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Forest Sector Net-Zero Roadmap

Phase I: Enabling the transition to a net-zero economy

Forest Solutions Group

Contents

Foreword

The world is increasingly confronted with the necessity of urgent and radical collective action to reduce greenhouse gas emissions and increase carbon removals to keep rising temperatures within a 1.5°C safe operating space. Reaching net-zero emissions by 2050 has emerged as the target that business, government and civil society must hit to avoid the worst impacts of climate change. In recent years, businesses and governments have been rising to the challenge by rallying behind commitments to reach net-zero emissions by mid-century. The business contribution to the transition to a low carbon economy extends beyond emissions reductions to harness its innovation capacity to bring to market the solutions the world urgently needs.

The accelerating race to net-zero is driving an increasing number of companies and governments to leverage carbon removals from forests and forest products to meet their net-zero ambitions (e.g., large-scale afforestation programs, carbon offset projects, incentives for the use of long-lived wood products). As stewards of sustainable working forests and manufacturers of wood-based products, the forest sector faces a unique opportunity to enable the global transition to a net-zero economy through the provision of scalable and cost-effective solutions for carbon capture and storage.

As forward-looking business leaders in the forest sector, we recognize the urgent need to decarbonize our operations and value chain. We also recognize the need to harness and deploy the full climate change mitigation potential of our sustainable working forests and products to grow a low-carbon circular bioeconomy. We hope that this Roadmap will inspire peers to follow suit and reach the critical mass needed to unlock capital and spur innovation and collaboration across sectors and value chains. To do so, we also call on policy-makers, investors and customers to join the effort to maximize the full transformative potential of the forest sector at a time when it is needed most.

Forest Sector Net-Zero Roadmap project leaders

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About this report

This report is Phase I of the Forest Sector Net-Zero Roadmap, developed by the members of the World Business Council for Sustainable Development's (WBCSD) Forest Solutions Group (FSG). In alignment with WBCSD's SOS 1.5 framework,[1] Phase I of the Roadmap delivers a holistic narrative of the forest sector's contribution to climate change mitigation, with a focus on its unique role in enabling the global transition to a net-zero economy.

This report lays the groundwork for Phase II to come in 2022 by providing a shared definition of net-zero and the forest sector, as well as a commitment from FSG members to setting an ambition to reach net-zero GHG emissions (GHG) no later than 2050 upon completion of the Roadmap.

The accelerating race to net-zero, with actions governments and the private sector are taking on forests, presents a tremendous opportunity for the forest sector to position itself as a key enabler of the net-zero transition. This will require successfully navigating a fast-changing operating landscape.

The Roadmap describes the imperative for climate action in the forest sector. It then introduces the three main levers for the forest sector to enable this transition:

A. Reduce GHG gas emissions in operations and across the value chain;

B. Increase carbon removals through sequestration in sustainable working forests and storage in forest products;

C. Grow the circular bioeconomy through the substitution of non-renewable and fossil-based materials with forest products.

Forest companies can realize the full potential of all three levers through targeted interventions in four key opportunity spaces:

1. Low-carbon operations
2. Climate-positive land use
3. Circularity
4. Product innovation

Engaging in carbon markets to generate additional value from activities will amplify the realization of these opportunities. Each opportunity space is described through a vision, a summary of the current state of play, some examples of interventions to help forest companies progress towards the vision, and enabling policies.

To accelerate this urgent and far-reaching transition, members of WBCSD's FSG call on peers, customers, investors and policy-makers to join the effort to unleash the full transformative potential of the forest sector.

1 Introduction

The world is living through a pivotal moment in the fight against climate change, as the understanding of the scale and urgency of the threat gains ground in every segment of society. Reaching net-zero emissions by 2050 has emerged as the target to hit to avoid the worst impacts of climate change. An increasing number of governments and major companies around the world are stepping up their ambitions through net-zero commitments that rely heavily on land-based carbon sinks as the most economical way to address residual emissions in the industrial sector. The forest sector is in the best position to respond to surging demand for high-quality land-based carbon sinks. Forest products provide additional climate benefits and should be considered as part of an integrated system with the sustainable working forests from which they originate.

Reaching a net-zero economy will require a deep transformation of every aspect of the economy. The forest sector is bound to see a dramatic change in its operating environment, driven by the different uses of forests and forest products for climate change mitigation. The transition to a net-zero economy both addresses an urgent threat and presents significant opportunities for companies that have a clear vision and ability to embrace change. This moment in time brings tremendous opportunities for forest companies to be a critical enabler of the transition to a net-zero economy. However, many questions related to land-use tensions, the science of forest emissions, the most appropriate accounting methodologies, and synergies with the nature-positive agenda remain unanswered.

With this Forest Sector Net-Zero Roadmap, leading members of WBCSD's FSG and partners are rising to the challenge and joining forces to pave the way to a net-zero transition within the sector and across the global economy. Phase I of the Roadmap sets the groundwork for Phase II to come in 2022 and delivers a holistic narrative of the forest sector's contributions to climate change mitigation, with a focus on its unique role in enabling the global transition to a net-zero economy.

Photo: Stora Enso

Objectives

FSG members have undertaken the ambitious task of developing a Roadmap that aims to bring the forest sector together on a shared understanding of its role in enabling the transition to a net-zero economy through interventions across the full value chain. The objectives are to:

- Drive credibility and consistency within the sector in the definition of net-zero strategies;
- Inspire businesses within the sector to adopt ambitious and credible net-zero climate strategies;
- Raise awareness of the role of working forests and forest products in climate change mitigation.

Approach

The framework for this Roadmap builds on the *SOS 1.5: The road to a resilient, zero-carbon future* report released by WBCSD in 2020 with input from across many industries. This report provides a framework to support companies in implementing net-zero strategies. It proposes five key steps (Figure 1) and 16 actions that companies at any stage can follow to accelerate their journey to net-zero.

Phase I of the Forest Sector Net-Zero Roadmap focuses on the first step of the SOS 1.5 roadmap: Understand climate opportunities and risks. It offers a sector-level perspective on the most relevant actions proposed to realize this first step. These are:

1. Ground net-zero ambition in your company purpose, showing commitment to all stakeholders;
2. Define multiple scenarios of vivid, distinct futures, gauging the range of uncertainty;
3. Understand your climate risks, quantifying implications across each scenario;
4. Identify new opportunities in a low-carbon economy, focusing on new value creation.

Figure 1: Five key steps to accelerate a company's journey to net zero

The content of Phase I of the Roadmap is based on following sources:

- Existing guidance and most recent literature;
- Interviews with 21 key forest stakeholders;
- Analysis of climate disclosures from 14 forest companies;
- In-depth consultations with the Forest Solutions Group.

Phase II of the Roadmap, to be developed in 2022, will provide practical guidance to support forest companies in creating and implementing net-zero strategies across their organizations and value chains based on the most relevant remaining steps of the SOS 1.5 roadmap.

Scope of the Roadmap

1. Although the Roadmap focuses almost exclusively on the issue of climate change, net-zero strategies need to address the interconnectedness between climate, nature and inequality. In addition to climate change, the world is facing a crisis of nature with sustained ecological degradation and biodiversity loss, as well as growing inequality, that is worsening as climate change disproportionately affects disadvantaged groups. Individual companies should keep these impacts on nature and people at the forefront of their net-zero strategies and implementation plans.
2. Although the role of the forest sector in climate change adaptation is rapidly gaining importance, the focus of this report remains primarily on its role in climate change mitigation.
3. Although elements of the local and regional context play a significant role in the interpretation and implementation of the report, the Roadmap offers a global perspective. Subsequent region- or company-specific roadmaps can best address regional specificities.

Audience

This Roadmap primarily aims to inspire and guide companies in the forest sector to adopt and execute ambitious climate strategies.

Phase I of the Roadmap more specifically aims to deliver a simple call to action to policy-makers, investors and customers to join the effort to unleash the full transformative potential of the forest sector.

Net-zero defined

Currently there is no universally agreed-upon definition of net-zero. The United Nations Framework Convention on Climate Change's (UNFCCC) *Race to Zero Lexicon* contributes to clarifying and harmonizing the language used to describe net-zero.[2] It builds on the definition provided by the Intergovernmental Panel on Climate Change (IPCC), which states that: "Net-zero emissions are reached when anthropogenic emissions of GHGs released into the atmosphere are balanced by anthropogenic removals over a specified period."[3]

The *Race to Zero* goes further in its characterization of achieving net-zero:

- The reduction of emissions following science-based pathways, with any remaining attributable GHG emissions being fully neutralized by permanent removals either within the value chain or through purchase of valid offsets.
- Permanent carbon removals could include biological approaches, such as reforestation, and technological solutions, such as carbon capture and storage. For natural climate solutions (NCS), this means accounting for the potential reversal of removals due to wildfires, pests or diseases and establishing requirements for permanent storage of carbon removals.[4]
- Purchasing offsets cannot be a substitute for emissions reductions, but rather a tool to compensate for unmitigated emissions along the decarbonization trajectory.

FSG members will aim to develop net-zero strategies in alignment with this definition, which currently stands as the most comprehensive and broadly accepted. Furthermore, FSG supports strong net-zero commitments aligned with the latest science, credible (use established and accepted frameworks) and defensible (through monitoring, reporting and verification). Science-based targets (SBTs) require that companies set interim targets and map out their trajectory in line with the scale of reductions required to limit global warming to 1.5°C from pre-industrial levels.

Net-zero commitments should flow down through the value chain as SBTs require the inclusion of scope 3 emissions. The Science Based Targets initiative (SBTi) provides the following guiding principles for corporate net-zero strategies:[5]

- **Guiding principle 1**
  Reaching net-zero emissions for a company involves achieving a state in which its value chain results in no net accumulation of carbon dioxide in the atmosphere and in no net impact from other GHG emissions.

- **Guiding principle 2**
  In accordance with the best available science, the Paris Agreement and the Sustainable Development Goals, companies should transition to net-zero in line with mitigation pathways that are consistent with limiting warming to 1.5°C with no or limited overshoot.

- **Guiding principle 3**
  The mitigation strategy followed by the company should inform long-term strategies and investments that mitigate exposure to climate-related transition risks, ensuring that the company's business model will continue to be viable in a net-zero economy.

Given the pace and magnitude of the changes that need to take place on a global scale to limit warming to 1.5°C, it is critical to place this Roadmap in the context of the rapidly evolving net-zero landscape. This report is released ahead of the ongoing revision of the GHG Protocol, the SBTi Net-Zero Standard, and other sector-specific accounting tools, such as the International Energy Agency's (IEA) sector projections. These updated guidance documents and tools will likely influence the sector's definition of net-zero, and will form the basis of the net-zero guidance to be developed in Phase II of the project in 2022.

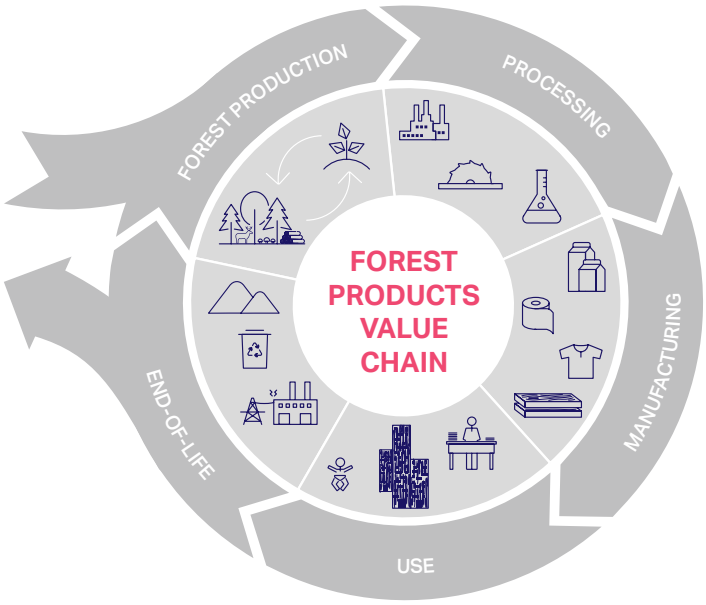
The forest sector defined

Within the scope of this Roadmap, the forest sector includes all economic activities that generally depend on the production of goods and services from forests. It encompasses the forest production (including nurseries), processing, manufacturing, use and end-of-life stages of the value chain (Figure 2).

FSG members' commitment

In alignment with WBCSD's membership criteria, upon completion of this Roadmap, FSG members commit to setting an ambition to reach net-zero GHG emissions no later than 2050 and having a science-informed plan to achieve it, which can include NCS and other carbon removal solutions. The GHG emissions reduction will include scopes 1 and 2, as well as the most relevant and influenceable elements of scope 3 based on the GHG Protocol. Each member company will also commit to reporting progress annually in standard, external communication.

Figure 2: The forest products value chain



② The imperative for climate action

The climate emergency

The science is clear on the need for ambitious climate action to keep the global temperature increase to a maximum of 1.5°C above pre-industrial levels to avoid devastating impacts on people and nature. *The 6th Assessment Report* of the IPCC establishes that human influence on global warming is irrevocable and that climate change is already affecting many weather and climate extremes, such as heatwaves, heavy precipitation, droughts and tropical cyclones in every region worldwide. The report states that the "global surface temperature will continue to increase until at least the mid-century under all emissions scenarios considered. Unless deep reductions in CO_2 and other GHG emissions occur in the coming decades, global warming of 1.5°C and 2°C will be exceeded during the 21st century."[6]

The forest sector is particularly exposed to these effects of climate change, as forest ecosystems become increasingly unstable with greater incidence of forest fires and droughts, hurricanes and windstorms, flooding, and pest outbreaks. While the world relies more heavily on land-based carbon sinks to avoid the worst effects of climate change, global warming itself brings uncertainty related to the future of these carbon sinks at a time when they are most needed. Indeed, the proportion of atmospheric emissions caused by humans that land and ocean sinks sequester decreases in scenarios with higher anthropogenic CO_2 emissions.

At the same time, climate system tipping points, such as increased melting of the Antarctic ice sheet and forest dieback, are more likely to occur at higher global warming levels.

Understanding climate risks in the forest sector

Companies across all sectors, including the forest sector, are awakening to the extent of the threat that lies ahead and are taking decisive action to address multiple climate-related risks to protect assets and transform business models to build climate resilience.

The Task Force on Climate-Related Financial Disclosures (TCFD) provides a framework to support companies in understanding and disclosing the financial implications of both physical and transitional risks impacting their business. The *Food, Agriculture and Forest Products TCFD Preparer Forum* report, published in 2020 by WBCSD with participation from FSG members, offers a comprehensive overview of forest sector-specific risks and opportunities linked to climate change, as well as guidance on the use of scenario analysis to understand potential business implications and performance in a range of possible future climate-related scenarios.[7]

As per the TCFD framework, there are two main groupings of risks and opportunities, organized into transitional (i.e., policy and legal, technology advances, market changes, and reputation) and physical (i.e., acute and chronic) categories. The tables in Appendix A offer a comprehensive overview of the main transitional and physical risks and opportunities that are relevant to the forest sector. With a clear understanding of these opportunities and risks, companies will be able to develop better solutions and products that support their climate ambitions.

As the science is now irrevocable and the window of opportunity is narrowing, companies across all sectors are bound to face mounting multi-front pressures coming from customers, activists, investors, regulators and employees to undertake ambitious climate action. The urgent and far-reaching response to the climate emergency needs to come from a joint endeavor from business, governments and civil society. Businesses that do not adapt will be at risk, while those that embrace change will see greater opportunities.

③ Enabling the transition to a net-zero economy

A fast-changing operating environment

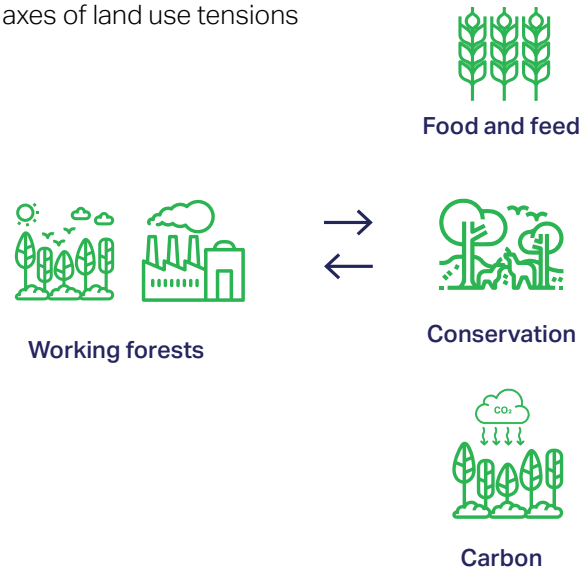
The race to net-zero has gained momentum in recent years, with a flurry of net-zero commitments from business and government. In 2020 alone, net-zero commitments by companies have more than doubled and the scale of NCS and offset pledges within these commitments is rising accordingly.[8] In addition to the use of land-based carbon sinks to satisfy demand for carbon credits, some companies are also directly investing in, or acquiring, forests. In parallel, there is an increase in the number of governments committing to net-zero. To meet the ambition of the Paris Agreement, 70% of countries that submitted an Intended Nationally Determined Contribution (INDC) included actions on forests to reach their emissions reductions target.[9] Examples of government actions on forests include:

- Deploying large-scale afforestation, reforestation and restoration efforts (e.g., the EU's plan to plant 3 billion trees by 2030 as part of the EU Forest Strategy);[10]
- Using biomass as a source of renewable energy (e.g., Brazil's ambition to increase the share of biofuels in the energy mix to 18% by 2030);[11]
- Incentivizing the production and use of long-lived wood products (e.g., Australia, Canada, New Zealand and the United States plan to include removals from forest products in their NDCs).[12]

While it is too soon to predict the precise impact that these cumulative actions will have on forest ownership structure or prioritized uses, stakeholders interviewed highlighted a predictable exacerbation of land-use tensions, as already observed in some areas of the world.

Figure 3 illustrates the main axes of land-use tensions, resulting from increased competition for finite land and resources. The tension between the use of land for food, feed, fiber and fuel has been deeply rooted in some landscapes for decades. The antagonism between the proponents of leaving forests untouched for conservation instead of managing them for productive use is set to gain ground in the coming years, fueled by diverging views on the most optimal outcomes for the climate and biodiversity. The third source of land-use tensions, carbon, is more recent, with increased investments in forest conservation carbon projects to establish no-touch forest carbon sinks that are inaccessible for productive use. It is important to note that the management of sustainable working forests focuses on productive use, as well as carbon and conservation outcomes.

Figure 3: The three main axes of land use tensions



The race to net-zero is fueling land use tensions between the proponents of protecting forests as opposed to using them for productive use. In reality there shouldn't be any tension here. One of the best ways to keep forests standing - to protect them - is to give them economic value through sustainable forest management. This will help prevent their conversion to alternative forms of land use.

Caitlin Clarke
Senior Conservation Fellow,
The Nature Conservancy

Credible net-zero pathways in the land-use sector will have to find ways to address these multiple needs and balance sustainable production and conservation outcomes in landscapes. To do so, forest companies should continue to explore location-specific strategies and approaches in the coming years to circumvent rising land prices and more difficult access to wood. These are some examples of approaches to address land-use tensions, with rationale:

Engage with forest smallholders
With large forest concessions becoming increasingly difficult to access, forest smallholders are expected to supply a much larger portion of future wood needs. It will therefore become critical to put in place the right incentives and support for smallholders to engage in sustainable forest management.

Invest in high-potential markets
With increased competition for supply in "traditional" wood-based product markets, forest companies will have the incentive to invest in regions with larger untapped potential, such as in Africa where land costs are lower and demand for wood-based products is rising.

Scale-up mixed production models
To reconcile land-use tensions, forest companies will have further incentives to scale up the implementation of mixed production models such as agroforestry.

Restore degraded land
With increased competition for arable land, the establishment of forest plantations on degraded land will become increasingly appealing.

Maximize material efficiency
With more restricted access to fresh fiber, forest companies will further invest in recycling, waste use and recovery, and cascading use of products.

Invest in sustainable intensification
Forest companies will have further incentives to invest in sustainable intensification practices and methods to increase yields while protecting valuable ecosystems.

Africa is well positioned to harness nature-based solutions by developing more sustainable forestry practices. If a socially fair transition to a circular bioeconomy can be harnessed – one in which resources are renewable, biologically based, sustainably managed and whenever possible, reused – the opportunity to boost rural employment and protect remaining intact forests will be significantly improved.

Justin Adams
Executive Director, Tropical Forest Alliance, World Economic Forum

The forest sector's levers of impact

A deep understanding of the forest sector's singular attributes and the continuous monitoring of future developments will help forest companies successfully navigate this rapidly changing landscape. The opportunities will largely outweigh the increased constraints on raw materials that are not limited to the forest sector. Forest companies have a chance to make a significant contribution to climate change mitigation and position themselves as a key enabler in the transition to a net-zero economy. The combination of the three key levers of impact described in Figure 4 constitute the forest sector's unique contribution to the transition to a net-zero economy:

A. Reduce GHG emissions in operations and across the value chain;

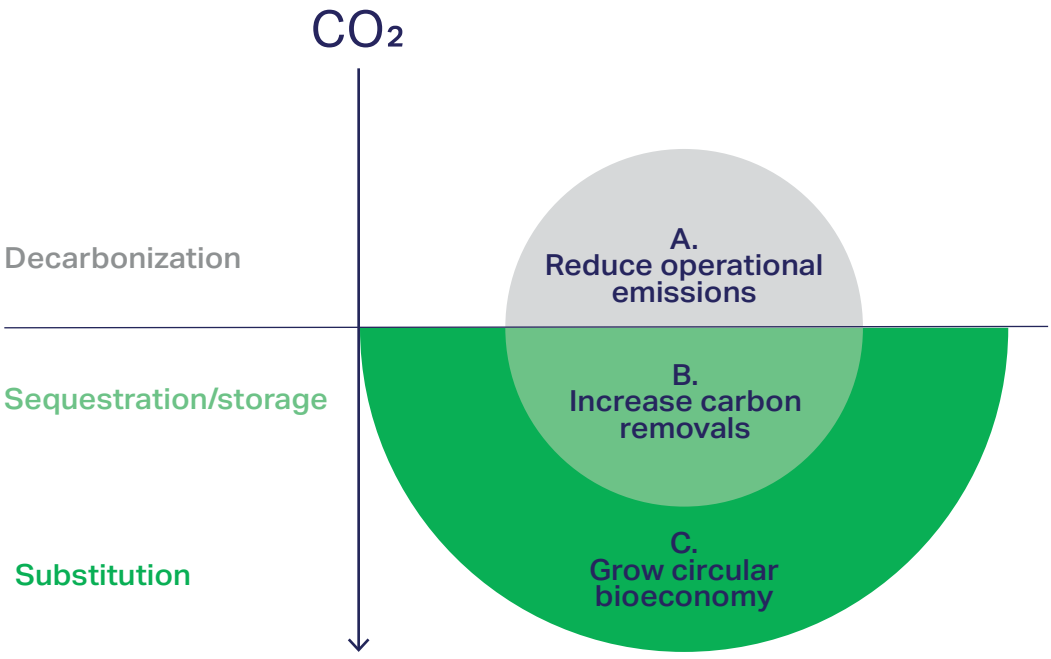
B. Increase carbon removals through sequestration in sustainable working forests and storage in forest products;

C. Grow the circular bioeconomy through the substitution of non-renewable and fossil-based materials with forest products.

The climate change mitigation potential of all three levers is cumulative and forest companies should be working on all three simultaneously to maximize their contribution to the net-zero transition.

However, in alignment with the carbon mitigation hierarchy, the forest sector's first lever of impact is to avoid and reduce emissions before focusing on other compensation mechanisms. Action on all three levers will require successfully navigating land-use tensions, as well as trade-offs that might occur between the three levers. For example, increasing carbon removals (Lever B) could involve managing forests primarily to maximize carbon stocks in forests and storage in forest products, while growing the circular bioeconomy (Lever C) could imply managing forests primarily for productive use to maximize the substitution effect.

Figure 4: The forest sector's three levers of impact



A. Reduce operational emissions

In alignment with the carbon mitigation hierarchy, the forest sector's first lever of impact is to avoid and reduce GHG emissions, before focusing on other compensation mechanisms. This first lever of impact is of utmost importance for a sound and coherent climate strategy.[13] The forest sector has made strong progress in decarbonizing and has demonstrated its commitment to further reducing emissions and to driving efficiencies across the value-chain. But a science-based and credible roadmap to net-zero is needed.

The climate mitigation hierarchy offers a roadmap to guide business in achieving global goals. The temptation to skip to steps lower in the hierarchy that are easier or cheaper will at best provide a temporary band aid to these complex global challenges and at worst, cannibalize efforts for meaningful change through emissions reduction.

Martha Stevenson
Senior Director Forest Strategy & Research, WWF

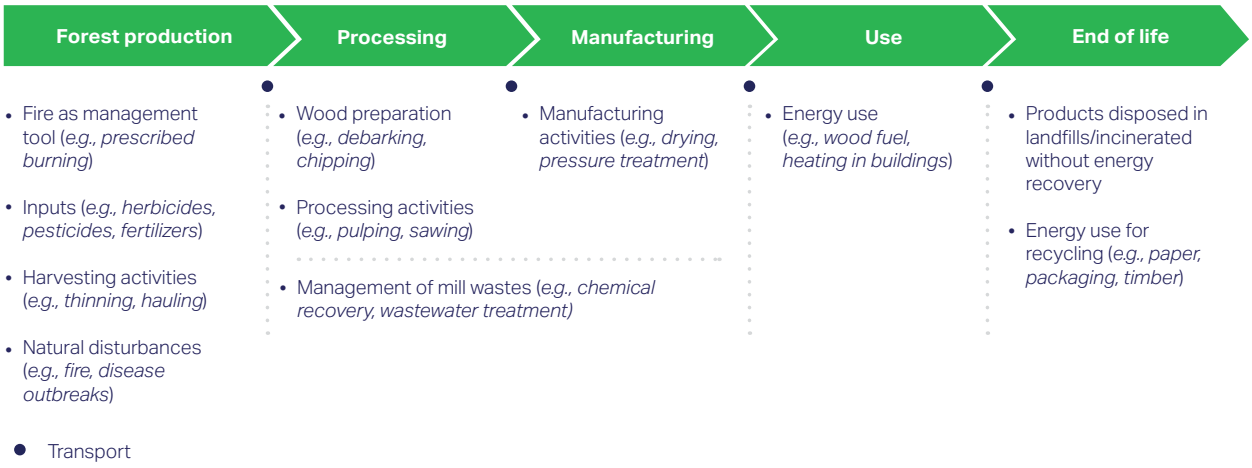
The forest sector's carbon footprint

Some segments of the forest sector, such as pulp and paper, are energy-intensive, creating an estimated 0.6% of total global GHG emissions, or 2% of total industry direct (energy and process related) CO_2 emissions.[14] Several factors will influence the individual carbon footprint of a forest company, such as the business model, product portfolio or region of operations. Regardless of these variations, the average carbon intensity of wood-based products is 0.5 tCO_2e/t product (scope 1 & 2).[15] This is relatively lower than other materials that wood-based products can substitute for or complement such as steel (1.8 tCO_2e/t product),[16] cement (0.9 tCO_2e/t product)[17] and plastic (2.9 tCO_2e/t product)[18] (scope 1 & 2). As these alternative materials accelerate their decarbonization journey, the competitive positioning of wood-based products in the medium to long term could be challenged.

GHG emissions occur along the full forest products value chain. The relative emissions intensity of each stage of the value chain will depend on individual company business models. With no reduction measures in place, most emissions typically occur at the processing, manufacturing and end-of-life stages of the value chain.

Figure 5 provides an overview of the main sources of GHG emissions along the forest products value chain, from forest production to end of life, based on a literature review.

Figure 5: Main sources of GHG emissions in the forest products value chain



The global standard for GHG emissions reporting, the GHG Protocol, divides emissions into three categories. Scope 1 emissions comprise all those directly under the control of a company. Scope 2 emissions come from the generation of power, heat, steam and cooling a company buys. Scope 3 emissions include emissions linked to a company's wider value chain.

Due to the complexity of global value chains and limited inter-organizational emissions data exchange, scope 3 emissions are typically more difficult to quantify and abate.

The review of climate disclosures from the 14 global forest companies revealed that while all companies quantify and disclose their scope 1 and 2 emissions (TPI: 79%), only 57% also disclosed their scope 3 emissions (TPI: 59%).

For these companies, scope 3 represents the major share of emissions (68% on average). As illustrated in Figure 6, the material scope 3 categories disclosed were "transportation and distribution" (up- and/or downstream), "purchased goods and services", "processing of sold products" and "end-of-life treatment".

Methodology

The content of this section is based on the climate-related disclosures of 14 global forest companies with their core business in forest management, pulp, paper, packaging, building materials, bioenergy and biomaterials. The 14 companies reviewed are Arauco, CMPC, Enviva, International Paper Company, Metsä Group, Mondi Group, Smurfit Kappa Group, Sappi Limited, Stora Enso, Sumitomo Forestry, Suzano, The Navigator Company, UPM-Kymmene and Weyerhaeuser. Together they own, manage or lease more than 20 million hectares of forest and have a combined revenue of more than USD $90 billion (2020). While all of them own processing or manufacturing operations, some do not own forests but source their wood instead. While the sample represents only a small fragment of the forest sector at a moment in time (July/August 2021), it nevertheless provides valuable insights into the climate strategies and disclosures of global forest companies leading in sustainability.

To provide perspective, the sample was benchmarked with a broader, cross-sectorial sample of companies from the Transition Pathway Initiative (TPI), established in 2017 by a collective of asset managers to assess companies' progress on the transition to a low-carbon economy. In 2021, TPI assessed 401 companies, representing 16% of global market value, and presented their findings in the *TPI State of Transition Report 2021*.[19]

Figure 6: Main scope 3 categories in the forest products value chain

Source: Adapted from GHG Protocol[20]

The percentage of emissions arising from scope 3 varies depending on the type of company and industry. For example, for industries such as financial/professional services or retail, the percentage of emissions coming from scope 3 will be significantly higher (around 90%) than those due to scope 1 and 2. As the ratio between direct (scope 1 and 2) and indirect (scope 3) emissions is relatively more balanced in the forest sector, net-zero commitments will focus on direct emissions, as well as the most relevant and influenceable elements of scope 3.

Reducing emissions in the forest sector

As GHG emissions in the forest sector are largely energy-related, as is the case for two-thirds of all global emissions,[21] energy-efficiency measures are essential to reducing operational emissions.

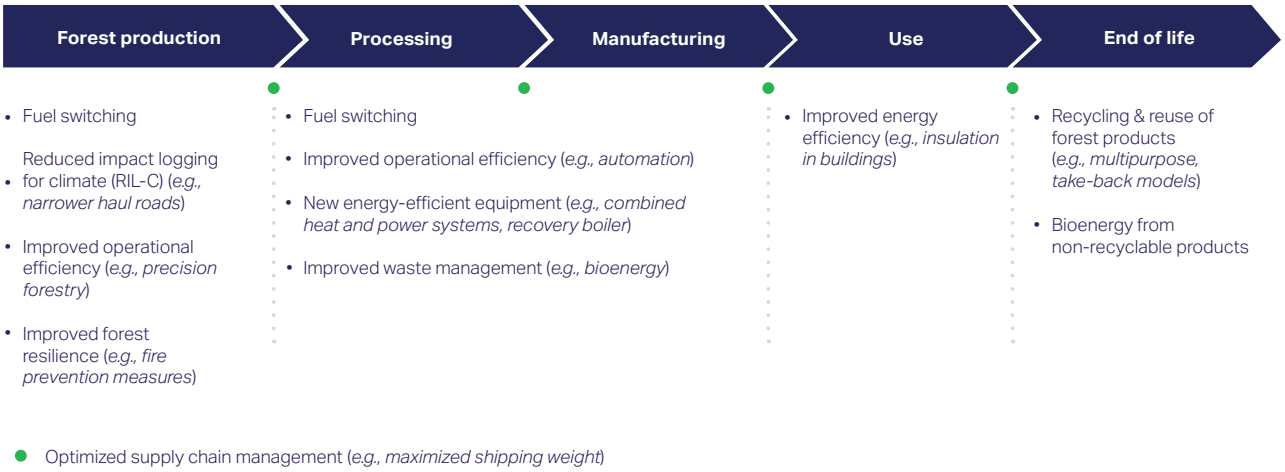
The International Energy Agency (IEA) found that, while energy use in global pulp and paper production increased by 6% from 2000-2018, the product output increased by more than 25%, indicating successful efforts in decoupling energy use from production.[22] The efficient use of renewable energy derived from bio-based process residues and by-products, which is a characteristic of the forest sector, contributes to reducing energy intensity. The 14 forest companies reviewed reported renewable sources to make up on average 68% of total energy consumption.

In addition to efficiency gains, the forest sector has also achieved significant GHG emission reductions in past years. The International Council of Forest & Paper Associations (ICFPA), representing 18 pulp, paper, wood and forest-fiber based associations active in 28 countries, reports a 21% reduction in GHG emission intensity since 2004.[23]

At the individual company level, all companies reviewed reported progress on previous emissions reductions, as well as plans for future reductions. Some 86% have a time-bound emissions reduction target in place (TPI: 69%) of which two-thirds confirm the target is verified, aligned with climate science and based on the GHG Protocol. 33% of the companies reviewed include scope 3 in emissions reduction strategies. The average target year for reductions is 2031, which is earlier than the TPI average of 2039. These short-term intermediary targets, coupled with ambitious long-term strategies, are important indicators of a robust implementation plan.

Based on the review of the 14 forest companies and recent literature, Figure 7 provides an overview of the main emissions reduction levers in use in the forest sector.

Figure 7: Main GHG emissions reduction levers in use in the forest products value chain



Some of the most frequently cited reduction levers in use among the companies reviewed are:

- **Energy efficiency gains:** achieved mostly through the dissemination and application of technologies such as combined heat and power (CHP) systems, recovery boilers, process innovations, and new energy-efficient equipment.
- **Fuel switching:** achieved by substituting for emissions-intensive energy sources (e.g., coal, oil) with cleaner alternatives (e.g., natural gas, electricity from a clean grid, biomass from a sustainably managed forest).
- **Renewable bioenergy:** achieved mostly through the use of biomass derived from the harvesting, processing and manufacturing of wood-based products and the efficient recovery and use of spent liquor in the kraft recovery process.

It is important to note that some of the greatest reduction levers for the forest sector will come from technologies and processes that do not yet exist or are not yet deployed at scale: Industry 4.0 technologies can improve operational efficiency along the value chain (e.g., automation, big data analytics);[24] new drying technologies (e.g., boost dryer, microwave drying) can increase energy efficiency in papermaking; and an integrated biorefinery can increase resource efficiency and provide bioenergy, which could be coupled with carbon capture and storage/utilization technology (CCS/U).[25] Common obstacles are carbon lock-in, high investment costs and commercial viability overall. Previous studies have estimated the reduction potential of current technologies in the pre-commercialization phase to reduce emissions by 63%[26] to 70%[27] for the pulp and paper sector in Europe.

The challenge of decarbonizing the forest sector's operations and value chains is immense. It will require large scale investment in R&D and new technologies. But the forest sector is already showing strong commitment and contribution to green growth, and with the right enabling policies, I believe this trend will only accelerate!

Jori Ringman
Director General,
Confederation of European Paper Industries

To address scope 3 emissions, in some cases the largest category of emissions, the companies reviewed report working across their value chains through actions such as incentivizing suppliers to set their own reduction targets, improving operational efficiency, and optimizing supply chain management up- and downstream (e.g., maximized shipping weight, optimized shipping routes and moving transport from road to water/rail).

Despite the progress in quantifying and reducing emission across the value chain, only 42% of companies reviewed have made a public commitment to net zero (21%) or carbon neutrality (21%). This Roadmap seeks to articulate the science-based actions companies can take in the short term and supports the adoption of credible longer term net-zero commitments.

A CARBON-NEUTRALITY COMMITMENT[28]	A NET-ZERO COMMITMENT[29]
Can be made on any organizational level (company-wide, for a single facility or on a national level) for any combination of scope 1, 2 and 3.	Covers scopes 1, 2 and 3.
Is flexible on emissions reductions, offsetting or timeframe.	Prioritizes emissions reductions and only allows offsetting to neutralize residual emissions.
Can be an intermediate step before a net-zero commitment.	Requires alignment with the Paris Agreement (i.e., in line with a 1.5°C future by no later than 2050).

Photo: Stora Enso

B. Increase carbon removals

Forests and forest products play an important role in climate change mitigation through their various interactions in the carbon cycle. They take up atmospheric CO_2 and store it for long periods of time in forest biomass, in soil, and in short- and long-lived forest products. Through the sustainable management of working forests, forest companies maintain and increase carbon sequestration in forests and storage in forest products, while securing and promoting other valuable ecosystem services. In addition, forest products provide a lower carbon, renewable alternative to fossil-based and non-renewable products. Growing the circular bioeconomy (Lever C) further amplifies the mitigation potential through the substitution effect.

Role of sustainable working forests in the carbon cycle

Forests are the largest terrestrial carbon sink, absorbing CO_2 from the atmosphere and storing it for long periods of time in living biomass (44% of total forest carbon stock), dead wood (4%), litter (6%) and soil organic matter (45%).[30] Annually, forests provide a net carbon sequestration effect of 7.6 Gt CO_2, an amount equal to approximately one-quarter of annual global energy-related CO_2 emissions.[31]

Working forests, primarily managed to produce wood and non-wood forest products, represent around 30% of the forested area globally. The IPCC emphasizes the critical role that sustainable forest management plays in maintaining and enhancing carbon stocks in working forests.[32]

As global warming threatens the permanence of forest carbon stocks through disturbances from direct and indirect climate change impacts, sustainable forest management plays an increasingly important role in avoiding losses from pests, diseases, fires and extreme weather events.[33]

Forest companies operate in different types of working forests, from managed natural and semi-natural forests, to plantation forests. There is still debate on the comparative climate change mitigation potential of these different types of forests, but in all types of forests carbon storage can be maintained through practices preventing calamities such as fire prevention measures (e.g., prescribed burning, establishing fire breaks), introducing more resilient species (e.g., more resilient to droughts) and sanitary interventions to contain biotic pests (e.g., bark beetles).[34]Measures such as rejuvenating dense forests and opening the canopy for residual trees,[35] planting more productive tree species and modifying the rotation length[36] can enhance carbon sequestration capacity. The age of forests also plays a major role, as carbon sequestration efficiency tends to decline with advanced maturity.[37]

While natural and semi-natural forests can be managed for increased carbon storage capacity for decades to centuries,[38] forest plantations are comparatively less effective at storing carbon for long periods of time but their sequestration rates can be higher due to their higher productivity.[39]

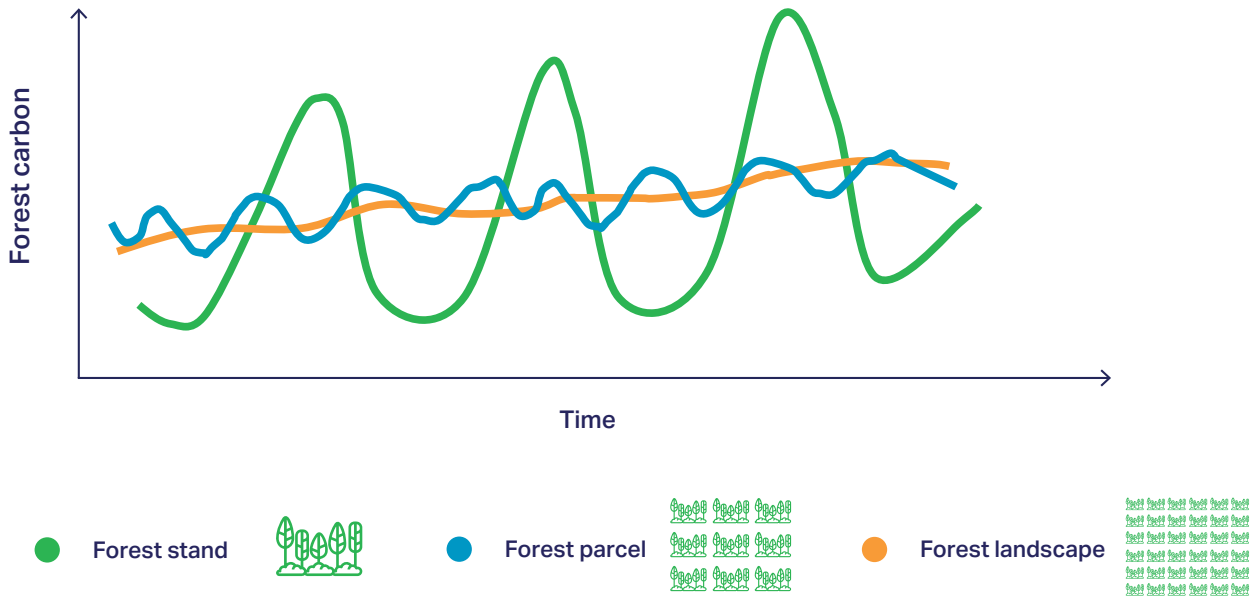
Even though they make up only 3% of global forests, their higher yield contributes to meeting the growing demand for forest products, thereby decreasing the pressure on natural forests. Also, when established on degraded land, forest plantations can significantly increase carbon stocks compared to the prior forms of land use.[40]

Figure 8 illustrates the impact of sustainable forest management on forest carbon on a stand, parcel and landscape level, illustrating how sustainable forest management can enhance forest growth in the long term on a landscape level.

Climate change is threatening forests when we need them most by exacerbating disturbances such as pests, disease or wildfire. We need to mobilize a partnership between governments and the private sector to undertake actions in our forests that will increase the amount of carbon sequestered while simultaneously plugging leaks like wildfires.

Jad Daley
President & CEO,
American Forests

Figure 8: Change of forest carbon stocks in sustainably managed forests



Source: Adapted from USDA[41]

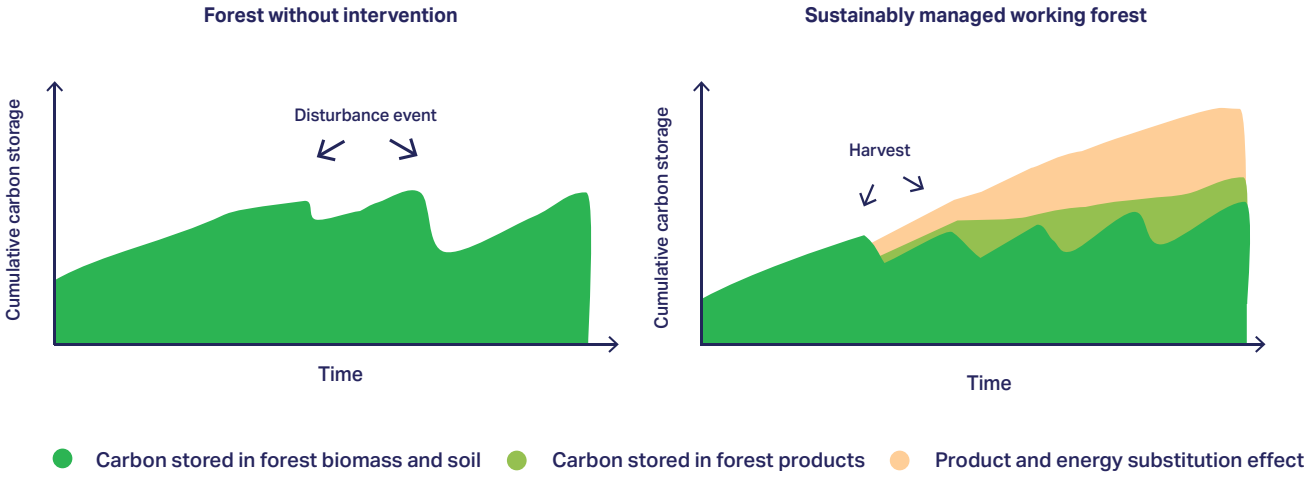
Figure 9 provides a visualized comparison of the cumulative carbon storage in a forest without intervention and a sustainably managed working forest. A systemic long-term view shows that sustainably managed forests have the potential for a net increase in cumulative carbon storage due to accumulating storage in forest products as well as the substitution effect. Sustainably managed forests are also less prone to disturbances from pests, diseases, fires and extreme weather events.[42]

An analysis of the mitigation potential of land stewardship options estimates that after reforestation, the second most effective NCS action is avoided forest conversion.[43] Therefore, to address the small share of deforestation linked to forest products, firm commitments by forest companies to deforestation-free operations and supply chains should be the basis of any action to increase carbon removals.

The promotion of sustainable forest management practices and engagement with the finance sector to accelerate investments in sustainable working forests will also contribute to countering deforestation. Indeed, driving up the economic value of sustainable working forests for investors is a proven way to prevent its conversion to alternative forms of land use.

It is important to note that in addition to sustainable forest management practices and conservation practices in the forests they own or manage, forest companies typically set aside a portion of the forest area under management for nature conservation and restoration. These areas are managed primarily to maximize the myriad of other ecosystem services and social benefits provided by forests, such as protecting and enhancing biodiversity in fauna and flora, water cycles management, the provision of food and medicine, as well as aesthetic, recreational and cultural values.

Figure 9: Comparison of a forest without intervention and a sustainably managed forest



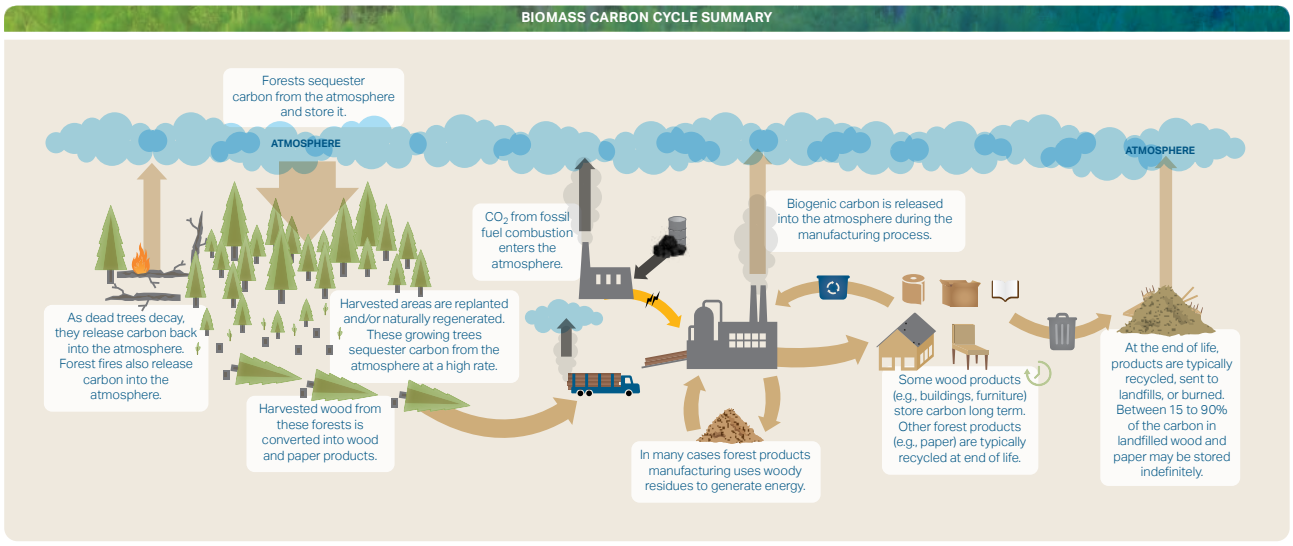
Role of forest products in the carbon cycle

Sustainable forest management can enhance forest growth, resulting in increased carbon sequestration and storage in forests that transfers to forest products when harvested. Forest products store 50% to 70% of the carbon that was in the original tree for the duration of the product's lifetime.[44] The IPCC acknowledges the climate mitigation potential of carbon storage in long-lived forest products.[45]

There is no consensus on how much carbon forest products store globally each year but recent estimates of annual net carbon capture range from 0.16 $GtCO_2e$/year[46] up to 0.4 $GtCO_2e$/year, representing nearly 1% of total annual GHG emissions.[47] As the demand for forest products is expected to continue to rise, so will the size of the carbon pool stored in forest products. As forest products are used, reused or recycled, the carbon remains stored for a longer period before re-entering the natural biogenic carbon cycle.[48]

The National Council for Air and Stream Improvement's (NCASI) biomass carbon cycle diagram (Figure 10) illustrates the biomass carbon cycle from the forest through to the harvested wood products, highlighting the renewability of the forest and the long-term storage of many forest products. This figure does not show the substitution effect, which is addressed in the next section.

Figure 10: Forest and forest product, including bioenergy, carbon cycle



Source: NCASI[49]

C. Grow the circular bioeconomy

The circular bioeconomy model is gaining momentum as an attractive business opportunity and as an important lever to decarbonize the economy. Through the substitution of non-renewable and fossil-based materials with forest products, the forest sector plays a key role in the growth of this economic model based on the sustainable consumption of biological resources to produce products and energy.

The substitution effect

In addition to the carbon forest products store, their use also reduces demand for fossil-based and non-renewable alternative materials. The substitution effect typically describes to what extent the use of a wood-based product avoids GHG emissions compared to the use of another product or material providing the same function. The IPCC considers the impact of forest products as a substitute for emissions-intensive materials a climate change mitigation lever[50] even though current GHG reporting to the UNFCC and related processes do not attribute the substitution benefits of forest products directly to the forest sector.[51]

The impact of the substitution effect will vary based on the materials or products substituted. As a comparison, the average carbon intensity of forest products is 0.5 tCO_2e/t product,[52] while other materials they can complement or partially substitute for have higher carbon intensities, such as steel (1.8 tCO_2e/t product),[53] cement (0.9 tCO_2e/t product)[54] or plastic (2.9 tCO_2e/t product).[55] In addition to carbon intensity, usage decisions should also factor in other sustainability attributes of forest products, such as the renewable source or recyclability.

In 2020, the Confederation of European Paper Industries (CEPI) estimated that in Europe, the substitution effect of forest-based industries is nearly equal to the net carbon sequestration in forests (10% of annual European fossil emissions) and 10 times the amount of annual carbon stored in forest products.[56] In the construction sector, where substitution calculations are already relatively advanced, estimates show that when wood is used as a construction material instead of non-wood alternatives (e.g., steel or cement), the savings in emissions are typically equal to more than twice the equivalent amount of carbon stored in the wood products.[57]

In the absence of a broadly recognized and credible accounting framework, few forest companies have quantified or disclosed avoided emissions from their product portfolios. Those who do typically adopt approaches that consider the full life cycle (i.e., from raw material extraction to final disposal) of forest products and their alternatives.[58]

This points to the importance of the "circular bioeconomy": a holistic approach to accounting for the climate change mitigation potential of forest products as part of an integrated system.

The circular bioeconomy is a process of change with an integrated vision of the future that shifts from extraction of finite resources, to a sustainable form of production based on renewable resources. It is one of the best tools we currently have to help fight climate change and nature loss.

Jose Carlos da Fonseca
Ambassador and Executive Director, Brazilian Tree Industry (IBA)

Decarbonizing through the circular bioeconomy

Currently, only an equivalent of 8.6% of total materials extracted cycle back into the economy; the other 92 billion tons of raw materials required to fuel the economy are extracted, processed, used and then discarded without any opportunity for recovering the materials.[59] As an alternative to the predominant "take-make-waste" economic model, the bioeconomy proposes a low-carbon economic model based on the sustainable consumption of biological resources – from agriculture, forestry and aquaculture – to produce food, feed, products and energy. In a circular bioeconomy, the biological resources are renewable, sustainably managed, recovered and reused as much as possible. A recent report by WBCSD and Boston Consulting Group (BCG) estimates the economic opportunity of the circular bioeconomy at USD $7.7 trillion for bio-based products by 2030, through the substitution of non-renewable resources with biological ones in 10 high-growth industries.[60] These include building materials and construction, packaging, and bioenergy and biofuels, as well as other more niche industries for the forest sector.

Through the substitution effect and the promotion of circular flows within operations, the forest sector finds itself at the heart of this transition to a low-carbon circular bioeconomy. To respond to this opportunity, the forest sector is innovating along three axes:

1. **Bringing wood-based alternatives to new markets**
   This consists of finding new applications for wood-based products to complement or replace existing materials in markets in which the forest sector does not traditionally sell. Through the uptake of wood as a raw material, these industries are advancing their individual decarbonization agenda. A good example of this is the use of dry lignin from wood to manufacture batteries for consumer electronics or electric cars, thereby supporting the sustainable energy transition or the growing uptake of wood-based fibers (man-made cellulosic fibers) contributing to a more sustainable fashion industry.[61]

2. **Increasing the uptake of wood-based materials in traditional markets**
   This consists of driving adoption within markets that are traditionally part of the forest sector value chain. The growing demand for engineered wood products, such as cross-laminated timber (CLT) in the building and construction sector, provides a good example of this.[62] In the packaging industry, forest companies are responding to growing demand for fiber-based packaging, and more recently 3D formed fiber, to complement or replace the use of plastics.[63]

3. **Maximizing material efficiency**
   This consists of increasing recycling, waste use and recovery, cascading the use of products and incineration for energy recovery at the end of life cycle. The valorization of materials, products and waste consists of seeking innovative ways to reuse products and industrial process waste, such as carbonate sludge, either as raw material input into manufacturing or as a feedstock for other industries such as chemicals or cement.[64] The incineration of wood-based materials originating from process residuals or products reaching the end of their life to generate bioenergy is another means to maximize material efficiency and coupling it with CCS/U technology can achieve negative emissions.

The circular bioeconomy model is gaining momentum as an attractive business opportunity and as an important lever to decarbonize the economy. The pace of innovation in the forest sector is expected to further accelerate in the coming years to keep improving the attributes and uptake of traditional forest products and bring to market more innovative applications of wood-based products in niche industries.[65]

To leverage the forest sector's full climate change mitigation potential, it is important to account for the climate benefits of working forests and forest products as part of a holistic and integrated system that takes into account all three levers of impact: reducing operational emissions, increasing carbon removals in working forests and forest products, and growing the circular bioeconomy.

We need to transition towards a climate-neutral and nature-positive economy - a circular bioeconomy powered by Nature that prospers in harmony with Nature. Forests, forestry and forest-based solutions are central to such transformation.

Marc Palahi
Director,
European Forest Institute

④ Key opportunities in a net-zero economy

The accelerating race to net-zero is impacting the operating landscape of forest companies, bringing new challenges and opportunities. While navigating this fast-changing environment, forest companies have a unique opportunity to explore new business models or ramp up efforts on existing ones to position themselves as leaders in the net-zero transition.

The stakeholder interviews have brought to surface four key opportunity spaces (Figure 11), presenting the greatest new avenues for climate change mitigation and business success in a net-zero economy. Forest companies can realize the potential of each of the three levers introduced in the previous chapter through targeted interventions in four key opportunity spaces. Engaging in carbon markets to generate additional value from activities will amplify the realization of these opportunities.

Most companies are active to different degrees in these opportunity spaces. In the following section, each opportunity space is described through a vision, a summary of the current state of play, some examples of interventions to help forest companies progress towards the vision, and enabling policies. None of these opportunities will be fully realized by forest companies acting in isolation. The large-scale transition to a net-zero economy will require concerted and collaborative action between corporations, investors, civil society, governments, customers and consumers.

Figure 11: Four key net-zero opportunity spaces to realize the potential of each of the three impact levers

Low-carbon operations

Vision: **The forest sector is taking action to decarbonize its operations in alignment with 1.5°C pathways and credible net-zero strategies, thereby sending a strong signal to customers, investors and regulators. This contributes to unlocking capital and spurring innovation and collaboration across the forest sector value chain to accelerate decarbonization.**

Tied to lever: A. Reduce operational emissions		
State of play	**Business interventions**	**Enabling policies**
• Policy-makers, civil society and business are increasingly calling for an urgent transition to a net-zero economy to mitigate the negative impacts of climate change. • The forest sector has made strong progress in decarbonizing and has demonstrated commitment to further reducing emissions and driving efficiencies across the value chain but is looking for a science-based and credible roadmap to net zero. • Alternative materials to forest products are accelerating their decarbonization, challenging the competitive positioning of wood-based products in the medium to long term (*e.g., "green steel", "green cement"*).	• Invest in improving operational and energy efficiencies (*e.g., automation, CHP systems*). • Invest in technological upgrades and new, breakthrough technologies (*e.g., bioenergy with carbon capture and storage/ utilization (BECCS/U)*). • Develop guidance for forest companies to drive credible and science-based net-zero strategies (Phase II of the Net-Zero Roadmap).	**Promotion of policies that:** • Facilitate financing and R&D to support decarbonization efforts across the sector (*e.g., negative emissions technologies, process innovation*). • Combine ambitious carbon pricing systems with provisions for border adjustment mechanisms for imported materials and products to prevent unfair competition and carbon leakage. • Avoid carbon lock-in and incentivize low-carbon technologies (*e.g., economic incentives to replace or upgrade emission-intensive technologies and infrastructure*). • Strengthen disclosure rules and their applicability to the forest sector, in line with TCFD and TNFD, to reward more sustainable companies.

Climate-positive land use

Vision: **The forest sector contributes its resources and expertise to scale up efforts by land managers to deploy high-quality land-based carbon sinks, thereby bringing more forests under sustainable management and driving investment into sustainable landscapes that provide environmental, social and economic benefits.**

Tied to lever: B. Increase carbon removals

State of play	Business interventions	Enabling policies
• Land-based carbon sinks such as nature-based solutions (NBS) and natural climate solutions (NCS) are key to reaching the targets set in the Paris Agreement as the only economical negative emissions solutions readily available at scale. • Science (IPCC) and governments recognize sustainable working forests for their role in maintaining and enhancing nature-based carbon sinks. • The race to net-zero is creating unprecedented demand from investors and companies for opportunities to invest in land-based carbon sinks to decarbonize portfolios or offset residual emissions. • Governments are increasingly committing to ambitious reforestation and afforestation programs. • Many areas of the world are facing an acute shortage of nursery capacity, resources, expertise and access to high-quality nature-based carbon sink projects to deliver on ambitions. • Through decades of practice, the forest sector has developed afforestation and restoration expertise, and invested in its nursery capacity to regrow harvested forests or for restoration activities.	• Engage in afforestation, reforestation and restoration efforts through long-term partnerships with governments, NGOs and other implementation partners. • Provide sustainable forest management services for other actors using forests as part of their offset strategy and transfer technical expertise in balancing economic, environmental and social benefits of forests. • Scale up smallholder programs and integrated land-use models such as agroforestry (*e.g., finance through carbon credits*). • Invest in nurseries for broader use (*e.g., government-led afforestation programs*). • Invest in R&D to further advance silviculture techniques to ensure climate adaptation, accelerate carbon sequestration and enable the sustainable intensification of the production of wood-based products.	**Promotion of policies that:** • Recognize and incentivize sustainable forest management practices that provide environmental, social and economic benefits. • Improve forest governance to prevent illegal logging and trade. • Promote robust, efficient and science-based voluntary and regulatory carbon markets. • Facilitate the mobilization of capital for forest investments in emerging markets. • Encourage reforestation and afforestation of degraded areas. • Support investments in the rural jobs, businesses and infrastructure necessary to support a strong forest economy. • All policies related to land use need to consider the link between a strong forest economy, well-managed resilient forests and the climate effect of forest products (*i.e., carbon storage and substitution*).

Circularity

Vision: The forest sector brings bio-based, resource efficient, and circular business models to scale. Product design optimizes the use and recovery of renewable resources, minimizes and valorizes waste from production, and improves the global recycling rates of wood-based products through collaboration across sectors and value chains, and with local authorities.

Tied to lever: A. Reduce operational emissions / C. Grow the circular bioeconomy

State of play	Business interventions	Enabling policies
• Public awareness and calls for implementation of circular models are increasing but the "take-make-waste" economic model remains largely predominant. • Paper and board were among the first products widely recycled and today remain among the most recycled materials globally. • Since forest products are renewable, recyclable and sometimes biodegradable, the forest sector is in position to bring efficient, bio-based, circular business models to scale.	• Apply circularity principles to sourcing strategies and product design to minimize waste and maximize recovery potential (e.g., *minimize additives that can compromise recovery potential*). • Keep improving production processes to minimize waste and maximize material efficiency (*e.g., increasing the number and lengths of recycling cycles*). • Innovate to enable effective reuse and upcycling of waste streams and processing residues within the value chain (*e.g., for energy generation or as feedstock for other industries*). • Collaborate across sectors and value chains and with local or regional authorities to improve the global recovery rate and reuse of wood-based products.	**Promotion of policies that:** • Stimulate the use of circular and sustainable bio-based materials such as wood-based products from sustainable working forests. • Promote the resource-efficient use of wood-based products in line with the cascading principles. • Promote investment in recycling infrastructure to improve quantity and the quality of recovered materials. • See the WBCSD *Policy brief: driving the transition to a circular economy*[66] for a full list of policy recommendations.

Product innovation

Vision: The forest sector ramps up investment in research and innovation to scale up the use of sustainably sourced forest products and build awareness of their unique attributes over non-renewable and fossil-based materials: low-carbon production, carbon storage and end-of-life benefits.

Tied to lever: B. Increase carbon removals / C. Grow the circular bioeconomy

State of play	Business interventions	Enabling policies
• As all sectors seek to accelerate their decarbonization journey, the demand for materials to complement or substitute for carbon-intensive and non-renewable materials is set to increase in industries such as packaging, construction, energy or textile. • Consumers are showing increased preference for sustainable products made from biological resources, perceived as more environmentally friendly. • Forest products provide a large-scale and cost-effective solution for carbon capture and storage, especially in long-lived products. They store carbon for the duration of their lifetime, including through recycling. • The pace of innovation across the full forest products value chain has accelerated in recent years and the forest sector will continue to enter new markets, providing innovative wood-based alternatives to emissions-intensive materials.	• Invest in R&D and uptake of traditional forest products (e.g., *awareness raising campaigns*). • Invest in R&D to find new applications for forest products (e.g., *lignin nanoparticles, food grade bio films*). • Accelerate research on the carbon impacts of wood-based products to build a science-based narrative to inform customer procurement decisions and raise consumer awareness.	**Promotion of policies that:** • Enable a level playing field by accurately reflecting and fostering the investment and time required to bring new products and innovation to market (e.g., *better integrate innovative renewable materials into new policies*). • Incentivize the use of renewable low-carbon biomaterials (e.g., wood-based products for construction, packaging, energy and other uses) and reward their climate benefits (e.g., *green public procurement*). • Incentivize research in product innovation and life-cycle analysis of forest products.

Leveraging carbon markets to realize net-zero opportunities

Voluntary and regulatory carbon markets are expected to rapidly mature, driven by soaring demand for carbon offsets from emerging net-zero strategies, especially from emissions-intensive industries. Engaging in carbon markets through the issuing of carbon credits on NBS or NCS initiatives (e.g., afforestation, conservation, improved forest management), GHG emissions reduction projects (e.g., low-carbon mill, CCS/U) and soon on forest products (e.g., mass timber construction) could provide an attractive source of additional income for forest companies and help accelerate the realization of the opportunities described above.

Today, it is mostly forest asset managers who are active in carbon markets; few large forest companies have issued carbon credits for their reforestation, conservation, improved forest management or GHG reduction activities. The low price of carbon combined with evolving and fragmented voluntary carbon markets and lack of widespread regulatory markets have so far not provided the right level of incentive to trigger action at scale. But areas of the world with robust carbon market and pricing policies (e.g., California, Australia, New Zealand) provide a window into prospective positive outcomes for the forest sector in addition to positive climate and social outcomes.

With the forest sector's increasing capacity to offer land-based carbon sinks and sustainable low-carbon products, a surge in financial flows is predicted from investors seeking long-term and stable returns through regulatory and voluntary carbon markets.[66] Assigning a value not just to carbon sequestration but also other ecosystem services such as watershed and biodiversity protection further drives up the value of sustainable working forests in the future.

Forests can offer many benefits beyond carbon sequestration. To attract more investment, the forest sector should strive to measure, value and communicate the full value of forests, beyond solely carbon storage. These include essential ecosystem services that are critical for society.

David Carlin
Program Lead,
TCFD and Climate Risk, UNEP FI

5 Conclusion

Achieving a net-zero economy will require a deep transformation of every aspect of the economy. Forest companies, like many others, will be facing a very different operating landscape in the coming decades. In the development of this Roadmap, leading companies and key stakeholders in the forest sector have come together on a shared understanding of the role of the forest sector in enabling the transition to a net-zero economy. By doing so, they are paving the way for their own success, as well as the success of the broader economy and society. This report lays the groundwork for Phase II of the project to come next year, that will provide guidance for business in the forest sector to drive credible and science-based net-zero strategies.

To accelerate this urgent and far-reaching transition, WBCSD's Forest Solutions Group members call on peers, customers, investors and policy-makers to join the effort to unleash the full transformative potential of the forest sector.

Forest companies

Take decisive action to decarbonize your company's operations and value chain, guided by ambitious, science-based net-zero strategies. Leverage the forest sector's unique attributes to realize the opportunities that stem from the transition to a net-zero economy.

Customers

When sourced responsibly, forest products are renewable, recyclable and store carbon for the duration of their lifetime. Join forces with the forest sector to increase recycling rates and accelerate your decarbonization journey by using forest products to complement or substitute for less sustainable alternatives.

Investors

Accelerate your portfolio's transition to net-zero, with forest sector investments that sequester carbon, substitute for fossil-based materials, protect nature, and provide rural livelihoods, while generating competitive financial returns. Demonstrate leadership in recognizing the inherent value of sustainable working forests before markets develop to more accurately value the ecosystem services and products they provide.

Policy-makers

The forest sector is a key enabler of the urgent transition to a net-zero economy. To deploy the forest sector's full climate change mitigation potential, promote policies that account for the renewability and climate benefits of working forests and wood-based products as part of a holistic and integrated system: the circular bioeconomy.

Appendix A

Transitional and physical risks related to the forest sector

Transitional risks			
Category	**Transitional risks/opportunities**	**Potential impact**	**Potential implication**
POLICY AND LEGAL	• Increased pricing of GHG emissions (e.g., EU Emissions Trading System (ETS), California cap-and-trade) or costs to comply with other relevant regulations (e.g., taxes on process waste, extended producer responsibility etc.)	Operating costs Competitiveness Capital investment Sensitivity to future pricing Revenues	• Particularly material for manufacturing and production sites • Regional GHG pricing schemes have potential to impact competitiveness between operators based in different regions • Required for transition to lower emissions or more efficient technologies • Companies that reduce their exposure to GHG emissions are less sensitive to changes in the cost of carbon and more competitive as a result • Rising demand for low-carbon materials and products • Forest product companies have potential new revenue streams from the sale of carbon credits
	• Requirements to provide detailed environmental information at product level (e.g., scope 3 emissions or sequestered carbon) in different jurisdictions	Operating costs Revenues	• Requirements to measure and provide new environmental information, particularly if standards or methodologies vary regionally • Changes in demand for products based on more detailed environmental information • May positively or negatively impact an organization's social license to operate
	• Regulations that promote biomass-based energy production and green building materials present opportunities for sales of bio-based products, for example: forest energy biomass; green wood-based products; substitution or complementing existing non-wood-based building materials	Operating costs Revenues	• Increased capital investment in research and development to meet demand for new products (e.g., requirement for wooden construction materials) • New revenue streams from sales of forest energy biomass and wooden building materials
	• Increased logging tax in producing countries or regulation of harvesting volume to prevent deforestation	Costs	• Increased costs for timber procurement
	• Regulations that encourage reforestation and afforestation of degraded areas	Revenues Costs	• Opportunities associated with tax bonuses and other government incentives • Enhancing future potential carbon stocks and opportunities

TECHNOLOGY ADVANCES	• Technological advances enabling efficiency gains in use of resources, production and distribution processes (e.g., development of ultrafiltration to enable wastewater reuse or new chemicals/fuels from waste streams)	Operating costs Sensitivity to future price changes	• Efficiency gains, cost reductions or reduced reliance on external input sources (e.g., reduced water consumption and reliance on external sources, reduced risk of shutdown in operations due to water shortage, especially in water stressed regions) • Reduced risk of exposure to future energy and other input price increases (depending on the success of efficiency measures)
	• Development of new low-carbon products that reduce or sequester carbon (e.g., increases to carbon content of soil) or can substitute for fossil fuel-based products (e.g., lignin, formed fiber bio composites)	Revenues Operating costs	• Changing demand for products and services and the development of new revenue streams for new products and services
MARKET CHANGES	• Changing consumer preferences for products seen as better/ worse for the environment (e.g., building material shifts to low-carbon products, inputs that increase yield and afforestation or renewable packaging and construction materials)	Revenues	• Changes to demand for low-emissions products and services based on a company's ability to reflect shifting consumer preference in their product portfolio and provide new solutions.
	• Demand for numerous forest products and bioenergy is increasing with the global population and could exceed wood-based material production, jeopardizing supply	Operating costs	• Increased demand and pressure on existing resources increases input prices (e.g., wood, energy and water) and output requirements (e.g., wastewater, solid waste, emissions, etc.)
	• Changes in demand for and use of renewable carbon-neutral products or by-products that can complement and/or substitute for similar fossil fuel-based products for internal energy generation (e.g., saw dust residue from solid wood products) or for higher value raw materials for other industries (e.g., packaging or construction)	Revenues	• Dependent on ability to meet demand for lower emissions products and services.
REPUTATION	• Increased stakeholder concern or negative/positive stakeholder feedback if company perceived to not be/to be living up to customer or societal expectations on climate action	Revenues	• Changes to demand for products and services dependent on ability to fulfill customer expectations • May positively or negatively impact an organization's social license to operate
	• Prioritization of conservation forests over sustainably managed forests because of negative reputation due to challenges by some non-governmental organizations (NGOs) and other actors	Revenues Operating costs	• Decreased demand for products and services due to negative impacts on reputation • Constraints on availability of primary logs for further processing
	• Companies face reputational risks and a threat to their license to operate if they make strategic decisions to ensure business resilience that neglect to account for the resilience of communities in which they operate and depend upon	Revenues	• Decreased demand for products and services due to negative impacts on reputation • Increased cost of capital due to increased business risk • Decreased ability to attract new talent due to negative reputation
	• Acceptability of sustainable forest management and working forests as a recognized NCS	Revenues Operating costs	• Dependent on recognition of the value of working forest investments • Perception of current sustainable forest management standards and methodologies to address NCS

Physical risks			
Category	**Physical risks/opportunities**	**Potential impact**	**Potential implication**
ACUTE	• Increased incidence and severity of extreme weather events such as cyclones and floods	Capital costs Revenues	• Damage to property and assets • Decreased production capacity due to business interruption to manufacturing operations and supply chains right down to losses at farm and plantation level
	• Temperature extremes may include occurrence of severe frost periods in the subtropics, causing damage to tree species (e.g., eucalyptus)	Capital costs	• Damage to tree species requiring expenditure to facilitate alternative water sources and/or replace lost trees.
CHRONIC	• Rising sea levels	Revenues Capital costs	• Decreased production capacity due to reduced availability of land for agriculture or forestry • Damage to facilities and assets in coastal areas (e.g., mills or factories) and logistical problems for distribution networks
	• Increased precipitation may cause erosion of forest soils and poor forest road conditions	Costs	• Impact on the ability to harvest and transport wood increases the cost of raw materials • Loss of soil productivity
	• Rising mean temperatures increase the risk of drought, water stress and forest fires, as well as the risk of hurricanes, tornadoes and typhoons in certain areas	Revenues Costs	• Decreased production capacity because of loss or damage to forests and plantations • Loss of growth potential due to soil damage • Increased silviculture costs to replant damaged forests • Reductions in precipitation creating water constraints, which limits water use in production mills and results in production losses
	• Increases in mean temperature leading to changes in tree species composition and increased susceptibility of forests to insect and disease outbreaks	Revenues	• Decreased production capacity because of loss or damage to forests and plantations • Increased silviculture costs to replant damaged/ degraded forests to more appropriate species
	• Tree growth and timber yield in some geographical locations predicted to increase because of gradual increases in temperature, precipitation and CO_2 levels in the atmosphere in some areas	Revenues	• Increased production capacity and new investment opportunities • Increased sequestration rates
	• Volume reduction in water sources for pulp mills can modify/ concentrate the chemical composition and temperature of water sources	Capital investment	• R&D spending needed to adapt to different chemical compositions and higher temperatures of water sources for pulp mills

Appendix B

Glossary

Term	Definition
Bioenergy with carbon capture and storage (BECCS)	Carbon dioxide capture and storage (CCS) technology applied to a bioenergy facility. Note that depending on the total emissions of the BECCS supply chain, it may result in negative CO_2 emissions or net removals of emissions from the atmosphere. (IPCC)
Carbon capture and storage/ carbon capture and utilization (CCS/U)	CCS = A process that separates (captures), conditions, compresses and transports a relatively pure stream of CO_2 from industrial and energy-related sources to a storage location for long-term isolation from the atmosphere. (IPCC) CCU = A process that captures and then converts CO_2 to new substances and products.
Carbon lock-in	Carbon lock-in happens when existing technologies, institutions and behavioral norms delay or prevent the transition to a low-carbon economy. Example: no replacing of an emissions-intensive system (e.g., coal-fired power station) due to high investment costs and a long payback period. (WRI)
Carbon offset	Tradable credits for any kind of mitigation effort (direct emissions reduction, carbon removal or sequestration, or avoided emissions) sold to a buyer who is not reducing their own absolute emissions but offsetting their emissions by paying a seller for reductions or removals elsewhere. (Oxfam)
Carbon sequestration	The removal of carbon from the atmosphere by biological sinks and storage in plant tissue. Sequestered atmospheric carbon does not include GHGs captured through carbon capture and storage. (WBCSD/WRI)
Carbon sink	Any process, activity or mechanism that removes greenhouse gases from the atmosphere.
Carbon storage	The maintenance of carbon dioxide or carbon in a physical reservoir or medium for a period of time.
Cascading use of wood	This strategy uses raw materials such as wood or other biomass in chronological sequential steps as long, often and efficiently as possible for materials and only recovers energy from them at the end of the product life cycle. (WWF)
Circular bioeconomy	The bioeconomy is the use of biological resources to produce food and feed, products and energy. In a circular bioeconomy, biological resources are renewable, sustainably managed, recovered and reused as much as possible. (WBCSD)
Greenhouse gases (GHGs)	Those gaseous constituents of the atmosphere, both natural and anthropogenic (human-caused), that absorb and emit radiation at specific wavelengths within the spectrum of terrestrial radiation emitted by the Earth's surface, by the atmosphere itself, and by clouds. This property causes the GHG effect, whereby heat is trapped in the Earth's atmosphere. Water vapor (H_2O), carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), and ozone (O_3) are the primary GHGs in the Earth's atmosphere. (CDR primer)
Industry 4.0	The automation and interconnectivity of traditional industrial practices through smart technologies such as cloud computing, big data analytics, internet of things and many others.
Mitigation (of climate change)	A human intervention to reduce emissions or enhance GHG sinks. (IPCC)

Natural climate solutions (NCS)	Actions to conserve, restore or improve the management of land and coastal ecosystems (e.g., forests, wetlands, grasslands, agricultural land) that increase carbon storage and/or avoid GHG emissions and therefore neutralize residual emissions. Forest pathways, such as reforestation, avoided forest conversion, natural forest management, improved plantations, avoided wood fuel harvest and fire management, cover two-thirds of the cost-effective NCS mitigation potential needed between now and 2030 to stabilize warming to below 2°C. (Griscom et al.)
Nature-based solutions (NBS)	Actions to protect, sustainably manage and restore natural or modified ecosystems, that address societal challenges (e.g., climate change, food and water security or natural disasters) effectively and adaptively, simultaneously providing human well-being and biodiversity benefits. (WBCSD)
Net-zero emissions	Net-zero emissions are achieved when anthropogenic emissions of greenhouse gases to the atmosphere are balanced by anthropogenic removals over a specified period. The reduction of emissions should follow science-based pathways that limit warming to 1.5°C, with no or limited overshoot, with any remaining attributable GHG emissions fully neutralized by permanent removals either within the value chain or through the purchase of valid offsets. This definition clarifies that purchasing offsets cannot be a substitute for emissions reductions but rather a tool to complete the neutralization process. (IPCC)
Physical risks	Risks related to the physical impacts of climate change. Physical risks resulting from climate change can be event-driven (acute) or longer-term shifts (chronic) in climate patterns. Physical risks may have financial implications for organizations, such as direct damage to assets and indirect impacts from supply chain disruption from fires, flooding, drought, pests, wind, etc. See transition risks. (TCFD)
Removal of carbon/GHGs	Biogenic or technological absorption or sequestration of carbon dioxide and other GHGs from the atmosphere. (WRI/WBCSD)
Residual emissions	The emissions remaining after implementing all technically and economically feasible opportunities to reduce emissions in all covered scopes and sectors. (C40)
Substitution	The ability to substitute non-renewable, fossil-based materials with renewable, bio-based products, such as forest products. (WBCSD)
Transition risks	Risks related to the transition to a lower carbon economy. Transitioning to a lower carbon economy may entail extensive policy, legal, technology and market changes to address mitigation and adaptation requirements related to climate change. Depending on the nature, speed and focus of these changes, transition risks may pose varying levels of financial and reputational risk to organizations. See physical risks (TCFD)
Working forest	Forests actively managed to generate revenue from multiple sources, including physical goods for sale (such as sustainably produced timber), while maintaining ecosystem services and social values; thus, they are not converted to other land uses. (WRI)

Appendix C

List of interviewees

The Forest Solutions Group secretariat, supported by PwC Canada, conducted 21 interviews with forest stakeholders to capture insights and perspectives on the topic of net-zero in the forest sector. The interviews took place in June and July 2021.

Organization	Name	Title
American Forest & Paper Association (AF&PA)	Jerry Schwartz	Senior Director, Energy and Environmental Policy
	Paul Noe	Vice President, Public Policy
American Forests	Jad Daley	President & Chief Executive Officer
Australian Forest Products Association (AFPA)	Ross Hampton	Chief Executive Officer
FAO's Advisory Committee on Sustainable Forest-based Industries (ACSFI)		Chair
Climate Smart Forest Economy Program (CSFEP)	Jamie Lawrence	Lead
Confederation of European Paper Industries (Cepi)	Jori Ringman	Director General
European Forest Institute (EFI)	Marc Palahi	Director
Forestry and Forest Products Research Institute (FFPRI)	Tohru Nakashizuka	Director General
Forest Stewardship Council (FSC)	Pina Gervassi	Climate and Restoration Director
FAO's Advisory Committee on Sustainable Forest-based Industries (ACSFI)	Jose Carlos da Fonseca Junior	Vice President
Brazilian Tree Industry (IBA)		Ambassador and Executive Director at Ibá
Brazilian Tree Industry (IBA)	Nathalia Granato Loures	Head of Sustainability and Forest Affairs
	Fábio Marques	Director at Plantar Carbon - Consultancy of Ibá
	Adriano Scarpa	Coordinator at Plantar Carbon - Constulancy of Ibá

International Council of Forest & Paper Association (ICFPA)	Derek Nighbor	President
Forest Products Association of Canada (FPAC)		President & Chief Executive Officer
International Union for Conservation of Nature (IUCN)	Chris Buss	Director, Forest Program
National Council for Air and Stream Improvement (NCASI)	Kirsten Vice	Vice-President, Sustainable Manufacturing & Canadian Operations
	Caroline Gaudreault	Program Manager, Sustainable Manufacturing & Climate
Programme for the Endorsement of Forest Certification Schemes (PEFC)	Ben Gunneberg	Chief Executive Officer
Sustainable Forestry Initiative (SFI)	Kathy Abusow	Chief Executive Officer
The Forests Dialogue (TFD)	Gary Dunning	Executive Director
The Nature Conservancy (TNC)	Caitlin Clarke	Senior Conservation Fellow
United Nations Environment Programme Finance Initiative (UNEP-FI)	David Carlin	Program Lead, TCFD and Climate Risk
World Economic Forum (WEF)	Justin Adams	Executive Director, Tropical Forest Alliance
We Mean Business Coalition (WMB)	Luke Pritchard	Manager, Nature-based Solutions (NBS)
World Resources Institute (WRI)	Rod Taylor	Global Director, Forests Program
World Wide Fund for Nature (WWF)	Fran Raymond Price	Global Forest Lead
	Martha Stevenson	Senior Director, Forest Strategy & Research

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This publication has been developed in the name of WBCSD. Like other WBCSD publications, it is the result of a collaborative effort by members of the secretariat and senior executives from member companies. A wide range of member companies reviewed drafts, thereby ensuring that the document broadly represents the perspective of WBCSD membership. Input and feedback from stakeholders listed above was incorporated in a balanced way. This does not mean, however, that every member company or stakeholder agrees with every word.

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ABOUT THE FOREST SOLUTIONS GROUP

WBCSD's Forest Solutions Group (FSG) is the global platform where leading business in the forest products sector build and share sustainable development solutions. FSG's mission is to grow an inclusive circular bioeconomy that is rooted in thriving working forests.

Follow us on LinkedIn and www.wbcsd.org/FSG

ABOUT WBCSD

WBCSD is the premier global, CEO-led community of over 200 of the world's leading sustainable businesses working collectively to accelerate the system transformations needed for a net zero, nature positive, and more equitable future. We do this by engaging executives and sustainability leaders from business and elsewhere to share practical insights on the obstacles and opportunities we currently face in tackling the integrated climate, nature and inequality sustainability challenge; by co-developing "how-to" CEO-guides from these insights; by providing science-based target guidance including standards and protocols; and by developing tools and platforms to help leading businesses in sustainability drive integrated actions to tackle climate, nature and inequality challenges across sectors and geographical regions.

Our member companies come from all business sectors and all major economies, representing a combined revenue of more than USD $8.5 trillion and 19 million employees. Our global network of almost 70 national business councils gives our members unparalleled reach across the globe. Since 1995, WBCSD has been uniquely positioned to work with member companies along and across value chains to deliver impactful business solutions to the most challenging sustainability issues.

Together, we are the leading voice of business for sustainability, united by our vision of a world where 9+ billion people are living well, within planetary boundaries, by mid-century.

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