Just how climate-friendly are timber buildings? It's complicated

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The number of people living in urban areas around the world will swell by upwards of 2 billion over the next three decades. Many of those people will need new homes. But building those with conventional

materials would unleash a gusher of carbon dioxide: Concrete, steel, glass and bricks for construction make up a combined 9% of global CO_2 emissions, according to research by the United Nations Environment Program.

Enter engineered wood, a seemingly no-brainer solution. Mass timber is not the typical lumber that has structured single-family houses in North America for decades. The wood components are strong enough to hold up an office tower or apartment block, and building with them is thought to emit much less CO_2 than using standard materials. And since wood is about 50% carbon, the material itself even stores a little carbon, to boot.

That's why more and more companies are embracing mass timber as a way to cut their carbon footprints and promote their green bona fides, including Walmart Inc., Microsoft Corp. and Alphabet Inc.'s Google. YouTube in November opened two new buildings at its San Bruno, California, headquarters that have timber structures, which the company says halve the emissions of a concrete-and-steel design.

But establishing just how much carbon is saved by building with timber isn't straightforward. There are still big unanswered questions: Is mass timber good for the climate irrespective of its source? And if one well-sourced wooden building saves on carbon, what would 100 million of them do?

Here, the no-brainer-ness of timber begins to splinter.

Architects and engineers have tools to estimate the carbon costs of timber over the whole life of a building. Specialized software lets users perform a life-cycle assessment, or LCA, to estimate any design proposal's carbon footprint, from harvest, to the manufacture of its component parts, to construction, to disposal. Sometimes designers will draw up two models—one timber, the other concrete or steel—to better

compare the carbon costs.

Among corporate clients as well as designers, "a lot of folks are really, really nervous about greenwashing" mass timber's climate benefits, says Stephanie Carlisle, a senior researcher at the University of Washington's Carbon Leadership Forum.

"So they want to have a system that backs them up." Carlisle helped develop tallyLCA, a software tool managed by a nonprofit, Building Transparency, that estimates the environmental impact of building designs. (Another tool widely used in the industry is One Click LCA.)

Life-cycle assessments look at the carbon spent moving logs from forest to mill. There's also the energy expended milling and manufacturing wood into mass-timber products such as cross-laminated timber (CLT) and glued laminated timber (glulam). In addition, there's the carbon released when construction cranes and tractors burn fuel, and even renovations and routine maintenance over decades.

"We make buildings out of timber, right?" says Mel Allwood, director and sustainability head of the London building group of Arup, the global design and engineering firm. "We don't just chop down trees and roll them into place. There's a whole bunch more processes that happen in between, and all of those cost us carbon."

But another critical concern is how the forest where the wood grew is managed, and life-cycle analyses don't comprehensively quantify the benefits from sustainable forestry.

Consider this analogy. By now, the growing popularity of electric vehicles has helped familiarize a pretty arcane point: that the climate-friendliness of any EV depends in part on how its electrons are sourced. A charging station that draws power from a coal plant ties a driver to

emissions that solar energy does not. Fortunately, the grid is cleaning itself up, and with time, taking the transportation sector with it.

Something similar is true of timber construction. Mass timber is typically made out of softwood trees like fir, pine, spruce and larch. But what kind of tree matters less to the carbon footprint than where and how it grew. "Provenance is everything," Allwood says.

The wood's origin, and the conditions of its home forest before and after being taken away, influence the overall climate impact of mass timber. Forest lands that conserve soil health, have trees ranging in age, guard against pests and wildfire and protect biodiversity all have a better chance of re-growing trees in perpetuity.

Mass timber buildings are still only a tiny niche in global construction. If the carbon accounting is tricky, the climate stakes for getting it wrong are relatively localized to those claiming its green-ness, at least for now.

But what would it mean for the world's land-use emissions if mass timber becomes mainstream?

Here, the exercise of estimating how much carbon pollution is embodied in a building bows to the complexity of ecosystem science and how carbon moves about the Earth.

Building-specific LCAs define the construction process—say from harvest to end-of-life disposal—and estimate who's responsible for how many emissions along the way. But that's not the kind of analysis that environmental researchers do, so may not be the most informative one in terms of global carbon, says Danny Cullenward, a senior fellow at the University of Pennsylvania's Kleinman Center for Energy Policy.

An LCA is simpler than a land-use analysis but misses meaningful

system-level insight, Cullenward says. It misses the complexity inherent in a biological system like a forest.

The key questions may not concern the wood's trail from harvest to disposal as much as the difference between harvesting the wood and not harvesting it in the first place. It's very difficult to know how long-lived wood products stack up against stable forests, carbon-wise. Ecosystems will always resist any supply-chain carbon accounting standard imposed on them. The answer to the systemic questions may always be some variation of "it depends."

And right now, the climate-friendliness of harvesting wood for mass timber hangs on a dispute about how to account for the carbon footprint of industrial forestry.

Most researchers of forest carbon net out harvested wood with stable regrowth elsewhere, following guidance from the United Nations' Intergovernmental Panel on Climate Change. Harvests accounted for in this way generally come out close to carbon neutrality.

People have misinterpreted that guidance, says Tim Searchinger, a senior fellow at the World Resources Institute and technical director of its agriculture, forestry and ecosystems program. He and colleagues recently ran a different kind of analysis on wood harvests, including for mass timber, undermining the assumption that wooden buildings are a climate gimme.

They say that harvesting wood isn't carbon neutral, and their analysis—published last summer in a WRI report and an article in the journal Nature—turns on this point.

Unharvested forests store more carbon than harvested ones do, even if trees regrow, because harvesting in and of itself reduces the trees' long-

term carbon-absorbing potential, they say. Logging consequently is responsible for about 10% of the current level of global emissions, and that is expected to continue through mid-century.

What other research doesn't correctly consider, Searchinger says, is that only 20% to 25% of a harvested tree makes it into the timber replacing concrete and steel. That's because 20% to 25% of a tree is underground, in the form of roots. Another 20% or so is the small branches usually lost as "slash," which gets burned or left to decompose. Another 10% or so is lost when the bark is stripped off.

In other words, most of a tree that gets harvested for mass timber ends up as waste or a byproduct, and releases much of the carbon it once stored.

"The reality is that only a small portion of a tree typically gets into a building," says Searchinger, who is also a senior research scholar at Princeton University. He adds a few moments later, "Wouldn't it be fantastic if all those beautiful wood buildings were really great for the environment or carbon neutral or whatever? But it's not true."

Harvesting wood for use in energy and construction "will likely increase atmospheric carbon for decades," Searchinger and colleagues have written. If mass timber grew into an industry-standard material, it would impose further demand on what WRI calls "a global land squeeze"—a competition among farms, forests and developed areas, essentially—that's becoming more critical as the human population swells.

The WRI paper provoked a blistering response from Brent Sohngen, a professor of environmental and resource economics at Ohio State University, who said it "makes no sense" and defended how the IPCC guidance has been interpreted. In his view, standard accounting already

includes the emissions from timber byproducts, which effectively makes Searchinger's approach a form of double counting.

The paper's headline-generating argument "sounds big and problematic, when it's just a restatement of an earlier incorrect argument," Sohngen wrote in an August blog post. (Searchinger, in turn, has assailed Sohngen's analysis.)

The WRI research also roiled mass-timber professionals, who pushed back at the idea that industrial forestry might be a source of emissions three times greater than aviation. It "sent this bomb into this very conscientious population who wants to do this right, for all the right reasons," says Nicole St. Clair Knobloch, principal at Olifant, a company that helps cities raise funds for wood construction.

Critics objected to the conclusions on myriad grounds. Mass timber is too small to be considered in the same breath as forces like agricultural deforestation, its advocates say.

They point out that engineered wood is largely taken from the existing harvests of industrial forests in nations that have caps on annual yield. They say the biggest threat to forests, in places like the U.S., isn't mass timber at all but development that turns forest permanently into real estate.

"The issues aren't coming from mass timber," says Scott Francisco, founder and director of Pilot Projects, a consultancy that works in urban design and environmental conservation. He's also co-founder, with WRI, of Cities4Forests, a network of cities united to conserve forests. "If you want to take issue with overharvesting, you kind of need to look at that for the big picture."

Although contentious, WRI's findings were not lost on the US concrete

industry. The National Ready Mixed Concrete Association has cited them in social media posts. Gregg Lewis, the association's chief communications officer and an architect, told Bloomberg Green the paper "should be eye-opening to anyone who has jumped on the 'wood is green' bandwagon."

Concrete and steel both play outsized roles in the planet's greenhouse gas emissions, spurring entrepreneurs, researchers and governments to try to shrink the materials' carbon footprints. The amount of CO_2 emitted for every ton of steel produced has been falling, thanks to efficiency and recycling, and pilot projects are testing new limits of low-carbon steel. Cement (a key ingredient in concrete) too has wrung per-ton efficiencies, and startups are busy making concrete with cement substitutes.

Concrete makers are working toward reducing concrete's high carbon load, Lewis said. If or how quickly concrete and steel decarbonize could change the calculus for mass timber. A future building project using poorly sourced wood, going up against a conventional design of reduced-carbon materials, could be challenged on climate-friendliness.

For the University of Washington's Carlisle, the technical sparring adds up ultimately to a richer general debate. "The best thing that this debate is doing, I think, is that it's making people think with nuance and with sensitivity around land management," she says. "And that is super important."

Mass timber might help cut carbon in important ways that don't come up in either narrow LCA or global land-use discussions. For decades, many have wished for denser, less auto-oriented communities built on transit lines. Mass timber provides another option for low-carbon districts of mid-rise buildings.

"That in itself is a climate solution," Knobloch, of the timber consultancy Olifant, says.

It's a good rule of thumb that a well-sourced mass timber building will be lower carbon than the equivalent made of concrete or steel. But what about the hotly disputed, macro-scale land-use concerns?

If mass timber is entering a boom analogous to the rise of solar and wind power and batteries, it's not apparent yet from market analysis.

There's not enough data to compile a global look at how mass timber construction stacks up with conventional sources, but the number may be "a lot less than 0.1%," said Art Schmon, vice president for engineered wood and mass timber at Forest Economic Advisors, LLC, a research firm based in Massachusetts. China and India have very little mass timber construction. In the US, mass timber had a market share of 0.6% for multifamily and nonresidential buildings in 2023.

In other words: The world could increase mass timber construction by an order of magnitude and it would still be like dropping a toothpick in a concrete mixer.

At the most, worries about mass timber depleting global forests are premature. Amy Leedham, an architect and carbon expert at design consultancy Atelier Ten, puts it this way, "There is no scenario in which we are ever building enough timber buildings for this to be an issue."