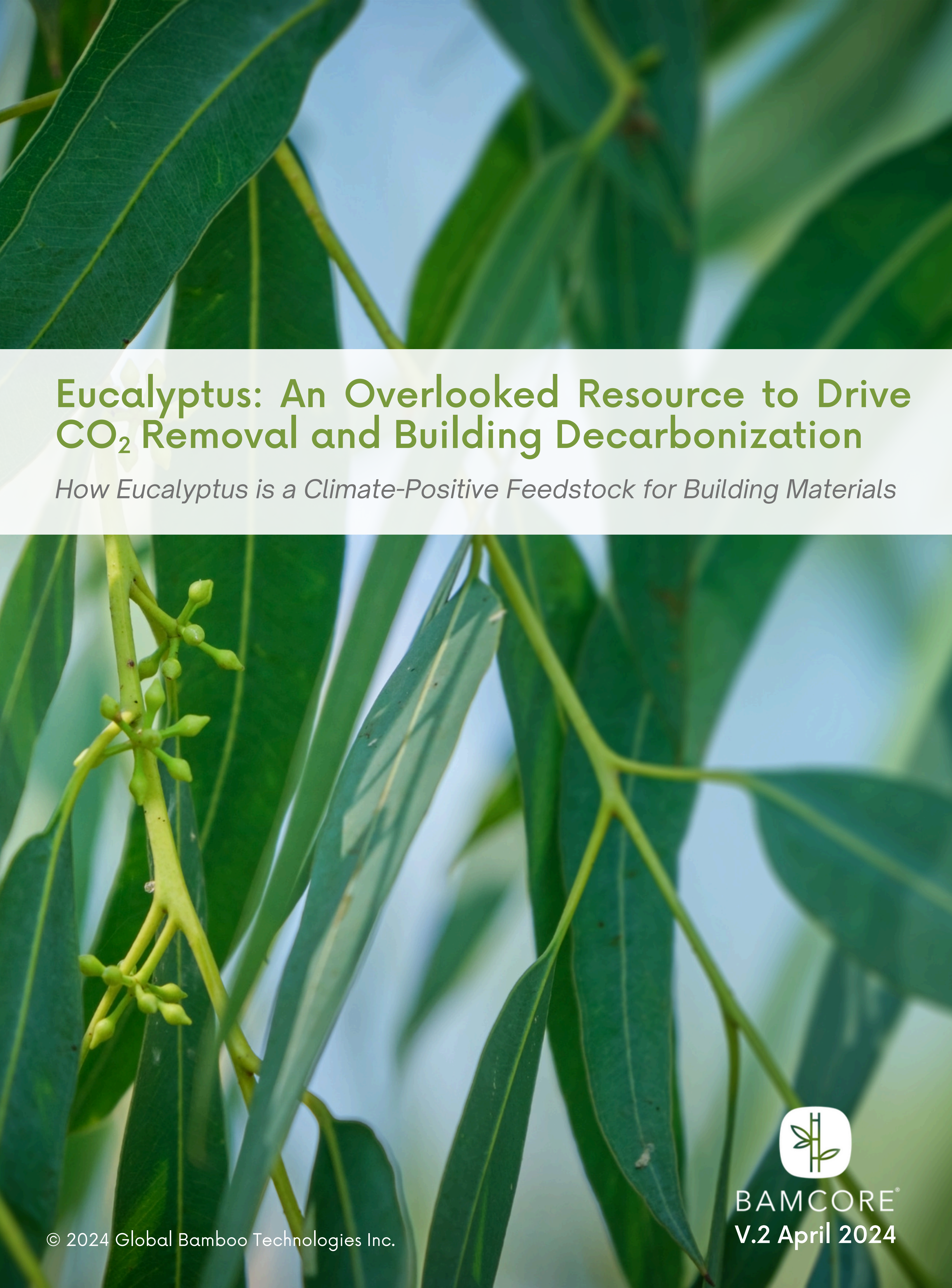

Eucalyptus: An Overlooked Resource to Drive CO_2 Removal and Building Decarbonization

How Eucalyptus is a Climate-Positive Feedstock for Building Materials

BAMCORE®

V.2 April 2024

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Executive Summary

Reaching the 1.5-degree threshold, potentially as soon as 2027, signals an urgent need for climate action.

Complementing emission reduction efforts, Carbon Dioxide Removal (the removal of CO2 already emitted into the atmosphere, “CDR”) has a critical role in avoiding the worst effects of the current climate crisis. The UN’s IPCC emphasizes the necessity for an aggressive CDR strategy, claiming the removal of 100 Gt to 1000 Gt CO2 by 2050 will be needed to achieve the ambitious targets of the Paris Agreement. Simultaneously, building emissions rose to a global all-time high in 2022.

Forests, which cover nearly a third of the land mass and have the capacity to remove 10–12 Gt CO2 annually, are an invaluable mechanism for CDR and offer significant potential for decarbonizing the built environment. The use of bio-based materials to extract carbon from the atmosphere and store it in buildings is just starting to be considered. Given the urgent need for CDR solutions, it is essential to prioritize fast-growing fibers over traditional long-rotation species like pine, spruce, and fir. Despite being the second most widely planted tree worldwide with high productivity rates and short rotations, *Eucalyptus* is often overlooked as a building material.

Eucalyptus, which today is seldom used in the structural frames of buildings, possesses the mechanical properties required for engineered wood products (EWPs), such as structural panels and cross-laminated timber. In fact, many species of *Eucalyptus* possess superior strength relative to conventional softwoods.

In addition, with a shorter harvest rotation cycle than pine, *Eucalyptus* can offer a significantly higher rate of CO2 removal. Beyond its CO2 removal capacity, numerous environmental and socioeconomic benefits of *Eucalyptus* further increase the case to be made for leveraging the fiber beyond its traditional uses as pulp/paper and as a fuel source. Once common misconceptions about *Eucalyptus*, such as excessive water consumption and high flammability, are clarified, it becomes evident that *Eucalyptus* can be a powerful tool for climate change mitigation through building decarbonization.

In our 2019 publication, *Carbon Farming with Timber Bamboo*, we argued that the fast growth and short annual harvest cycle of timber bamboo can accelerate carbon sequestration and transform bamboo plantations into perpetual carbon farms. Here, like timber bamboo, we argue that *Eucalyptus* provides a fast-growing, extremely strong structural fiber that can lead a new generation of building decarbonization.

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Climate Change and the Need for Carbon Dioxide Removal

Populations of polar bear cubs near the north pole and Emperor penguins near the south pole are rapidly dwindling. In between, humanity is suffering successively the hottest summers and winters ever recorded, is being battered by hurricanes, cyclones and storms with frightening frequency, and is experiencing wildfires on all non-Antarctica continents that are emitting enormous amounts of CO2.

Emissions from fossil fuels continue to grow with no "peak oil" in sight. Current policies presently in place around the world are projected to result in about 2.7°C warming above pre-industrial levels by end-of-century, as compared to the Paris Agreement's targeted maximum rise of 1.5°C and its worst-case limit of 2°C. Scientists now project that humanity will start exceeding the target of 1.5°C as soon as 2027 (just three years away). Nation-state follow-through on the Paris Agreement has been tepid, and humanity's overall response to climate change remains, on the whole, lackluster.

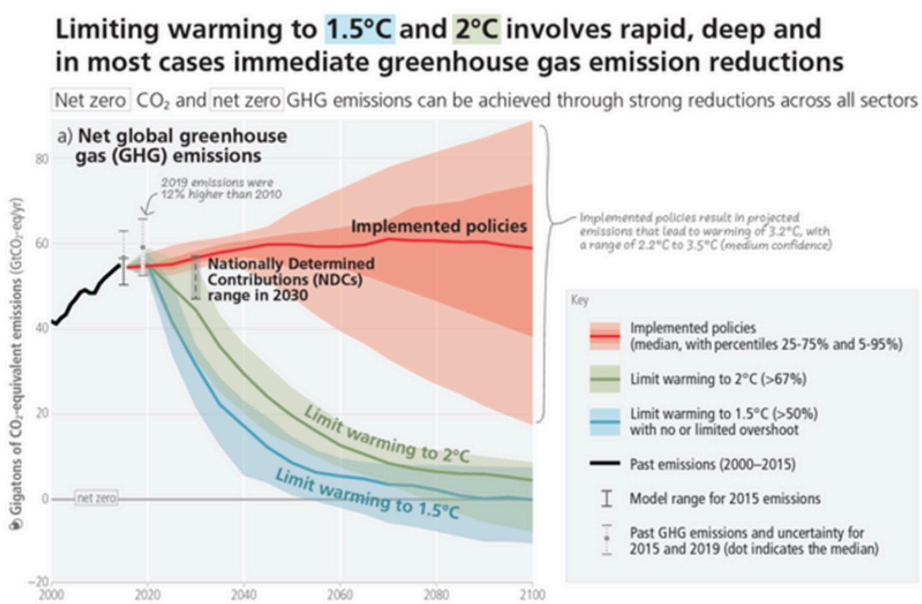
In its September 2023 Global Stocktake report, UN scientists projected humanity could possibly stay below the damaging but hopefully livable 1.5°C only if we lowered emissions from the 2019 levels by 43% by 2030 and 60% by 2035. Realistically, these are highly unlikely without the worst global depression in modern history. Emission reduction alone is not sufficient to reach these and future targets. Carbon dioxide removal serves as a "negative emission," and because greenhouse gas emissions persist in the atmosphere long after being emitted (over 120 years for CO2), CDR is urgently needed now and for the coming decades alongside annual emission reductions.

Figure 1 illustrates the critical role of CDR. The figure shows the annual emissions from (1) the total national emission reduction commitments reached through the Paris Agreement (pink shading) and (2) the annual emission projections required to limit the warming to 2°C (green shading) and 1.5°C (blue shading). The conclusions are distressing. First, there is a visible and large gap (unshaded area) between emissions reductions committed through the Paris Agreement and the further emission reductions needed to limit warming to 1.5°C and 2°C. The negative emissions effected through CDR are needed to fill this gap, yet CDR is still in its infancy. Second, since nearly every nation is underperforming in their Paris Agreement commitments, the current projections of national contributions (shaded pink) are actually much higher than shown. Thus, the factual gap is even larger, and CDR is needed even more.

The UN IPCC's Sixth Assessment Report projects required CDR of between 100 and 1000 Gt CO2 before 2050.

The report also estimates that forests, in particular, can be responsible for removing 10–12 Gt CO2 per year from the atmosphere. Carbon removal is achieved by photosynthesis of trees, starting as seedlings and growing to their full-term maturity, which can vary depending on the species and the end use of the harvested wood in the case of plantations. However, to effectively "remove" CO2, the sequestered CO2 needs to be stored for at least decades. This can happen within the forest of mature trees (i.e., by not harvesting them), but this will require a significant area of land that is already in declining supply due to requirements for food production and continuing urbanization. While it is critical to maintain natural forests to store carbon absorbed from trees prior to earlier growth, without periodic harvesting (and durable storage of the products), forests have a diminished role in continuing CDR. Mature forested areas store a lot of carbon, but the sequestration rate is very low or null.

Figure 1. Global emissions pathways consistent with implemented policies and mitigation strategies



Source: IPCC, 2023 Sixth Assessment Report of the Intergovernmental Panel on Climate Change

On the other side, tree plantations for timber products have lower standing stocks of sequestered CO_2 but higher current sequestration rates. Therefore, in planted forests, we can harvest wood products before full-term, natural maturity and keep some or all the harvested biomass in longer-term storage. Doing this in managed tree plantations achieves accelerated carbon removal beyond what occurs in a mature standing natural forest. To fill this role as a significant CDR engine, the harvested wood can be stored durably in building structures. Critically, the faster the growth of the tree and the sooner the plantation can be rotated or harvested, the more effective trees can be as CDR tools.

Forests cover about 31% of the Earth's land surface or 4.06 billion hectares. Forests established through natural regeneration cover around 3.75 billion ha (93%), while forests established through planting and/or deliberate seeding (i.e., plantations) cover around 294 million ha (7%). Globally, *Pinus* is the dominant genus of planted trees, primarily found in temperate regions.

Eucalyptus is the second most widely planted genus of trees worldwide and is found principally in tropical and subtropical regions. Total *Eucalyptus* plantations exceed 22 million ha, with the top three countries holding nearly 60% of the total —Brazil (22%), China (20%) and India (17%). Importantly, relative to climate change mitigation, *Eucalyptus* has significant advantages over other tree species.

In general, the *Eucalyptus* growth rate (i.e., its CDR rate) is about 1.5 to four times faster than the broad range of *Pinus* (spruce and fir). This higher productivity means more land efficiency in producing wood products (more wood produced per area unit) and it enables more rotations of harvesting over time for the same expected amount of wood.

After eight years of research and product development, we believe that carbon farming of *Eucalyptus* and timber bamboo and storing the harvested wood products durably in building structures are two of the most overlooked, near-term, low-cost CDR opportunities humanity has.

Biogenic Building Materials for Carbon Mitigation

As much as 40% of annual global greenhouse gas emissions result from construction and buildings. Yet, construction and buildings lack the attention and policy support that other less polluting sectors have gained, e.g., transportation.

The climate impact of buildings is even greater when the forward demand for buildings is considered. Projections point to an additional 2.6 trillion square feet of new floor area by 2060. This is equivalent to building a new New York City every month for 40 years. Two-thirds of total building emissions result from ongoing operations of buildings (heating/cooling, lighting, electrical, etc.) over their service years life (50-100 years). However, one-third of building emissions occur entirely during the manufacturing and construction of building materials. Thus, around 10-12% of all greenhouse gas emissions result from that year's construction of buildings and other construction projects. These upfront emissions are called embodied emissions or embodied carbon.

Over the past 50 years, the architecture, engineering, and construction AEC industry has made progress in reducing the operating emissions of buildings. Still, very little has been achieved relative to the embodied emissions of buildings. The UNEP warns that embodied carbon is projected to surge from 25 percent to nearly half by 2050. In contrast, the share of operational carbon emissions will shrink due to increased adoption of renewable energy and improvement of energy-efficient buildings. However, the good news is that when building materials are biogenic, they store carbon removed from the atmosphere, thus reducing their carbon footprint.

Subsequently, the carbon absorbed during the regrowth of the harvested biogenic material can lead to negative emissions (or net sequestration). This version of nature-based CDR lowers the overall/upfront embodied carbon of the building.

The fight against climate change is highly time-dependent because there are numerous

irreversible tipping points that, once tipped, accelerate further climate change. Given this fact, we must evaluate emissions released today as far more critical than emissions released in the future. When this "time value of carbon" is considered, the importance of focusing on a building's upfront embodied emissions is clear. The critical opportunity we have is to develop and employ carbon-storing materials in our buildings at a global scale as soon as possible.

The climate benefits associated with using fast-growing timber and other bio-based materials in buildings are not immediate. There are carbon emissions associated with harvesting, manufacturing, transporting, and installation. In reality, the benefits come from the CDR of the biogenic material when it regrows after being harvested, thus compensating for the emissions. This is where short rotation, or speed-of-growth, advantages occur; the carbon released is re-sequestered faster. For example, pine and other temperate softwood trees, a common source for structural material, take 25–75 years to reach maturity. Within the critical near-term period (i.e. until 2040-2050), longer rotation timber is not even carbon neutral, let alone carbon negative.

Thus, short-rotation biogenic building materials like timber bamboo (which has an annual partial rotation once maturity is reached after 5-9 years) and *Eucalyptus* (which can be harvested for engineered wood products in as little as 10-15 years)are far more impactful in achieving needed nearer-term CDR.

Figure 2 illustrates the time lag before a biogenic structural fiber reaches carbon negativity (i.e., net CO2 storage) and lowers atmospheric temperatures by incorporating the regrowth speed. The figure shows that it can take more than 20 years for conventional structural timber (sawn wood) to generate net CDR. The shorter the regrowth, the quicker the net CDR occurs. This is the carbon advantage of timber bamboo and *Eucalyptus*. In addition to direct CDR benefits, when biobased construction products replace higher embodied carbon building materials such as concrete and steel, a second upfront carbon emission reduction benefit occurs, though not as CDR. This "substitution effect" can be significant.

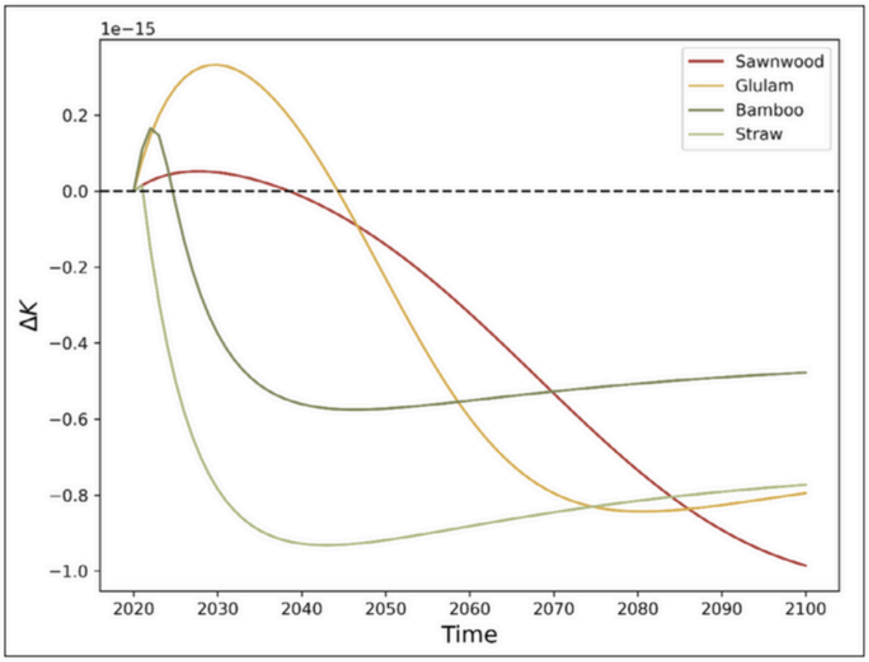


Figure 2. Global Temperature Change (GTP) of different bio-based construction materials considering the production (cradle-to-gate) emission and subsequent biogenic carbon sequestration from replanting 1 kg of each

Source: Göswein, V., Arehart, J., Phan-huy, C., Pomponi, F., & Habert, G. (2022). Barriers and opportunities of fast-growing biobased material use in buildings.

Eucalyptus as a Climate-Positive Feedstock for Building Materials

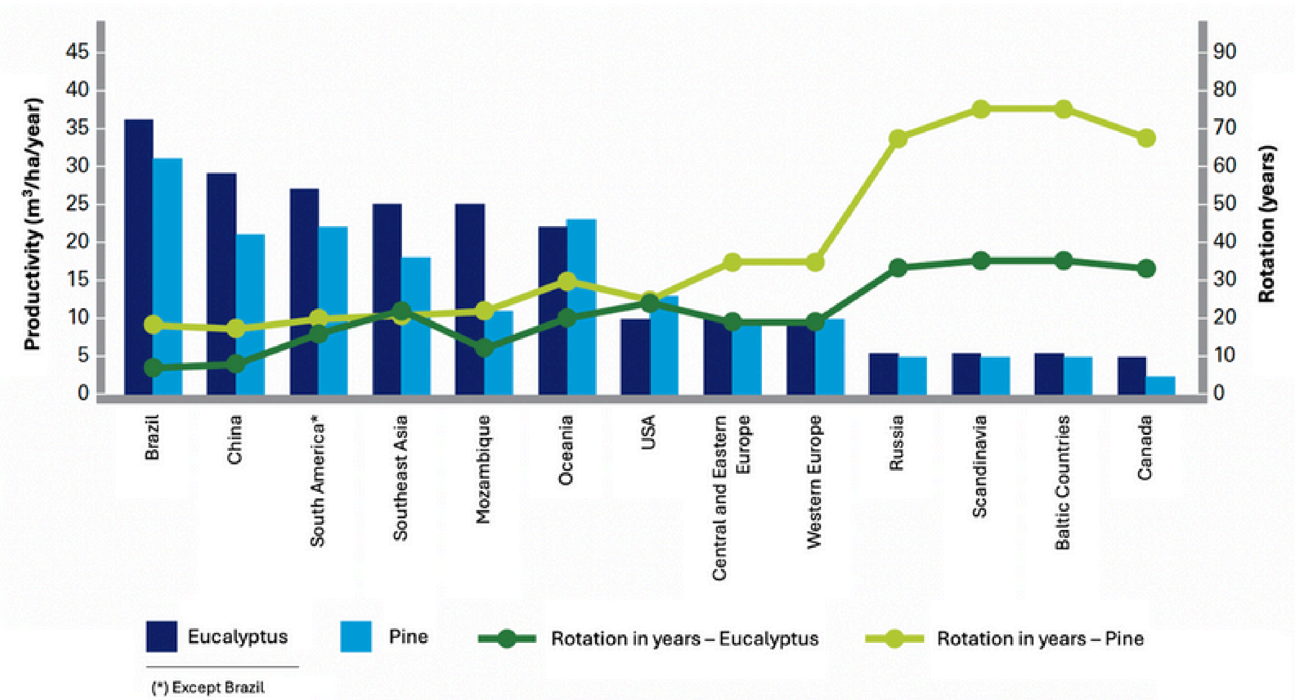
Today, the vast majority of planted forests for wood products consist of *Pinus* in the Northern Hemisphere. Yet the biggest increase in population and urbanization (and thus demand for structural materials) is expected to occur in the Global South (where *Eucalyptus* is dominant).

In fact, the top 15 countries that account for nearly 90% of the world's total Eucalyptus plantation area are in regions where the estimated investment potential in green buildings will be over $22 trillion by the year 2030.

Eucalyptus is a logical choice to solve for the mismatch between timber supply and building stock demand. Given their short rotations and high productivity, *Eucalyptus* plantations can contribute to a new generation of lower embodied carbon building materials. Usually, *Eucalyptus* is planted in different climatic regions compared to pine, spruce, and fir, and their optimal climatic areas do not generally overlap. However, in almost every region where *Eucalyptus* and *Pinus* are both planted, *Eucalyptus* has both shorter average rotation (period between planting and harvesting of trees) and higher productivity (measured as the volume of wood produced per unit area per year).

Figure 3 shows both benefits of *Eucalyptus* for 13 countries and geographic regions. First, notice that the six left-most regions all show visibly shorter rotation for both *Pinus* and *Eucalyptus* (the right-hand axis for the green and blue dotted lines). These six are all tropical or sub-tropical growing regions. The seven more temperate regions on the right have both longer rotation periods (higher lines) and slower growth rates (shorter bars). Overall, 11 of the 13 regions show shorter rotations to maturity and higher biomass accumulation per ha per year for *Eucalyptus* than *Pinus.*

Figure 3. Productivity and average rotation of planted trees worldwide



Source: Ibá. 2017 Relatório Anual

Notably, Brazil is home to the highest productivity and the shortest rotation of both *Pinus* and *Eucalyptus* genus. This is due to climate and soil conditions, as well as continuous investments in breeding optimization (hybridization and clonal development) and silvicultural operations (e.g., soil preparation, fertilization, and competing vegetation control). In 2022, the average productivity for Brazilian *Eucalyptus* plantations (32.7 m3/ha/year) was slightly more compared with *Pinus* productivity (30.9 m^3/ha/year). This productivity rate of *Eucalyptus* in Brazil represents approximately 1 tonne of carbon uptake from the atmosphere per hectare per month. It also represents a sizeable increase in land-use efficiency since *Eucalyptus* plantations require a quarter less land than *Pinus* to produce the same amount of feedstock. However, since the dominant use of *Eucalyptus* is principally for low-value, short-lived products like pulp and energy (fuel) products, the climate advantages of *Eucalyptus* are generally missed. Today, *Eucalyptus* is harvested for durable, long-lived products such as building materials in very small amounts.

Eucalyptus as an Engineered Wood Product

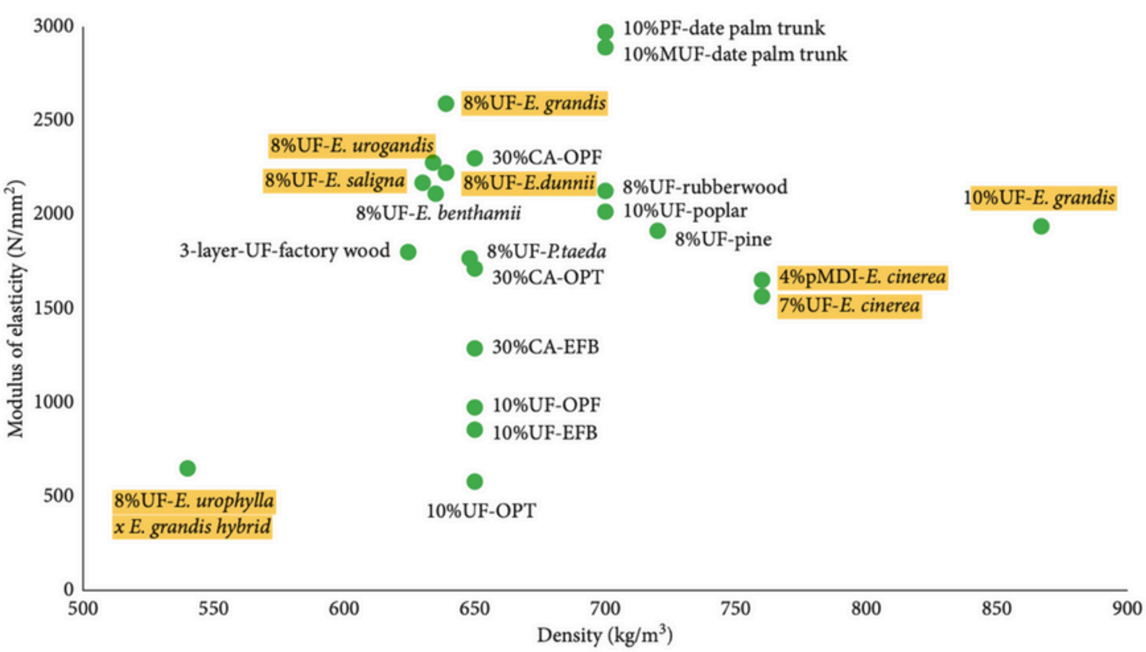
For *Eucalyptus* to durably store carbon in building structures, it must also possess mechanical properties sufficient to bear vertical, horizontal, and lateral loads in a building and to the degree that it can satisfy and be incorporated into national and regional building codes. As raw saw timber for framing buildings, *Eucalyptus* is not an ideal material to substitute for slower-growing softwood dimensional framing materials used as studs, plates, posts, etc.

But when Eucalyptus is included in an engineered building component, like structural panels and cross-laminated timber, it becomes a superior building component providing load-bearing capacities far exceeding traditional softwood timber.

Research and testing (both internal and independent labs) of multiple species of *Eucalyptus* in EWPs show that it is "stronger" than conventional softwoods by a margin exceeding 30-50%. One widely used measure of "strength" is the modulus of elasticity (MOE), which measures resistance to bending.

Figure 4 shows the MOE versus density results of incorporating *Eucalyptus* and other species into particleboard with varying types of glue. Notice that the majority of data points show *Eucalyptus* to have higher MOEs than others. More telling is that even at lower densities, *Eucalyptus* has the same or higher MOEs than pine, poplar, and rubberwood.

Figure 4. MOE-density for particleboard made with Eucalyptus spp. and other wood species



Source: Lee Seng Hua, et al. "Engineering Wood Products from Eucalyptus spp." *Note: UF: urea-formaldehyde; PF: phenol-formaldehyde; MUF: melamine-urea-formaldehyde; pMDI: polymeric 4,4-diphenylmethane diisocyanate; CA: citric acid; OPT: oil palm trunk; OPF: oil palm frond; EFB: empty fruit bush

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Environmental and Socioeconomic Benefits of Eucalyptus

From an environmental perspective, Eucalyptus trees have numerous ecological benefits aside from their efficiency at capturing CO2. Often thought of as a pioneer species, Eucalyptus can tolerate low soil fertility and acidic soils and can even contribute soil nutrients, stabilize topsoil, and reduce salination on degraded lands.

When part of natural succession, *Eucalyptus* plantations can function as foster ecosystems that often promote the establishment and succession of native woody species. It has also been found that regeneration is higher in *Eucalyptus* plantations compared to, for example, plantations of *Pinus* spp., a trend that is attributed partially to more light availability within the canopies of *Eucalyptus* plantations. One study showed nearly nine times higher biomass accumulation in mixed eucalypt-native species plantations than in native-only plantings, demonstrating the value of integrating eucalypts as a transitional phase in restoration if wood production is one of the expected outcomes. Once established, they can also contribute to the conservation of biodiversity by providing a suitable habitat both for the regeneration of native woody species and for forest herb species, as well as producing pollen and nectar that have been essential in the life cycles of many insects and birds.

Furthermore, *Eucalyptus* species can be used in agroforestry systems where they have been shown to increase crop yield, often with higher quality. In successional agroforestry systems, *Eucalyptus* trees quickly create a canopy layer, providing shade and protection for succession plants beneath them. Their rapid growth and deep roots also help to break up compacted soils, and with regular pruning and laying down of the biomass in tree rows, they contribute greatly to the replenishment of above and below-ground organic matter.

Lastly, there are silvicultural techniques, such as forest mosaic planting, that can connect plantation areas with preservation areas, creating ecological corridors with benefits for biodiversity, soil, and water. Mosaic management has been shown to stabilize water flow across plantation areas, maintaining both the hydrological regime and the wood supply. There is no better example of this than Brazil's Forest Code, which legally requires a percentage of land (anywhere from 20% in the Atlantic Forest region to 80% in the Amazon rainforest) to be kept as forest. There, exotic *Eucalyptus* can become important allies of tropical forest restoration, with the income from wood production able to offset 44-75% of restoration implementation costs without undermining the ecological outcomes.

From a socioeconomic perspective, the benefits of Eucalyptus are just as plentiful. For many rural farmers, it can serve as a buffer against financial crisis on land unsuitable for productive farming and, in some countries, is approved as collateral for bank borrowing capital.

Eucalyptus is also a high-value cash crop that, under favorable market conditions and with proper management, can generate more income than many agricultural crops. In general, eucalypt trees provide a better return for farmers as compared to other livelihood alternatives such as annual crop production, animal keeping, and other non-farm activities. The sale of *Eucalyptus* poles and products has the potential to raise farm incomes, reduce poverty, increase food security, and diversify smallholder farming systems.

Comments on Popular Views of Eucalyptus

The wide presence of Eucalyptus has spawned many popular, but inaccurate, views about these trees. Two important ones surround the Eucalyptus's water use efficiency and its perceived higher risk of fire.

First, *Eucalyptus* is sometimes criticized as a water-hungry crop; but research shows the opposite. In **Figure 5**, nine tree species are compared for the efficiency of water consumption compared to the volume of biomass produced. *Eucalyptus* hybrid shows a water use efficiency ratio of 0.51 (liters/gram) produced, which is the most efficient of the nine species examined. This perception likely arises because the water uptake of multi-tonne Eucalypt trees per area is, in fact, greater than the water uptake of a smaller crop. However, the research shows that *Eucalyptus* is far more efficient in water use when compared to biomass grown.
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Figure 5. Water consumption per biomass production of eucalyptus compared with other tree species

Tree species	A = B / C Water consumption / biomass production (liters / gram)	B Water consumed (liters / year)	C Biomass produced (g)
Eucalyptus hybrid	0.51	5234	10418
Albizzia lebbek	0.58	2742	4710
Syzigium cumini	0.61	2920	4772
Prosopis juliflora	0.71	3468	4883
Acacia nilotica	0.76	2971	3904
Acacia auriculiformis	0.86	2950	3426
Dalbergia sissoo	0.89	3588	4010
Azadirachta indica	0.90	1481	1646
Pongamia pinnata	1.30	1358	1040

Source: Kaur and Monga,2021. Eucalyptus Trees Plantation: A Review on Sustainability and Their Beneficial Role.

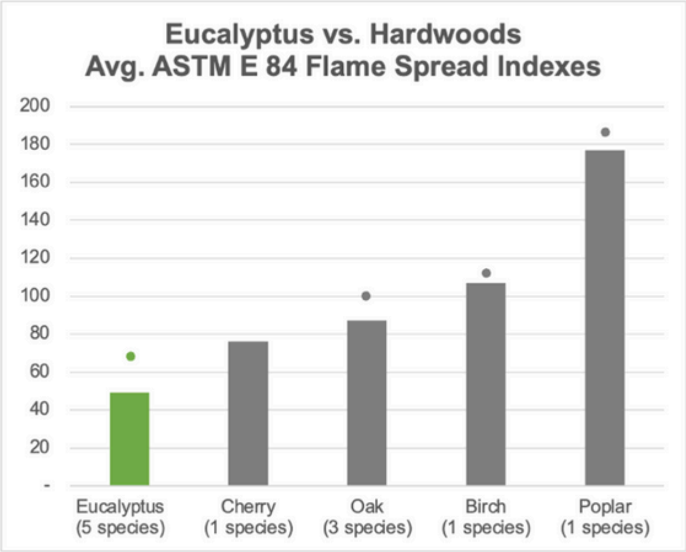
Another key reason for its reputation as a water guzzler is related to the common management systems for *Eucalyptus* plantations. The quality of the ecosystem services provided by tree plantations will depend greatly on the choice of management system used. Fast-growing plantations are usually managed on short rotations (4–7 years) to be used for short-lived pulp and paper products. Because large volumes of water are needed in order to reach productivity targets over short timescales, water production and regulation services may perform poorly. There is evidence that suggests long-term management with less intervention results in the best performance across all hydrologic functions. We predict that moving away from intensive management and extending rotations for longer-lived products like sawn timber will help improve *Eucalyptus*'s reputation.

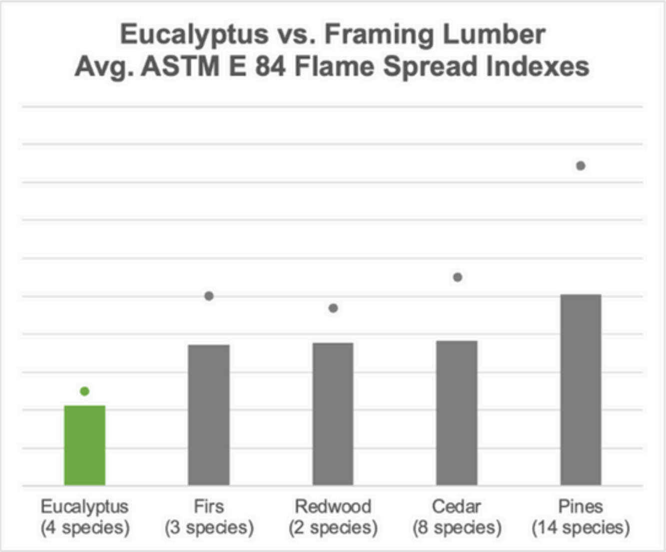
Second, *Eucalyptus* is often believed to be a highly flammable tree, as seen in its notable presence in fires in Australia and California (Oakland Tunnel Fire, 1991 and Mount Tam Fire, 2004). The flammability of live *Eucalyptus* trees can't be doubted. Research has shown that it is not more flammable when compared to other popular plantation species in Chile (*Eucalyptus globulus v. Pinus radiata, Acacia dealbata, and Acacia Melanoxylon*). The flammability of these trees is largely a function of the volatile organic compounds (VOCs) present in their leaves while the trees are still living.

Eucalyptus used in building materials, of course, have leaves removed, but they are also air-dried or kiln-dried, removing VOCs. A common measure of flammability is the flame spread index, as specified in the ASTM E-84 standardized test protocol. Two different US Dept. of Agriculture reports summarize E-84 flame spread rates for various commonly used woods – one compares hardwoods, and the other compares framing woods.

For each case, **Figure 6** displays the average (bars) and the highest single observation (dots) for the major species reported. The lefthand chart shows that *Eucalyptus* has the slowest flame spread rating of the significant hardwoods compared by a large factor. The righthand shows that *Eucalyptus* also has the lowest flame spread rating of the four framing species, again by a material major. In both cases, *Eucalyptus* showed the slowest single flame spread rating included in the averages.

Figure 6. ASTM E 84 flame spread indexes for sawn boards of various hardwood species (left) and for untreated wood products (right)





Source: White, R. USDA, FS, Forest Products Laboratory. " Fire Performance of Hardwood Species" ; USDA, Forest Service. Forest Products Laboratory. Flame Spread Index for Wood Products.

Conclusion

There is an urgent need to remove carbon dioxide from the atmosphere and to decarbonize the built environment. Fast-growing structural fibers accomplish both.

In April 2019, BAMCORE published *Carbon Farming with Timber Bamboo* to introduce timber bamboo as a new structural fiber source that could be used for framing buildings because it has superior strength and carbon-capturing properties compared to the more commonly used temperate softwoods. Here we introduce *Eucalyptus* as a similarly overlooked yet highly valuable alternative fiber source for the structural frames of buildings. In comparison with traditionally used sources like *Pinus* species, *Eucalyptus* trees exhibit superior strength and higher biomass productivity. Most importantly, their fast regrowth allows for shorter harvest rotations and, subsequently, more CO2 capture, accelerating the decarbonization of buildings compared to conventional framing materials used in North America.

References

Agriculture Organization of the United Nations (FAO). (2020). Global Forest Resources Assessment 2020: Main Report. FAO, Italy.

Alemayehu, A., & Melka, Y. (2022). Small scale eucalyptus cultivation and its socioeconomic impacts in Ethiopia: A review of practices and conditions. *Trees, Forests and People*, 8, 100269. https://doi.org/10.1016/j.tfp.2022.100269

Architecture 2030. Why the Built Environment. https://architecture2030.org/why-the-built-environment/

Bayle, G. (2019). Ecological and social impacts of eucalyptus tree plantation on the environment. *Journal of Biodiversity Conservation and Bioresource Management*, 5(1), 93–104. https://doi.org/10.3329/jbcbm.v5i1.42189

Betts, M. G., Phalan, B. T., Wolf, C., et al. (2021). Producing wood at least cost to biodiversity: Integrating Triad and sharing-sparing approaches to inform forest landscape management. *Biological Reviews*, 96(4), 1301–1317. https://doi.org/10.1111/brv.12703

Climate Action Tracker. (2022). 2100 Warming Projections: Emissions and expected warming based on pledges and current policies. November 2022. Retrieved from: https://climateactiontracker.org/global/temperatures/

Göswein, V., et al. (2022). Wood in buildings: the right answer to the wrong question. IOP Conference Series: *Earth and Environmental Science*, 1078, 012067.

Guerrero, F., Carmona, C., Hernández, C., Toledo, M., Arriagada, A., Espinoza, L., Bergmann, J., Taborga, L., Yañez, K., Carrasco, Y., et al. (2022). Drivers of Flammability of Eucalyptus globulus Labill Leaves: Terpenes, Essential Oils, and Moisture Content. Forests, 13, 908. https://doi.org/10.3390/f13060908

Ibá. (2017). Relatório Anual. Brasília, DF: Ibá.

Ibá. (2023). Relatório Anual. Brasília, DF: Ibá.

IFC. (2019). Green Buildings—A Finance and Policy Blueprint for Emerging Markets. https://www.ifc.org/content/dam/ifc/doc/mgrt/59988-ifc-greenbuildings-report-final-1-30-20.pdf

IPCC. (2023). Climate Change 2023: Synthesis Report. Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, H. Lee and J. Romero (eds.)]. IPCC, Geneva, Switzerland, pp. 35-115. doi: 10.59327/IPCC/AR6-9789291691647

Kaur, & Monga. (2021). Eucalyptus Trees Plantation: A Review on Suitability and Their Beneficial Role. *International Journal of Bio-resource and Stress Management*, 12(1), 016-025. https://doi.org/10.23910/1.2020.2174

References

Lee, S. H., Lum, W. C., Antov, P., Kristak, L., & Tahir, P. M. (2022). Engineering Wood Products from Eucalyptus spp. Advances in Materials Science and Engineering, 2022, Article ID 8000780. https://doi.org/10.1155/2022/8000780

Messier, C., Bauhus, J., & Sousa-Silva, R. (2021). For the sake of resilience and multifunctionality, let's diversify planted forests. *Conservation Letters*, DOI:10.1111/conl.12829

Reuters. (2023). More likely than not world will soon see 1.5C warming: WMO. Reuters. https://www.reuters.com/business/environment/more-likely-than-not-world-will-soon-see-15c-warming-wmo-2023-05-17/

Ritchie, H., Roser, M., & Rosado, P. (2020). CO_2 and Greenhouse Gas Emissions. OurWorldInData.org. Retrieved from: https://ourworldindata.org/co2-and-greenhouse-gas-emissions

Ro, C. (2023). Brazil Already Has Its Best Tool Against Deforestation. Forbes. https://www.forbes.com/sites/christinero/2023/01/06/brazil-already-has-its-best-tool-against-deforestation/?sh=b90d1f41c755

UNFCC Co-facilitators on the technical dialogue. (2023). Technical dialogue of the first global stocktake: synthesis report. United Nations Framework Convention on Climate Change.

United Nations Environment Programme, & Yale Center for Ecosystems + Architecture. (2023). Building Materials and the Climate: Constructing a New Future. https://wedocs.unep.org/20.500.11822/43293.

USDA, Forest Service, Forest Products Laboratory. Flame Spread Index for Wood Products. Retrieved from https://www.terramai.com/userfiles/file/Technical/USDA_Flame_Spread_Index_for_Wood.pdf

White, R. (2000). Fire Performance of Hardwood Species. XXI IUFRO World Congress, Kuala Lumpur, Malaysia.