Missing the Forest

How forest practices impact the carbon embodied in mass timber projects

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University of Washington & Ecotrust

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The Miller Hull Partnership

November 12, 2019  
Carbon Friendly Forestry
Why do we care about buildings or forests?
LIVING BUILDINGS at EVERY SCALE
We cannot meet climate goals without also eliminating embodied carbon emissions by 2040.

Annual Global Building Sector CO₂ Emissions

- **Building Operations**: 28%
- **Transportation**: 23%
- **Industry**: 20.3%
- **Concrete, Steel & Aluminum**: 22.7%
  - Concrete: 11.1%, Steel: 10.1%, Aluminum: 1.5%
- **Other**: 6%

*Source: 2018 Global ABC Report, IEA*
HIGH PROBABILITY OF MEETING 1.5°C
(67% CHANCE)

Peak Emissions in 2020

65% (reduction by 2030)

340 GtCO₂
(1.5°C, 67% Chance)

500 GtCO₂
(1.5°C, 50% Chance)

Global Emissions in GtCO₂

2020  2025  2030  2035  2040  2045  2050
Zero CO₂ Emissions
Goal B: 100% Healthy Material Choices by 2020

Objective B.1: Design to achieve the LBC Materials Petal
- Vet all specified products for Red List compliance
- Design every project to be embodied carbon neutral
- Specify wood as FSC certified or 100% salvaged/reclaimed
- Specify products with disclosed ingredients through a Declare Label, C2C Gold or better rating, or properly disclosed HPD
- Specify products with an Environmental Product Declaration (EPD) that makes 10% improvement of GWP over a forthcoming established baseline
- Every project sends at least 1 advocacy letter to a product manufacturer/industry supporting healthier materials
- Identify recycled content and/or local sourcing for final assembly
FOREST CHOICES MATTER

- Forest carbon balance exerts a significant influence on our global climate.

- Coastal forests in the Pacific Northwest are among the most productive ecosystems on the planet.

- Choices around how forests are treated and where we source wood products from are moving to forefront of business decisions amidst our climate crisis.
02  Life Cycle Assessment in the built environment
Results per Life Cycle Stage, itemized by Division

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<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>3,903,087 kg</td>
<td>11%</td>
<td>21%</td>
<td>11%</td>
<td>16%</td>
<td>20%</td>
</tr>
<tr>
<td>1,517,192 kg CO₂eq</td>
<td>12%</td>
<td>18%</td>
<td>23%</td>
<td>31%</td>
<td>27%</td>
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<tr>
<td>7,453 kg SO₂eq</td>
<td>17%</td>
<td>23%</td>
<td>23%</td>
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<tr>
<td>492.5 kg Neq</td>
<td></td>
<td></td>
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<tr>
<td>108,202 kg O₃eq</td>
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<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>1,925E+007 MJ</td>
<td></td>
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</tbody>
</table>
Design Option Comparisons

Massing
Structural Material
Finish Material
Assemblies

Full Building Assessment

Total Embodied Environmental Impact / Area
Living Building Challenge - Carbon Offset
LEED v4 Life Cycle Assessment Credit
Detailed Material Selection
Impact by LCA Stage, Spec Section, Revit Category, Revit Material
Tally System Boundaries

Cradle to Grave
60 Years Building Life
Industry Standard Transportation Distances
Inclusive of Architectural / Structural Elements
Exclusive of Mechanical / Electrical / Plumbing Elements

Optional to include:
Operational / Construction Energy
• Embodied Carbon Analysis and Reduction
• Responsible Wood Sourcing
• Building Products and Construction Carbon Offset

• Embodied Carbon Analysis and Reduction
• Responsible Wood Sourcing
**EPD®**

**THE INTERNATIONAL EPD® SYSTEM**

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**Summary of Environmental Product Declaration**

**Central Concrete**

<table>
<thead>
<tr>
<th>Mix</th>
<th>340PG9Q1</th>
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<tbody>
<tr>
<td>San Jose Service Area</td>
<td></td>
</tr>
<tr>
<td>EF V2 Gen Use P4000 3&quot; Line 50% SCM</td>
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</table>

**Performance Metrics**

<p>| | |</p>
<table>
<thead>
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<tbody>
<tr>
<td>28-day compressive strength</td>
<td>4,000 psi</td>
</tr>
<tr>
<td>Slump</td>
<td>4.0 in</td>
</tr>
</tbody>
</table>

**Environmental Impacts**

<table>
<thead>
<tr>
<th>Impact name</th>
<th>Unit</th>
<th>Impact per m3</th>
<th>Impact per cyd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total primary energy consumption</td>
<td>MJ</td>
<td>2,491</td>
<td>1,906</td>
</tr>
<tr>
<td>Concrete water use (batch)</td>
<td>m3</td>
<td>6.66E-2</td>
<td>5.10E-2</td>
</tr>
<tr>
<td>Concrete water use (wash)</td>
<td>m3</td>
<td>8.56E-3</td>
<td>6.55E-3</td>
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<tr>
<td>Global warming potential</td>
<td>kg CO2-eq</td>
<td>271</td>
<td>207</td>
</tr>
<tr>
<td>Ozone depletion</td>
<td>kg CFC-11-eq</td>
<td>5.40E-6</td>
<td>4.14E-6</td>
</tr>
<tr>
<td>Acidification</td>
<td>kg SO2-eq</td>
<td>2.26</td>
<td>1.73</td>
</tr>
<tr>
<td>Eutrophication</td>
<td>kg N-eq</td>
<td>1.31E-1</td>
<td>1.00E-1</td>
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<tr>
<td>Photochemical ozone creation</td>
<td>kg O3-eq</td>
<td>46.6</td>
<td>35.7</td>
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</tbody>
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A sample EPD for a concrete mix design by Central Concrete Supply Co.

*Credit: Central Concrete Supply*
LCA Impact Categories

- Use of Energy and Resources
- Climate Change
- Acidification of Land and Water Resources
- Eutrophication
- Destruction of Ozone Layer
- Formation of Photochemical Oxidants

GWP (CO₂)
Architectural Embodied Carbon Workflow
03 Seeing forests in Life Cycle Assessment
WHERE ARE TREES + FORESTS IN YOUR LCA?

- You probably won’t find them.
- LCAs usually simplify “biogenic carbon” accounting by assuming managed forests to be “carbon neutral.”
- This leaves forest practices that increase or decrease carbon storage in the forest off the balance sheet.

Fundamental choice of what reference scenario is used to quantify changes in carbon storage due to land-use decisions.

In our presentation today, we consider the change in forest carbon storage relative to the current landscape condition. This should be comparable to what the atmosphere sees.

An alternative approach could consider a no timber utilization scenario. This would essentially treat any timber harvested as carbon emitted (relative to leaving the forest alone).
04 Getting numbers from the forest
A sample of 67 properties across western Oregon and Washington, with forest conditions estimated from a remote sensing dataset, simulated under alternative management approaches for 100 years.

We considered two management scenarios...

- max sustained timber yield (LONG rotations)
- max net present value (SHORT rotations)

..under two sets of management contraints.

- comply with State Forest Practices Act (FPA)
- comply with Forest Stewardship Council (FSC)
WHAT RIPARIAN BUFFERS LOOK LIKE

on coastal Oregon timberland
WHAT RIPARIAN BUFFERS LOOK LIKE
under Oregon state law
WHAT RIPARIAN BUFFERS LOOK LIKE

under FSC
WHAT GREEN TREE RETENTION LOOKS LIKE

*initial forest conditions*
WHAT GREEN TREE RETENTION LOOKS LIKE following the first harvest (on 10 acres)

4 trees per acre (FPA Rules)

10% of basal area (FSC Rules)

30% of basal area (FSC Rules)
05 Getting to embodied “upstream” carbon in wood products
UNPACKING GLULAM’S EMBODIED CARBON
from a smattering of EPDs and LCAs

For 1 m³ of glulam, you might expect...

~8–15 kgCO₂e Forest Operations

~45–50 kgCO₂e Lumber Production

~50–110 kgCO₂e Glulam Production

890–1,080 kgCO₂e in the product
Forest practice carbon impact is calculated as change in carbon stored in standing live and dead trees at the end of 100 years of management.

Carbon embodied in products divides this change by the volume of wood produced.

This calculation is very sensitive to the timeframe used for calculation if carbon stocks or timber yields show major jumps or trends over time.
ADDING FORESTS TO THE MIX
for Glulam

This is how much fossil carbon is emitted to make 1 cubic meter of the wood product.

This is how much carbon is in the product.

This is how much carbon storage changed in the forest.
Report Information:
- Title: Full Building Summary
- Date: 4/9/2019
- Author: Brie Jones
- Company: Miller Hull Partnership, LLP
- Project: Gorton Bounds Bunkhouse
- Location: 214 Westridge Rd., Decatur Island, WA 98
- Gross Building Area: 450 ft²
- Expected Building Life: 60 years

Goal and Scope of Assessment:
- Full Life Cycle Assessment of the Gorton Bounds Cabin Revit Model

Transportation Impacts:
- Biogenic Carbon:
  - Exclude biogenic carbon

Output Summaries:
- Bill of Materials (Excel)
- Contribution Assessments (PDF)
- Life Cycle Stage
  - Division
  - Revit Category

On-site Construction:
- Electricity: [source]
- Heating: [source]
- Water: [source]

Annual Site Energy Use:
- Electricity: 10000 kWh [source: Regional grid mix - US - West, NERC region]
- Heating: 500 kBTU [source: Natural gas - US - West]
06 Building impacts of wood procurement
WING POINT RESIDENCE - LOOM HOUSE
EMBODIED CARBON IMPACT REPORT

RESULTS SUMMARY

Tally for Revit - Analysis Boundaries

Report Date: July 10, 2019
Gross Area: 3,944 ft² (365 m²)
System Boundaries: Cradle to Grave
Biogenic Carbon: Not Included
On-Site Construction Energy: Not Included
Operational Energy: Not Included
Revit Model Boundaries: Ceilings, Curtain Panels, Curtain Wall Mullions, Doors, Floors, Railings, Roofs, Stairs, Structural Columns, Structural Foundations, Structural Framing, Walls, and Windows.

TOTAL GWP: 118,223 kg CO₂-Eq (118 metric tons)
TOTAL GWP / AREA: 323 kg CO₂-Eq/m²

*Including PVs

RESULTS BREAKDOWN

% of Total Embodied Carbon Impact

CARBON IMPACT BY MATERIAL

GREENHOUSE GAS EQUIVALENCIES

Emissions Equivalent to:

- 25 passenger vehicles driven for one year
- 289,054 miles driven by an average passenger vehicle
- 14 homes powered for one year
- 15,074,889 number of smartphones charged

Carbon Sequestered by:

- 1,955 tree seedlings grown for 10 years
- 139 acres of U.S. forests in one year

STRAATEGIES TO REDUCE EMBODIED CARBON

- Sourcing locally available raw materials
- Transporting materials with low carbon vehicles
- Minimizing waste and increasing recycling efforts during construction
- Using systems and products that have long life spans to help mitigate replacement during building’s lifespan.
- Designing a building that is adaptable to different programs in the future

LCA Summary
MATERIALS PERFORMANCE SUMMARY

LOOM HOUSE
COMPLETION: 2019

EMBODIED CARBON  118  MT
RED LIST
100% eradicated
FULL BUILDING ANALYSIS
LOOM HOUSE
Glulams Only

GLOBAL WARMING POTENTIAL (kgCO₂eq)

3%

1,318 KgCO₂eq
CARBON SEQUESTERED BY...
16 ACRES OF U.S. FORESTS
21.8 TREE SEEDLINGS GROWN FOR ONE YEAR

*GWP factors per regional forest provided by Ecotrust, then factored back in to cradle to grave tally analysis.

LCA Software:
Tally 2019 for Revit

Wood Data (CLT & Glulams)
EPDs:
Transportation Distance:
Varies per study
End of Life Assumptions:
75% Recovered, 22% Incinerated, 3.5% Landfilled

Steel Data
EPDs:
American Institute of Steel Construction - Fabricated Hot Rolled Structural Steel Sections
LCA:
GLO Steel Rebar Worldsteel (2014)
RNA Hot Rolled Structural Steel Sections AISC (2010)
RNA Steel Hot Dipped Galvanized Worldsteel (2007)
GLO Steel Sheet Ginning and Bending (2014)
US Electricity Grid Mix (20/4)
US Lubricants at Refinery (20/4)
GLO Compressed Air / Bar (2014)
US Metal Rod Forming (2010)
GLO Value of Scrap Worldsteel (2014)
Transportation Distance:
40 km
End of Life Assumptions:
98% Recovered, 2% Landfilled

+ Ecotrust
MATERIALS PERFORMANCE
KENDEDÁ BUILDING FOR INNOVATIVE SUSTAINABLE DESIGN
COMPLETION: 2019

EMBODIED CARBON: 1,360 MT

LBC RED LIST
395 kg
$CO2e\text{ per m}^2$

LBC RED LIST COMPLIANT
PARTIALLY REMOVED
NOT TARGETED FOR REMOVAL

*structure and enclosure only
Kendeda Building
Atlanta, GA
FULL BUILDING ANALYSIS
LIVING BUILDING AT GEORGIA TECH
Glulams Only

6.2%

64,973 KgCO₂eq
CARBON SEQUESTERED BY...

76.5 ACRES OF U.S. FORESTS
1,074 TREE SEEDLINGS GROWN FOR ONE YEAR

LCA Software:
July 2019 for Revit

Wood Data (CLT & Glulams)
EPDs:
Transportation Distance:
National (USA)
End of Life Assumptions:
11.5% Recovered, 22% Incinerated, 66.5% Landfilled

Steel Data
EPDs:
American Institute of Steel Construction - Fabricated Hot-Rolled Structural Sections
Commercial Metals Company - Concrete Reinforcing Steel
LCI:
GLO Steel Rebar Worksteel (2014)
INSA Hot-Rolled Structural Steel Sections AISC (2010)
INSA Steel Hot, Deep Galvanized Worksteel (2007)
GLO Steel Sheet Stamping and Bending (2011)
US Electrically Sired Mix (2011)
US Lubricants at Refinery (2011)
GLO Compressed Air / Gas (2011)
US Metal Prod - farming (2013)
GLO Value of Scrap Worksteel (2014)
Transportation Distance:
60 km
End of Life Assumptions:
58% Recovered, 4% Landfilled
Confidential Project

California
Timber Sourcing Comparison

EXCLUDING CONCRETE PODIUM & CORE

GLOBAL WARMING POTENTIAL (kg CO₂ eq)

- 2,520,015
- 2,497,374
- 2,396,889
- 1,709,413
- 1,064,294
- 843,393
- 638,092
- 632,803
- 63,253

1.76 MILLION kg CO₂ eq
CARBON SEQUESTERED BY...

- 2,078 ACRES OF U.S. FORESTS
- 29,197 TREE SEEDLINGS GROWN FOR ONE YEAR

*FSC equivalency survey not completed or accounted for in the information provided. GWP may be higher than what is shown for PEFC sourced timber.
EXCLUDING CONCRETE PODIUM + CORE

MASS TIMBER SOURCING OPTIONS

Glulams + CLT

208%

4.74 MILLION KgCO₂eq

CARBON SEquestered BY...

5.561 ACRES OF U.S. FORESTS

78,468 TREE SEEDLINGS
GROWN FOR ONE YEAR

*GWP factors per regional forest provided by Ecotrust. Tree seeded back in to cradle to grave Tally analysis.

LCA Software:

July 2019 for Tally

Wood Data (CLT & Glulams)

EPDs:

American Wood Council and Canadian Wood Council - North American Glue Laminated Timbers

Transportation Distance:

Varies per study

End of Life Assumptions:

14.5% Recovered, 22% Incinerated, 63.5% Landfilled

Steel Data

EPDs:

American Institute of Steel Construction - Fabricated Hot-Rolled Structural Sections

Commercial Metals Company - Concrete Reinforcing Steel

LCA:

GLO Steel Steel Worldwide (2011)

RNA Hot Rolled Structural Steel Sections, NSC (2010)

RNA Steel Hot Strip Rolled Steel Worldwide (2007)

GLO Steel Steel, Shaping and Bending (2011)

US Electrically Welded (2011)

US Lubricants at Refineries (2011)

GLO Compressed Air Frac (2010)

US Metal Roll Forming (2010)

GLO Value of Steel Worldwide (2011)

Transportation Distance:

4516

End of Life Assumptions:

98% Recovered, 2% Landfilled
07  Where do we go from here?
Instead of simulations, we would prefer observed carbon stock change and timber outputs at spatial and time scales less sensitive to short-term fluctuations in timber output and carbon stocks.

Every major timber producer has data at their fingertips to make these calculations for their ownership. When is Carbon Disclosure coming to forestry?

What does a negative embodied carbon value imply for wood products?
ON SEEING THE FOREST

from the builder’s view

➢ Forest practices matter

➢ Choosing responsibly-produced timber matters

➢ We need better information from focused forestry research

➢ We need more and better EPDs for forest products

➢ We should advocate for policies that support greater forest carbon sequestration
Thank you.

David Diaz
Huge Forest Data Nerd
University of Washington & Ecotrust

Chris Hellstern
AIA | LFA | LEED AP | CDT
The Miller Hull Partnership

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