To Build or Not to Build with Wood,

that is the Question.

atelier ten

Authors

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Amy Leedham is an Associate Director of the San Francisco office and leads the US carbon practice. As a registered architect, Amy combines her expertise in building physics and architecture to foster communication between the design team and technical consultants in the pursuit of design excellence. During her time at Atelier Ten, she has delivered some of our most complex projects with ambitious goals such as net zero energy, zero water waste, enhanced occupant health, and carbon neutrality.

Atelier Ten - Maggie Smith, LEED AP BD+C, LFA

Maggie is an Associate in Atelier Ten's San Francisco office. She is an expert in the firm's Carbon Practice and heads up the Innovative Materials Working Group, which includes investigating claims and applications for mass timber buildings. Maggie has significant experience in life cycle analysis and implementing carbon reduction strategies, and enjoys driving her clients to make smarter carbon decisions on projects. She has experience developing sustainability targets for new masterplans, establishing portfolio-level sustainability targets, and managing ambitious low carbon projects.

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Isabelle Hens is an environmental designer at Atelier Ten in San Francisco. She is a key member of the carbon practice and leads the envelopes working group, which studies building envelopes at the intersection of embodied carbon, operational carbon, and occupant experience. Isabelle has published two peer-reviewed journal articles on mass timber, presented her work on timber unitized curtain wall at four conferences, guest lectured on sustainability at several California universities, and taught the first class on the embodied carbon of buildings offered at UC Berkeley. Isabelle is a member of the Embodied Carbon Group within the AIA California Climate Action Committee.

Introduction

To Build, or Not to Build with Wood, That is the Question.

The use of wood in buildings is not a new phenomenon, but with increasing focus on reducing global carbon emissions, the building industry has embraced mass timber construction in recent years. The benefit of building with a renewable resource that is also beautiful has caught the imagination of the industry as well as mainstream media, resulting in a sea of conflicting information about whether using mass timber is 'good' or 'bad,' and leaving many asking whether they should build with wood or not.

Decision making has become incredibly nuanced and the desire for a simplified answer to this complex question has yielded articles presenting mass timber as both the hero and villain of the construction industry. One recent article, "Wood is Not the Climate-friendly Building Material Some Claim it to Be,"[1] published by the World Resources Institute (WRI) exemplifies this trend. Critical review and additional perspectives on this subject are essential checks and balances, but black and white conclusions do not reflect the evolving and complex nature of whether wood is a beneficial choice for a specific project. Atelier Ten collected additional perspectives on this topic based on our experience addressing these challenging questions to address some of the most critical points in the article. The global perspective on impacts of forestry and construction practices is a critical one, but discussing these points in the context of decisions that can be made at the project scale is important to move the conversation forward.

The John W. Oliver Design Building at the University of Massachusetts Amherst was the first academic building in the United States to use cross-laminated timber (CLT). With Leers Weinzapfel Associates

Claim 1: Most wood (and its stored carbon) is lost during production

Atelier Ten: *A significant amount of carbon is still sequestered in buildings, but this underscores the importance of responsible forestry.*

The authors of the WRI article claim that only a small portion of a harvested tree typically makes it into a building, arguing that a large amount of a tree's biomass is stored in its roots and branches, which are left behind during logging. Then, once at the lumber mill, the bark of the tree is burned, and the chips and sawdust created during milling are either burned or turned into paper or furniture, which do not offer the same long-term sequestration benefits of mass timber.

Atelier Ten coordinates with every project team to develop a project-specific timber procurement strategy. FSC certification was prioritized for mass timber elements and exterior cladding at Kresge College, UC Santa Cruz. With Studio Gang Architects

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The WRI article is correct that slash, roots, and branches often do get left behind in forests, which can make up as much as 35-50% of the tree's original biomass.[2] While there are ecological benefits to leaving this material in forests, it does decay quickly, leading to biogenic carbon release. However, once a log makes it to a mill, there is little wood waste. Bowyer et. al. estimates that less than 1% of logs harvested in North America end up as waste. The majority (52%) is processed into lumber, 36% is transferred to other facilities to create paper and furniture, and 11-12% is recovered for energy production. While paper, furniture, and energy production [3] are not long-term storers of carbon, they are productive uses of wood, and each have their own process for greenhouse gas emissions accounting. The demand for wood chips and sawdust exists independently for these industries (they would be directly manufactured if needed), and therefore their carbon emissions should not be attributed to mass timber when comparing structural materials.

Furthermore, ISO 21930 applies a "carbon-neutrality" assumption for sustainably managed forests which means any wood that is left to decay in the forest or to be incinerated at the mill is releasing back the same carbon it removed while the tree was growing, with a net impact of zero. Knowing that this is an oversimplification of a complex topic, Atelier Ten advocates for responsible forestry and timber traceability for all mass timber projects.

Claim 2: Harvesting wood is not carbon neutral because of the opportunity cost

Atelier Ten: *This does not acknowledge the spatial and temporal limitations of forests. Also, sustainably managed forests can provide higher carbon sequestration value than unmanaged forests.*

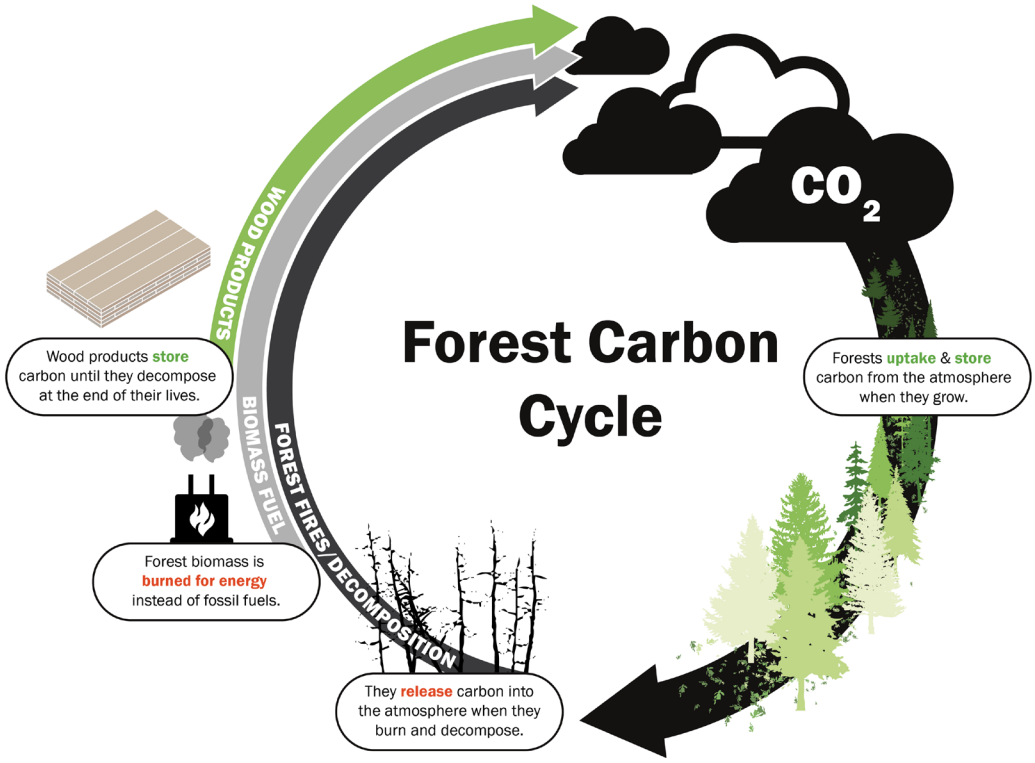

FIGURE 1 – Forests are complex and dynamic systems that can regenerate under the right circumstances. The forest carbon cycle is a closed loop system, and a forest can be a carbon sink, carbon source, or carbon neutral depending on the spatial and temporal scale. The impact of human activities on forests must be considered over the appropriate time frame and spatial boundaries.

The authors of the WRI report argue we should be measuring the carbon opportunity cost by comparing wood harvesting against a no-harvest scenario. They provide the analogy of a savings account: if you deposit some money and withdraw some money, you are worse off than if you would have continued to deposit money.

Forests are fundamentally different from savings accounts – there are spatial and temporal boundaries to consider when assessing forest carbon stocks. The carbon stock of individual stands naturally ebbs and flows as a result of disease, wildfire, and regrowth. However, when evaluating the sequestration benefit of forests at the macro scale, meaning over longer time frames, across North America, and including the full range of activities that influence carbon, we see that forest carbon stocks are increasing.[4] Furthermore, sustainable forest management leads to better carbon outcomes than unmanaged forests, which are susceptible to wildfire and disease, ultimately resulting in catastrophic carbon release. New, young trees sequester carbon faster than old trees, so a controlled harvest and replacement yields more carbon storage and avoids large pulse emissions from the loss of old trees.[5]

Claim 3: End-of-life emissions of biogenic carbon are often unaccounted for and negate any sequestration benefit

Atelier Ten: *It is important to account for end-of-life emissions, but only a small portion of the initial sequestration is actually lost.*

The WRI authors state the loss of biogenic carbon sequestration from the end-of-life decomposition or burning of wood is often not accounted for, negating any sequestration benefit.

Atelier Ten does account for end-of-life emissions in our whole building life cycle assessments in accordance with ISO 21930 standards. The UL Product Category Rule (PCR) Guidance for Structural and Architectural Wood products states in Appendix A that to report any sequestration benefit, you must factor in end-of-life loss of sequestration for the most common disposal scenario in North America: landfilling. End-of-life emissions are calculated in accordance with the EPA Waste Reduction Model (WARM), which provides a landfill carbon adjustment factor of 88% for mass timber.[6] This means that only 12% of the initial biogenic carbon sequestration is lost over a 100-year period as the mass timber slowly decays in a landfill, after which point it is considered permanently sequestered.

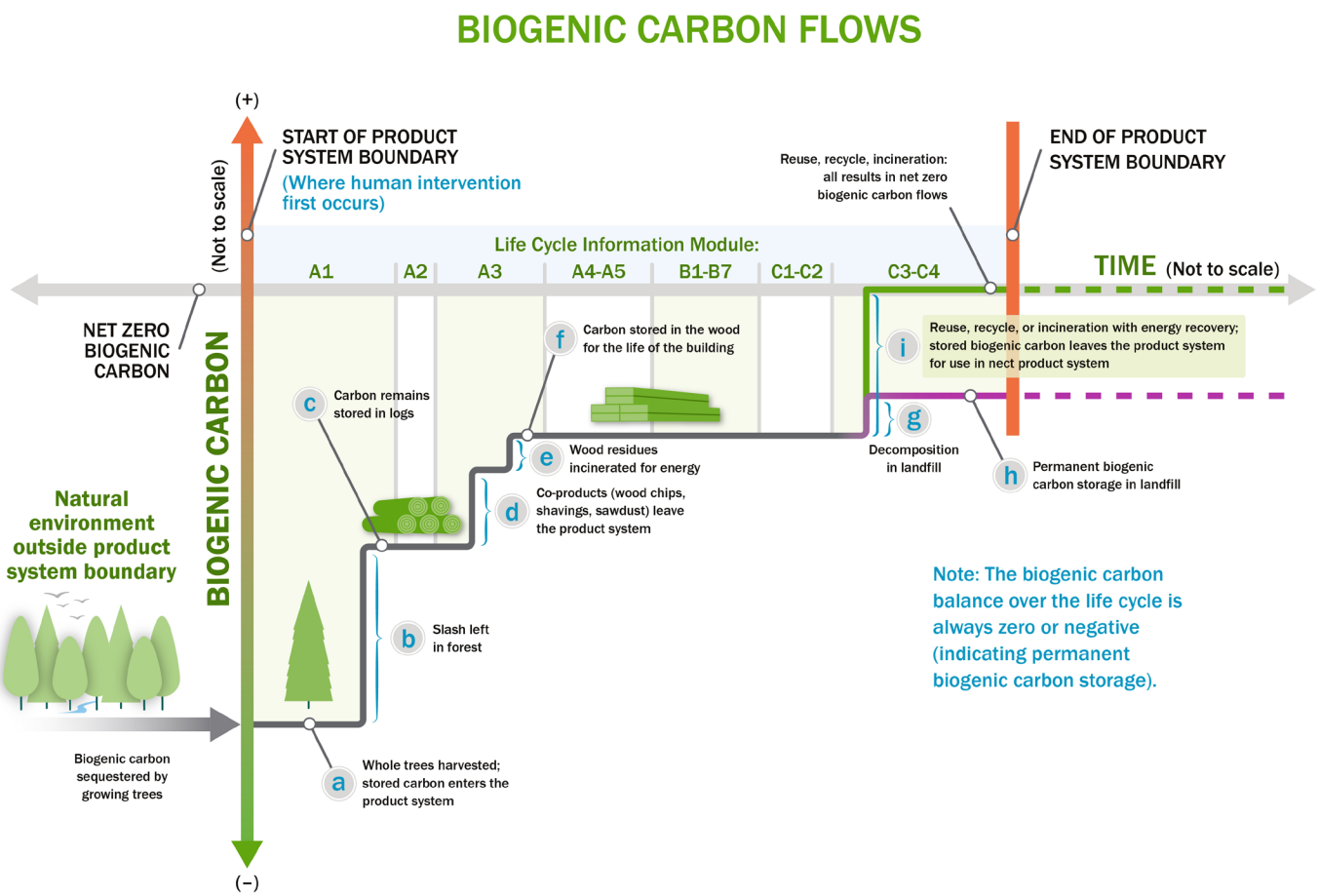

FIGURE 2 – Biogenic Carbon Flows for Wood Products per ISO 21930. Biogenic carbon is the carbon stored in bio-based materials that was originally removed from the atmosphere by photosynthesis and, under natural conditions, would eventually cycle back to the atmosphere as CO2 due to degradation processes
ADAPTED FROM – https://www.woodworks.org/resources/how-to-include-biogenic-carbon-in-an-lca/

Claim 4: Mass timber does not reduce carbon emissions now – it creates a "lag" in the sequestration potential of forests

Atelier Ten: *We believe mass timber can reduce emissions now, and in fact offers an opportunity to overlap the carbon sequestered in buildings and forests simultaneously.*

The WRI report argues that even if trees are replanted, using wood in construction will increase climate warming for decades, relative to using steel and concrete. They claim there is a "lag" in carbon stock that could result in a temporary increase in global warming, arguing that when a tree is cut, there is carbon lost in the roots, branches, and manufacturing, and it can take many years for the new tree to re-coup that lost carbon.

The claim above hinges on the controversial assumption that "the carbon clock" starts ticking at the point of harvest rather than at the point of planting. However, many others, including Sohngen (2023), disagree and believe the clock should start at the point of planting given that a substantial portion of mass timber comes from future-oriented plantation forests that plant trees for the purpose of harvesting.[7] Looking at it this way, there is a period of overlap between the wood sequestered in a building and the regrowth of a tree.

Compared to concrete and steel, which lead to an immediate release of carbon emissions before building occupancy, wood reduces and delays emissions until the end of life of the building. This reduction and time delay is significant because CO2 has a long residence time – once emitted, it remains in the atmosphere and will contribute to global warming for centuries through the phenomenon of radiative forcing. The radiative forcing effects add up over time, so much so that delaying carbon emissions by 50 years would lead to a 73% reduction in the total warming impact over a 100-year period.[8]

As a final note, Churkina et. al., 2020 found that mass timber buildings can hold sequestered carbon at 3x the density of trees in a forest.[9] That means using mass timber offers the chance to expand the sequestered carbon stock.

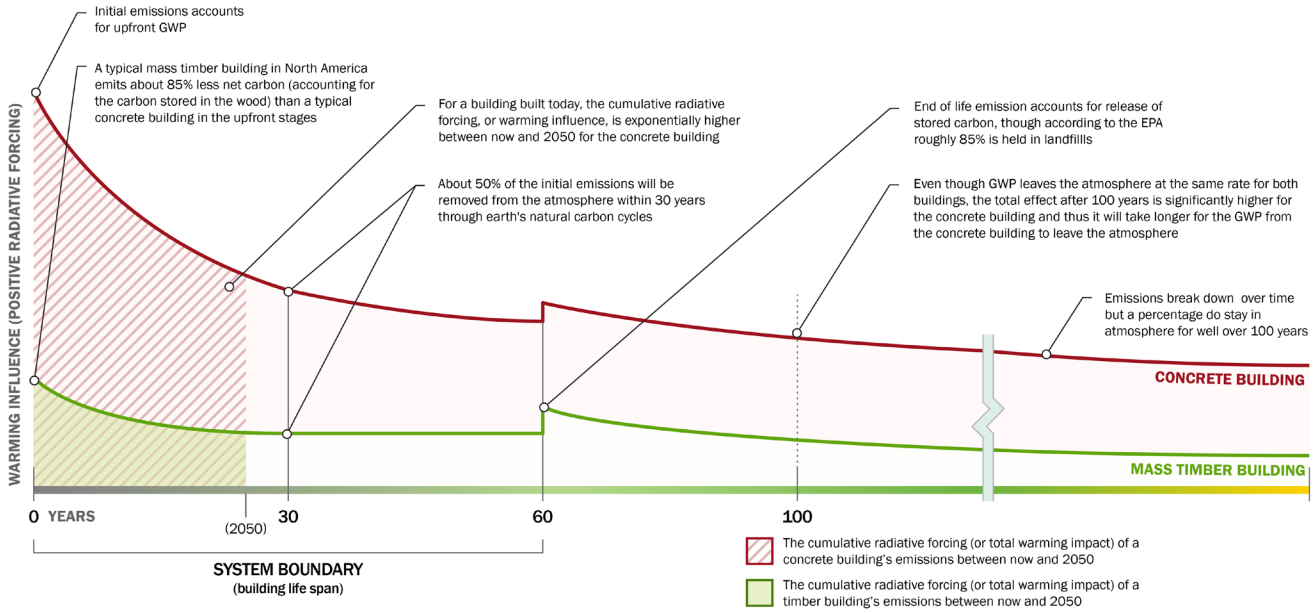

FIGURE 3 – Comparison of the total warming effect of emissions from a typical timber building to those of a typical concrete building. The cumulative impact of lower upfront emissions and the delay in the release of sequestered carbon mean timber buildings typically have a significantly lower warming impact to concrete buildings, especially in the critical time period between now and 2050.

Claim 5: Relying on plantation forests in warm climates for mass timber might yield climate benefits, but not when factoring in the growing needs for wood

Atelier Ten: *We agree there are regional differences in the sequestration potential of forests, but with selective timber sourcing, forests worldwide can offer significant savings relative to concrete and steel.*

The authors of the WRI report argue that different forest types offer various levels of sequestration potential. Wood harvested from fast-growing forest plantations in warm, wet parts of the world does offer climate benefits over concrete or steel, but these forests alone cannot meet the growing demand for wood. Not all forests provide significant carbon savings. For example, mass timber that is harvested from a natural forest (such as in the Western United States) only provides a 25% reduction in GHG (Greenhouse Gas) emissions compared to concrete or steel buildings; an amount the authors argue is too small to justify major investments.

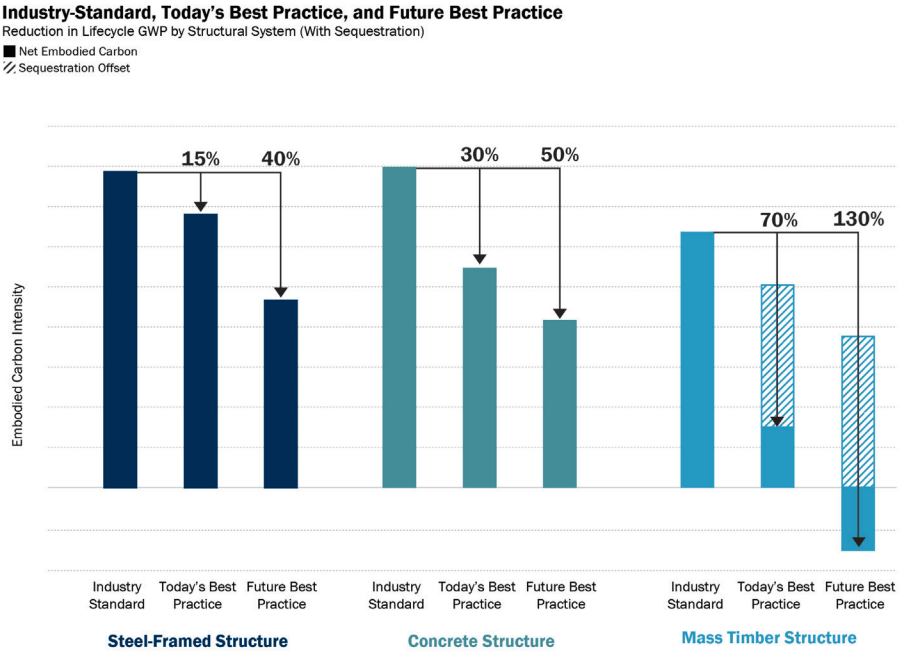

FIGURE 4 – Comparison of the GWP intensity for industry standard, today's best-practices, and predicted future best-practices (roughly 2035) for the three primary structural materials. The reductions in the future best practice scenarios are low-carbon blended cements and cement replacement for concrete, electric arc furnace with zero-carbon electricity for steel, and zero carbon electricity for timber. Even though steel and concrete show significant reduction potential in the future, they do not get close to the reductions afforded by mass timber.

Atelier Ten believe even 25% is a significant savings. Especially in today's market, where there are limited options for low-carbon concrete and steel, mass timber is often the single most valuable carbon reduction measure a project can achieve. Furthermore, the 25% reduction cited in the article does not appear to include the benefit of biogenic carbon sequestration. In accordance with life cycle assessment standards, Atelier Ten does report biogenic carbon sequestration in whole building life cycle assessments, which shows even more significant savings compared to concrete or steel (by about 70% on average).[10] Biogenic carbon sequestration always accounts for end-of-life emissions and is reported separately to ensure maximum transparency.

To fully realize the sequestration potential, Atelier Ten advocates for sourcing mass timber from responsibly managed forests and pushes for timber traceability down to the source forest and sourcing as locally as possible. Sourcing wood from North America can avoid many of the challenges facing global timber harvest.

Claim 6: Mass timber would have large adverse effects on the world's forests

Atelier Ten: *Even the most conservative mass timber adoption scenarios project that forest growth will outpace growing demand.*

The use of mass timber for the expansion of Kresge College not only reduced the project's embodied carbon footprint, but also celebrated the unique character of the project location with Studio Gang Architects

The WRI authors propose that world-wide adoption of mass timber cannot be met by available forest land.

In North America and Europe, carbon forest stocks are growing fast enough that they can support an uptake in mass timber. In the United States specifically, forest growth is projected to outpace mass timber demand by nearly 20%, even under the most conservative scenarios (highest demand vs. lowest forestry inventory estimates).[11]

Globally, studies show that forest volume is increasing without increasing area, crop production is increasing volume without increasing area, and fertility rates are decreasing worldwide.[12] In the short term, we will need more buildings to house the aging population, but in the long term, it should stabilize before we run out of land to grow timber. It is also important to acknowledge that alternative building materials (concrete and steel) are finite resources too.

Mass timber is not going to make sense for every building, so we do not need to project scenarios where every building will require wood. Code and structural limitations will necessitate the use of concrete and steel structures, so it is important that these industries continue to explore low-carbon solutions. In the meantime, there is room for mass timber adoption to grow and be an important strategy for reducing embodied carbon in the built environment.

Conclusion

As the tipping point for catastrophic global warming approaches and the window to reduce emissions is closing, we need all the carbon reduction strategies we can get. It is essential to find the balance between doing the best we can now while also identifying potential blind spots and advancing our collective understanding of global carbon emissions. It is also critical to acknowledge the tendency towards “carbon tunnel vision” while there are other important issues like the biodiversity crisis. We need strategies that can address carbon and any number of the other critical global issues. Mass timber construction is not single-handedly going to prevent climate change, but if done right, it can reduce the carbon impact of a project in the critical time period for avoiding the worst effects of global warming while also increasing biodiversity and supporting a healthy ecosystem. As an industry, we need to push for building re-use, material transparency, and the decarbonization of all our building materials. Critical thinking, open discussion, and sharing of information are essential for the building industry to advance. While the understanding of global carbon emissions continues to evolve, there are key opportunities for a project team to consider when determining if and how to use mass timber:

- ❑ Just use less. Maximize the re-use of existing buildings and design buildings to use as little new material as possible.
- ❑ Understand the boundaries and limitations of whole building life cycle assessment and use it as a design and decision-making tool.
- ❑ Transparency is key, both in terms of GWP emissions reporting and timber sourcing information.
- ❑ Choose the most effective structural system for your building typology, massing, and geological conditions.
- ❑ Prioritize sourcing from sustainably managed forests. Sourcing wood from North America is a good starting point but timber procurement is really an evolving menu of options and the best solution for one project might not be the best for another.
- ❑ Incorporate design for deconstruction strategies to minimize waste and extend the lifespan of wood products.

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