# WOOD: CONCRETE OF THE 21ST CENTURY

USING A REGIONAL MATERIAL TO CUT CARBON EMISSIONS, BUILD SUSTAINABLY, AND CREATE A CARBON NEUTRAL CITY

Executive Summary:

Seattle, a historic timber town, is grappling with the 21st century realities of curbing carbon emissions, promoting density, smart growth and fostering an architecture of place. Wood, Seattle's oldest building material, offers a solution to these issues. Contemporary research suggests that wood, a local resource, vastly outperforms other common building materials like concrete and steel in terms of both carbon emissions and sequestration. This scientific research is occurring in step with the emergence of new engineered wood products and a greatly improved technical understanding of wood's material properties. Coupling these new engineered wood products with sustainability imperatives, architects, engineers and researchers are solving age-old problems of durability, stability and fire-safety; making wood a truly viable commercial alternative to carbon intensive materials like concrete and steel. Many people even think that wood will be the concrete of the 21st century.

New wood products can re/connect Seattle building culture with local, low-embodied energy materials that foster the uniqueness of place and support local industries and green jobs. Considering the rich history of timber in the Pacific Northwest, the City of Seattle is well suited to be the first city in the United States to embrace the use of these new wood building systems to sustainably address urban density needs and meet its pledge to be a carbon neutral city by 2050.

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"Why Not Timber High Rises?"

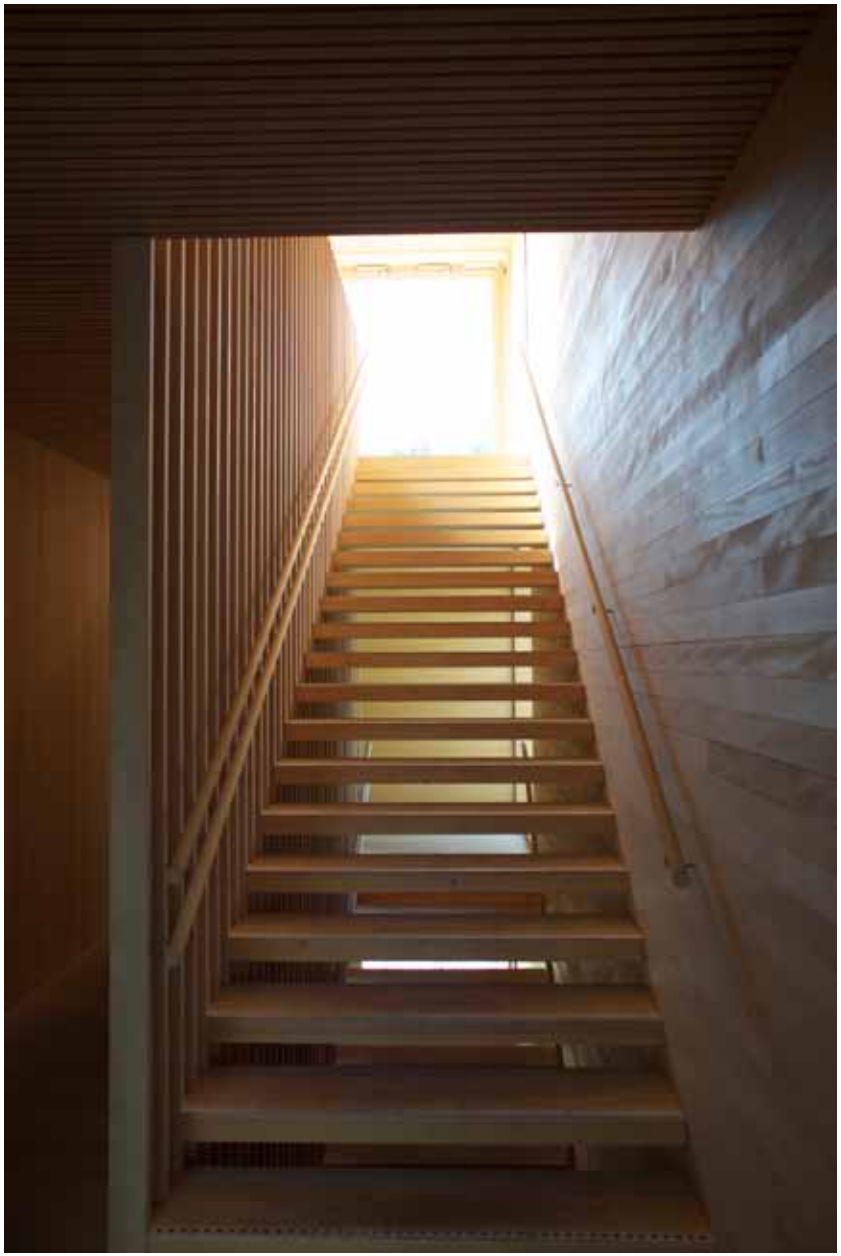



Photo by Emily Woods

## Seattle and the Northwest

- Nearly 22 million acres of the 43 million acres in Washington State is forested, accounting for over half of the state's total land
- Lumber created the first boom in Seattle and Henry Yesler, with his steam-powered sawmill, became the city's first millionaire

Forests in Western Washington. Source: NASA

1905 Western Washington State. Photo by Darrius Kinsey

Seattle around the 1870s. Source: Washington State Digital Archives

# RECONNECT WITH SEATTLE'S HISTORY

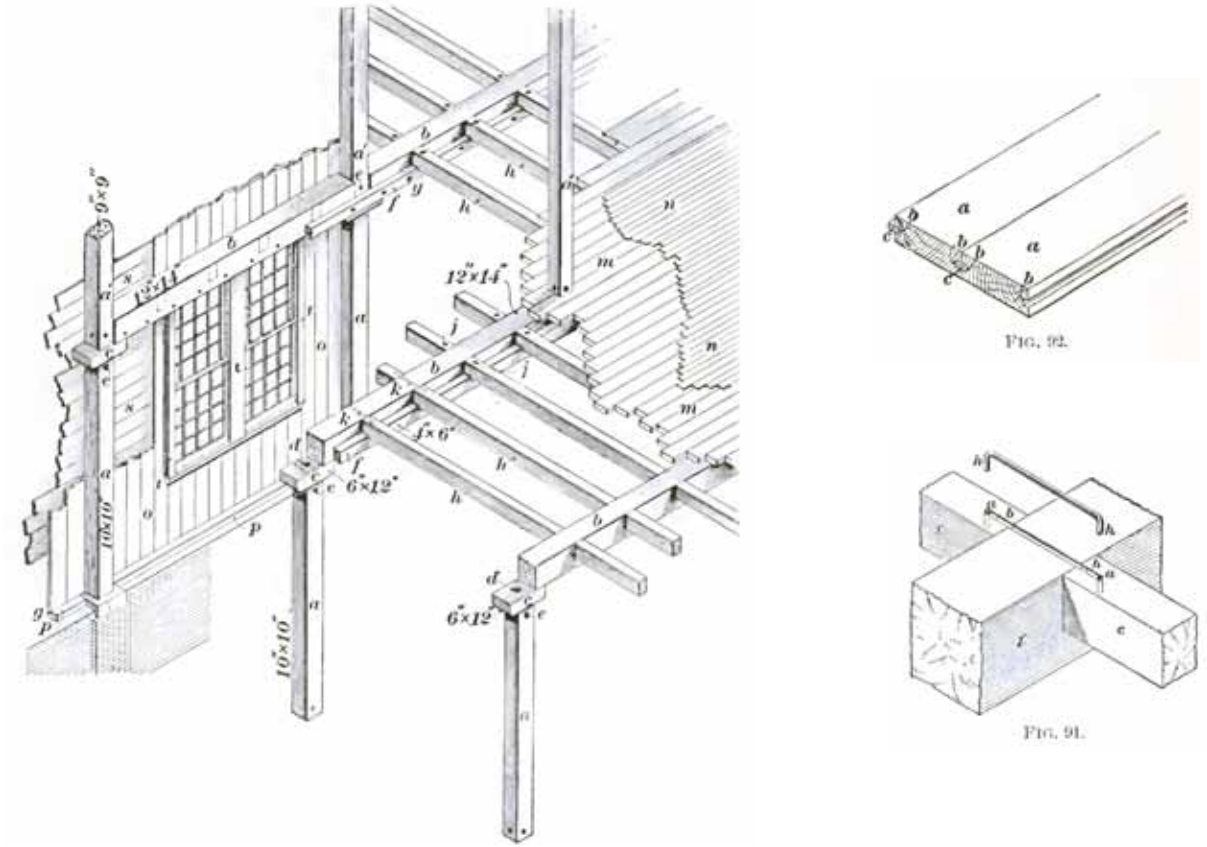
## Seattle's Architectural Heritage and Legacy of Urban/Commercial Timber Buildings

- Wood and masonry was readily available in the Puget Sound region and other fire proof technologies were more expensive and less familiar. Because of this Seattle turned to an approach called slow-burning construction (also called mill construction, semifireproof or fire-resistive) rather than true fire-proof construction
- The 1899 "A Treatise on Architecture and Building Construction" describes slow-burning construction as:

  *"The individual members, such as beams, columns, etc, are so proportioned that they retain strength enough to do the work required of them even after one-third of their bulk has been charred or burned."*

4-story timber building at 1024 E Pike Street Capitol Hill, Seattle, constructed in 1913 and still in use today. Courtesy Brendan McKeon

3-story timber building at 613 E Pine Street in Capitol Hill, Seattle, constructed in 1917 and still in use today. Courtesy Brendan McKeon




Slow Burning Timber Construction technology from *A Treatise on Architecture and Building Construction*, 1899

# RECONNECT WITH SEATTLE'S HISTORY

## Seattle's Historic Commercial Timber Buildings:

- Timber construction is flexible and adaptable over time
- Timber construction is robust and capable of lasting hundreds of years if properly cared for
- Timber is beautiful and creates calming interior spaces
- Timber is inherently fire-resistive and can survive fires without compromising the structural integrity of the building

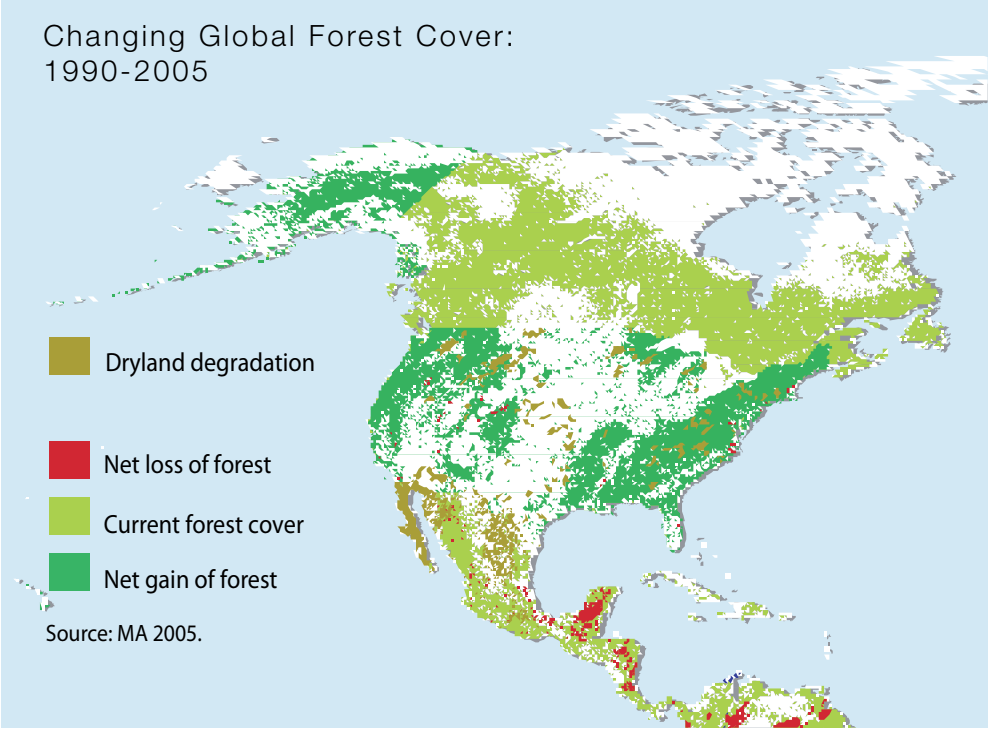
Value Village, Capitol Hill, Seattle constructed in 1916

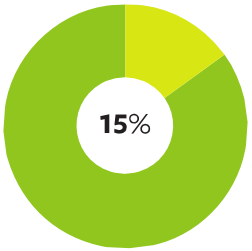
Elliott Bay Books, Seattle

Elliott Bay Books, Capitol Hill, Seattle constructed in 1918 as a Ford Service Center

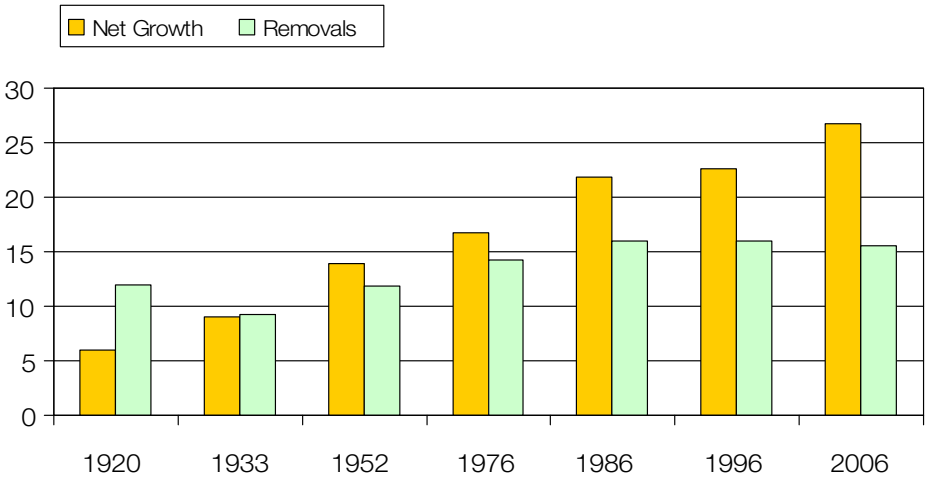
## Washington State Forestry:

- Forest stock is increasing every year on a sustainable trend
- Annual forest growth exceeds harvest
- Forest products are Washington's second largest industry
- Increasing the use of wood in commercial building projects supports local jobs and industry
- With housing crisis sawmills and wood manufacturers are suffering



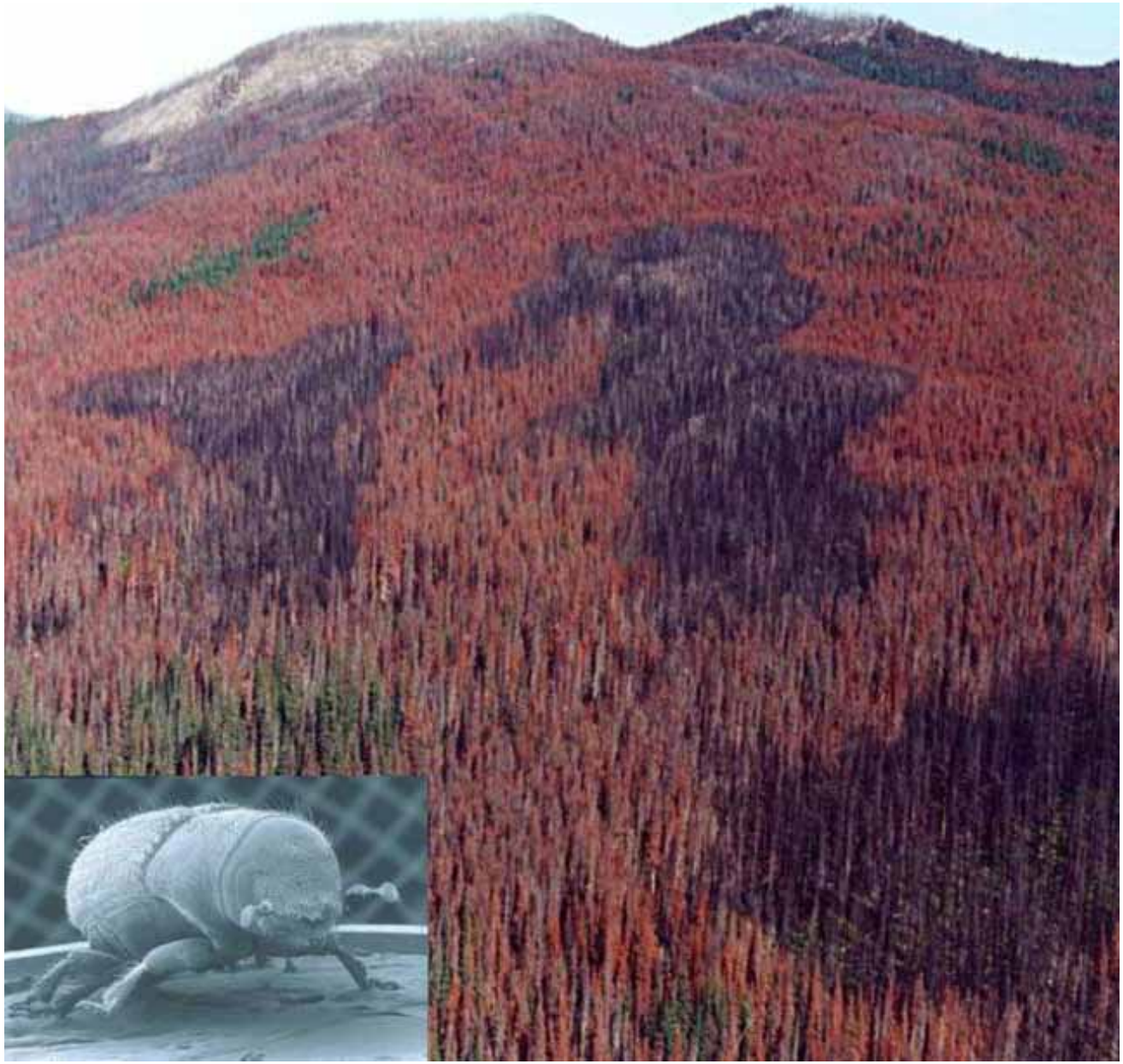

Washington's forest products industry is the second largest manufacturing sector in the state at almost 15% of total manufacturing. Source: Choosewashington.com




Source: Smith et al., USDA - Forest Service (2009).

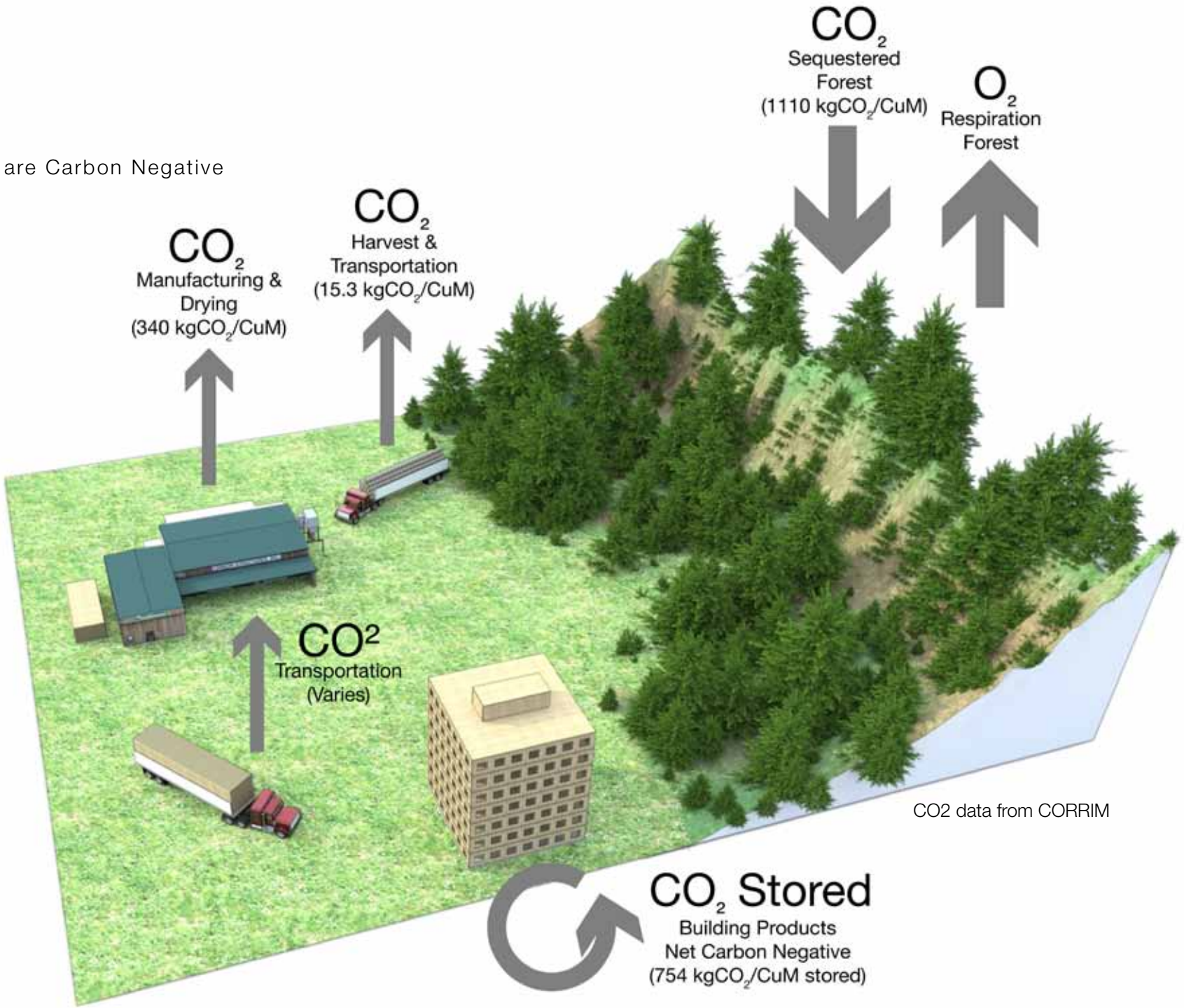
## The Mountain Pine Beetle

- The Pine Beetle has devestated an area the size of Wisconsin in British Columbia, Canada and has entered the American West
- British Columbia's largest source of CO2 emissions is currently from their dead standing Pine Beetle killed wood
- While the trees are still standing this wood can be harvested and used for building products, diverting CO2 emissions from the atmosphere and making use of an otherwise waste material
- Harvesting Pine Beetle killed trees also prevents devestating forest fires and the release of huge amounts of CO2 into the atmosphere



Source: Dr. Frank Lam University of British Columbia

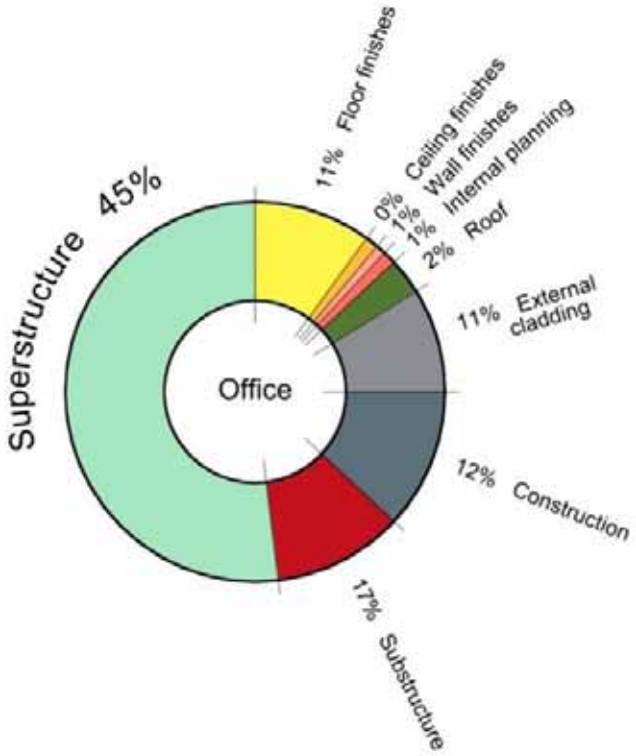
Wood Products are Carbon Negative




CO2 data from CORRIM

## Carbon Emissions and Building Materials

- Wood is a carbon negative building material which almost no other structural material can also claim




Embodied carbon in building components. Source: Arup

## Net Carbon Emissions in Producing a Ton of:

| Material | Net Carbon Emissions (kg C/metric ton) |
|---|---|
| Framing lumber | 33 (-457 with carbon stored in product) |
| Medium density fiberboard (virgin fiber) | 60 (-382 with carbon stored in product) |
| Brick | 88 |
| Glass | 154 |
| Recycled steel (100% from scrap) | 220 |
| Concrete | 265 |
| Concrete block | 291 |
| Recycled aluminum (100% recycled content) | 309 |
| Steel (virgin) | 694 |
| Plastic | 2,502 |
| Aluminum (virgin) | 4,532 |

1. Values are based on life cycle assessment and include gathering and processing of raw materials, primary and secondary transportation

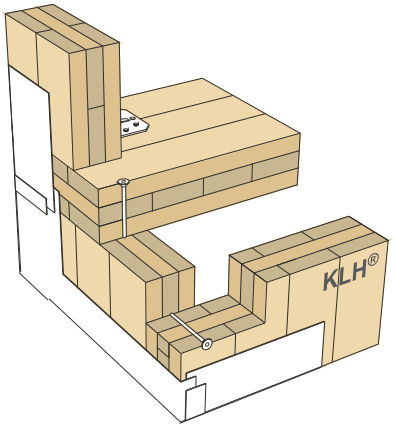
2. Source: USEPA (2006)

3. A carbon content of 49% is assumed for wood

# A MATERIAL FOR THE 21ST CENTURY

## Massive Wood Building Materials

Cross Laminated Timber (CLT). Source: MMK




CLT. Source: KLH UK

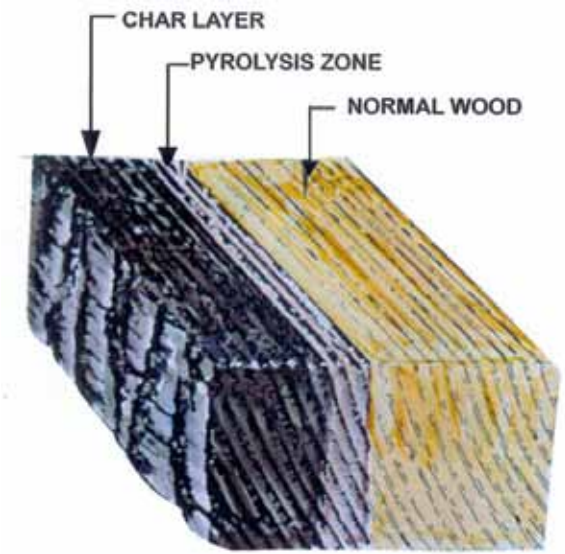
Massive Wood building materials like Cross Laminated TImber (CLT) are engineered wood products that have enhanced performance charateristics:

- Much stronger and safer that traditional stud construction
- Highly fire resistive
- Incredibly fast construction times
- Cost competitive with concrete and steel
- Clean and quiet construction process
- Ideal for tight urban sites
- Uses local NW materials and local industries
- Sustainable material for carbon negative construction

Cross Laminated Timber project at the University of British Columbia, Canada. Source: Structurlam

## Massive Wood and Fire

- Heavy timber forms a semi-protective layer of char during a fire event
- The char layer slows the speed and penetration of the fire into the wood
- Massive wood floors and walls can burn for extended periods of time without losing their structural integrity
- FPInnovations of Canada has recently finished fire testing CLT floors and walls showing that a 7-layer CLT floor fully loaded can be exposed to fire for nearly 3 hours before failing. A 5-layer CLT wall with one layer of gypsum board can be exposed to fire for over 2 hours before failing.




Charring behavior. Source: Unknown

CLT wall fire testing. Source: FPInnovations

CLT floor fire testing. Source: FPInnovations

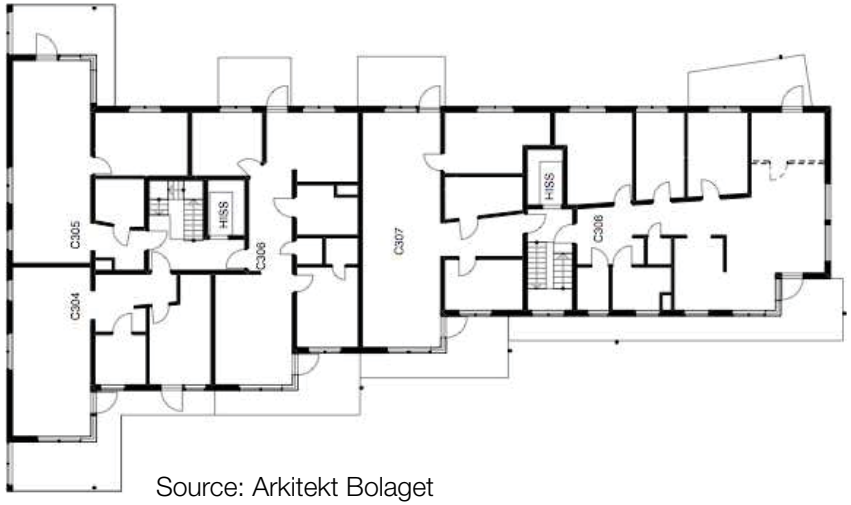
## Kaden Klingbeil's E3: Berlin, Germany

- Germany's first 7-story wood building
- This building is not allowed under current Seattle Building Codes
- Massive wood construction consisting of Heavy timber post and beams with infill solid wood walls
- All wood floor and walls fire tested to reach a minimum 90 minute rating

Source: Kaden Klingbeil

## Växjö's Limnologen, Sweden

- 8-story massive wood building; at the time of completion, was the tallest timber building in Sweden.
- The project consists of four eight-story buildings containing 134 apartments
- This building is not allowed under current Seattle Building Codes




Source: Arkitekt Bolaget

## Schankula's H8, Bad Aibling, Germany

- Germany's first 8-story wood building
- Massive wood construction
- Each wood floor took only two days to complete, and the entire wood structure was completed in only three weeks
- This building is not allowed under current Seattle Building Codes

Source: Schankula Architekten

Source: Schankula Architekten

## Waugh Thistleton's Stadthaus, London

- 9-story massive wood building
- All walls are Cross Laminated Timber
- Wood cut construction times by an estimated 23 weeks
- Cross Laminated Timber walls achieve up to a 120-minute fire rating
- This building is not allowed under current Seattle Building Codes

Stadthaus under construction. Source: Waugh Thistleton/KLH UK

The Stadthaus. Source: Techniker

Massive wood construction. Source: Techniker

Interior of the Stadthaus. Source: Waugh Thistleton

## Schools: The City Academy, Nowich

- 3-story CLT school designed by Sheppard Robson with Ramboll Engineers and CLT provided by KLH UK
- Internal steel frame with load bearing CLT exterior walls
- Contractor, Kier, praised speed and cleanliness of CLT system
- Kier estimated 4-6 months savings in construction time
- Dozens of schools built with CLT in the UK

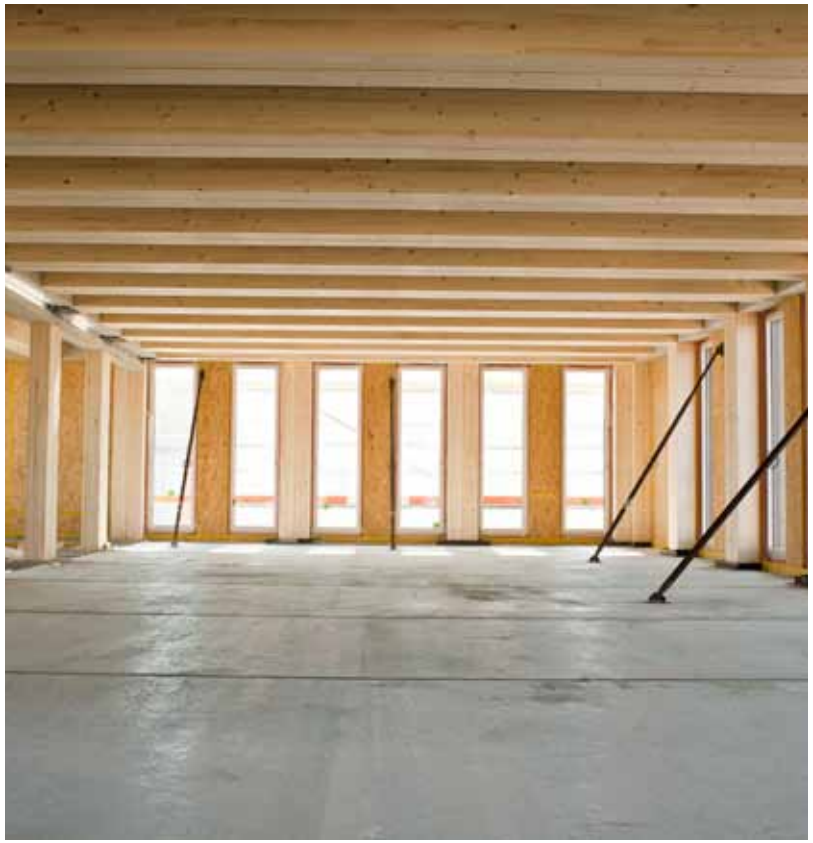
Illustrations of school: Source Sheppard Robson

The City Academy under construction

## Cree Rhomberg's 20-Story Timber Highrise: The LifeCycle Tower (LCT)

- Demonstrates wood as a truly urban option
- Prefabrication allows for fast construction time and cost competitiveness
- Massive wood wall system and hybrid massive wood/concrete floors
- First LifeCycle Tower under construction now in Dornbirn, Austria

Source: CREE Rhomberg



LCT One under construction. Source: CREE Rhomberg

## Vancouver, British Columbia's Timber Highrise Feasibility Study: Tall Wood

- Michael Green Architects have designed prototype for 12, 20 and 30-story massive wood buildings
- Demonstrates carbon neutral construction for highly urban areas

TALL WOOD

**OPTION 1 -** Up to 12 Storeys

**OPTION 2 -** Up to 20 Storeys

**OPTION 3 -** Up to 20 Storeys

**OPTION 4 -** Up to 30 Storeys

Source: Michael Green Architects

A New Massive Wood Building Type

- Demonstrate Seattle as an innovator and leader in sustainability
- Timber construction supports Seattle's goal of being carbon neutral by 2050
- Seattle can lead the rest of the nation in cabon neutral construction and establish expertise in this new field
- Architecture and construction supports local green industries and jobs
- Reconnect Seattle with its unique architectural heritage in a modern and sustainable way

SEATTLE CLIMATE ACTION PLAN

architecture 2030

CORRIM
Consortium for Research on Renewable Industrial Materials

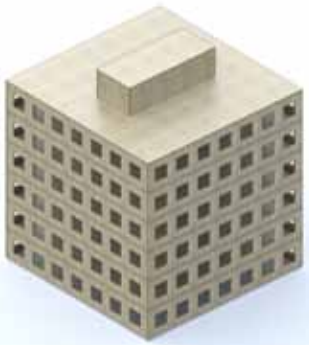
CASCADIA
REGION GREEN BUILDING COUNCIL

2.0

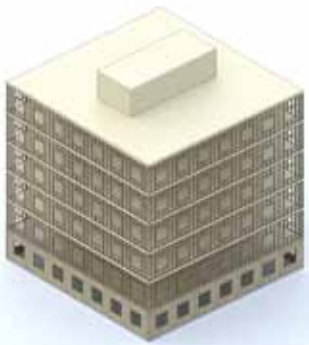
LIVING BUILDING CHALLENGE™

## Massive Wood Implementation

- Compile research from Canada and Europe on commercial applications of massive wood buildings
- Explore incentives for developers that encourage the use of wood in commercial development by recognizing the amount of embodied carbon in building products
- Engage recognized regional leaders in the field, such as CORRIM, Carbon Leadership 2030, Arch 2030, Cascadia
- Collaborate with the Seattle Department of Planning and Development to create a code-alternate system that allows new timber technologies in built construction in Seattle (address the following: Fire/Life Safety, Structural, Acoustics, Seismic, Energy Performance)



6-story CLT building

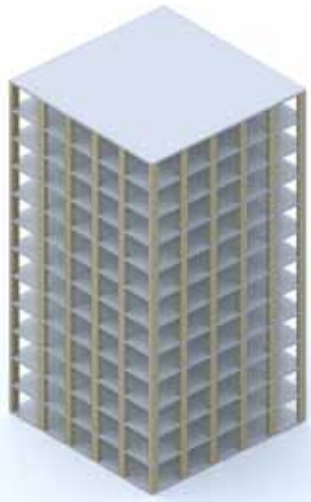


5-story light wood stud building over a 1-story CLT podium

7-story CLT building

7-story CLT structure over a 2-story concrete podium

8-story CLT structure over a 2-story concrete podium



Maximum 20 story LifeCycle Tower concrete and timber hybrid building system or FFTT building

JOSEPH MAYO, LEED BD + C, REGIONAL ASSOCIATE DIRECTOR AIA NORTHWEST AND PACIFIC

Intern Architect, Mahlum

SELECT PROJECTS:

University of Washington Student Housing Phase I, Seattle, WA

Contact: jmayo@mahlum.com

HANS-ERIK BLOMGREN, MS, PE, SE

Structural Engineer, Arup

SELECT PROJECTS:

Bill and Melinda Gates Foundation Campus; Seattle, WA

Seattle Civic Center; Seattle WA

Museum of Flight Pedestrian Bridge; Tukwila, WA

Four Seasons Hotel and Residence; Seattle, WA

Contact: Hans-Erik.Blomgren@arup.com

APPENDIX:

Why Not Timber High Rises?