effects of CO_2 were recognized, it was clear that photosynthesis could dramatically alter the level of CO_2 in the atmosphere. Fourth, the scientific foundations for understanding the global carbon cycle and anthropogenic climate change—and the importance of plants and in particular forests—were thus laid at the very beginning of scientific inquiry into these topics.

A point of particular interest from the perspectives of architecture and design (as well as the history of science) is that the design of laboratory facilities contributed importantly to the scientific advances outlined above. Liebig's laboratory in Giessen (Fig. 1) had a tremendous impact on scientific progress and practice. The laboratory was laid out in a way that provided storage space for instruments, glassware, and chemicals, that permitted access to multiple researchers, and was large enough to accommodate hands-on educational activities and allow for demonstrations of laboratory technique. High ceilings, good ventilation, and ample daylight were critical to undertaking a wide variety of experiments. In addition, the laboratory featured vented enclosures designed for safely conducting experiments at high temperatures while evacuating noxious gases. The laboratory was positioned immediately adjacent to a lecture theatre, highlighting the interaction between educational and research functions. By having a working space that encouraged active engagement with students in the creative process of science, Liebig was able to make voluminous contributions in applied chemistry from the 1830s to the 1860s.

There is current urgency to the topics first explored by Liebig and Arrhenius. It is now clear that mitigating the potentially devastating effects of global climate change will require not only reductions in greenhouse gas emissions, but also the active withdrawal of carbon from the atmosphere. Although research has suggested possible technological fixes (such as the implementation of giant amide-based air processors to scrub CO_2 from the atmosphere), a recent U.S. National Academy of Sciences report highlights the fact that currently existing "negative emissions" technologies essentially all involve forestry (and to lesser extent agriculture) and essentially harness the ability of plants to act as atmospheric CO_2 scrubbers.[5] These technologies include (1) protecting forests that serve as large carbon sinks and stores, such as coastal forested wetlands; (2) carbon-centred reforestation; (3) carbon-centred forest management; (4) producing and applying biochar (charcoal made from agricultural and forest waste biomass, applied to soils); (5) the implementation of bioenergy plantations that capture carbon emissions at the point of combustion (BECCS: biomass energy with carbon capture and storage).

Implementing these strategies will necessarily involve collaboration between scientists who continue in the vein of Liebig and Arrhenius and professionals in the areas of forestry, planning, and design. An example of what this will look like from a design perspective is the redesign of urban tree planting implemented since 2016 in Stockholm, Sweden (Fig. 2). The city has invested in a large-scale pyrolysis system to process the majority of waste wood from urban forestry operations and recycle the biochar generated in an urban tree planting mix with structural soil. The system avoids emissions of carbon from waste biomass and enhances the physiological status and carbon uptake of the urban forest—as well as providing the additional suite of ecosystem services associated with urban trees, including stormwater diversion, reduced urban heat island effects, shading for UV protection, and enhanced amenity value.

Notes:

1. R. R. van der Ploeg, W. Böhm, and M. B. Kirkham, "On the Origin of the Theory of Mineral Nutrition of Plants and the Law of the Minimum," Soil Science Society of America Journal 63, no. 5 (September 1999): 1055–62.
2. Kelpie Wilson, "Justus von Liebig and the Birth of Modern Biochar," The Biochar Journal (2014), http://www.biochar-journal.org/en/ct/5.
3. Akihiko Ito, "A Reinterpretation of the Earliest Quantification of Global Plant Productivity by von Liebig (1862)," New Phytologist 167, no. 3 (September 2005): 641–43.
4. Julia Uppenbrink, "Arrhenius and Global Warming," Science 272, no. 5265 (May 1996): 1122.
5. National Academies of Sciences, Engineering, and Medicine, Negative Emissions Technologies and Reliable Sequestration: A Research Agenda (Washington, DC: National Academies Press, 2018)
6. Bjorn Embrén, "Planting Urban Trees with Biochar," The Biochar Journal (2016), https://www.biochar-journal.org/en/ct/77.

04

WOODLAND DIVERSITY: FOREST REGIONS IN NORTH AMERICA

Curtis Ho (graphics)

Daniels Faculty of Architecture, Landscape, and Design, MArch

Alexandra Ntoukas (text)

Daniels Faculty of Architecture, Landscape, and Design, MLA

Hundreds of tree species can be found on the land on which Canada is situated and beyond its national borders. There are hundreds of forest maps that abide by human-made borders and do not show how all forests are connected to one another. The ecoregions shown on this map loosely correspond to where tree species can and cannot grow.

Ecoregions are areas that are ecologically and geographically distinct. The boundaries of ecoregions are fluid. Indigenous and introduced species may affect where a tree grows. Climate change and fluctuation and weather events shift conditions, challenging the boundaries of an ecoregion and the assumed range of a species. Historical factors such as heavy logging or mining and urbanization have long-term trajectories of devastation for local ecologies, impacting the future growth and establishment of trees.

The changing diversity of Canada's forests is immense, but the diversity of peoples is far greater. The result is many relationships and understandings of the forest that are unique to the land where Canada exists. This leads to the critical message underlying this chapter: Canada's diversity is its strength and we as designers must make space for and promote Canada's histories, ecologies, peoples, and ways of knowing.

CANADIAN CAROLINIAN FOREST

- CANADIAN CAROLINIAN FOREST

BOREAL TUNDRA WOODLAND

- 3.1 ALASKA BOREAL INTERIOR
- 3.2 TAIGA CORDILLERA
- 3.3 TAIGA PLAIN
- 3.4 TAIGA SHIELD
- 4.1 HUDSON PLAIN
- 5.1 SOFTWOOD SHIELD
- 6.1 BOREAL CORDILLERA

BOREAL MOUNTAIN SYSTEM

- 2.4 SOUTHERN ARCTIC
- 3.1 ALASKA BOREAL INTERIOR
- 3.2 TAIGA CORDILLERA
- 5.4 BOREAL PLAIN
- 6.1 BOREAL CORDILLERA
- 7.1 MARINE WEST COAST FOREST

BOREAL CONIFEROUS FOREST

- 3.4 TAIGA SHIELD
- 4.1 HUDSON PLAIN
- 5.1 SOFTWOOD SHIELD
- 5.3 ATLANTIC HIGHLANDS
- 5.4 BOREAL PLAIN

TEMPERATE MOUNTAIN SYSTEM

- 11.1 MEDITERRANEAN CALIFORNIA
- 5.2 MIXED WOOD SHIELD
- 5.3 ATLANTIC HIGHLANDS
- 6.1 BOREAL CORDILLERA
- 6.2 WESTERN CORDILLERA
- 7.1 MARINE WEST COAST FOREST
- 8.2 CENTRAL USA PLAINS
- 8.4 OZARK/OUACHITA-APPALACHIAN FORESTS

TEMPERATE CONTINENTAL FOREST

- 5.2 MIXED WOOD SHIELD
- 5.3 ATLANTIC HIGHLANDS
- 8.1 MIXED WOOD PLAINS
- 8.2 CENTRAL USA PLAINS
- 8.3 SOUTHEASTERN USA PLAINS
- 8.4 OZARK/OUACHITA-APPALACHIAN FORESTS
- 8.5 MISSISSIPPI ALLUVIAL AND SOUTHEAST USA COASTAL PLAINS

CAROLINIAN/EASTERN DECIDUOUS FOREST

- CAROLINIAN/EASTERN DECIDUOUS FOREST

POLAR

- 1.1 ARCTIC CORDILLERA
- 2.1 NORTHERN ARCTIC
- 2.2 ALASKA TUNDRA
- 2.3 BROOKS RANGE TUNDRA
- 2.4 SOUTHERN ARCTIC

TEMPERATE STEPPE

- 6.2 WESTERN CORDILLERA
- 9.2 TEMPERATE PRAIRIES
- 9.3 WEST-CENTRAL SEMIARID PRAIRIES
- 9.4 SOUTH CENTRAL SEMIARID PRAIRIES

TEMPERATE DESERT

- 10.1 COLD DESERTS

TEMPERATE OCEANIC FOREST

- 7.1 MARINE WEST COAST FOREST

SUBTROPICAL MOUNTAIN SYSTEM

- 11.1 MEDITERRANEAN CALIFORNIA
- 13.1 UPPER GILA MOUNTAINS
- 6.2 WESTERN CORDILLERA
- 8.4 OZARK/OUACHITA-APPALACHIAN FORESTS

SUBTROPICAL STEPPE

- 10.1 COLD DESERTS
- 8.3 SOUTHEASTERN USA PLAINS
- 9.4 SOUTH CENTRAL SEMIARID PRAIRIES

SUBTROPICAL DESERT

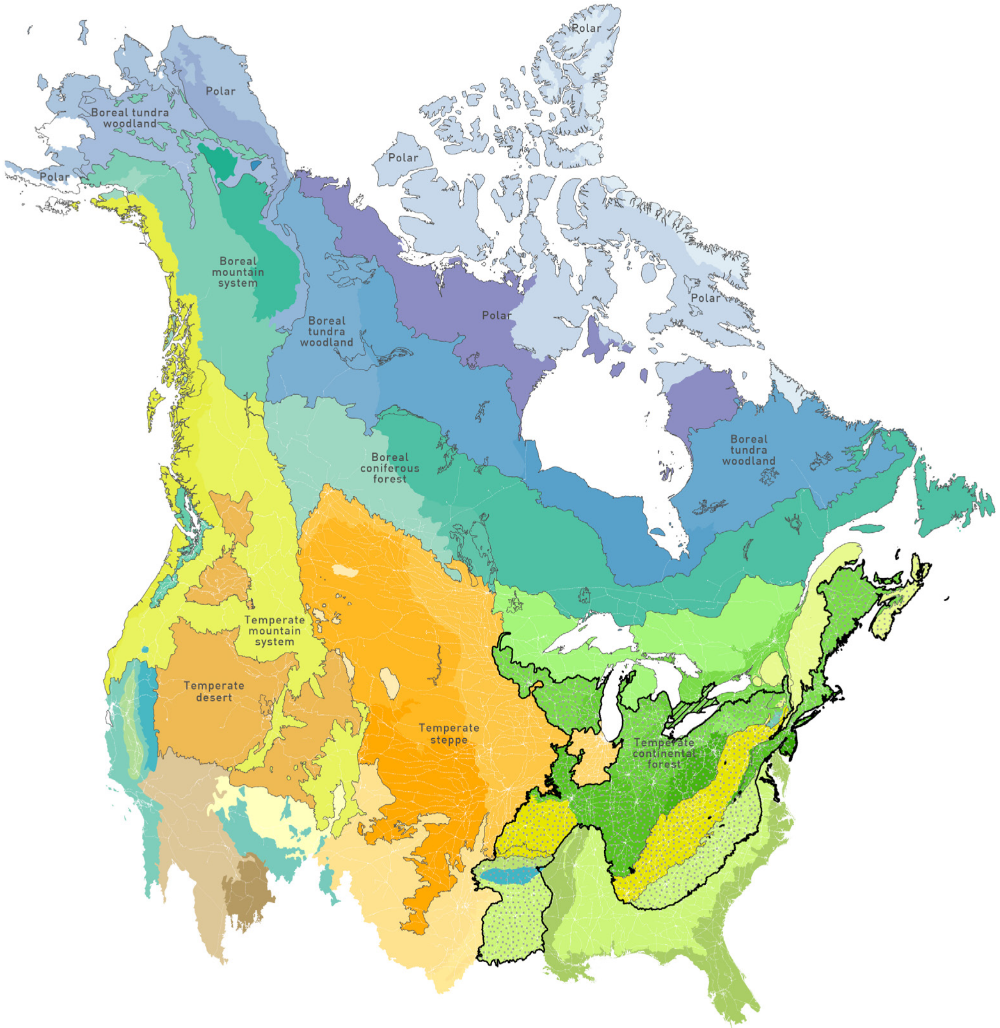
- 10.2 WARM DESERTS
- 11.1 MEDITERRANEAN CALIFORNIA
- 12.1 WESTERN SIERRA MADRE PIEDMONT

SUBTROPICAL HUMID FOREST

- 8.3 SOUTHEASTERN USA PLAINS
- 8.4 OZARK/OUACHITA-APPALACHIAN FORESTS
- 8.5 MISSISSIPPI ALLUVIAL AND SOUTHEAST USA COASTAL PLAINS

SUBTROPICAL DRY FOREST

- 11.1 MEDITERRANEAN CALIFORNIA



“Our approach to forestry is easier understood when standing in the woods. On paper, it is best summarized as the ongoing pursuit of our social license and implementation of our land ethic. In other words, we feel obligated to prove to the public that we are worthy stewards of the forest, and we do what we do primarily because we love the forest, and secondly because it supports our business.”

SUSTAINABLE FORESTS

Malcolm Cockwell
Haliburton Forest and Wild Life Reserve, Managing Director

Haliburton Forest & Wild Life Reserve Ltd. and its affiliates are peculiar in the Canadian forestry sector. We own 250,000 acres of private land in a region where most is Crown. We are integrated from seedling to finished product in an industry that tends to specialize. And in an era of projected expertise, the motto of our forestry crew is, “We haven’t figured it out yet.”

Our approach to forestry is easier understood when standing in the woods. On paper, it is best summarized as the ongoing pursuit of our social license and implementation of our land ethic. In other words, we feel obligated to prove to the public that we are worthy stewards of the forest, and we do what we do primarily because we love the forest, and secondly because it supports our business.

The foundation of our approach to forestry is information. Each tract of the forest is inventoried and evaluated on a regular basis: trees must be measured if they are to be managed. If an area is considered eligible for harvesting, a prescription is written, like a medical prescription that a doctor would give a patient, but with much longer perspective that spans decades or centuries.

Foresters then implement the prescription by applying paint to individual trees: orange is to be cut, blue is to be protected, red is to be avoided, and no paint at all implies minimal disturbance. Our mindset during “treemarking” is to remove the worst trees first, maintain or enhance diversity, and recover economic values like mature, high quality trees while protecting ecological values like stick nests. We remove approximately one-third of the timber during each harvest, which tend to occur on twenty-year rotations.

During these harvesting activities, foresters and loggers alike cooperate with recreational users. There are lots of them: half of Haliburton Forest’s business model relies on tourism activities like hiking, camping, hunting, and dog-sledding. However, we do not implement aesthetic buffers within our property that would hide our logging activities. We are proud of what we do in the forest, and we welcome opportunities to explain our practices to the public.

Harvested trees are trucked to our sawmills, then cut into lumber. This process is closely monitored—like trees, sawlogs must be

Forwarder and crane cutting and harvesting logs in Haliburton Forest


Debarker at the Haliburton Forest Sawmill


Lumber grader inspecting processed boards from the sawmill at Haliburton Forest & Wild Life Reserve.

measured in order to be managed. Industrial products such as pallets, truck flooring, and railway ties are our bread and butter, but we also produce appearance-grade products for cabinetry, furniture, and residential flooring. Some lumber is directed to our value-added facilities, where we manufacture log homes, furniture, and paddles.

Research informs our forestry practices. There are at least twenty-five boots-on-the-ground research projects being coordinated by the Haliburton Forest Research Institute at any time, ranging from lake ice formation rates, to timber growth measurements, to the population dynamics of red-backed salamanders beneath dead woody debris at various stages of decay. A meaningful portion of our revenue is reinvested in research programs.

Sustainable forest management is underwritten by robust markets for forest products. The stronger the demand for wood, and the higher the value of the finished products being manufactured, the greater the incentive to maintain and enhance the biological machinery of a healthy forest. For this reason, we are eager to support the up-and-coming mass timber industry.

OLD MATERIALS, NEW TECHNOLOGY: NEW VISIONS FOR MASS TIMBER

Mike Yorke
Carpenter's District Council of Ontario
President

"With an expansion of timber use in cities, the construction and land development sectors can have a great impact on these resource-based [northern] communities in a symbiotic relationship: many lumber mills have been closed over the last decades, and here is a chance to reopen, renew and revitalize both plants and communities."

Look around at the skyline of any city in North America and chances are it has been built by members of the Carpenter's Union. Whether made of concrete or glass and steel, that is a real part of our legacy. An older legacy also exists in many North American cities, one of mass timber buildings being the earliest built infrastructure in urban centres. Well over a hundred years ago, carpenters working on mass timber buildings were a common sight—in Vancouver's Yaletown, Liberty Village in Toronto, and warehouse districts in cities such as Minneapolis and Edmonton. Buildings up to ten storeys were often constructed of wood, and in those days the beams and columns were made of solid old-growth timbers of 24 x 24", which are pretty hard to find today. This is where innovative technologies in wood production come in, taking smaller components and manufacturing them into larger pieces, allowing for the structural integrity and strength needed to construct wood buildings of heights never before thought of. Building components such as glulam have been around for decades (think of those massive arches in sports facilities), but now new manufacturing technologies such as cross-laminated timber (CLT) and nail- and dowel-laminated timber (NLT and DLT) are augmenting this older approach and bringing forth a renaissance in wood construction. To match this evolution, our training programs have responded to ensure that our members arrive on site knowledgeable in timber construction best practices with all safety requirements in hand. Training centres such as the Chicago Regional Council of Carpenters and Toronto's College of Carpenters and Allied Trades (CCAT) are meeting the needs of industry by ensuring that skilled workers are available for these new developments. Our apprenticeship contributions check-off helps pay for curriculum development, and in Ontario the CCAT had a substantial grant

The College of Carpenters in Toronto training centre ensures the next generation of workers are educated on advancements in mass timber.

from the former government to pay for the development of the four-week timber course.

In Canada mass timber is really in its infancy, so we can learn from Europe about its potential and the benefits of developing this sector, one of which is the meeting of climate change standards—as US president Joe Biden has signaled his administration's plan to rejoin the Paris Climate Accord, greater use of timber will allow our industry to lead, not follow. Another real benefit is in economic development and the creation of prosperity in northern communities. Many lumber mills have been closed over the last decades, and here is a chance to reopen, renew and revitalize both plants and communities. With an expansion of timber use in cities, the construction and land development sectors can have a great impact on these resource-based communities in a symbiotic relationship. Government support for program development was crucial, as according to Cristina Selva, executive director of the CCAT, "nothing of this nature existed across Canada." Also key to a successful training program has been the involvement of industry leaders such as Moses Engineering, Quadrangle Architects, and suppliers of products—Nordic Structures for the CLT and Rothoblaas of Italy for screws, hardware, and steel connectors. Again, collaboration is crucial. So far, in Canada at least, the sector has been dominated by projects sponsored by the public sector—libraries, community centres, and university and college projects. This allows for the cost of engineering support knowledge to be shared and subsidized by many projects. However, the IT/high-tech sector is not far behind, and not waiting either, so expect to see numerous projects from companies such as Amazon, Google, Facebook, and Microsoft, all of whom are interested—for mass timber's green luster, certainly, but also for the ambient environment it creates for employees, a benefit of biophilic design. As stated earlier, we are only beginning to see the re-emergence of mass timber as a key building material in North America, but through training and collaboration with our contractors and the industry, the Carpenter's Union will remain on the leading edge of change, building our cities and developing our next generation of workers—just as we have done for the last 140 years!

INTERVIEW: LEARNING FROM THE LAND

Doug Anderson
Bungee Métis
Daniels Faculty of Architecture, Landscape, and Design, University of Toronto, Adjunct Professor

Fiona Lu
Daniels Faculty of Architecture, Landscape, and Design, MArch

Fiona Lu was in conversation with Doug Anderson on learning from the land and his work with the Dr. Eric Jackman Institute of Child Study


Doug leading a gathering to work on the land along the Humber River

Doug Anderson teaches the graduate-level course Indigenous Perspectives on Landscapes at Daniels. In the third year of my master's, I had the opportunity to take Doug's course. I was attracted to it because in my eight years of architectural education in Canada there had never been a course like this offered. Recently, I had the opportunity to speak with Doug again to talk about how Indigenous perspectives should be incorporated in mass timber design.

Fiona:
In your writing in the second edition of Natural Curiosity, you outline commonly agreed on qualities of Indigenous perspectives: a strong sense of spirituality; a deeply rooted sense of place; the recognition that everything is related; and an emphasis on reciprocity. Can you describe how these qualities are incorporated into the curriculum at the Jackman Institute of Child Study (JICS) Lab School, such that we can also include as part of our guidelines for a mass timber construction studio?

Doug:
If you look at the qualities of the Indigenous perspectives from the Natural Curiosities document, a few things come to mind: how does the whole process become as holistic as possible in a way that it considers what I call "full cost accounting"? In the place where the harvesting is taking place, is there a relationship with the people in that treaty area at all, and should there be? That should be a question right away.

If you want to have an Indigenous perspective on this, it would be good to get the people from the area where the growing and harvesting is taking place, for whom that land has always been a deep concern. It depends on the person you go to—not every Indigenous person who is a member of that treaty will have an understanding of what the deep questions are—but there are people who can be approached from within those territories.

For example, they will have a will certainly have a much deeper sense of what the biodiversity is than a forester, even more than a botanist or ecological scientist. I had a friend who is from northeast of Toronto (his reserve is called Scugog) who was personally responsible in his family for the knowledge of thousands of plants, and I am sure even some modern science has not even heard of.

Now, if someone is involved in the business of harvesting trees, they may not feel like they have the luxury to contact an Indigenous person who is a member of that treaty. I am assuming from what you said that the people [from Haliburton Forest] are harvesting as ethically as they can. There is a will on their part to try to do this in a way that is it is reciprocal in the sense that they are asking, "if we are going to take something, how are we going to put something back?"

Fiona:
How do we connect the next generation of students with the concept of forest—the urban forest, the vast and varied Canadian forest, and the global forest?

Doug:
There are no real, serious, Canadian, human laws that really look at the full cost accounting of the whole thing. I like how they are talking

Doug leading a gathering around the fire for his Daniels graduate course Indigenous Perspectives on Landscapes

about reducing how much stuff we are shipping in from Europe and where else we get our wood, which is a way of approaching full cost accounting. The City of Toronto has a climate change strategy that talks about reducing our carbon emissions. They claim that they are meeting their carbon emission reduction targets. The problem is that most of the carbon created by the people that live here is created somewhere else in the world. Full cost accounting would say, for example, the shipping containers that come in uses up enormous amounts of carbon, and you can build that analysis into the overall assessment of this.

Where it may be more challenging is in asking how the production of these sites where the trees are being harvested is being managed. I have seen this quite a bit in Ontario, north of Toronto, where they plant a bunch of trees in a row, nothing else is really surviving there, and mow them down once they are done. If we are harvesting trees, depending on how much land these people have access to, there can be some wonderful ways of restoring forests in the long term and deep consultation with Indigenous knowledge.

There is human law, Canadian human law, and Indigenous human law. Where Canadian laws stop, Indigenous law continues to be more deeply grounded in natural law, fire principles, and sacred laws. How do we manage these sites in a way that is a bit more in keeping with Indigenous law?

Fiona:
What can one do in a situation where direct Indigenous knowledge is hard to come by?

Doug:
If you are in an area, city, or community where you do not have access to Indigenous knowledge, I think it is important to know that there are ways in which people come into relationship with plants. It is not like you have to go into a ceremony or lodge, but I think it is important to ask how a family, neighbourhood, or community may have a sense of responsibility for a particular area that serves them well. Rather than planting trees as a good cause, we should be planting trees for food.

We need to bring our families and children to these sites and help them develop relationships with certain plants that will serve them. As they grow them, protect them, harvest them, and cultivate them, we will be teaching our children how to survive.

This knowledge is not hidden. If you go on the internet you can find what certain plants are for—lots of people are sharing information. If you are in an area where there are no elders or Indigenous people, it is important to acknowledge what land you are on: real land acknowledgement is going to the land and water and protecting it.

Sources of Indigenous Knowledge

Joseph Pitawanakwat (Anishinaabeg)
Creator's Garden

Robert Lipscombe (Anishinaabeg)
Amik Tree Service

Deborah MacGregor (Anishinaabeg)
Professor, York University, expert on traditional ecological knowledge and Indigenous environmental justice

SPECIFYING WOOD(S)

This is an exerpt from Jane Hutton, "Specifying Wood(s)", in Daniel Ibanez, Jane Hutton, Kiel Moe (Editors), Wood Urbanism: From the Molecular to the Territorial, Actar, 2019.

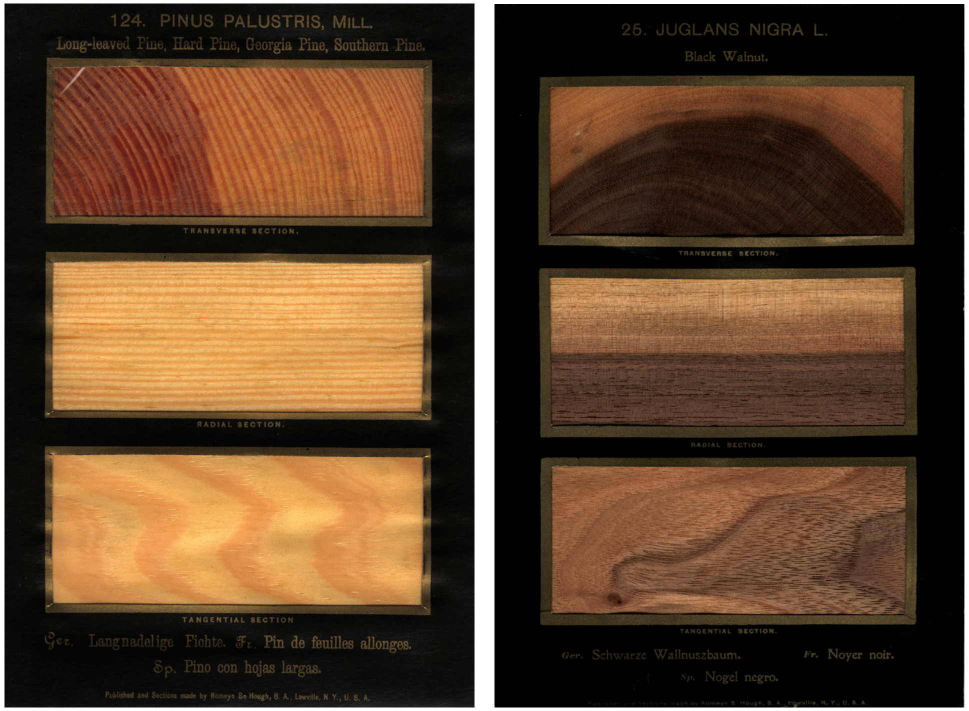
Jane Mah Hutton
School of Architecture, University of Waterloo
Assistant Professor

"To maintain a generic understanding of wood (...) is to disregard its complex landscape entanglements and to forgo its most interesting design opportunities."

Wood has become the charismatic material of the sustainable building industry. Its carbon storage, its light weight and easy workability, its lower processing requirements, and its potential renewability all support claims that wood is the seminal construction material of the future-present. Wood's promising comeback and new relevancy have sparked widespread interest in architecture and design venues, formulators of emerging precedents and practices, professional competitions, and university research centres. All of this momentum seems to affirmatively answer the question, posed in a recent Boston Globe headline: "Will the cities of the future be made of wood?"[1]

But what exactly is this wood?

In this moment of renewed enthusiasm for wood's potential, it is tempting to see wood as one thing—to ascribe positive benefits to the entire category and promote its use everywhere. "Wood" is better understood as "the woods": thousands of species, enmeshed in highly specific ecological configurations, of untold physical properties and propensities, with deep human dependencies and relations with other species. To maintain a generic understanding of wood, therefore, is to disregard its complex landscape entanglements and to forgo its most interesting design opportunities. To simply build with more wood is to reproduce and exacerbate existing conditions. To overlook the immense diversity of species, properties, and landscapes where trees grow is to ignore the material's greatest strengths and richest offerings. Perhaps rather than specifying wood, we should be talking about "specifying wood(s)." "Specifying" is, of course, the designer's task of selecting materials for use. Here, the aim is to unpack



Left:Plate no. 124. Pinus palustris, Mill (Long-leaved Pine): Hough, The American Woods, (Vol. 5, 1894). Reproduction: North Carolina State University Libraries, Special Collections. Right: Plate no. 35. Juglans nigra L. (Black Walnut): Hough, The American Woods, (Vol. 2, 1891). Reproduction: North Carolina State University Libraries, Special Collections.

generic understandings of wood by highlighting the relationships between different types of forests and wood products and examining the collective management and design of wood producing landscapes. In different ways, we can ask: What are the relationships between wood products and landscapes? How is wood specification related to forest outcomes? And how might the design of the forest or wood producing landscape impact the wood that we build with?

Over the twentieth century, global consumption of all material categories—biomass (wood and crops), fossil fuels, metals, and construction materials (cement, asphalt, etc.)—increased exponentially. In terms of relative importance by mass, the previously dominant biomass was eventually eclipsed by construction materials such as concrete, steel, and plastics, which gained prominence in the midcentury.[2] Nevertheless, global (non-fuel) wood harvesting from old growth, regenerating, and planted forests continues to increase around the world.[3] Close to 60 billion cubic feet of industrial round wood (again for non-fuel use) are produced per year, supplying demands for structural lumber, concrete formwork, new composite wood products, packaging, and paper.[4] Significant developments in engineered and composite wood products including fibreboard, plywood, laminated veneer, and glulam have shaped architectural applications and the consumption patterns of wood. The landscapes where these trees and future wood products grow are as divergent as their eventual applications.

A third of the world's wood now comes from "planted forests" or plantations, and this figure continues to rise. The term "planted forests" includes a range of conditions, from monocultures of the same age class and uniform density to plantings that include native species of different age classes intended to mimic certain natural ecological processes. In two decades, global plantations have expanded from 440 to 652 million acres, mostly concentrated in South America, followed by Asia[5] (although Asia's plantations are expanding the fastest).[6] Plantations are designed to increase output and profit per area, and so tend toward the monoculture production of a few species (often with little genetic diversity), encouraging rapid rotation to maximize returns. Vast regions of these tree plantations are dominated by a few economic stronghold genera: for every 10 hectares of the world's plantations, two will be planted with pine (Pinus spp.), one will be planted with eucalyptus, and one will be planted with rubber tree (Hevea spp.), acacia, or teak (Tectona spp.).[7]

The very same conditions that facilitate fast-growing trees for sawn wood and composite products are associated with a range of negative, interconnected social-ecological issues stemming from the loss of forests with the land's conversion to plantations, the displacement of Indigenous and other landholders, social injustices, the increasing lack of genetic and biological diversity, and threats posed by genetic modification, land degradation, erosion, water pollution due to applied chemical fertilizer and pesticides, and drought, all of which are exacerbated by the effects of climate change.[8] Furthermore, various international programs that provide funds for plantations as sites of carbon sequestration or ecosystem services are incentivizing the conversion of natural forest to fast-growing plantations. Acknowledging these consequences, initiatives such as the World Wildlife Fund's New Generation Plantation platform are rethinking plantations in light of the need to also support Indigenous and local people, ecological integrity (discussed through the metric of ecosystem service provision), and conservation agendas.[9]

About half of the world's wood products come from primary and modified "natural forests," with the remaining 12 percent of global wood coming from so-called semi-natural and planted forests (SNFP).[10] As plantations continue to grow in size, natural forests are decreasing by 16 million acres per year, especially in tropical areas where the forest is rapidly being converted to farmland. Within the category of "natural forests," different management practices have had vastly different outcomes in forest structure, biodiversity, and ecological integrity. In these terms, the best practices include "retention and selection" systems that retain and remove groups of trees strategically to support structural diversity, seed retention, and the regenerating understory.[12] Clear-cutting produces the poorest outcomes, heightening problems associated with little structural diversity, erosion, and little biodiversity. International agendas to increase the sustainability of managed natural forests focus on designating more preservation areas, designating more forests for soil and water protection and cultural use, increasing forest management plans for productive forests and conservation, and increasing the ongoing success with third-party forest certification programs, such as the Forest Stewardship Council certification.[13]

While the complexity and scale of globalized, industrialized wood material streams can't be overstated, even an individual architect might begin to ask: How do specifications and demands for certain species or certain wood products become inscribed in forests and plantations? What, for example, are the consequences of specifying only perfect, clear (knot-free) lumber? Of demanding only a single species? Of only working with larger, longer timbers? Instead of simply using what is most available in the market or having a fixed idea of what wood products one works with, designers could see the forest as a dynamic and always fluctuating material source (and, of course, an ecology that goes far beyond a material source). By learning more about the processes of the forest in living motion, designers could see their work in concert with its changes, generating more useful, robust, and creative specifications: for example, ones that take advantage of surpluses due to infestations, invasions, and climate events; ones that take on lesser known species[14] or products of silvicultural experiments; and ones having smaller dimensions and undervalued imperfections. Furthermore, the buildings and landscapes that designers make through these specifications have the potential to beautifully capture the dynamics of the forest in their very fibres.

Just as we can ask how designing with wood shapes the forest, we can ask how designing the forest shapes its dynamics and the wood products that come from it. While humans have always intentionally shaped forest dynamics, the forest has also long been a formative design site for the discipline of landscape architecture. The foundations of landscape architecture and modern forestry, for example, can be seen in the collaborative work of Frederick Law Olmsted and future US Forest Service chief Gifford Pinchot: at the Biltmore Estate in Asheville, North Carolina, in the 1890s, they developed an integrated landscape of scientific management, reclamation, productive woodlands, and education, which united productive and cultural agendas.[15] In the 1970s, while consulting for the British Forestry Commission, landscape architect Dame Sylvia Crowe developed guidelines to produce forests of varied structures and usage, and to ascribe tree plantation patterns according to landform character. Crowe's forestry work brought discussions of woodland character and the visual impacts of landscapes to the regional scale.[16] These notable precedents foreshadow contemporary interests in the making of, and designing within, productive woodlands today.

While no individual's single wood specification will shift the course of global forestry, there are numerous examples of ways that specifications touch the forest, all beginning with an understanding of the relationships between wood consumption and the workings of the forest. By engaging with these interconnectivities, with forest dynamics, and with the temporal dimensions of forest growth, designers have the potential to specify wood(s), rather than just "wood" alone. By understanding the relationships between the source and the product, designers have the potential to impact the design of both. Rather than external elements, these extended relationships should be constitutive of wood design in this coming era of its prominence.

Notes:

1. Courtney Humphries, "Will Cities of the Future Be Built of Wood?," The Boston Globe, 5 July 2014.
2. Fridolin Krausmann, Simone Gingrich, Nina Eisenmenger, Karl-Heinz Erb, Helmut Haberl, and Marina Fischer Kowalski, "Growth in Global Materials Use, GDP and Population During the 20th Century," Ecological Economics, no. 68, 2009.
3. Vaclav Smil, Making the Modern World: Materials and Dematerialization (Chichester: Wiley, 2013), 47.
4. C. Jurgensen, W. Kollert, and A. Lebedys, "Assessment of Industrial Roundwood Production from Planted Forests," Planted Forests and Trees Working Paper Series, no. 48 (2014), 18.
5. Jurgensen, et al., "Assessment," 14.
6. Food and Agriculture Organization, "Global Data on Forest Plantations Resources," Forest Genetic Resources, no. 29 (2001), figure 2, "Distribution of annual new planting areas," http://www.fao.org/docrep/004/Y2316E/y2316e0b.htm.
7. Food and Agriculture Organization, "Global Data," table 1, "Annual Plantation Rates of New Plantation and Plantation Areas by Regions and Species Groups in 2000."
8. See for example Thomas Miller Klubock, La Frontera: Forests and Ecological Conflict in Chile's Frontier Territory (Durham: Duke University Press, 2014).
9. Tim Payn, Jean-Michel Carnus, Peter Freer-Smith, Mark Kimberley, Walter Kollert, Shirong Liu, Christophe Orazio, Luiz Rodriguez, Luis Neves Silva, and Michael J. Wingfield, "Changes in Planted Forests and Future Global Implications," Forest Ecology and Management, no. 352 (2015): 57–67, http://newgenerationplantations.org/multimedia/file/12b486cb-ea24-11e3-9f9e-005056986313.
10. Food and Agriculture Organization, "Global Data," 18.
11. Food and Agriculture Organization, "Global Forest Resources Assessment 2015: How Are the World's Forests Changing?" (Rome: Food and Agriculture Organization of the United Nations, 2016), http://www.fao.org/3/a-i4793e.pdf.
12. Abhishek Chaudhary, Zuzana Burivalova, Lian Pin Koh, and Stefanie Hellweg, "Impact of Forest Management on Species Richness: Global Meta-Analysis and Economic Trade-Offs," Scientific Reports, no. 6, (April 2016): 239–54.
13. Food and Agriculture Organization, "Global Forest Resources," 23–27.
14. WWF International, "Guide to Lesser Known Tropical Timber Species" (Gland, Switzerland: WWF International, 2013), http://www.worldwildlife.org/publications/guide-to-lesser-known-tropical-timber-species.
15. Roxi Thoren, "Deep Roots: Foundations of Forestry in American Landscape Architecture," Scenario Journal, no. 3 (April 2014), http://scenariojournal.com/article/deep-roots/.
16. Sylvia Crowe, The Landscape of Forests and Woods (London: Her Majesty's Stationery Office, 1978).

PLACES OF PRODUCTION:
FOREST AND FACTORY

05

"This research option studio was a vehicle to explore how a sustainable Canadian resource—wood—and its automated production could inspire a variety of approaches to thinking an existing industrial site and the design of a new production facility. The results were an intense exploration into the interrelationships between forestry, sustainability, landscape, and built form."

THE PEDAGOGY OF WOOD AND ARCHITECTURE

Brigitte Shim
Daniels Faculty of Architecture, Landscape, and Design
Professor

Robert Wright
Daniels Faculty of Architecture, Landscape, and Design
Interim Dean

This design studio began with a collaboration between The Daniels Faculty of Architecture, Landscape, and Design and our industry partner Element5, a Canadian CLT company whose new production facility in St. Thomas, Ontario, will house a technologically advanced and fully automated CLT and glulam production line capable of producing 45,000 metres of CLT annually. Element5 connects CLT manufacturing to sawmills to transportation networks to their own forests in Northern Ontario.

This research option studio was a vehicle to explore how a sustainable Canadian resource—wood—and its automated production could inspire a variety of approaches to thinking an existing industrial site and the design of a new production facility. The results were an intense exploration into the interrelationship between forestry, sustainability, landscape and built form. Students were asked to examine a broad range of issues, from the challenging structural systems needed to address the long spans for factories and the future of the industrial site, to language and identity. The studio also forced an examination of the province-wide approach to forestry and wood and its role as a sustainable resource.

The studio pedagogy was driven by providing a variety of learning opportunities. At the outset, the faculty selected a range of global case studies, exposing our students to a broad range of conceptual approaches to forest and design. The studio benefited from numerous site visits—to a managed forest reserve, a CLT skills training facility, current CLT projects in the Toronto area—as well as several studio visits to architect's offices where they shared unbuilt CLT work. The faculty curated a Forest and Design Lecture Series linking the forest, wood, and design to an understanding related scientific and cultural issues; these lectures were open to our students, the Daniels faculty, and the University of Toronto community. Students in our studio were always learning from leading experts in the fields of forestry, architecture, landscape architecture, engineering, and mass timber, and building a strong knowledge base; these learning opportunities were combined with in-class lectures, desk crits, and reviews throughout the term.

FOREST AND THEORY PRECEDENTS

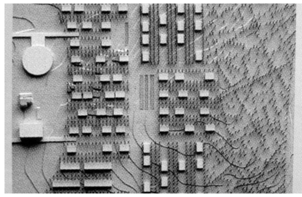
The following precedents in architecture and landscape design were given to the students as a primer for the work to be undertaken during the studio. Each case study was researched by a student and synthesized for the class in a presentation format.

Blue Wall Center
Studio Gang and SCAPE, 2010

Bosco Verticale
Stefano Boeri, 2014

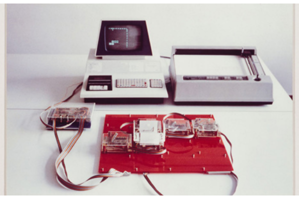
Duisburg Nord Landscape Park
Office of Peter Latz, 1991

Forest Building
SITE (James Wines), 1978



Forest City
Herzog & de Mueron, 1992

Forest Restoration
Sasaki, in progress

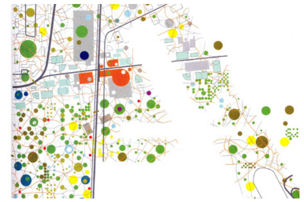


Generator
Cedric Price, 1976–80

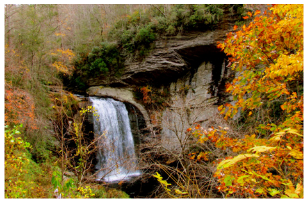
KAIT Workshop
Junya Ishigami, 2008

Okutama Forest Therapy Trail
Toru Mitani/Yuuji Suzuki, 2010

Parc des Buttes-Chaumont
Jean-Charles Alphand, 1867



Downsview Park Competition
Various authors, 2000



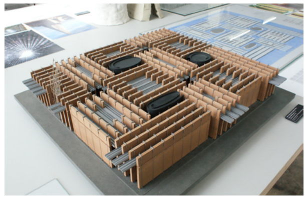
Pisgah National Forest
Gifford Pinchot, 1892

Red Ribbon Park
Turenscape, 2007

Sustained-Yield Unit
US Forest Service, 1944

Zurich Wilderness Park
Federal Office of the Environment, 2007

The Bloedel Reserve
Various authors, 1988



Swiss Sound Box
Peter Zumthor, 2000

Trees To Expo
Barclay MacLeod, 1969

Botanical Garden of Bordeaux
Gironde France, Catherine Mosbach, 1858

STUDIO SITE VISITS: EMERGING TRENDS IN WOOD ARCHITECTURE

Our studio visits to mass-timber construction sites, unbuilt projects, and architects' office in the city of Toronto

The Arbour

Moriyama & Teshima Architects; presented by Carol Phillips

Led by partner Carol Phillips, students visited the Toronto office of Moriyama & Teshima Architects and learned about ongoing projects using mass timber technologies. The Arbour, a joint venture with Acton Ostry Architects, is located on the Waterfront Campus of George Brown College and is set to be the first mass timber institutional building in Ontario. It will host the School of Computer Technology and School of Architectural Studies, the local community, and a mass timber research centre. The ten-storey building will feature a CLT flat-plate system that creates an open, beamless structure that conserves volume and material cost. The Arbour has a building goal of net-zero carbon emissions.

Golden Avenue

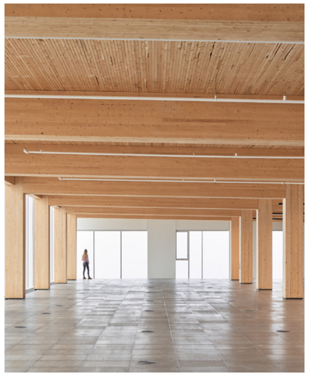
Superkül; presented by Andre D'Elia.

Known as the Golden Nugget, 35 Golden Avenue is a three-storey, 600-square-metre commercial office building that is home to many small and medium-sized businesses. Students visited the adjacent building, where the office of Superkül is located, and were subsequently given a tour of the new build. Responding to the industrial history of the west-end site, steel columns and beams are exposed, supporting the modern-industrial NLT-manufactured floor, roof, and stairs of the building. NLT panels varied from six to eight feet in width, which significantly reduced the cost of construction. Large second- and third-floor balconies and a flexible rooftop create outdoor spaces for occupants.

Academic Wood Tower

Patkau Architects and MJMA; presented by Ted Watson

Academic Wood Tower by Patkau Architects and MJMA exhibits innovation in design forecasting. When the students visited MJMA, they learned that the Goldring Centre for High Performance Sport completed in 2014 was, from its inception, intended to be the first of a two-part construction. An existing concrete base connected to Goldring will become the foundation of the fourteen-storey Academic Tower. The original steel design of the tower was scrapped in favour of timber construction using glulam columns, beam braces, and cores, and CLT floor decks, dramatically reducing carbon emissions during all phases of construction. Additional sustainability features include greywater irrigation using rainwater, photovoltaic energy production, and a green roof.



80 Atlantic

Quadrangle Architects; presented by Wayne McMillan

Students had the opportunity to visit the office of Quadrangle Architects and the construction site of 80 Atlantic Avenue in Liberty Village, guided by project team member Wayne McMillan. The upper four storeys of this five-storey office building are built with NLT flooring supported by glulam columns and beams. The exposed post-and-beam structure in the office spaces was welcoming to the point that some students hugged the columns. The large windows, airy atmosphere, and functional office design accomplished by mass timber products simultaneously elevate the aesthetic, environmental, and experiential benefits of office life.

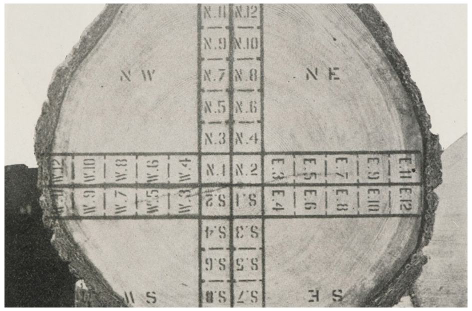
DANIELS MIDDAY TALKS: FORESTRY AND DESIGN SERIES

Curated by

Brigitte Shim
Daniels Faculty of Architecture, Landscape, and Design
Professor

Robert Wright
Daniels Faculty of Architecture, Landscape, and Design
Interim Dean

A curated lecture series shared with students and faculty exploring the inextricable link between forestry and design in the production of timber products



Forest Primers

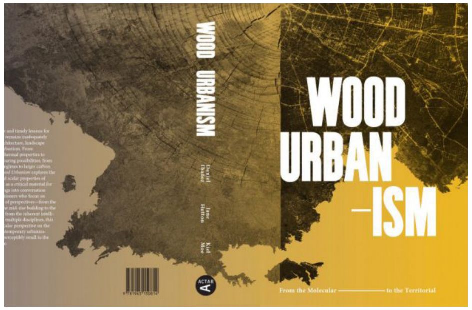
Dan Handel

Dan Handel is an architect and curator whose work focuses on research-based exhibitions with special attention to underexplored ideas, figures, and practices that shape contemporary built environments. He was the inaugural Young Curator at the at the Canadian Centre for Architecture in Montreal, has developed exhibitions for the Venice Biennale and the New Institute in Rotterdam, and was curator of architecture and design at the Israel Museum.

Forests, Architecture, Sustainability

Dr. Sean Thomas

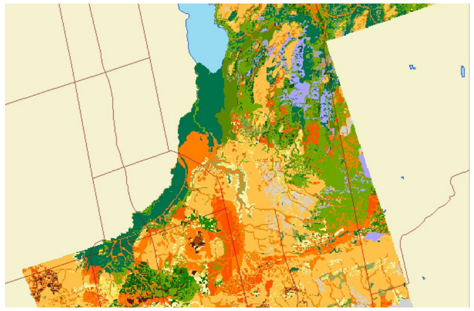
Sean Thomas has been preoccupied with the comparative biology of trees and forest responses to the intentional and accidental impacts of humans for some twenty-five years. Sean's research focuses on how trees and forests respond to human impacts—intentional impacts through forest management, and unintentional impacts via local, regional, and global changes in the environment.



Wood Urbanism

Jane Mah Hutton

Jane Mah Hutton is a landscape architect, whose research looks at the extended relationships of materials in design, examining links between the landscapes of production and consumption of common building materials. Her design research has focused on material flows and urban change, and has been published and exhibited in venues in Canada, the US, the UK, and China.



The Southern Ontario Forest

Dr. Danijela Puric-Mladenovic

Danijela Puric-Mladenovic is a Daniels faculty member working for the Ministry of Natural Resources, Science and Research Branch, Natural Heritage Information Centre. Her research and professional work are focused on forests in settled and urban landscapes. Her research has a specific focus on conservation, restoration, and integrated spatial planning and management of forests in urban and peri-urban to rural landscapes and their interfaces.

Mass Timber Buildings

Craig Applegath

Craig Applegath is the founding principal of DIALOG's Toronto studio and a passionate designer who believes in the power of built form to meaningfully improve the well-being of communities and the environments they are part of. Craig focuses his energies on leading innovative planning and design projects that address the complex challenges facing our communities, as well as on his advocacy of sustainable building design and urban regeneration and symbiosis.

Urban Forests

Dr. Sandy Smith

Sandy Smith is the newly appointed director of the Daniels Faculty's forestry graduate programs. She specializes in forest health and urban forests, specifically using natural controls to address invasive species, with research focused on biological control of forest insects, earthworms, and plants such as dog-strangling vine and phragmites. Sandy is best known for her contributions augmenting native natural enemies for biological control in forested systems.

HINDSIGHT IS 20/20
FOREST CULTURE: PANEL DISCUSSION

Moderated By:

Brigitte Shim
Daniels Faculty of Architecture, Landscape, and Design
Professor

Panel discussion at Daniels, 26 September 2019

What meaning do forests have in our lives? Part of the Hindsight Is 20/20 public programming series at Daniels, Forest Culture was a panel discussion featuring noted experts in the field of forestry, including Dan Handel, Stephanie Seymour, and Scott Jackson. Moderated by Brigitte Shim, a professor at Daniels and consumer of architectural wood products through her private practice, Shim-Sutcliffe Architects, the panel considered the meaning of the forest from several perspectives. The nuanced mosaic of the contemporary forest was highlighted through each panelist's presentation: the forest means Indigenous, the forest means sustainable, the forest means culture—there is not one kind of forest, there are many.

As we look towards the future, it is evident that the diversity in our understanding of forests is essential to addressing issues of climate change, resource management, and sustainable design. A collaborative, cross-disciplinary approach is needed to identify and overcome the existing barriers to economic and environmental sustainability in the Canadian context.
Within the Daniels Faculty, the architecture, landscape, forestry, and visual studies programs offer innovative and cross-disciplinary understandings of the forest, preparing a new generation of designers to mediate the raw material industry and advocate for the forests of the future. Event can be viewed on the faculty's YouTube channel, UofT Daniels.

Dan Handel

Dan Handel is an architect and curator whose work focuses on research-based exhibitions with special attention to underexplored ideas, figures, and practices that shape contemporary built environments. He was the inaugural Young Curator at the Canadian Centre for Architecture in Montreal, has developed exhibitions for the Venice Biennale and the New Institute in Rotterdam, and was curator of architecture and design at the Israel Museum.

Scott Jackson

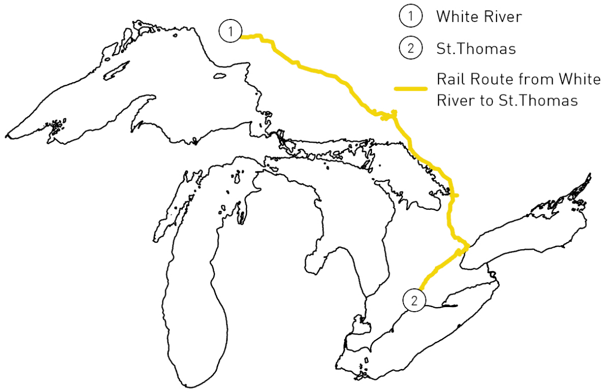
Scott Jackson has over twenty years of experience in the field of natural resource policy and conservation science. Prior to joining Forests Ontario, Scott spent thirteen years as the manager of forest policy for the Ontario Forest Industries Association, an organization that acts as the provincial voice for the forest sector in Ontario. He also acted as a key liaison to other resource sectors, municipal government officials, and non-governmental organizations. Scott is currently the Director of Indigenous and Stakeholder Relations at Forests Ontario.

Stephanie Seymour

Stephanie Seymour is an Anishinaabe-kwe from Garden River First Nation who is currently conducting research for her PhD in Forestry at the University of Toronto. Her research focuses on the possibilities of reducing or eliminating herbicide use on managed forests in Ontario using both a scientific and holistic approach. Stephanie has a knowledge of the historical and contemporary issues facing Indigenous people, as well as a background in forestry and resource management.

ST. THOMAS: A CITY OF INDUSTRIES

Alexandra Ntoukas
Daniels Faculty of Architecture,
Landscape, and Design
MLA

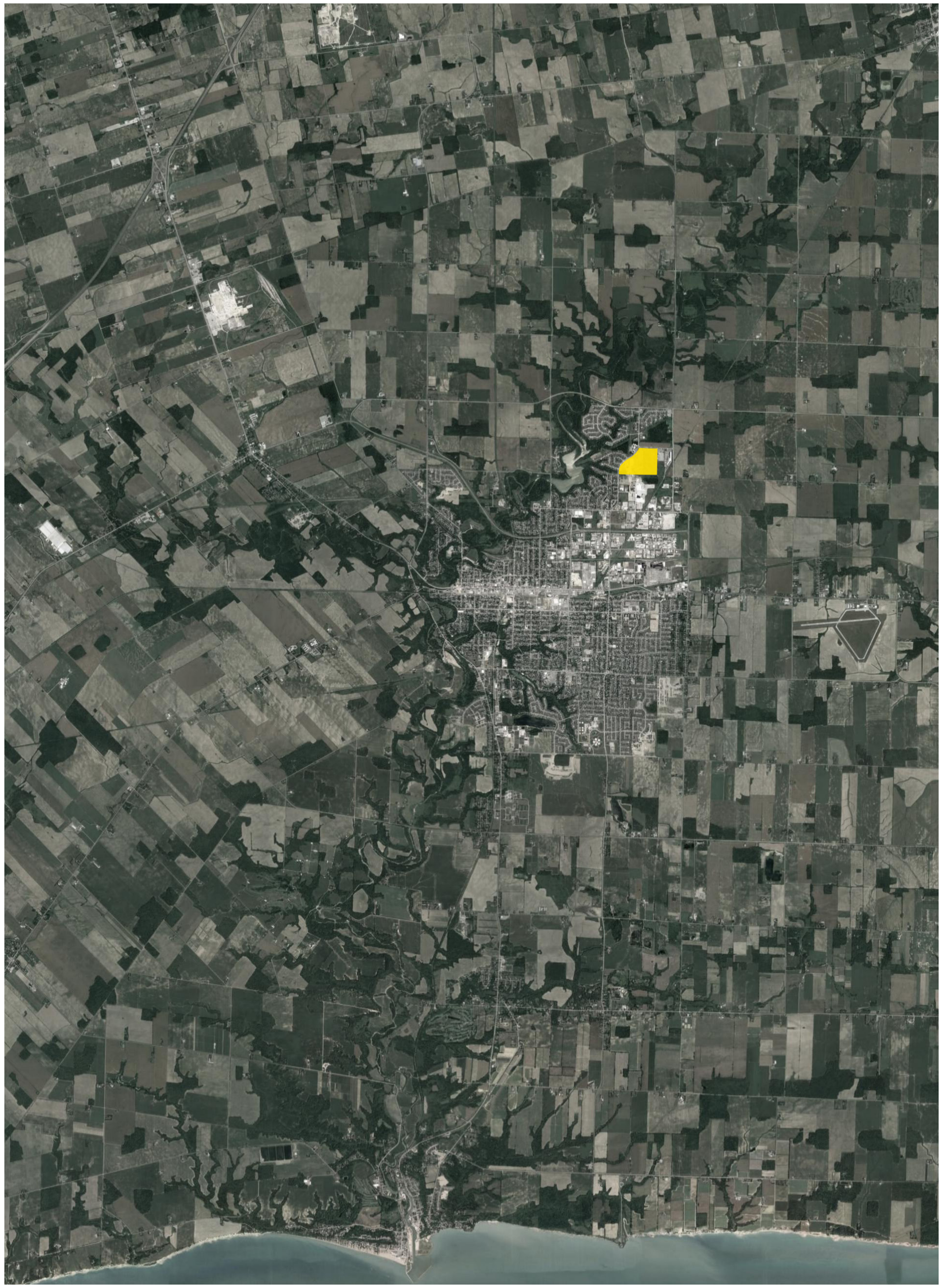


The Forest

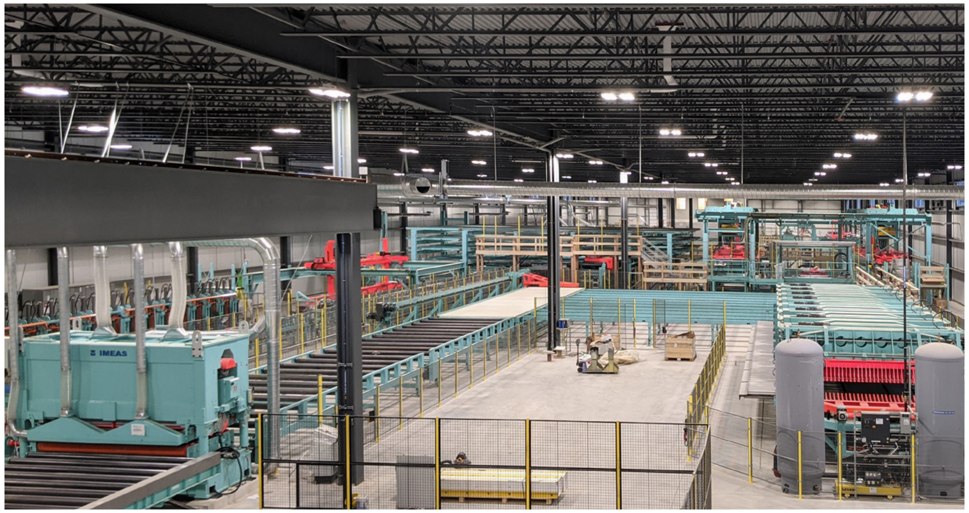
The present-day city of St. Thomas is situated in Southwestern Ontario, south of London and north of Lake Erie on the traditional lands of the Anishinaabe and Haudenosaunee. St. Thomas is covered by the Upper Canada Land Surrenders, specifically the McKee Purchase Treaty #2 of 1790 and Between the Lakes Treaty #3 of 1792.[1] St. Thomas belongs is located within Elgin County and is south of Middlesex County, where Munsee Delaware Nation, Oneida Nation of the Thames, and the Chippewa of the Thames First Nation reside.[2]

European settlers arrived in this area at the beginning of the nineteenth century.[3] At the time, they would have encountered predominately dense, forested land, and were tasked with clearing this land for commercial agriculture.[4] Wood was harvested indiscriminately; it differed in quality and once harvested was distinguished for different uses, from building homes and barns to constructing fences, providing heat and fuel, and so on.[5] Most relevant to the identity of St. Thomas was the wood used as raw material for railway construction. The first railway in St. Thomas was established in 1856, marking rapid economic growth in the city. Proximity to US markets and increasing railway connectivity made St. Thomas a central economic hub.[6] A total of twenty-six railways have existed in St. Thomas, granting it the title 'The Railway City.'[7] Due to the voracity of agrarian settlers, by the end of the nineteenth century the forest of Southwestern Ontario was essentially gone. Environmental awareness became a growing phenomenon on a global-scale, and local conservation efforts included forest initiatives aimed at preventing forest fires and erosion and ensuring a future supply of timber.[8]

St. Thomas is classified under ecoregion 7E. It is part of a larger mixed woods ecozone in Southern Ontario. Temperatures are moderate, with cool winters and hot, humid summers. Despite the impacts of historical and present-day agriculture and growing suburban development, this ecoregion is the most species rich in all of Canada. The forests that exist in the area now are composed of hardwoods and mixed hardwood-conifer species. Many rare Carolinian forest and tall-grass prairie species exist solely in this part of the world.[9]



Satellite Image of St. Thomas, Ontario: 42.46N 81.06W, eye altitude 46.63 km



Interior of the Element5 CLT factory in St. Thomas

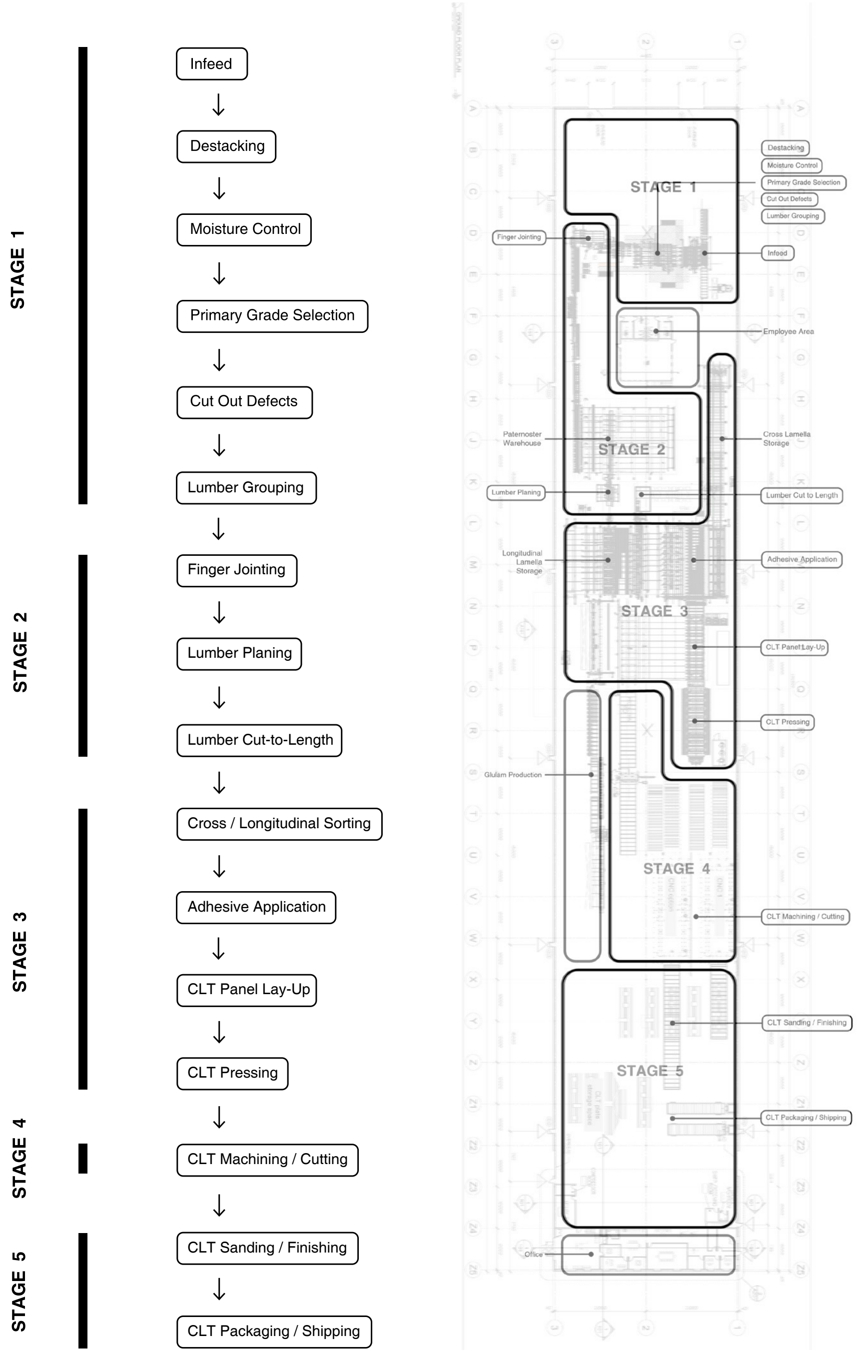
The Factory

In the mid-twentieth century, railway use across Ontario declined as the automobile industry boomed. Adjusting to the market, automobile factories moved into St. Thomas and became the city's new industry, providing a foundation for economic prosperity up until the 2008 global recession. Local factories then closed and thousands of people were faced with unemployment.[10]

Now, over a decade later, St. Thomas is growing and its economy is diversifying.[11] To successfully integrate itself into the community, the new factory proposed by Element5 must adapt to this local identity. By creating different opportunities and relationships with and for the community, Element5 can increase their resiliency in times of economic downfall and re-position itself as a leader in sustainable, community-integrated industrialism.

Technological innovations in timber-related industries have had profound spatial impacts in our landscapes. Each innovation prescribes its own measure of specificity for both the forest and factory. The timber industry is currently witnessing a new measure of increased specificity due to laminated timber technologies: technology alters relations with the forest through specifications of forest type, tree species (primarily spruce, pine, and fir), grade, and size.[12] The factory is altered to accommodate a state-of-the-art manufacturing line with a footprint of approximately 80 m^2.

The interaction of production capabilities between forest, factory, and designer is unprecedented. Laminated timber offers novel specificity for designers utilizing wood products. As is the case for timber technologies, buildings themselves require complexity when planning for the future. Future-proofing a building acknowledges the changes that can occur during its lifespan. The 12,320m^2 rectangular factory for Element5 must consider a future where both the interior and exterior of the factory can grow and evolve into new uses. This objective stays true to the growth and economic diversity of St. Thomas.



Stages of CLT production

Site image of St. Thomas

The Site

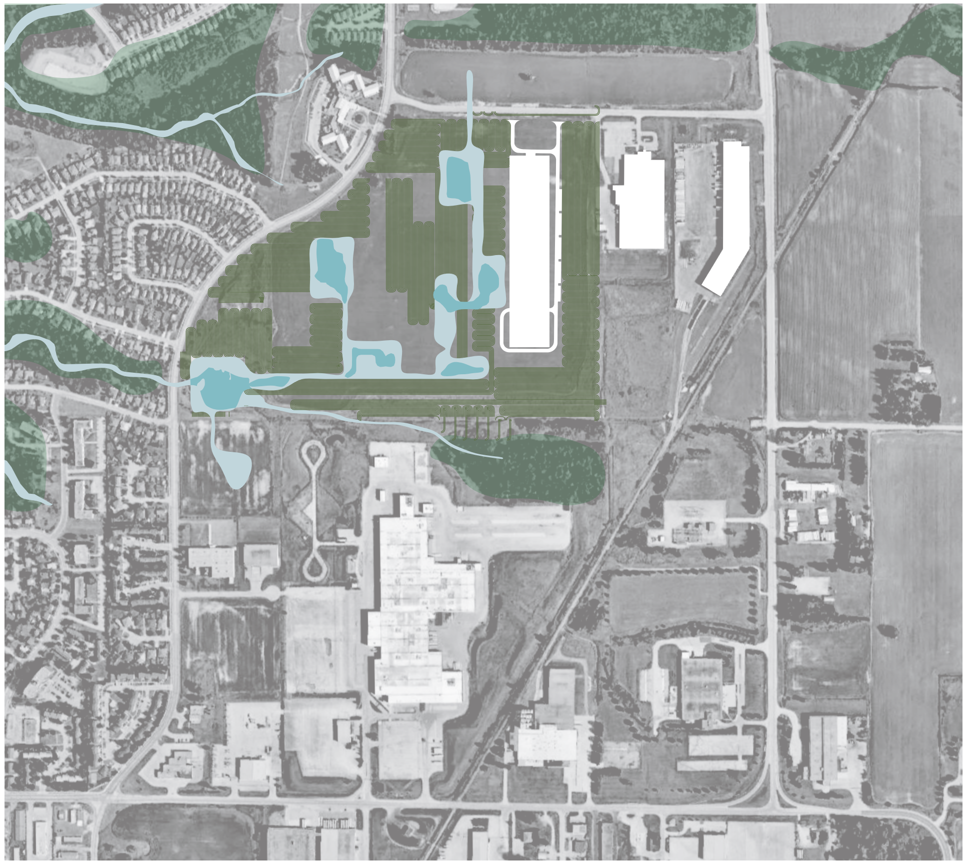
The factory site for Element5 in St. Thomas is a generic industrial site. It is adjacent to an existing industrial landscape and a railway, encroaching suburban development, on relatively flat land, with small pockets of forest and larger ravine systems nearby. These traits are typical of for an industrial landscape in southwestern Ontario.

The studio Places of Production: Forest and Factory, challenges students to rethink how industry operates in Canada, a land where primary resources like wood continue to drive the economy. Beginning with the regional scale, students were asked to reconsider the relationship between forest and factory to achieve a sustainable, future-proof model of value-added production. At the scale of the site, new principles for the forest and factory are incorporated, where the current and future needs of factory workers and local community drive the on-site programming. Five unique schemes were generated as a result: Adaptable Futures, Biostack, New Back 40, Public Good, and N-Arboretum. This studio demonstrates the unlimited potential of a generic industrial site when regional and local sustainability is placed at the forefront of design.

Notes

1. Government of Ontario (website), Map of Ontario Treaties and Reserves, 2018, updated 22 February 2021, https://www.ontario.ca/page/map-ontario-treaties-and-reserves#t6a
2. St. Thomas-Elgin (website), "Multiculturalism," https://www.welcometoste.ca/resources/multiculturalism.
3. City of St. Thomas (website), "A Brief History of St. Thomas," https://www.stthomas.ca/visiting_us/a_brief_history_of_st__thomas.
4. J. David Wood, Perspectives of Landscape and Settlement in Nineteenth Century Ontario (Toronto: McClelland and Stewart Limited, 1975).
5. Wood, Perspectives of Landscape and Settlement.
6. City of St. Thomas, "A Brief History"
7. "Our History," Elgin County Railway Museum, https://ecrm5700.org.
8. Bruce Hodgins, Jamie Benidickson, and Peter Gillis, "The Ontario and Quebec Experiments in Forest Reserves 1883–1930," Journal of Forest History 26, no. 1 (January 1982): 20–33.
9. Government of Ontario (website), "The Ecosystems of Ontario—Part 1: Ecozones and Ecoregions," 2015, updated 25 March 2021, https://www.ontario.ca/page/ecosystems-ontario-part-1-ecozones-and-ecoregions.
10. Wood, Perspectives of Landscape and Settlement.
11. Wood, Perspectives of Landscape and Settlement.
12. Canadian Wood Council (website), "Lumber Properties," https://cwc.ca/why-build-with-wood/strong/structural-design/lumber-properties; Canadian Wood Council (website), "Grades," https://cwc.ca/how-to-build-with-wood/wood-products/lumber/grades.

The highlighted area in yellow is the site of Element5's factory and the studio projects. 42.48N 81.09W, eye altitude 5.31 km



Adaptable Futures

Dylan Johnston
MArch

Caroline Kasiuk
MLA

Michael Macneill
MArch

Niko McGlashan
MArch

Approaching the project from the watershed scale is critical to acknowledging this site's future role in restoring the currently fragmented Carolinian forest of the region. A series of wetlands were developed and integrated with existing drainage patterns, linking the site to regional ecosystem services. Water features were carefully located at low points in elevation alongside a phased planting strategy for forest succession. Wetland and recreation programs complement a mass timber factory designed with a fully adaptive structure. These elements enable a holistic vision for a sustainable landscape and building relationship over the next hundred years.

Biostack

Miranda Fay
MArch

Fiona Lu
MArch

Jennifer Tran
MLA

Sidney Tsao
MArch

Biostack goes beyond being just a place for production and aims to establish sustainable relationships between the architecture of production, the community, and the environment. The design proposes a comprehensive factory building with an efficient production line that has the added capacity of recycling the byproducts of the factory into energy generation and landscape remediation. It also proposes an adjacent program of therapeutic waters running on the energy generated on-site and offering an added service for the local community. Through energy generation, research, and recreation, this design demonstrates that the factory has potential beyond production that should not be overlooked.

New Back 40

Curtis Ho
MArch

Safina Moloo
MArch

Alexandra Ntoukas
MLA

Holly Smith
MArch

New Back 40 takes the design of a mass timber factory to the provincial and regional scale. The design is premised on challenging the reliance of the timber industry on only spruce, pine and fir. The project visualizes the cost of transporting these specific species and the potential devastation of monocultural cultivation. The project locates local and regional remnant woodlots on agricultural land ("back forties") as repositories of diverse local woods. The intent is to have the factory become the catalyst that reactivates and re-connects this fractured landscape of woodlots. The factory itself seeds a series of nature trails from reconnected woodlots, capable of becoming nurseries for a diversified line of local engineered timber products.

Public Good

Enica Deng
MArch

Katherine Liu
MLA

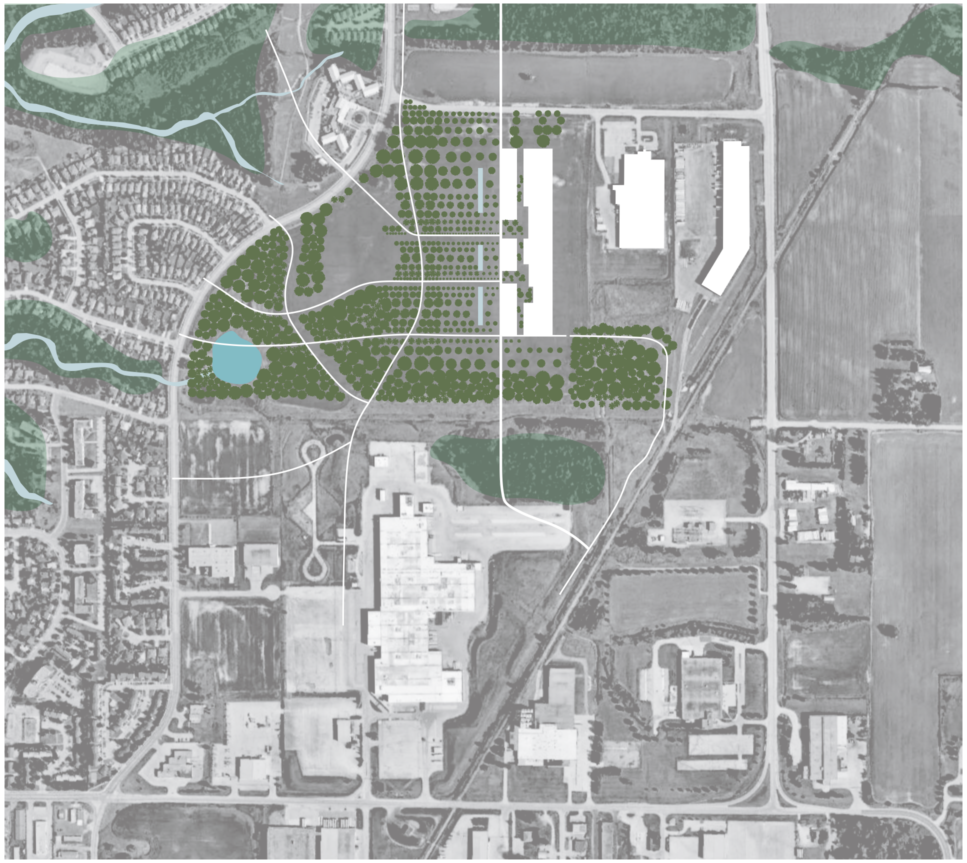
Vincent Wu
MArch

Roger Xu
MArch

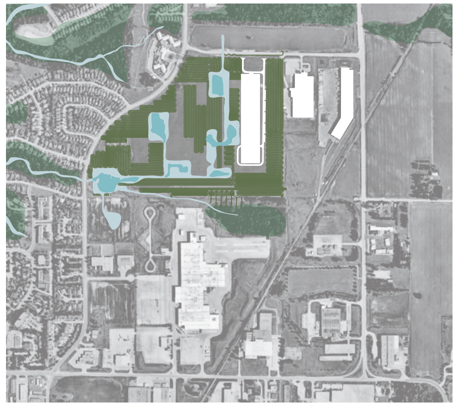
This project creates concentric zoning where the periphery is used for human activities and the interior acts as a sanctuary for endangered species from adjacent habitats

A boardwalk is introduced along with the trade school and factory to activate the building periphery and discourage people from entering the sensitive interior.

The project proposes a constructed wetland, prairie, and woodland that are built inside of the courtyard, where people can experience nature without disturbing the habitat.



The Site

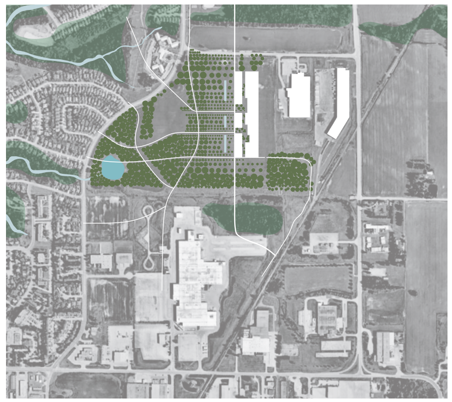


Adaptable Futures

Biostack

Public Good

New Back 40



N-Arboretum

N-Arboretum

Tharshni Shanmuganathan
MLA

Hrishikesh (Rishi) Tailor
MArch

Blake Wallace
MArch

Ranran Zhang
MArch

N-Arboretum, a factory for Element 5, is a catalyst for timber research. Large-scale reforestation reintroduces endangered tree species, which can become viable sources of timber in the future. Located in the ordinary, small suburban town of St. Thomas, it challenges the typical characteristics of "employment/industrial" lands, which are generally places with large swathes of concrete and tarmac that are uninviting to the general public. The project shows how large industrial lands can be used as an opportunity for reforestation and indirectly contribute towards greater local biodiversity.

ADAPTABLE FUTURES

Dylan Johnston
MArch

Caroline Kasiuk
MLA

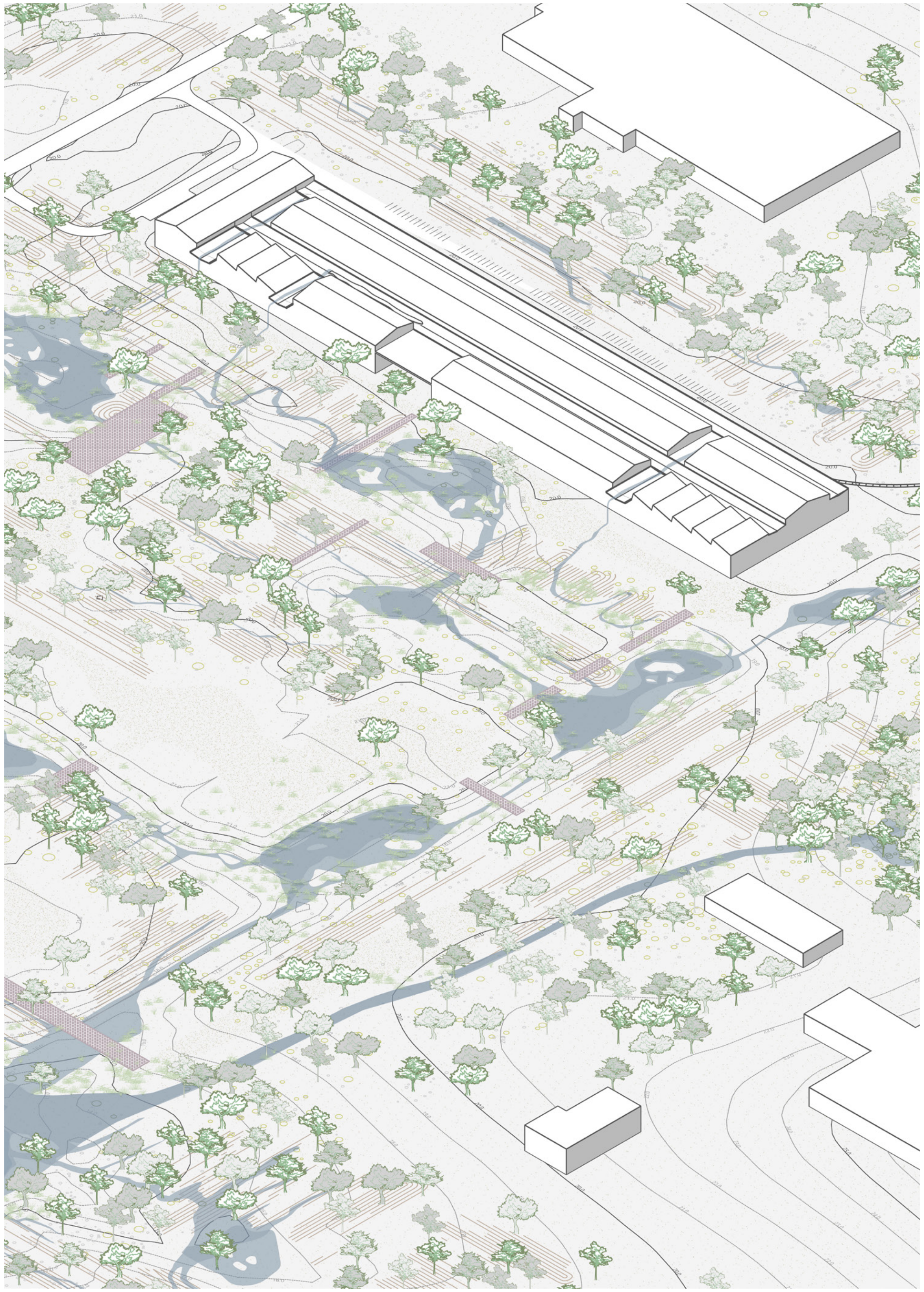
Michael MacNeill
MArch

Niko McGlashan
MArch

Designing for a Climate of Uncertainty

> *The greenest building is one that is already built.*
>
> *—Carl Elefante*

This project is aimed towards the future. The field of architecture tends to overlook this crucial dimension of sustainability; drawings merely offer a glimpse into a privileged moment in time. Given the intrinsic importance of sustainability in mass timber and forestry, it is apparent that the temporal scale is integral to the project. The design of the factory fulfills a service life of at least one hundred years by envisioning the life cycle of the building and its context. Future-proofing governs all aspects of the design, from the scale of the watershed region down to the structural details.

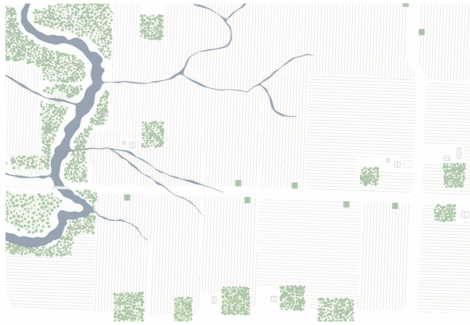


Proposed Site Axonometric: drainage run-off from the building is incorporated into ecosystem services

Adaptive Ecosystems

The temporal framework of the project begins in the 1700s. At that time, the ecosystem was undisturbed and predominantly a wet forest and wetland. Over the next two centuries, the watershed was colonized and agriculture became the primary land use. Only traces of the watershed's previous condition remain. The intervention proposes to return the landscape into a wetland and forested area. While existing farm fields are rows that facilitate agricultural runoff, the project aims to re-till the site to create inundation ponds. Ultimately, the site will be an example for the remainder of the watershed region. If enough farms follow suit over time, it will substantially benefit the watershed's overall health.

1700



1880

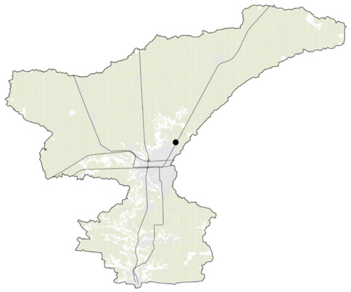
2019

2020

2045

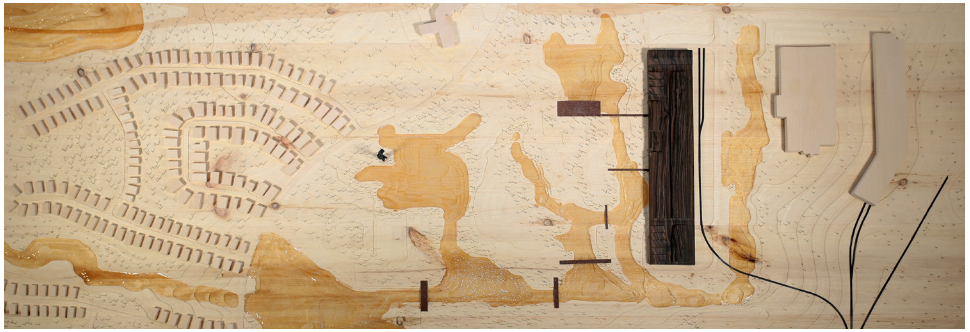
2100

View of the proposed relationship between the landscape and the factory



Regional Watershed: anthropogenic land use

Regional Watershed: ecosystem services



Model of adaptive wetland and ecosystem Services

0m 100m

Possible Futures

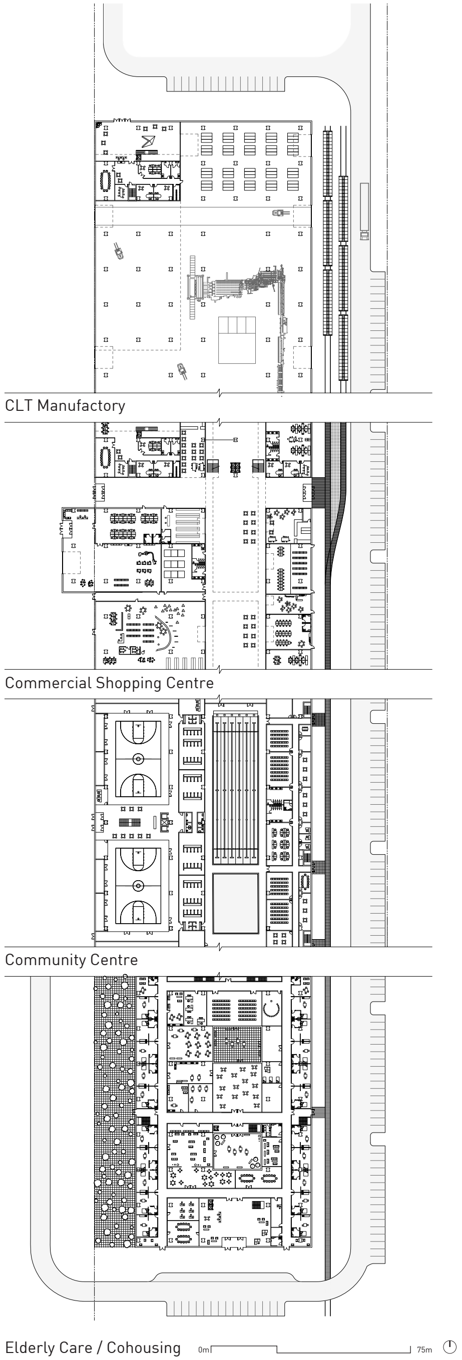
Following the same trajectory as the landscape, the factory is designed to improve over time. Its generally open layout means it will be capable of hosting a multitude of alternate uses in the future with minimal modifications to the original structure.

The long span in the core of the building can accommodate the width of an Olympic-size swimming pool. The shoulder spans can house basketball and multi-use courts.

Since every structural bay has the potential to house a mechanical system, distributing ventilation across a potential cohousing project is already accommodated for.

The shoulder spans on either side of the core can subdivide into retail space. The core then performs as an arcade for primary circulation.

Based on the building's size, a scenario in which several programs occupy the building simultaneously is conceivable, with the building becoming a community hub. A community centre, cohousing project, and commercial space are complementary programs that could potentially coexist.



Elderly Care / Cohousing

Proposed Site Plan—CLT Manufacturing Facility

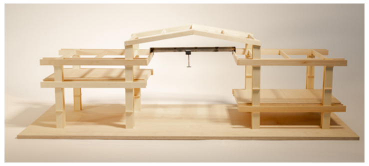
1:100 Structural Model

Designing for Flexibility

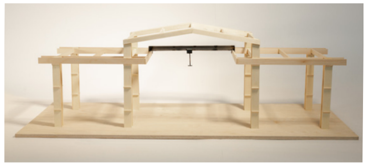
Due to the pragmatism of the factory, a single bay design is repeated to meet the program requirements. The detail and attention devoted to this single bay ultimately informs the entirety of the factory.

A double glulam Gerber box beam is used for the long span. The beam's depth is equal with the shorter spans on either side: this crucial detail makes possible the future infill of CLT floors and an even clearance of three metres to complement future programs.

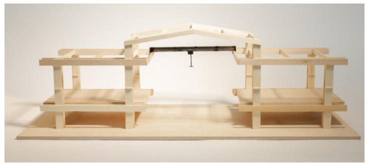
Paired with the double Gerber system, a box beam is used for the middle span. Whereas HVAC typically poses a challenge for mass timber structures, here the services are concealed inside the hollow box beam. This detail prevents visual clutter and maximizes the potential for modularity as the CLT floor panels can be removed or rearranged.



Partial Second and Third Floor

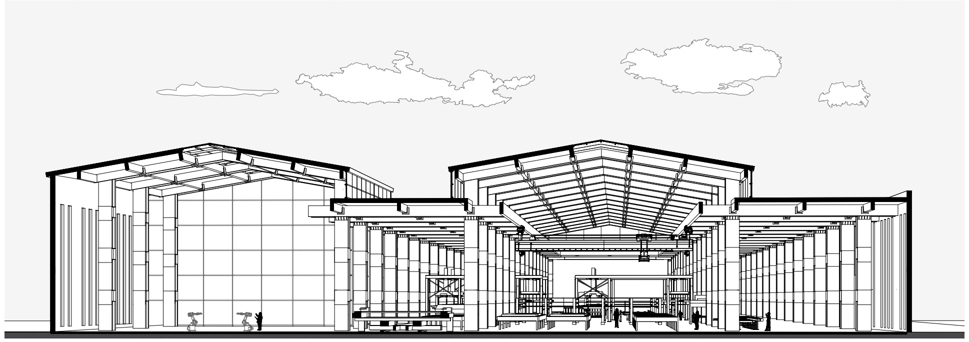


Ground Floor Only

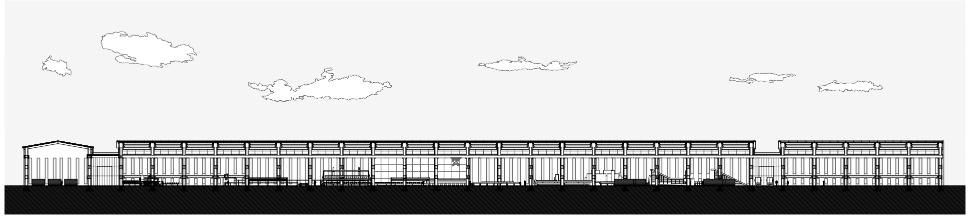


Split Second Floor

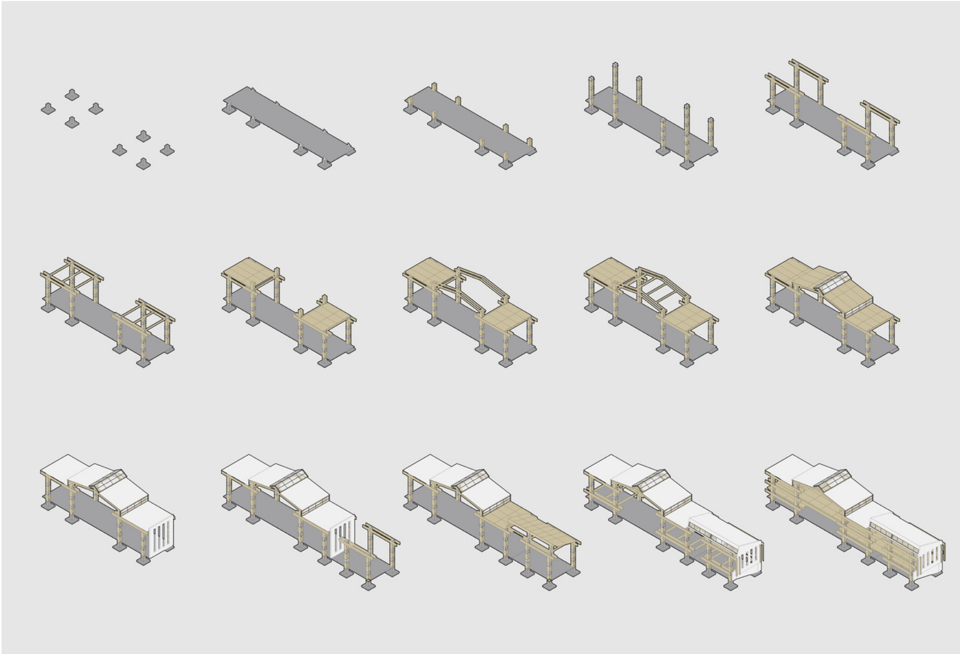
Continuous Second Floor



Cross Section

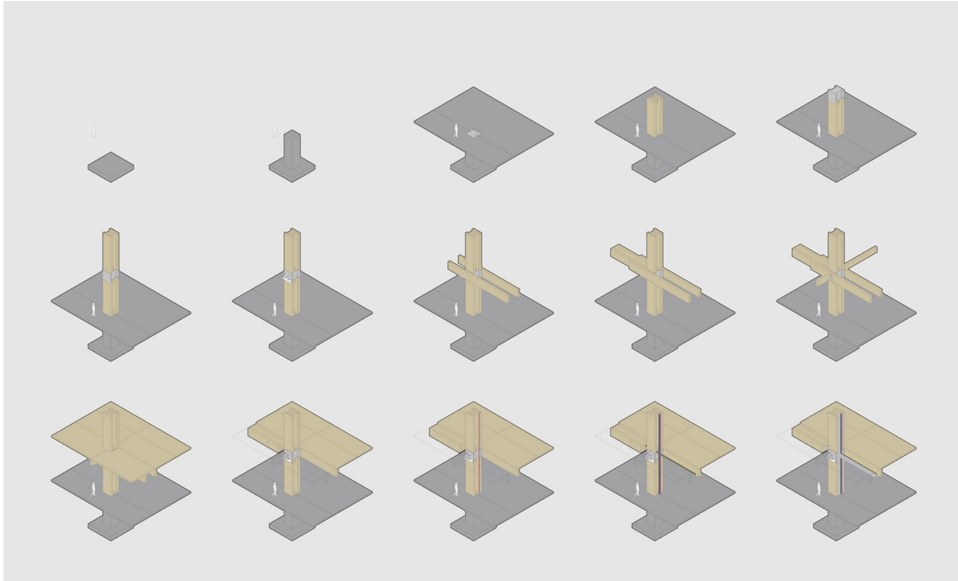


Long Section



Assembly Diagrams: Structural Bay Sequence and Building Expansion

Interior View

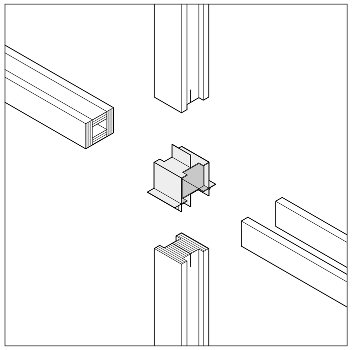


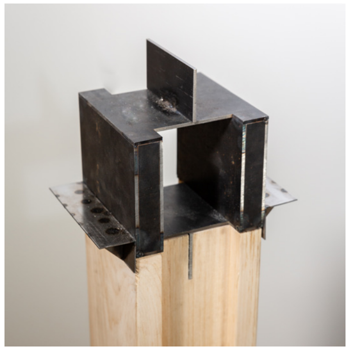
Isolated Column: Sequence of Assembly and Integration of Systems

The Future Is in the Details

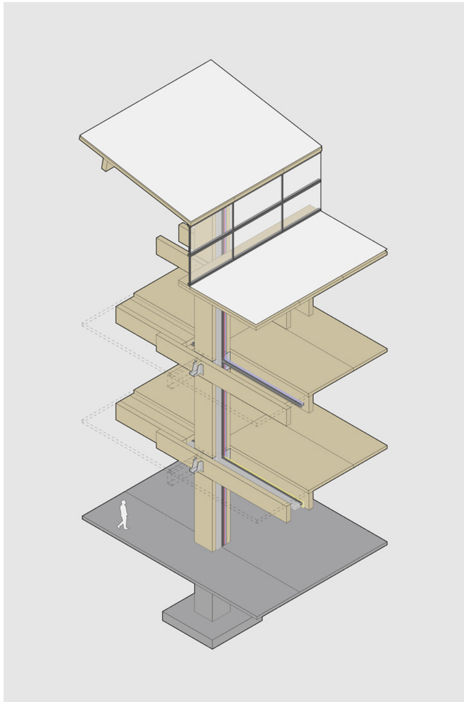
A custom steel node allows mechanical services to pass through the column and structural system. This makes it possible to remove adjacent CLT floor panels without interfering with mechanical hardware, whilst simultaneously allowing for the maintenance of building services with minimal destruction to floor and wall elements. The node performs as an anchor for the Gerber beam and as a double knife plate to connect the adjoining glulam columns.

The combination of wood and steel in the column demonstrates the benefits of two structural materials working in tandem. Due to advances in prefabrication, composite materials can be incorporated without having to schedule multiple trades. As a result, isolating the strengths of both materials can enhance building performance. In this instance, the steel node offers considerably more stiffness.





Custom Steel Connecting Node



Floor to Ceiling Axonometric Section

1:10 Structural Column Detail

BIOSTACK

Miranda Fay
MArch

Fiona Lu
MArch

Jennifer Tran
MLA

Sidney Tsao
MArch

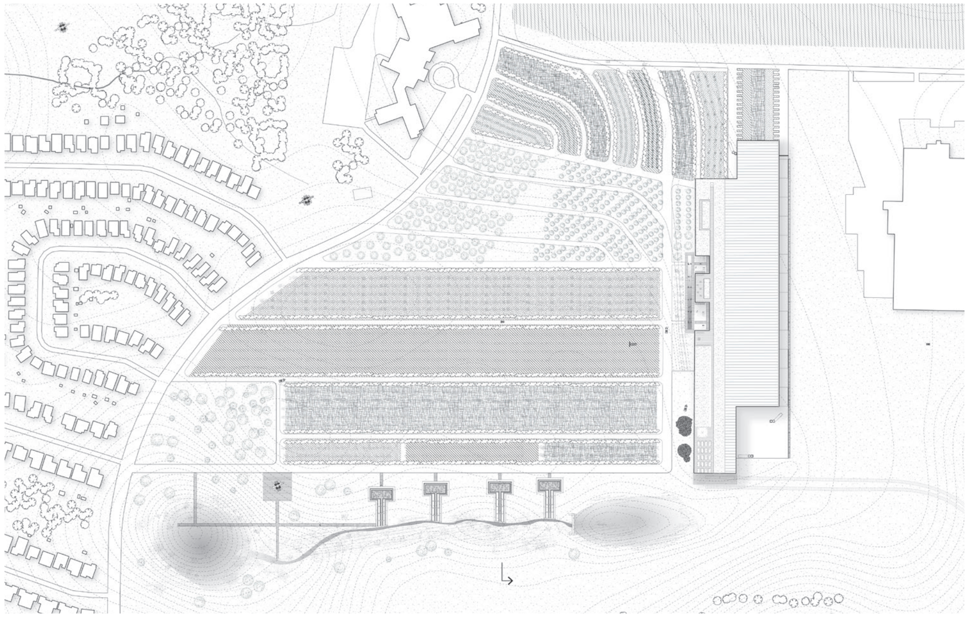
Beyond a Place of Production

This factory building design for Element5 goes beyond being just a place for production and aims to establish sustainable relationships between the architecture of production, the community, and the environment. This design proposes a comprehensive factory building with an efficient production line that has the added capacity of recycling the byproducts of the factory into energy generation and landscape remediation. Factories are typically isolated from the community in which they exist; the design proposes an adjacent program of therapeutic waters running on the energy generated on-site, offering an added service for the community.

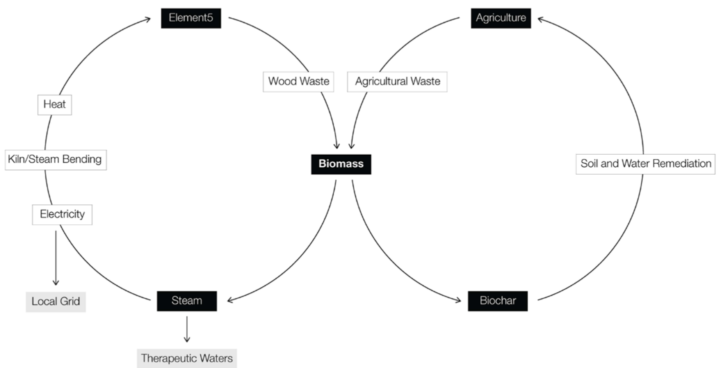
View of the building exterior. The chimney stack emits exhaust as the biomass generator powers the factory

Factory and Biomass Feedback Loop

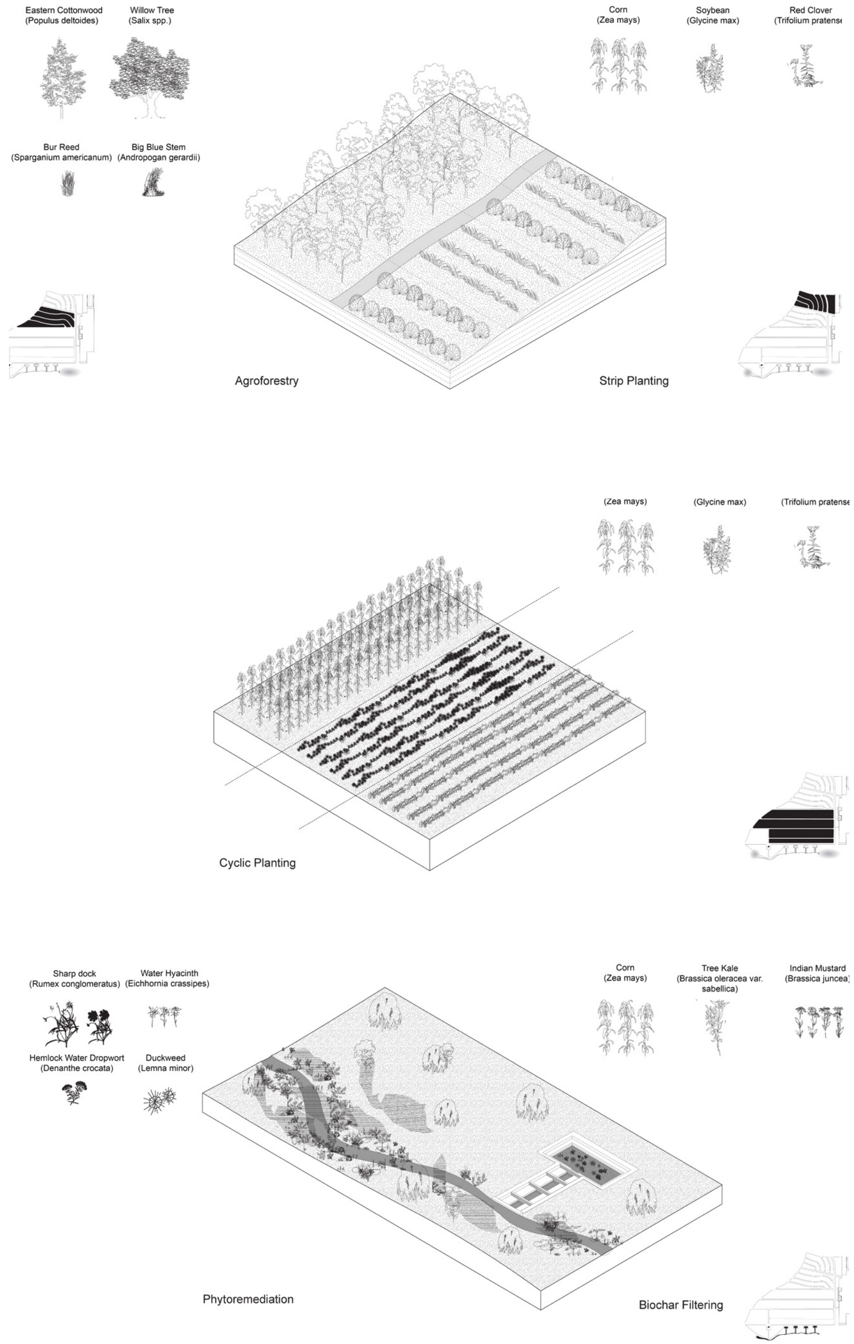
The landscaping around the site is designed as a living laboratory for researching land management methods and phytoremediation. The planting is divided into three areas of experimentation: agroforestry, strip planting, and cyclic planting. The biochar that is a byproduct of burning biomass can be used to absorb the phosphorus in the water and soil to remediate the accumulation of phosphorous over decades of fertilizer use. The research and data collected on the different types of land management on-site can be implemented at a larger scale.



Site plan. Surrounding agricultural land provides agricultural waste that powers the factory building

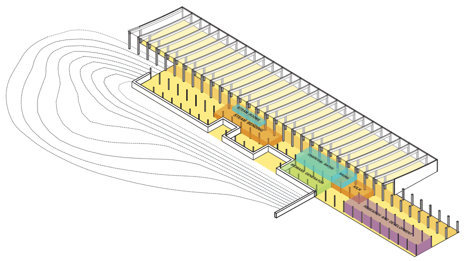


Building Operation Cycle



On-site land and water-management strategies

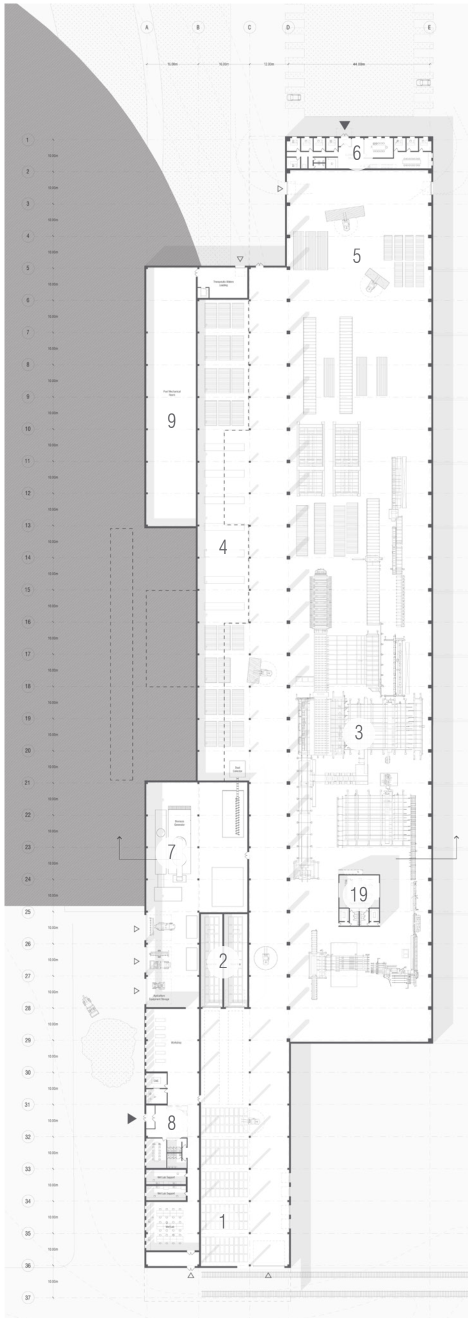
Floor Plans



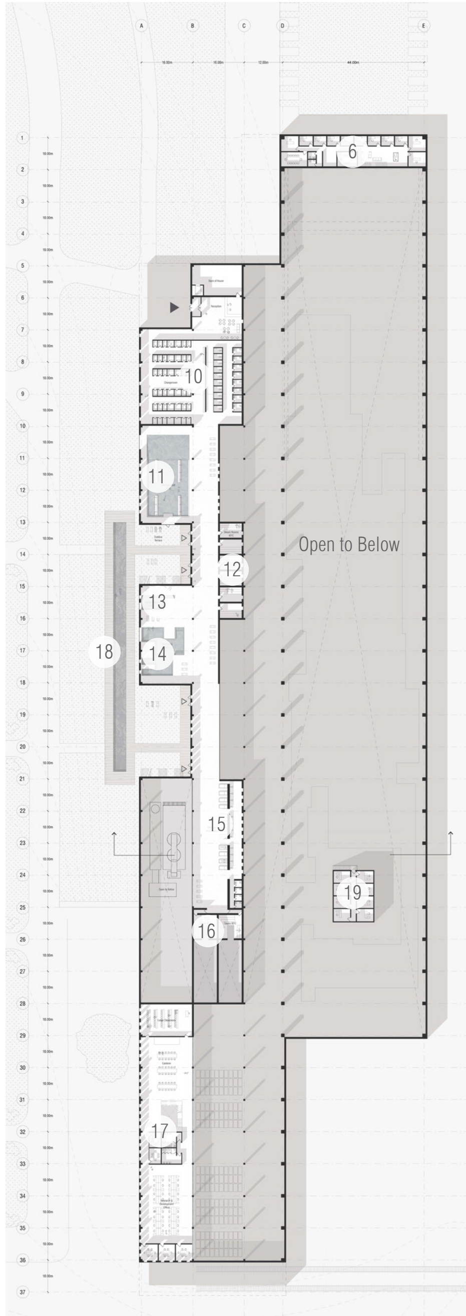
The main production line for Element5 is located on the ground floor. Adjacent to the production line is the biomass research and development lab. The lab opens directly into the landscape for ease of access to the living lab. At the intersection of production and research is the biomass generator. As it is the heart of the project, the generator is central in the plan.

1 Loading
2 Kiln
3 CLT Processing
4 Steam Bending
5 Packaging and Shipping
6 Element5 Office
7 Biomass Generator
8 Research Development
9 Pool Mechanical
10 Change Room
11 Epsom Salt Pool
12 Steam Room
13 Cold Plunge Pool
14 Hot Plunge Pool
15 Mud-baths Rooms
16 Sauna
17 Research and Development
18 Exterior Pool
19 Staff Lounge
20 Roof Terrace
21 Biochar Green Roof Lab

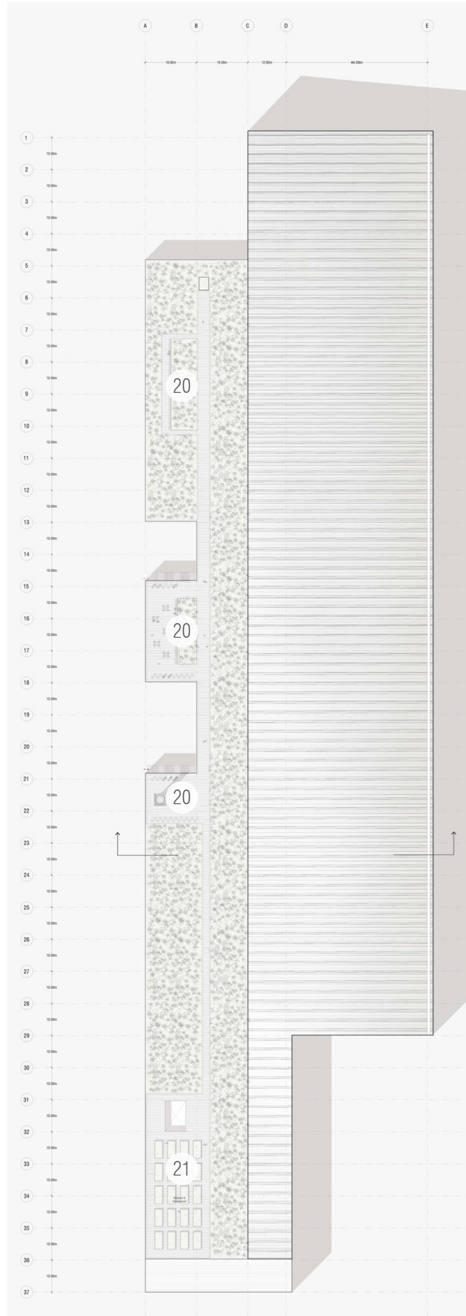
0m 10m 20m 30m



Ground Floor Plan

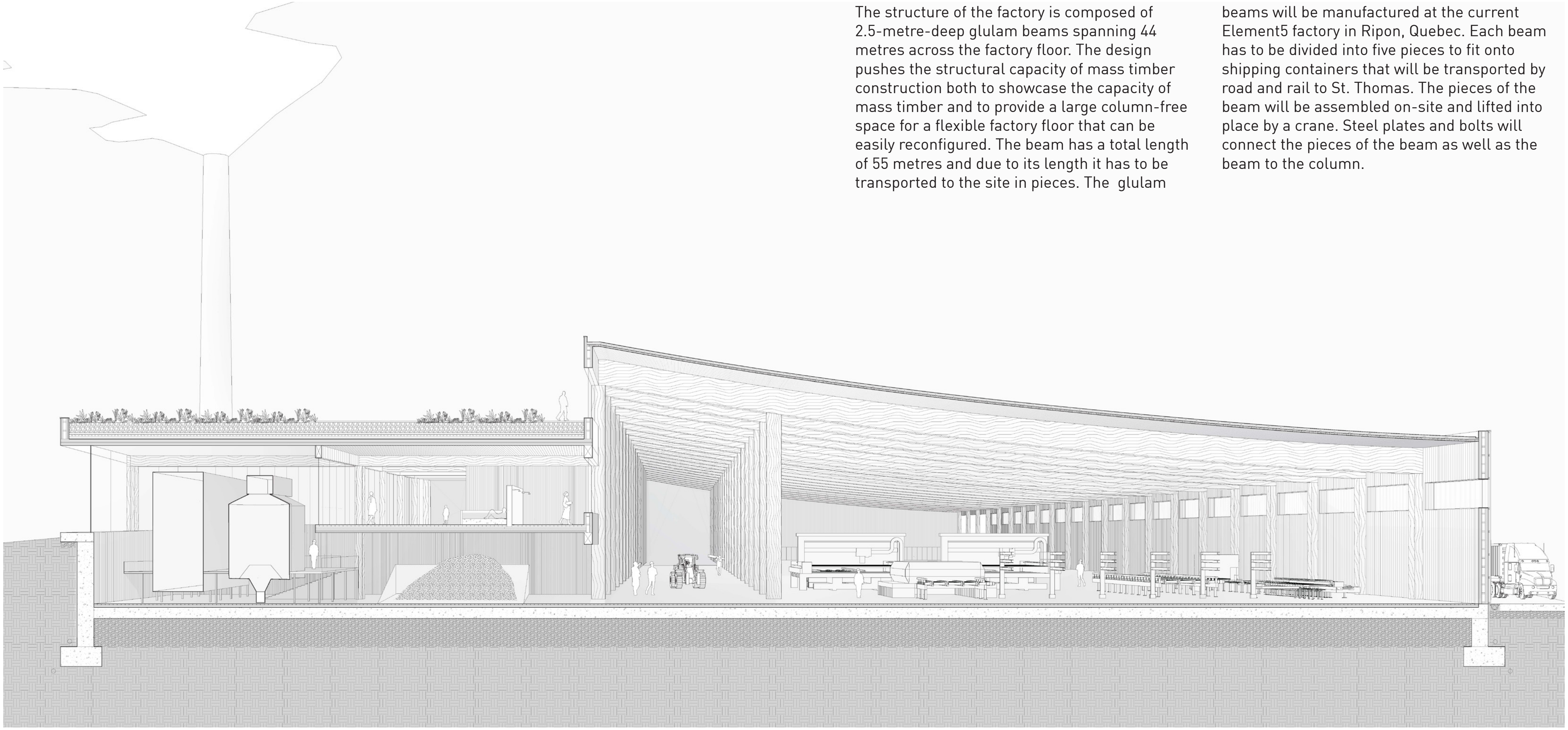


Second Floor Plan

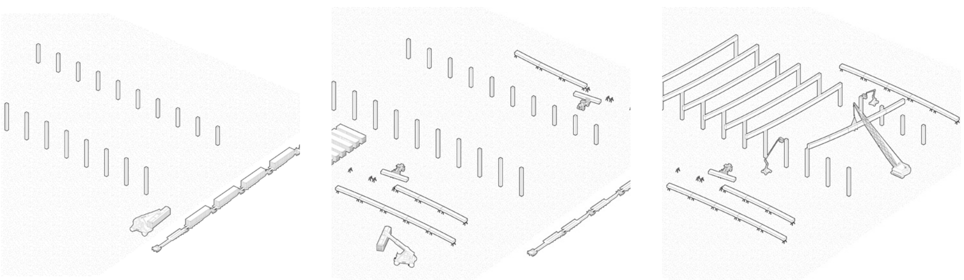


Roof Plan

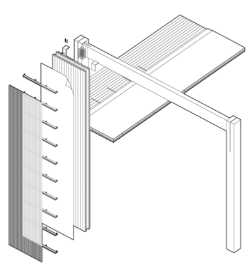
The structure of the factory is composed of 2.5-metre-deep glulam beams spanning 44 metres across the factory floor. The design pushes the structural capacity of mass timber construction both to showcase the capacity of mass timber and to provide a large column-free space for a flexible factory floor that can be easily reconfigured. The beam has a total length of 55 metres and due to its length it has to be transported to the site in pieces. The glulam beams will be manufactured at the current Element5 factory in Ripon, Quebec. Each beam has to be divided into five pieces to fit onto shipping containers that will be transported by road and rail to St. Thomas. The pieces of the beam will be assembled on-site and lifted into place by a crane. Steel plates and bolts will connect the pieces of the beam as well as the beam to the column.



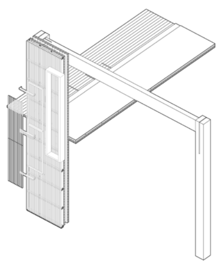
Cross section through the factory



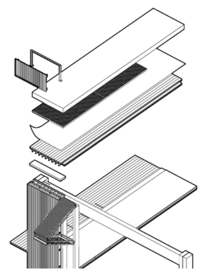
On-site glulam assembly logistics



Wall assembly



Window assembly



Roof assembly

View of the outdoor pool

Rendering of the factory floor with therapeutic waters beyond it

Model of the factory building

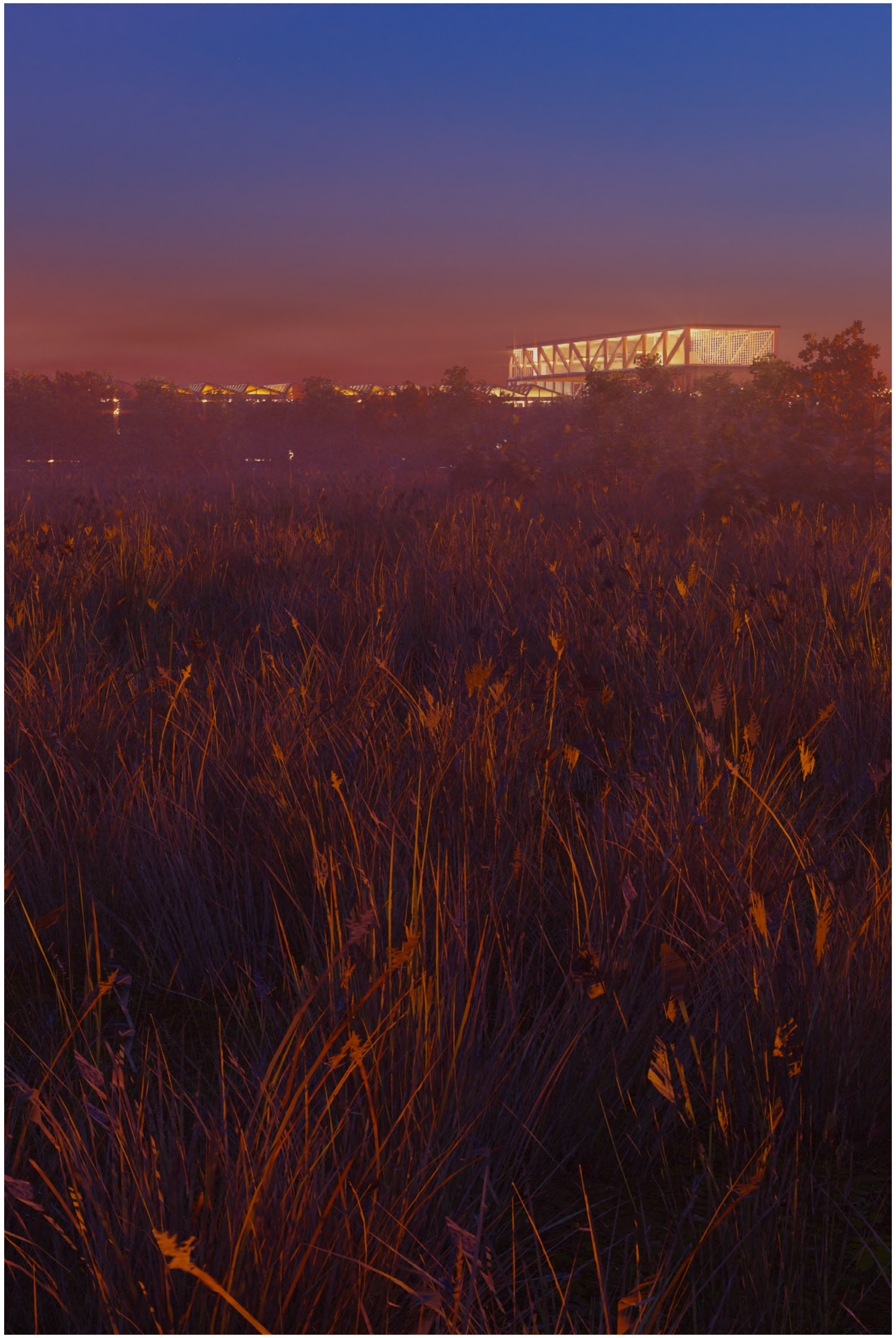
Rendering of the sauna overlooking the kiln

NEW BACK 40

Curtis Ho
MArch
Safina Moloo
MArch
Alexandra Ntoukas
MLA
Holly Smith
MArch

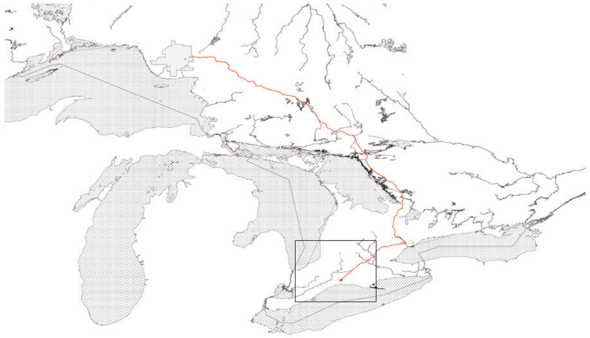
A Powerful but Fragmented Industry

There are 225 native tree species in Canada, but we base a multi-billion dollar industry on only nine. Many of these nine species are under threat due to monocultural agroforestry and a growing global spread of invasive insect species. New Back 40 experiments with future-proofing the industry and the ecologies it relies on by expanding the products of the mass timber industry to include limited quantities of local species. The intent is to connect the fragments of dwindling “back forty” woodlots in Southern Ontario and form linear arrangements. The addition of a small-batch hardwood sawmill and offices for the Ontario Woodlot Association are situated in Ontario’s first CLT factory in order to economically and politically incentivize the reconnection and diversification of this fragmented region and industry.



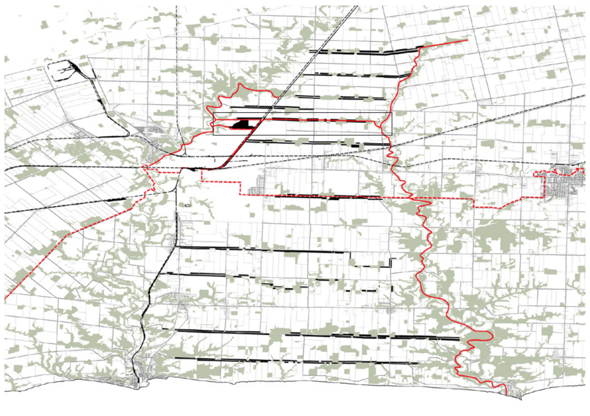
Research: Fragments and Networks

Regional Mapping



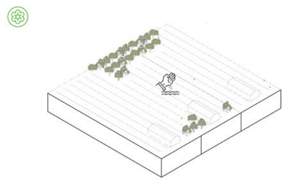
The carbon cost of transportation: 357 M tonnes of CO_2e/annually

Patterns and Networks: fragmented woodlots, trains, and bike paths

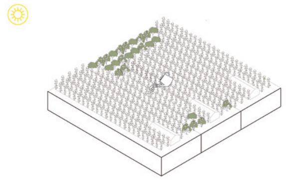


Regional Strategy: woodlots (dotted) proposed connections (black), and proposed nature trails (red)

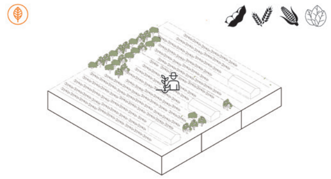
Financial Cycle of Southern Ontario Farms



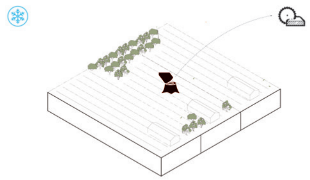
Spring: tilling and sowing



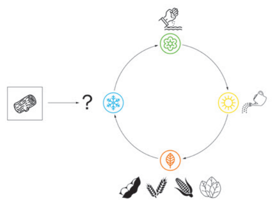
Summer: tending and re-sowing



Autumn: harvesting perennial crops



Winter: we propose logging woodlots



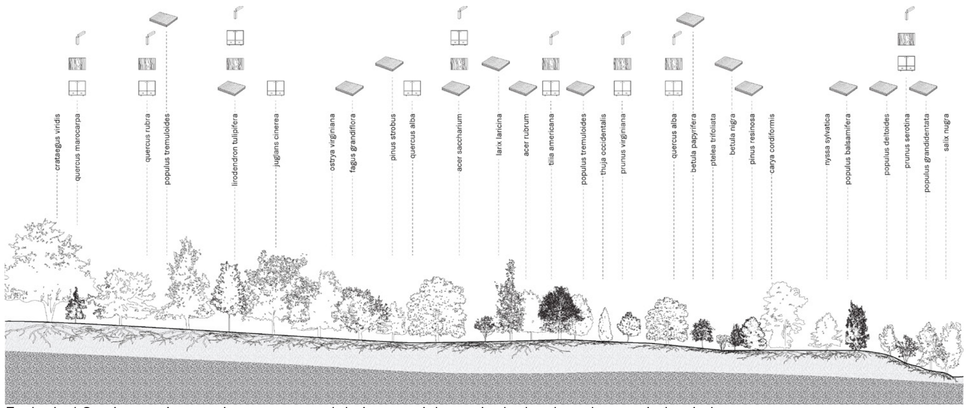
Micro-agroforestry acts as winter income

Connecting Fragments

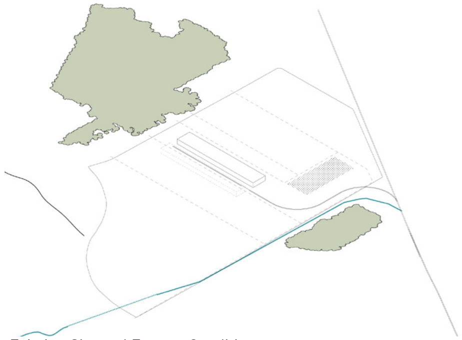
Despite the carbon sequestration of mass timber, a large amount of carbon is still emitted by the transportation of raw materials. New Back 40 identifies the linear pattern of woodlots created by the "back forties" of farm lots. Reconnecting these fragmented woodlots creates a linear supply chain of local hardwoods. The creation of a green corridor would permit the additional opportunity to create touristic nature trails through the region. Historically, farmers have had to supplement their winter season incomes by trucking and contracting; however, this option is declining due to more specialty corporations taking hold. New Back 40 aims to target the low-income winter season in Ontario by introducing a local agro-forestry industry. Element5 provides an opportunity to modernize and capitalize on the traditional timber industry. The regional vision is to see the growth of ecologically native trees become economically and socially tied to local communities.

2–5 years: existing fragmented "back forties" (woodlots) are able to produce a limited supply of hardwood for small-batch production

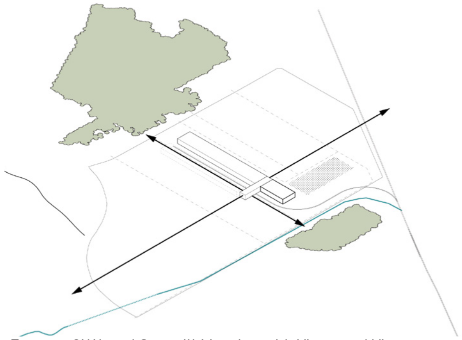
20–30 years: back forties are reconnected, further supporting permaculture and a larger supply line



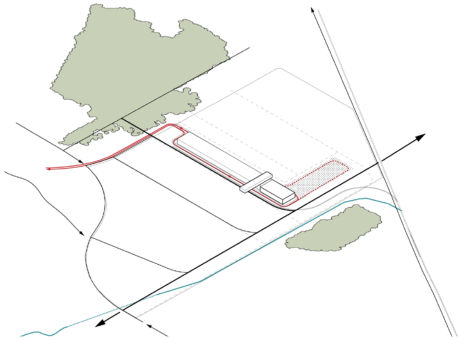
Ecological Section: native species strategy and their potential uses in the hardwood mass timber industry



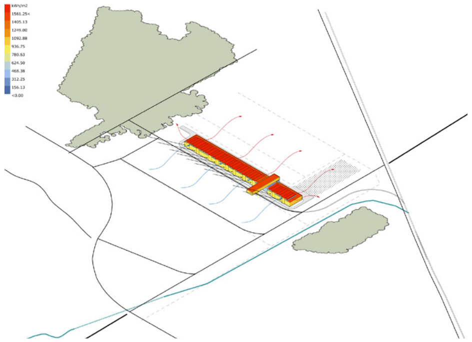
Existing Site and Factory Condition



Factory, OWA and Sawmill Massing with Views and Vistas

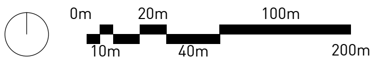


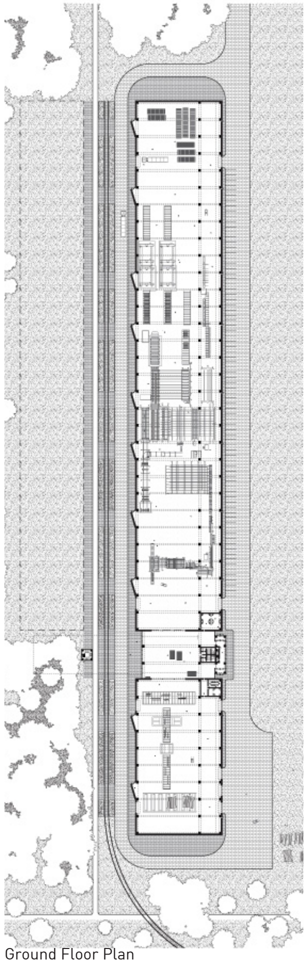
Transportation: Pedestrian Paths and Desired Development



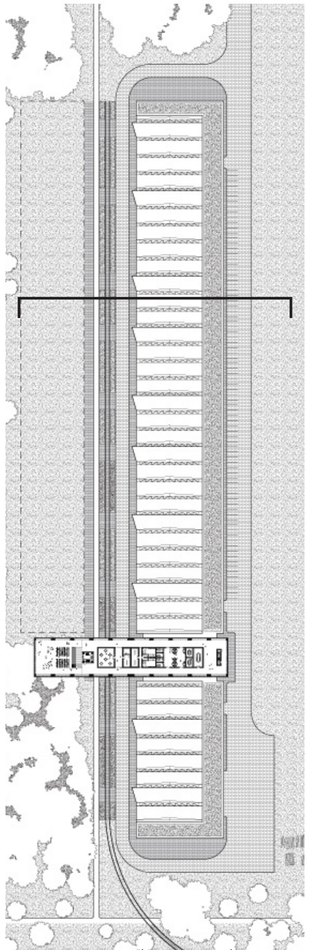
Building Envelope: Solar, Wind, and Pedestrian Views

Final Phase: Complete natural succession, Expansion of stream, trails and foundations for factory expansion.

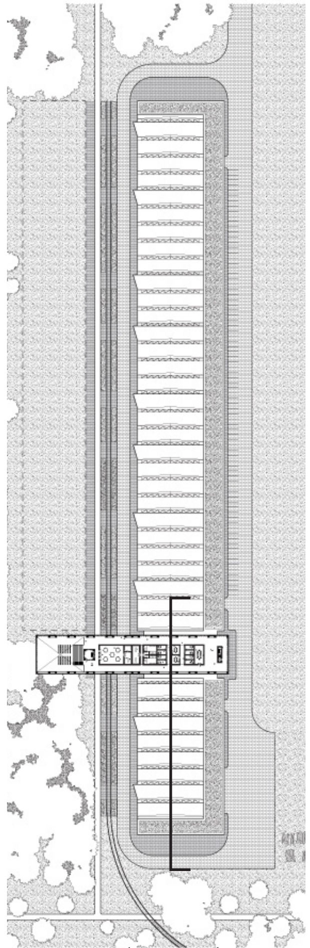




Ground Floor Plan



Second Floor Plan (OWA Bridge)



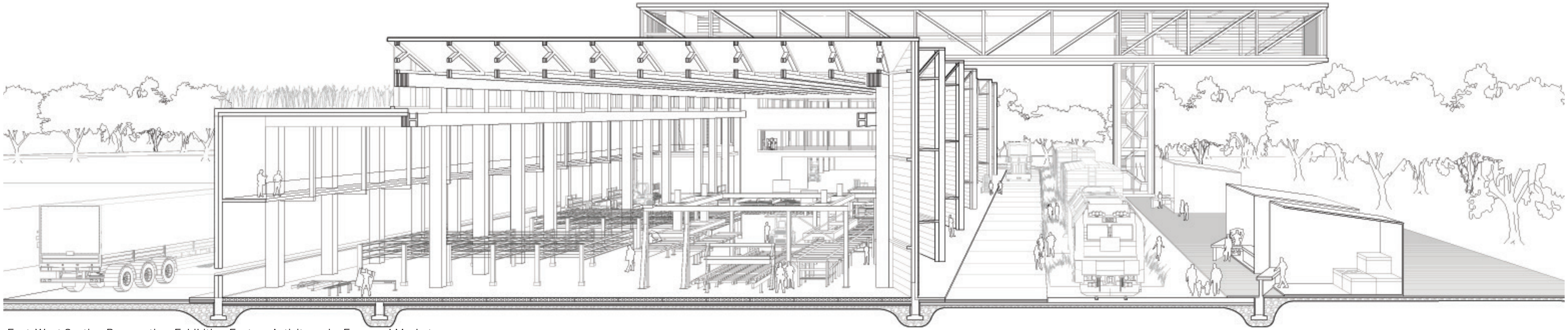
Third Floor Plan (OWA Bridge)

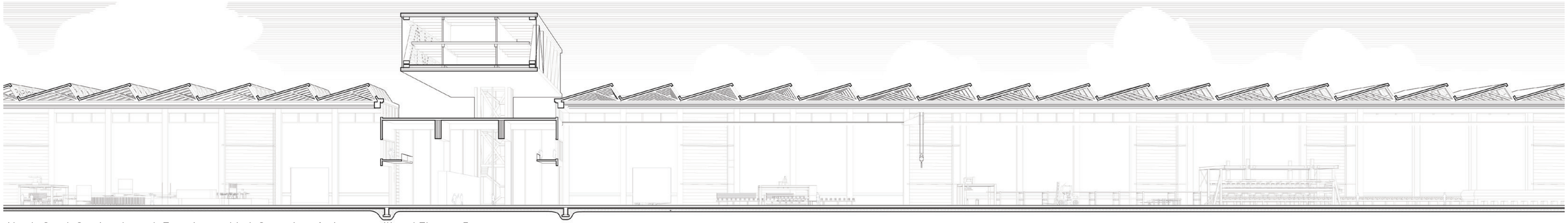
Site Strategy: Seeding Reconnection

Our site strategy introduces a hardwood sawmill and the Ontario Woodlot Association (OWA)—an NGO that provides policy knowledge, regulation, exhibitions, and resources for woodlot forestry. The OWA currently acts as a node for small-batch hardwood sawmills in Southern Ontario. Our addition of a small batch hardwood sawmill for the OWA as a co-owner incentivizes and educates farmers to become stewards of the New Back 40. The proximity of the OWA and the sawmill will increase the chance of serendipitous exposure of Element5's research and development of native hardwood use in CLT and put Element5 in close proximity to an association well-versed in the procedure of advancing policy and regulation. The regional massing strategy takes a linear approach, essentially "plugging in" to the fragmented woodlots, ecology, and supply lines we aspire to reconnect. The site is treated as a starting seed and nodal point between crossing networks, existing and proposed.

Repetition as Architecture:

The factory for Element5 engages in repetition to physically display the industrial capabilities of a CLT factory and its products. The sawtooth roof is created from a repetition of solar optimized angles for shading in the summer and northern exposure in the winter. The roof floats atop the factory providing east-west natural ventilation. An incision is made in the facade at eye level, offering employees views to the outside without comprising privacy. The superstructure is made up of repeatable bay sections clad in zinc-coated standing seam. The sections are broken up by angled leaves, offering glimpses to each phase of CLT production from the main roads. The leaves are clad with hardwood CLT acting as weather test samples. The west of the site is an elevated open space, planned in line with the bay dimensions to accommodate potential factory expansions. The development of the west side includes a thoroughfare for pedestrian traffic and experimental pavilions that provide space for local farmers' markets on weekends. Office spaces and semi-public seminar spaces for the OWA, hardwood sawmill, and Element5 are programmed into the 'bridge,' which also acts as a viewing platform to all operations. The bridge serves as a landmark for the factory and over time appears to be lifted by the growing forest, symbolizing the connection between industry, forest, and community.


East-West Section Perspective: Exhibiting Factory Activity and a Farmers' Market


North-South Section through Experimental Lab Space interfacing sawmill and Element5


Exterior Render

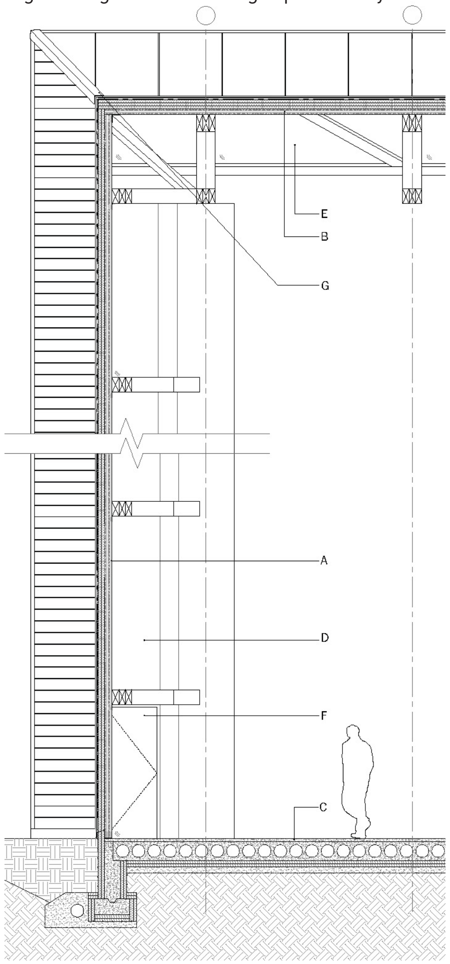
Structure and Details:

The superstructure is a repetition of the same bay at various frequencies, taking advantage of the planar construction of CLT, reducing tooling times, and maximizing economies of scale. The design utilizes two structural systems: glulam post-and-beam and glulam trusses. The main factory space consists of a lower section with a green roof and a taller section with a sawtooth roof. The lower section utilizes glulam post-and-beam to span the shorter distance.

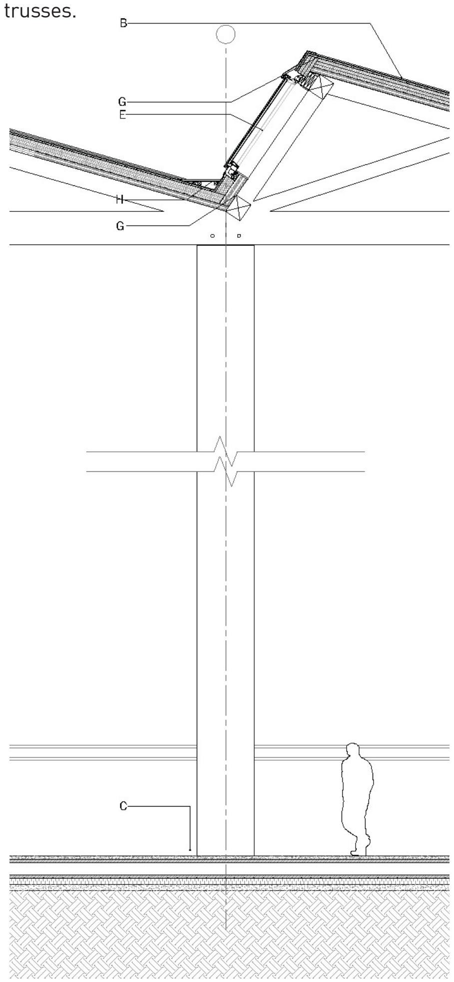
Physical Model 1:250

Interior Render of Factory

The main factory space is spanned using a glulam truss integrated into the sawtooth roof, which frames into glulam columns. The truss allows for a large span without deep beams, permitting a high ceiling. Lateral bracing is provided by CLT wall panels along the exterior. The bridge uses a deep truss with glulam elements to span the large distance above and across the factory. Both cores for the bridge are also created using glulam trusses.



East-West Open Leaf Wall Detail



North-South Section Roof Detail

A. WALL ASSEMBLY
- 1" Hardwood Exterior siding
- Rainscreen Clip System
- Aluminium Strapping
- Waterproof Membrane
- 4" Rigid Roxul Insulation
- Air Vapour Barrier
- 3-Ply CLT

B. ROOF ASSEMBLY
- Zinc Standing Seam Roofing
- ½" Sheathing
- 1" Air Space
- Roofing Membrane
- 6" Rigid Roxul Insulation
- A/V Membrane
- 3-Ply CLT

C. FOUNDATION
- 2" Concrete Topping
- 12" Hollow-Core Slab
- Air Vapour Barrier
- 4" Rigid Roxul Insulation

D. TRIPLE GLZ. CURTAIN WALL
E. TRIPLE GLZ. SKYLIGHT
F. EXIT DOOR
G. METAL FLASHING
H. WOOD FRAMING

PUBLIC GOOD

Vincent Wu
MArch

Enica Deng
MArch

Katherine Liu
MLA

Roger Xu
MArch

Factory / Trade School / Natural Habitat

Our project is about public good. Specifically, it is about reconsidering the site conditions of a factory, its program, and not having such a clear delineation between uses but blurring the boundaries of what is factory, what is public, and what is the site of the landscape.

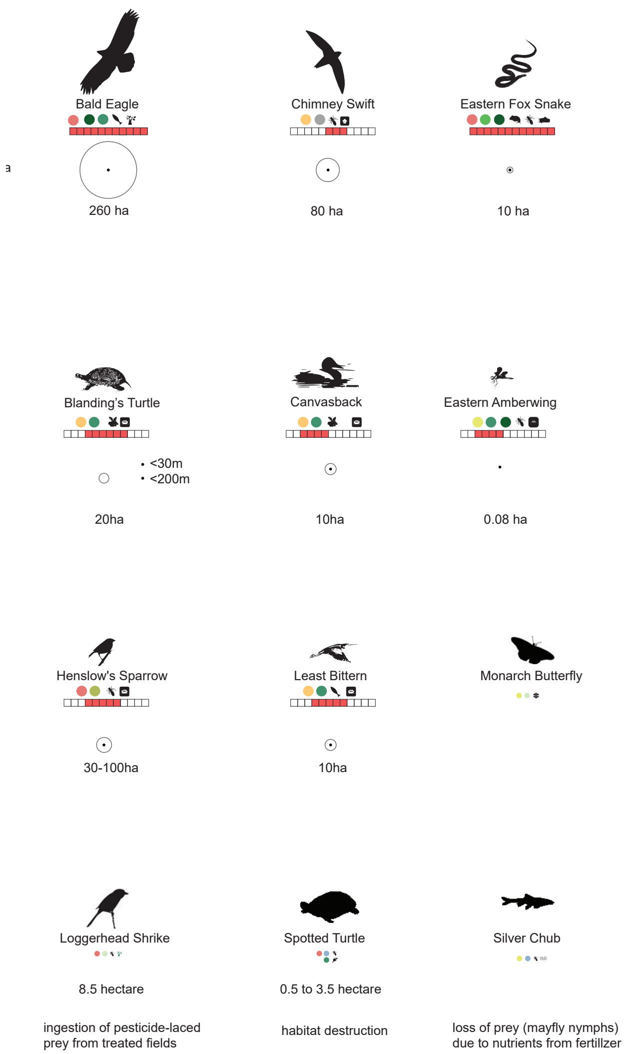
We were inspired by the history of St. Thomas, where unemployment rates increased after the decline of the automobile industry, as well as the fragmented habitat due to agriculture, to inform our decisions about public good. We proposed that the project not only consider the factory, but include a trade school, a public space, and a consideration for the natural habitat.

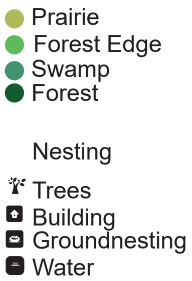
Exterior Render

Rebuild Fragmented Habitat

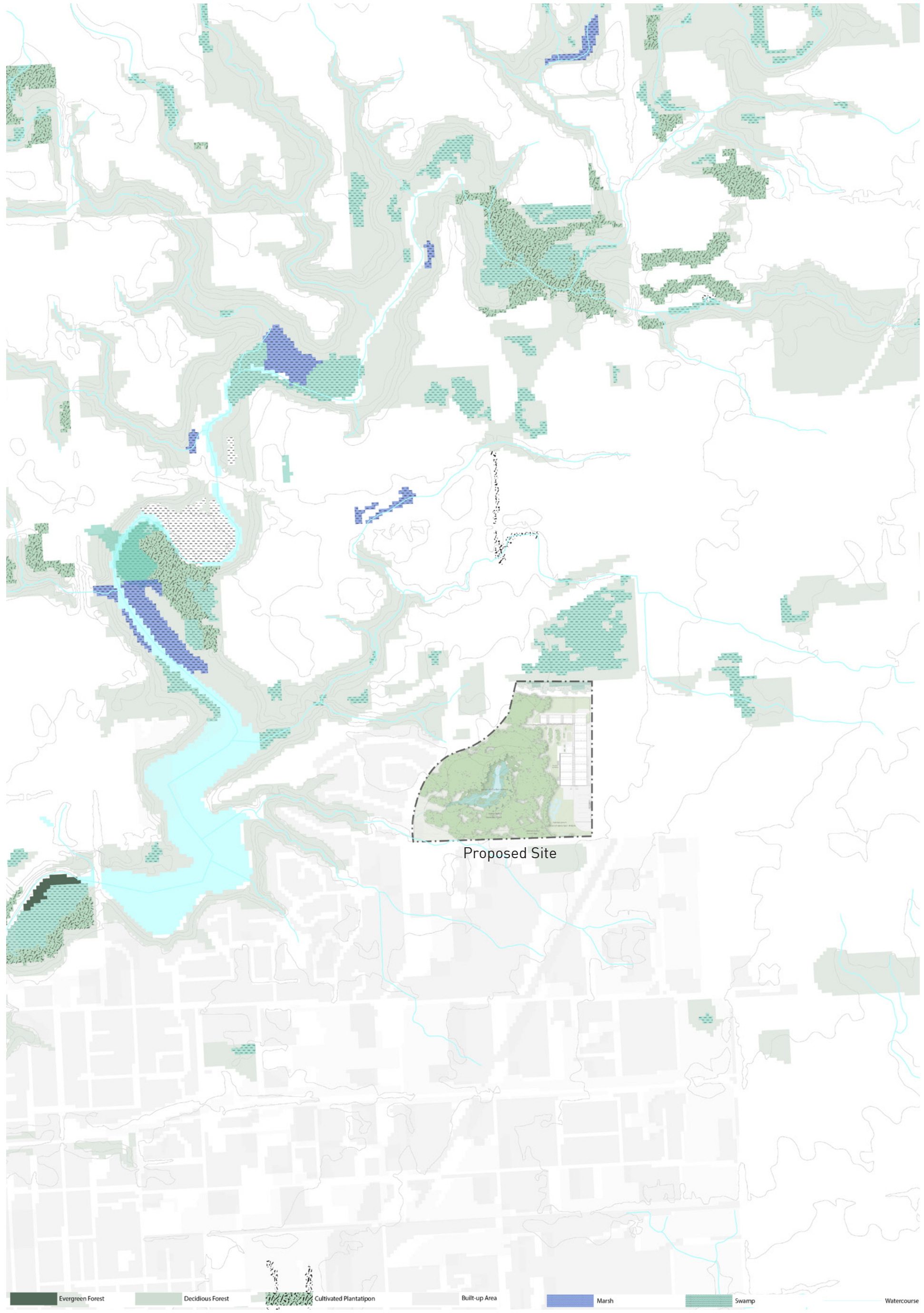
Wetlands have been hammered by development over the last century. Southern Ontario has lost more than 70 percent of its wetlands, with losses increasing to 85 percent in Southwestern Ontario, Niagara, Toronto, and parts of Eastern Ontario. Habitat loss is the key driver of species decline.

Therefore, for the landscape part of the project, the main idea is to connect the fragmented green spaces in the region and create a concentric zoning where the periphery is used for human activities and the inner core becomes the habitat for several locally endangered species.





Existing Endangered Wild Animals



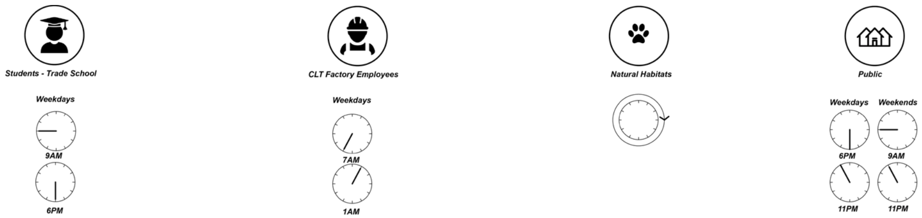
Existing Fragmented Habitat

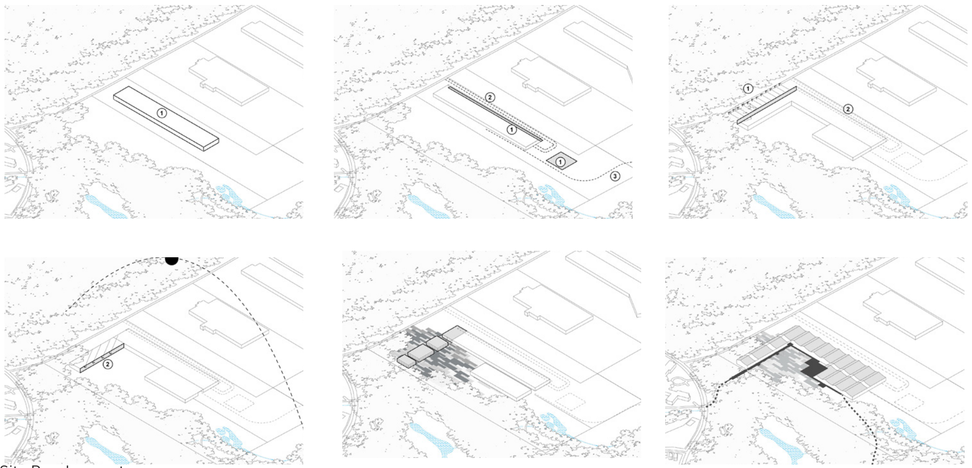
Site Development

Historically, St. Thomas has been a heavy-industrial city with a significant portion of its population employed by these industries. However, the recent decline of the automobile industry indicates that these workers will need to be retrained for employment in new industries.

Therefore, we are designing a factory that will serve the industry and coexist with a public school and trade school. Focusing on public good, we decided to blur the boundaries of one solid program to reimagine what a factory is for the people who use it, the industry that it serves, and the natural habitat it can provide.

Existing Big-Box Factories



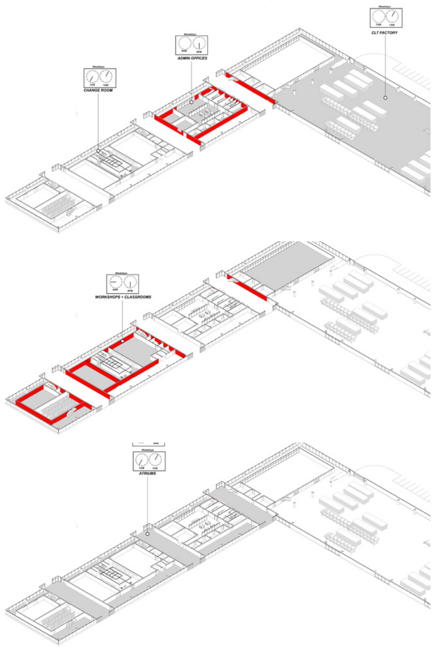


Site Development

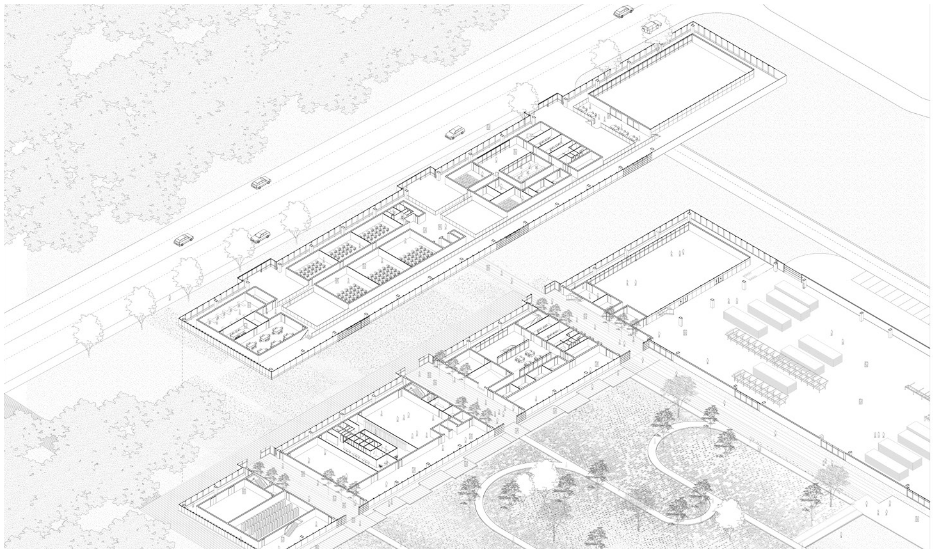
Public Good Site Plan

Trade School

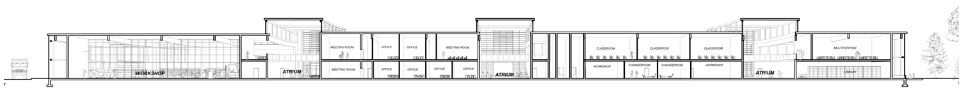
Our project challenges the traditional idea of factory as an isolated box. We achieved the transition to a public presence by creating a trade school beside the factory. The trade school serves the local community and also retrains unemployed workers, while allowing for public activity and flexible use. All the programs are arranged in a way that they can be secured for workers only or open to the public, depending on the schedule. The three big atriums in between become gathering spaces as well as passages through which people can access the courtyard behind.



Trade School Daily Schedule



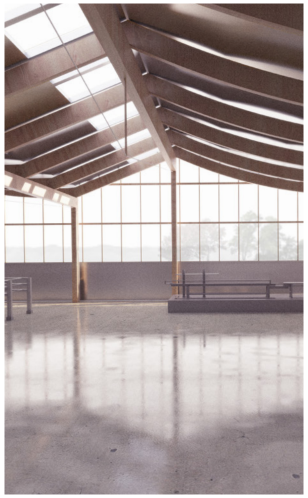
Trade School Exploded Axo



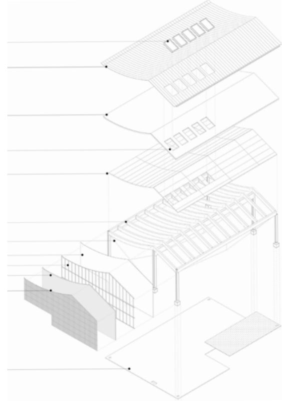
Trade School Section

Structure

For the structural design of the project, our goal is to optimize natural sunlight and ventilation for users' mental and physical health. Therefore, we chose glulam beams with tension cable instead of a traditional beam structure to minimize structural components, hence allowing for more daylight and natural air to flow within the factory and trade school.



Factory Interior



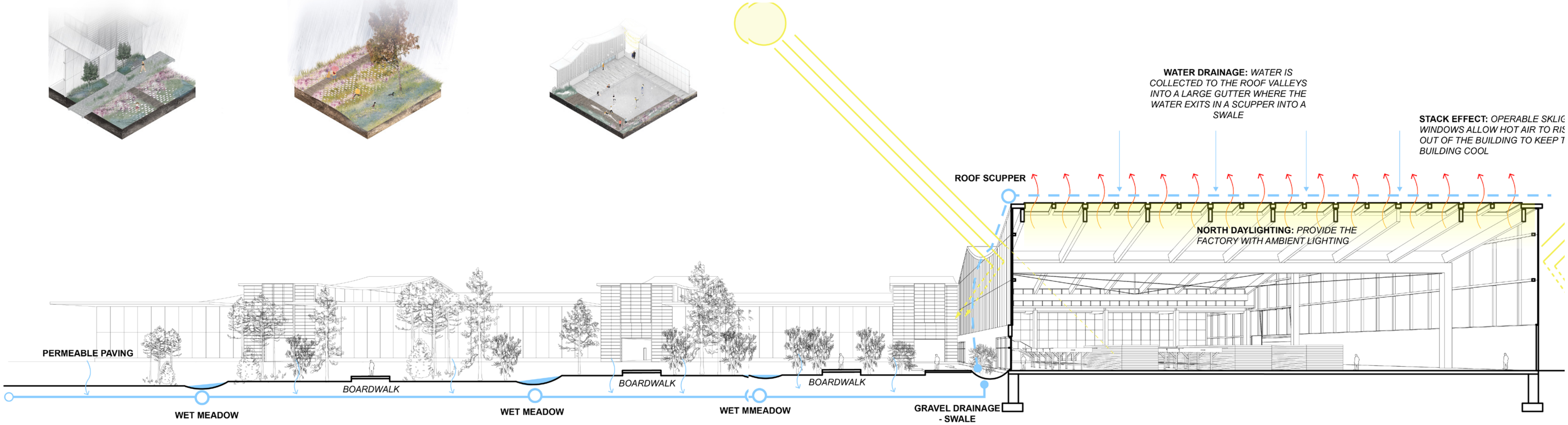
Exploded Structure

Factory Interior Model

Factory Exterior from Natural Habitat Looking towards Factory

Courtyard

The courtyard landscape connects into the building through the atrium. A boardwalk built along the trade school and factory intensifies the edge of the building to increase programming in and around the building and away from the adjacent habitat. Micro-habitats, such as constructed wetlands and prairies, are built inside of the courtyard for people to experience nature without disturbing the habitat beyond.



Factory Section from North to South

N-ARBORETUM

Hrishikesh (Rishi) Tailor
MArch

Blake Wallace
MArch

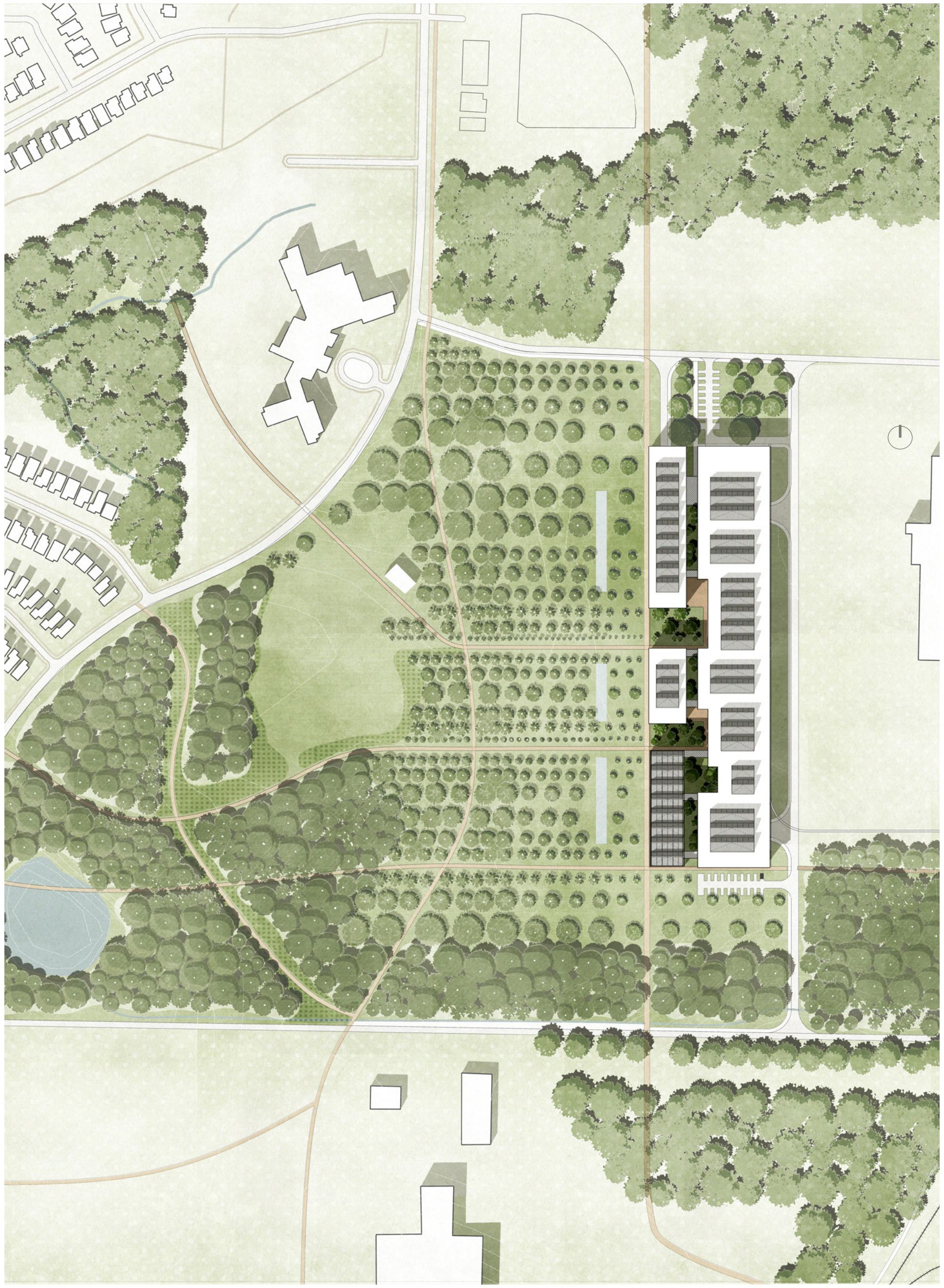
Tharshni Shanmuganathan
MLA

Ranran Zhang
MArch

Factory / Timber Research / Reforestation

Located in the ordinary, suburban small town of St. Thomas, N-Arboretum, a factory for Element5, acts as a catalyst for timber research and large-scale reforestation that includes reintroducing endangered tree species that can become viable sources of timber in the future.

The project also questions the architecture of the typical factory. Usually, a factory can be considered to be a monolithic building with a large footprint, built for a purely utilitarian purpose. N-Arboretum tries to move away from this tendency by breaking down the mass and creating courtyards between the different phases of the building.

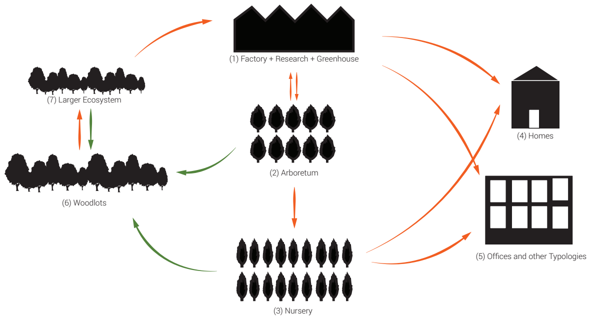


Site Plan

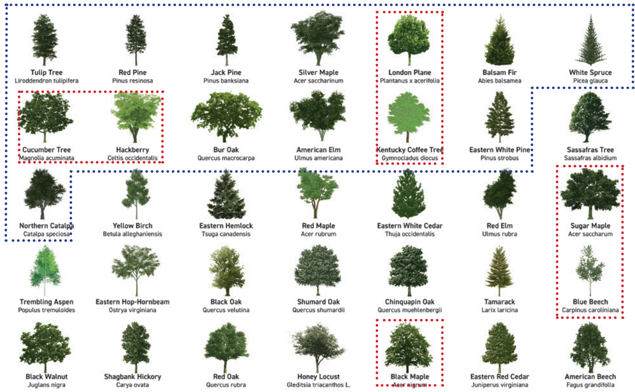
The Big Picture

Currently, the town of St. Thomas has disjointed woodlots in the employment lands and residential neighbourhoods. N-Arboretum aims to be a part of the network where the woodlots are contiguous through a network of green connections or "nurseries" proposed in the empty lots. If the existing building needs to expand, the young trees are transferred to nearby site. This allows for a healthier local ecosystem.

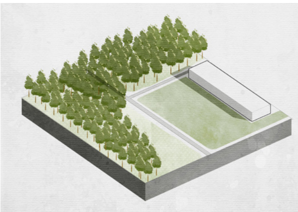
The proposal is as follows: The factory and arboretum provide an area to research endangered species of timber in addition to existing species. They become part of large-scale nurseries that form the "green connection." Through natural processes, the species studied become part of the local woodlot, and ultimately part of the larger ecosystem.

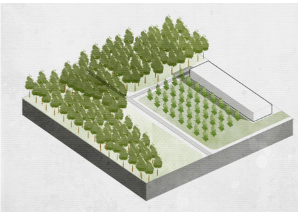


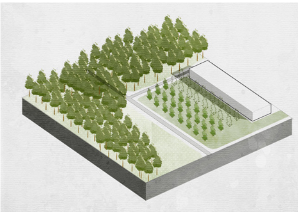
The Big Picture. Network of flow of materials into and from natural ecosystems

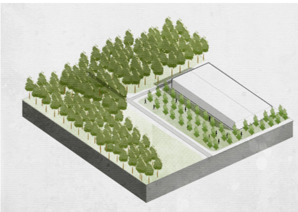


Native Species List. Blue: timber sources; red: endangered timber sources


(1) Existing woodlots to be expanded


(2) Planting nursery trees in empty space


(3) Transferring the younger trees

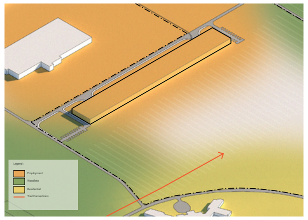

(4) Expanding the built form if needed

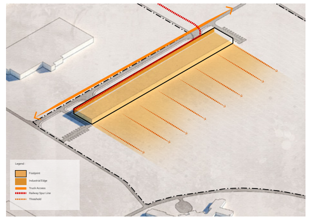
Re-introducing Endangered species

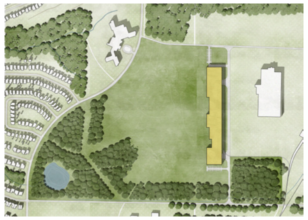
The diagram on the left shows the native species of trees that are found in the woodlots and larger ecosystem. The ones outlined in blue are going to be a part of the arboretum, as they are the main sources of timber. The ones outlined in red (London plane, Kentucky coffeetree, cucumber tree, and hackberry) are endangered species that are to be reintroduced into the ecosystem through the Arboretum.

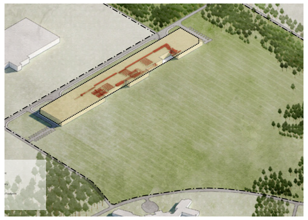
Site Phasing

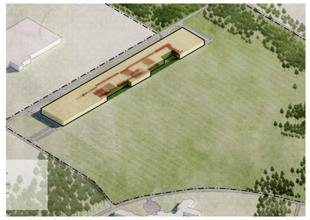

Existing—Plan

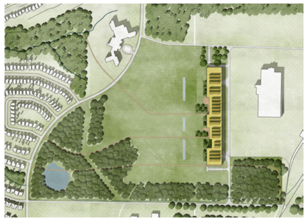

Site Conditions

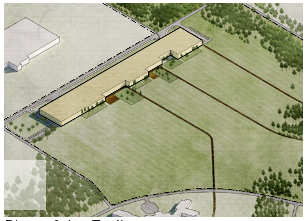

Phase 1.0—Industrial Edge

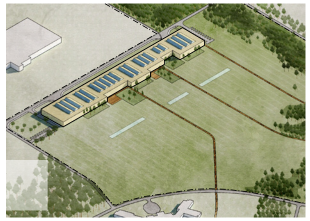

Phase 1.1—Dense Planting

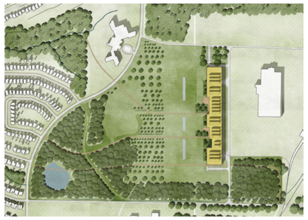

Phase 1.2—Machine Layout


Phase 1.3—Courtyards

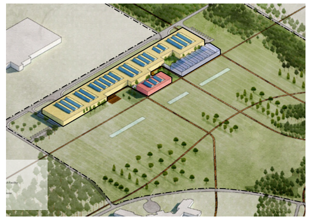

Phase 2—Form and Reservoirs


Phase 2.1 —Trail


Phase 2.2—Skylights and Reservoirs


Phase 3—Arboretum Planting


Phase 4—Greenhouse and Research Addition


Phase 4—Greenhouse and Research Addition


Phase 5.1—Factory Addition

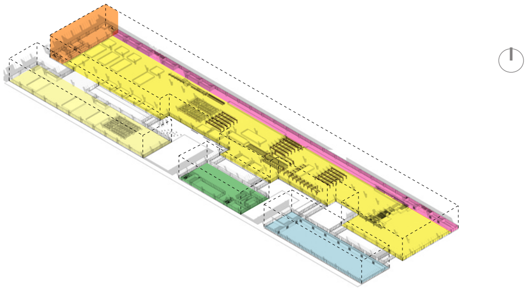

Phase 5.2—Completed Planting

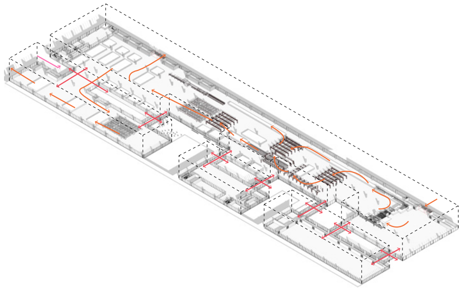

Phase 5.2—Completed Planting

Program

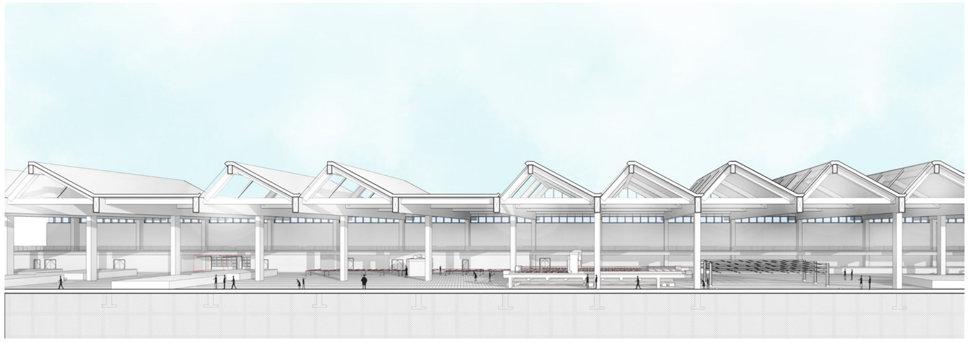
- Office
- Phase 1 Factory
- Back of House
- Greenhouse
- Research Workshop
- Addition to Factory

Flow of materials: The raw materials are taken in from the south entrance on the southeast side, where the loading docks and tracks are. It moves north through all the processes where the final product is available for display from the office. They also move to the addition in the north for new products that can be created with CLT panels.





East-West Section, facing north through an exterior courtyard



North-South Section, facing east

Floor Plan


Interior—Phase 1 Factory


Interior—Factory Addition

Interior

The structure of glulam beams and columns and CLT panels creates the interior of the space. The wood used in the structure creates large spans with a warm environment for the workers in the factory.

The structural grid allows for spaces of different scales. Pockets of interior spaces are created when courtyards are carved out of the massing; these pockets can be used for interior storage of timber products.

The facade has different levels of opacity based on the location, allowing light into the spaces accordingly.

The skylight is open to the northern sky, which allows it to illuminate the interior of the spaces without causing glare. The skylights are located on top of the main stages of the timber production process, thereby highlighting them and providing illumination for the important aspects of the process.

Exterior

The exterior of the project is formed by the intersection of massing and courtyards. The facades consist of the slits of openings and varied levels of opacity. Most of the translucency and transparency is kept at the first level to provide exterior connection.

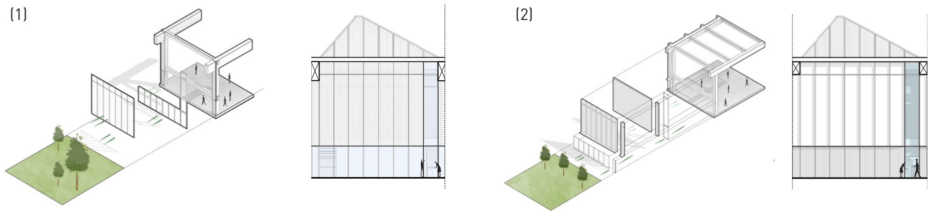
Expression

The project allows for the expression of the structure on the exterior. The facade is made of a simple grid and panels that can easily be replaced if the use of the building changes. The facade on the east is completely solid with clerestory windows on the top; everywhere else, the facade plays on different levels of opacity.

Overall, there are two modules of facades:

(1) Elevation facing courtyards: translucent panels make up the bulk of the module to allow for a faint presence of nature into the interior while diffusing the light entering the building. Glazing is present on the first level to provide a more direct visual connection. Slits of glazing are present adjacent to the main columns and beams to allow for a peek into the building structure.

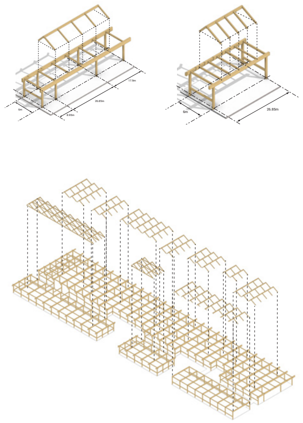
(2) Elevation facing the landscape: opaque panels make up the bulk of the module. Translucent panels are on the first level while the slits of glazing are located adjacent to the structure.

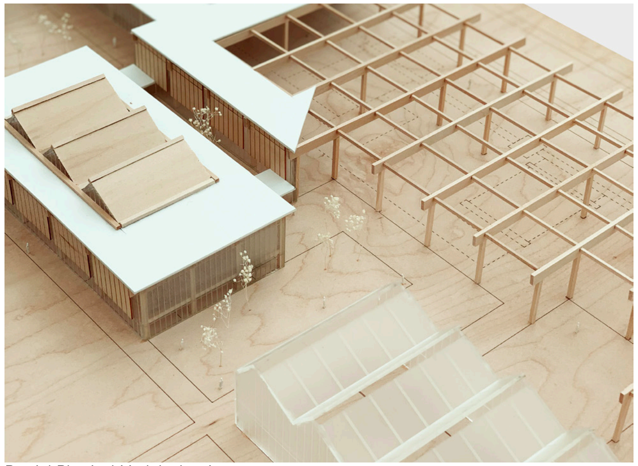


(1) Elevation facing the courtyards; (2) Elevation facing the landscape


Main Elevation


N-Arboretum: Architecture and Landscape


Structural Frames


Partial Physical Model, showing structure

Structure

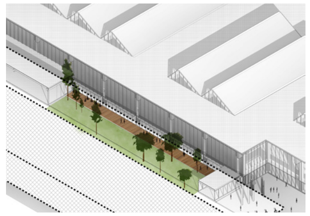
The structure consists of glulam beams and columns arranged in a regular grid. The building consists of two grids: 6 x 26.85 m and 6m x 17.9 m. Along the grid, additional beams and ridges also frame the skylight angled towards the north. The two grids are based on the layout of the machinery, and allow for large spans within the space. The roof and walls are made with CLT panels that provide lateral stability to the building.

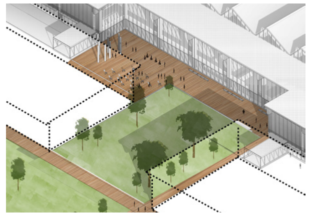
Courtyards

The courtyards are carved out of the massing of the building based on the layout of the machinery.

They are occupied by native trees and plants, while having outdoor decks of different scales. There are two types of courtyard: interior and exterior. The interior courtyards are places of rest for users of the building. The exterior courtyards are open to public; they are for public events and for displaying new products. The decks are connected to the larger trail network outside.

The courtyards allow for breaking down the large massing of the building. They also act as the buffer or interstitial space between the building and the additions. They allow natural light into the interior spaces, and provide an important visual and physical connection to nature outside.


Interior Courtyard—Axonometric


Exterior Courtyard—Axonometric


Exterior Courtyard—Elevation

Contributors

This publication contains essay contributions from key authors who have shared their expertise and passion for the subject matter.

Doug Anderson
Bungee Metis
Daniels Faculty of Architecture, Landscape, and Design, University of Toronto, Adjunct Professor

James Bird
Daniels Faculty of Architecture, Landscape, and Design, University of Toronto, MArch
The Dene Nation, Knowledge Keeper
RAIC Indigenous Task Force, Member
Indigenous Initiatives, University of Toronto, Council Member

Dave Bowick
Blackwell Structural Engineers, Principal
Daniels Faculty of Architecture, Landscape, and Design, University of Toronto, Adjunct Professor

Patrick Chouinard
Element5

Malcolm Cockwell
Haliburton Forest and Wild Life Reserve, Managing Director

Oliver J. Curtis
Boston Architectural College, Faculty of Landscape Architecture, Instructor, Information Design

Dan Handel
Department of Interior, Building, and Environment Design, Shenkar College of Engineering, Design, and Art, Professor

Jane Mah Hutton
School of Architecture, University of Waterloo, Assistant Professor

Dr. Anne Koven
Daniels Faculty of Architecture, Landscape, and Design, University of Toronto, Adjunct Professor
Mass Timber Institute, Director

Dr. Jesse LeCavalier
Daniels Faculty of Architecture, Landscape, and Design, University of Toronto, Associate Professor

Dr. Henry Lickers
Haudenosaunee Elder of the Seneca Nation, Turtle Clan
International Joint Commission, Canadian Commissioner
Retired Environmental Science Officer for Mohawk Council of Akwesasne

Alan Organschi
Regenerative Building Lab, Yale School of Architecture, Director
Gray Organschi Architecture, Principal

Dr. Danijela Puric-Mladenovic
Institute of Forestry Conservation, University of Toronto, Professor

Dr. Sean Thomas
Institute of Forestry Conservation, University of Toronto, Professor

Mike Yorke
Carpenters' District Council of Ontario, President

Acknowledgements

The Daniels Faculty thanks the Canadian Wood Council for their enthusiastic support for this publication. The Canadian Wood Council has enabled us to disseminate the stellar student work from our Masters of Architecture and Landscape Architecture programs along with our studio journey.

The Daniels Faculty appreciates the time Element5 Co. leaders spent with our graduate students explaining the CLT manufacturing process from the entry of raw lumber on a railway spur line to the various stages of the manufacturing process and the way the manufactured CLT goes out of the factory to building sites across North America. The students' understanding of the Element5 production flow enabled them to tackle the challenge of designing of a contemporary factory and its surrounding landscape.

Element5's future factory expansion allowed our students to reimagine the traditionally insular factory building and explore how it could be combined with new and innovative programs to ensure a vital future for places of production in the life of local communities. How to future-proof the factory and ensure that it could have many lives and future uses was an ongoing discussion throughout the studio.

This publication is a product of the combined efforts of architecture and landscape architecture students in the Fall 2019 Option Studio at the Daniels Faculty of Architecture, Landscape, and Design.

Studio Instructors

Brigitte Shim, Robert Wright

Studio Members

Enica Deng
Miranda Fay
Curtis Ho
Dylan Johnston
Caroline Kasiuk
Katherine Liu
Fiona Lu
Michael MacNeill
Niko McGlashan
Safina Moloo
Alexandra Ntoukas
Tharshni Shanmuganathan
Holly Smith
Hrishikesh (Rishi) Tailor
Jennifer Tran
Sidney Tsao
Blake Wallace
Vincent Wu
Roger Xu
Ranran Zhang

Invited Guests and Critics

We would like to extend our gratitude to the people and offices who contributed to an enriching semester of learning. Many thanks to:

Craig Applegath
Dr. Sean Thomas
Dave Bowick
Tei Carpenter
Donald Chong
Patrick Chouinard
Leland Dadson
Andre D'Elia
Omar Gandhi
Max Garcia
Dan Handel
Jane Mah Hutton
Scott Jackson
Dr. Anne Koven
Janna Levitt
Tero Nokelainen
Renee MacKay Lyons
Liat Margolis
Wayne McMillan
Daniel Pearl
Dr. Brady Peters
Carol Phillips
Dr. Danijela Puric-Mladenovic
Lasse Rajala
Stephanie Seymour
Simon Rayment
Sidewalk Labs
Dr. Sandy Smith
The Building Show
Ted Watson
Jane Wolff
Mike Yorke

Image Credits

Forest and Other Friends, p. 23

Oliver Pauk. Prescribed Burn, 2015, High Park Nature accessed February 17, 2021. https://highparknature.org/article/prescribed-burns-in-high-park/.

Morningstar Studio / Jeanne Morningstar Kent.. Elm Tree Bark Used In Longhouse Construction. https://www.morningstarstudio9.com/?fbclid=IwAR1fRl8-hNNgdSVQmIJN4_sgfnzRp_cGH9q4Py2R1M1vElZ1FheTRUaxGpI

Curious Import, p. 26

Expo'70 Official Guide. Place of publication not identified: The Japan Association, 1970.

BCFS100ca. Trees to Expo '70. Published July 13, 2012. YouTube video, 9.06. https://youtu.be/Xdm4svX73m4

BCFS100ca. Trees to Expo '70. Published July 13, 2012. YouTube video, 5.42. https://youtu.be/Xdm4svX73m4

Nominal Versus Actual: A History of the 2x4, p. 30

Dorothea Lange. LC-DIG-fsa-8b35514. Library of Congress.

Tennessee Valley Authority. Office of the General Manager. Information Office., Defense houses under construction, 1941, Library of Congress accessed February 17, 2021.https://catalog.archives.gov/id/280727

Arthur Rosthstein. LS-USF34-024434-D. Library of Congress.

The Reforestation Imperative, p. 34

Danijela Puric-Mladenovic, Vegetation of the Region of Peel, 1800s, 2020.

Danijela Puric-Mladenovic, Forest Cover in Southern Ontario, 2020.

From Supply Chains to Distribution Loops, p. 38

Procedure for Equipping a Typical AGF Unit for Overseas Movement: February 1943 in James A. Huston, The Sinews of War: Army Logistics 1775–1953 (Washington, D.C.: Office of the Chief of Military History, U.S. Army, 1970), 503.

Wood Ethics, p. 43

Ema Peter Photography. BC Passive House Factory by Hemsworth Architecture.

Sanjana Patal. Mass Timber Products Diagram, 2019.

Inciting A Mass Timber Revolution, p. 46

Curtis Ho. White River Forest Products to Element5 Map. 2020.

Craig Heinrich. 2020. Photograph.

Grand Visions & Devilish Details: Building A Global Carbon Sink, p. 50

Images courtesy of Gray Organschi Architecture.

Mass Timber Primer, p. 56

BNKC architecture + urban design & Blackwell Structural Engineers. "77 Wade" in Canadian Architect, "Mass Timber Primer", Elsa Lam, Nov 13, 2019. https://www.canadianarchitect.com/mass-timber-primer/

Dave Bowick, Mass Timber Primer, 2019. Digital Diagram.

Forests and Carbon, p. 66

Wilhelm Trautschold, Liebig's laboratory at Giessen, 1841.

Bjorn Embrén, "Planting Urban Trees with Biochar," The

Biochar Journal (2016), https://www.biochar-journal.org/

en/ct/77.

Woodland Diversity: Forest Regions in Canada, p. 72

Curtis Ho, Woodland Diversity, 2020.

Sustainable Forests, p. 75

Images by Rob Stinson, 2015. Provided by Haliburton Forest and Wild Life Reserve.

Old Materials, New Technology: New Visions for Mass Timber, p. 78

Images provided by Mike Yorke.

Interview: Learning From the Land, p. 80

Image by Fiona Lu, 2019.

Image by Irina Rouby Apelbaum, 2019.

Specifying Wood(s), p. 84

Plate no. 124. Pinus palustris, Mill (Long-leaved Pine): Hough, The American Woods, (Vol. 5, 1894). Reproduction: North Carolina State University Libraries, Special Collections. Right: Plate no. 35. Juglans nigra L. (Black Walnut): Hough, The American Woods, (Vol. 2, 1891). Reproduction: North Carolina State University Libraries, Special Collections.

Forest Theory and Precedents, p. 92

Blue Wall Center
Image courtesy of Studio Gang.

Bosco Verticale.
Image courtesy of Alexandra Ntkoukas.

Duisburg North Landscape Park, Duisburg, Federal State of North Rhine Westphalia, Germany. Wikimedia Commons. 2016. Photograph.

https://commons.wikimedia.org/wiki/File:Duisburg_Landschaftspark_Duisburg-Nord_29.jpg#filelinks

Forest Building
Forest Building in Richmond, Virginia, designed by James Wines & SITE for BEST Products Co. in 1978 (C) SITE New York.

Forest City
Model for a forest city, 1992, from Herzog & de Meuron, urban projects. (Tokyo: TN Probe, 1997). © Herzog & De Meuron

Forest Restoration
Courtesy of Sasaki

Cedric Price, "View of Working Electric Model for Generator". Between 1976 and 1979. Chromogenic colour print mounted on cardboard. 12.6 x 17.3cm. DR1995:0280:108. Cedric Price fonds. Canadian Centre for Architecture

KAIT Workshop
Maurizio Mucciola, KAIT Workshop by Junya Ishigami Architects, September 22, 2009, Flickr accessed March 10, 2021. https://flic.kr/p/8V5MQQ

Okutama Forest Therapy Trail
Courtesy of Studio on Site.

Parc Des Buttes-Chaumont
Public Domain

Downsview Park Competition
Image Courtesy OMA.

Pisgah National Forest
Jeff Gunn, Pisgah National Forest. October 27, 2012. Flickr accessed March 11, 2021. https://flic.kr/p/dpAfFi

Red Ribbon Park
Courtesy of Turenscape.

Zurich WIlderness Park
Wildnispark Zürich-Sihlwald, looking south from the lookout tower Hochwacht, over the Lake of Zürich Lake to the Alps. Wikimedia Commons accessed May 17, 2021. https://commons.wikimedia.org/wiki/File:Wildnispark_Z%C3%BCrich-Sihlwald,_looking_south_from_lookout-tower_Hochwach_over_Z%C3%BCrich_Lake_to_the_Alps.JPG

Sustained-Yield Unit.
Niko McGlashan, Haliburton Forest Sawmill, 2019. Photograph.

Swiss Sound Box
Pep Romero Garcés, "Peter Zumthor, edíficios e projectos 1986-2007". October 29, 2008. Flickr accessed March 11, 2021. https://flic.kr/p/aWRZDH

The Bloedel Reserve
Jonathan Miske, Zen Garden, June 22, 2018, Flickr accessed March 10, 2021. https://flic.kr/p/27qKgT5

Botanical Garden of Borseaux
J.W. Botanical Garden of Bordeaux. Wikimedia Commons accessed May 17, 2021. https://commons.wikimedia.org/wiki/File:Jardin_botanique_de_Bordeaux_5.jpg

Trees To Expo
Boris Spremo, 1969. Photograph. Toronto Star Archives. Exhibitions - Japan - Osaka (World's Fair) 1970. tspa_0006153f. https://www.torontopubliclibrary.ca/detail.jsp?Entt=RDMDC-TSPA_0006153F&R=DC-TSPA_0006153F&searchPageType=vrl

Site Visits: Emerging Trends in Wood Architecture, p. 94

Image courtesy of Moriyama & Teshima Architects and Acton Ostry Architects in Joint Venture.

Image courtesy of MJMA and Patkau Architects.

Scott Norsworthy. The Golden Nugget. Photograph, 2019. https://superkul.ca/projects/commercial/35-golden-avenue/.

Doublespace Photography. "12106-DSYB-31." Photograph. 2019.

Daniels Midday Talks: Forestry and Design Series, p. 96

G.H. Rochester, The mechanical properties of Canadian woods together with their related physical properties. Ottawa, Department of the Interior, Canada: 1933.

Sean Thomas, "Biochar field trail." Photograph. 2021.

Daniel Ibañez, Jane Hutton, and Kiel Moe. Wood Urbanism: From the Molecular to the Territorial. New York: Actar, 2020.

Smith, Sandy. "Plane trees fall." Photograph. 2008.

Danijela Puric-Mladenovic. "Predictive vegetation modeling for forest conservation and management in settled landscapes." University of Toronto, 2003. https://openlibrary.org/works/OL13311683W/Predictive_vegetation_modeling_for_forest_conservation_and_management_in_settled_landscapes.

Forest Culture: Panel Discussion, p. 98

John H. Daniels Faculty. "Forest Culture." Streamed September 26, 2019. YouTube video, 1:37.33. https://www.youtube.com/watch?v=GhwToHjt2mA&ab_channel=UofTDaniels.

John H. Daniels Faculty. "Dan Handel." 2019. https://www.daniels.utoronto.ca/events/2019/09/26/forest-culture.

John H. Daniels Faculty. "Scott Jackson." 2019. https://www.daniels.utoronto.ca/events/2019/09/26/forest-culture.

John H. Daniels Faculty. "Stephanie Seymour." 2019. https://www.daniels.utoronto.ca/events/2019/09/26/forest-culture.

St. Thomas: A City of Industries, p. 100

Curtis Ho, Railway route from White River to St. Thomas. 2021. Digital diagram.

Google Earth 7.3.3. 2018. St. Thomas, Ontario. 42.46 N 81.06 W, Eye alt 46.63 km.

Chris Latour, Interior office view of the Element5 CLT factory in St. Thomas, Ontario. 2020. Photograph.

Sidney Tsao, Stages of CLT production. 2019. Digital diagram.

Miranda Fay, Site image of St. Thomas area, Ontario. 2019. Photograph.

Google Earth 7.3.3. 2018. St. Thomas, Ontario. 42.48 N 81.09 W, Eye alt 5.31km.

Student Responses: Re-Conceptualizing the Industrial Landscapes, p. 106

Images and diagrams provided by students.