Facts & Trends: Forests, Forest Products, Carbon and Energy

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About the WBCSD Forest Solutions Group

The mission of the World Business Council for Sustainable Development (WBCSD) Forest Solutions Group is to provide business leadership in expanding sustainable forest-based solutions to meet the needs of people now and in the future. Thirty leading member companies, representing all stages of the forest product supply chain, are engaged driving a broad spectrum of sustainability initiatives using the WBCSD platform.

The group's working scope intends to clarify misperceptions about the forest-based industry, address a range of sustainability challenges and opportunities, often based on open stakeholder dialogues, and emphasize the importance of the forest-based industry as a key part of a low-carbon and bio-based economy.

The Council's forest-related publications document successful experiences in sustainable forest management and demonstrate the sustainable use of forest products are essential elements in climate change mitigation and adaptation policies.

Recent examples include:

- Changing Pace – Public Policy options to scale and accelerate business action towards Vision 2050, Forests chapter (2012)
- The Sustainable Forest Products Industry, Carbon and Climate Change: Key messages for policy-makers 3rd edition (2011)
- Recommendations for Government Negotiators to Effectively Include Harvested Wood Products within the UN Framework Convention on Climate Change (2011).

WBCSD's Vision 2050 and Changing Pace

Vision 2050 – The new agenda for business

The forests of 2050 have regained much of their capacity to protect against climate change and biodiversity loss and to meet the resource needs of society.

- Forests cover more than 30% of the world land area.
- The total stock of carbon sequestered in forests is 10% higher or more than 2010 levels.
- Deforestation has significantly reduced.
- Primary forest coverage is held intact and expanded somewhat. Primary forests are no longer used for wood, wood products, new farmland or biomass. This practice sequesters carbon and protects biodiversity, water and additional ecosystem services.
- Yield and harvest from planted forests have increased threefold from 800 million cubic meters to 2.7 billion cubic meters to meet demand for wood, paper and biomass. The land area for purpose grown trees has increased by 60%.
- Some limited additional volume of wood continues to flow from modified natural forests, which are managed at lower levels of intensity, thus providing another carbon bank.

To stave off impacts from climate change and human interference, all three classes of forests are managed to ensure provision of sustainable products and services and to protect forest health.

Changing Pace: Public policy options to scale and accelerate business action towards Vision 2050

With Changing Pace WBCSD intends to deepen the discussion around the best policies that can help lunch the realization of Vision 2050. The pathway toward Vision 2050 is framed by the following recommendations and rough estimates.

- Undertake massive public and private reforestation programs for future industrial and energy needs, and raise the global forest carbon stock by 65 gigatons of carbon; this equates to more than 400 million hectares of new forest land at maturity, versus current deforestation trends. It brings the world's total forest cover significantly above 1990 levels.
- Spare 4 million hectares of primary forest from destruction each year; compensate land owners for the opportunity costs of not harvesting them for commercial roundwood and/or turning the land to other uses.
- Conserve 5 million hectares of modified natural forests yearly by shifting harvests to planted forests where yields and quality are significantly enhanced through improved selection and better forestry practices.

Contents

Executive Summary

Facts and Trends: Forests, forest products, carbon & energy **provides an overview of simple facts and trends about forests, forest products, carbon and energy. Developed by WBCSD Forest Solutions Group members with extensive technical support from the National Council for Air and Stream Improvement (NCASI), it supports the ongoing dialogue within the WBCSD membership and with other forest-focused stakeholders in government, civil society and business.**

The emphasis of this document is on facts and trends driving the forest product industry today and in the near future. It underlines the importance of sustainable forest management and the forest-based industry in a resource-constrained world and its indispensability to a future low-carbon and bio-based economy.

This document uses existing data from the Food and Agricultural Organization of the United Nations, documents prepared by the World Resources Institute (WRI), and publically available resources from many other research organizations and scientists.

Forests

Facts

- Forests cover almost one-third of the world's land surface
- About 36% are primary forests, 7% are planted forests, and 58% are classified as other natural generated forests
- Carbon stocks are increasing, yet net forest area continues to decline due to persistent deforestation in the Southern Hemisphere, primarily in tropical forest areas
- Planted forest area is growing rapidly, with much of this happening in China

Trends

- High-productivity planted forests provide a large and growing share of the wood required by the forest products industry
- Sustainable forest management and wood procurement certification programs continue to grow, with about one-quarter of industrial roundwood now coming from certified forests
- Planted forests tend to be more productive than natural forests and thus better to meet the demand for roundwood; high productivity planted forests supply a growing share of global fiber demand
- In 8 out of 10 top producing countries, forest cover tends to be stable

Forest products

Facts

- The forest products industry is an economically significant and highly competitive industry globally
- Between 25% and 30% of global wood products and paper manufacturing output is destined for export from the country of origin
- Harvesting of industrial roundwood has been stable despite increasing production of paper, paperboard and wood-based panels, due to the increasing use of recovered fiber

Trends

- Demand for forest biomass is increasing, particularly for energy production; this can present a challenge to conventional forest products manufacturers
- Producers of electricity and other energy products will sometimes be competing for forest biomass normally used for conventional forest products, driven by policies incentivizing biomass for energy. If not carefully crafted, such policies can have adverse impacts on forests and ultimately can cause market distortions
- Global production and use of recovered paper has been increasing drastically since 1990

Carbon

Facts

- Forests and forest products store carbon; wood is an inherently low-carbon intensity material
- Forest products also reduce societal emissions of greenhouse gases when they displace more greenhouse gas-intensive products in commerce
- The benefits of substituting wood-based building materials for alternative materials are especially significant

Trends

- The carbon stocks in global forests are currently increasing by about 1 gigaton of carbon (Gt C) per year due to reduced rates of deforestation and forest growth and expansion
- The annual net growth in the stocks of carbon in forest products represents a large enough removal of carbon from the atmosphere to offset one-half or more of the emissions from the forest products value chain

Energy

Facts

- Energy consumption by the forest products industry represents about 1.5% to 2% of global final energy use
- Approximately one-half of the energy required by the industry is supplied by biomass
- The paper industry is a world leader in using combined heat and power and has significantly reduced its energy consumption compared to 1990 levels
- Most of the emissions from the forest products value chain are associated with fossil fuel combustion, purchased electricity and methane attributable to the decomposition of discarded forest products in landfills

Trends

- The sector continues to improve its energy efficiency
- Estimates indicate that current levels of paper recycling are avoiding the release of approximately 300 million metric tons of CO_2 equivalents in landfill methane per year
- Growth in the pool of carbon in products is adequate to offset one-half of the industry's value chain emissions

Facts and Trends 1

Production and trade of forest products

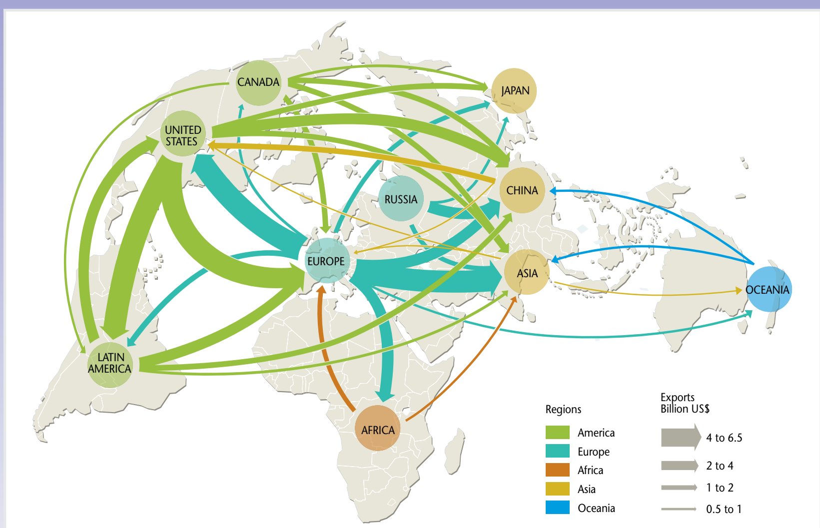
The forest products industry is economically significant and globally competitive. Recovered paper supplies a large and increasing share of the industry's fiber requirements. Increasing demand for forest biomass, particularly for energy production, could present a challenge to conventional forest products manufacturers.

Wood and paper products are distributed around the world, with the top ten producing countries accounting for between two-thirds and three-quarters of global production. The industry is highly competitive internationally, with between 25% and 30% of global wood products and paper manufacturing output destined for export from the country of origin (FAO 2012).

Since 1990, global production of sawn wood has been constant, but the production of paper, paperboard and wood-based panels has increased dramatically. Despite this growth in production, the harvesting of industrial roundwood has barely changed and is currently slightly below what it was in 1990. This has been made possible by the increased use of wood-based materials that were previously discarded, particularly recovered paper. Global production and use of recovered paper has more than doubled since 1990 (FAO 2012). The global recycling rate in 2009 was estimated to be 55.6%, up from 48.6% only five years earlier (ICFPA 2011). This illustrates the importance of "cascading" in the wood fiber system. Wood fiber is first used in its virgin form, then it is recovered for use in additional paper products, and finally, when it is no longer useful as a raw material for paper, it is often used as a source of biomass energy.

The forest sector is currently the largest industrial user of wood by a wide margin, but other industrial uses for forest biomass are growing. In particular, biomass is increasingly being used as a substitute for fossil fuels used to produce electricity and other energy products. In 2010, biomass was used for 1.5% of the electricity produced in the world, or about 500 terawatt hours (TWh). The International Energy Agency (IEA) has projected that this could increase to about 5% in 2030 and 7.5% in 2050, suggesting that electricity production could become a major use for biomass (IEA 2012). Demand for conventional wood products and wood fuel will also grow with an increasing global population. The potential impacts of increasing demand for wood have been the subject of many studies. The specific results of these studies vary, but they tend to agree on several general points:

Figure 1: Global trade in primary wood and paper products 2006



Source: UNEP 2009[1]

1. Design credit to Philippe Rekacewicz assisted by Cecile Marin, Agnes Stienne, Guilio Frigieri, Riccardo Pravettoni, Laura Margueritte and Marion Lecoquierre. Available at http://www.grida.no/graphicslib/collection/vital-forest-graphics.

Table 1: Ten largest producers of wood-based forest products

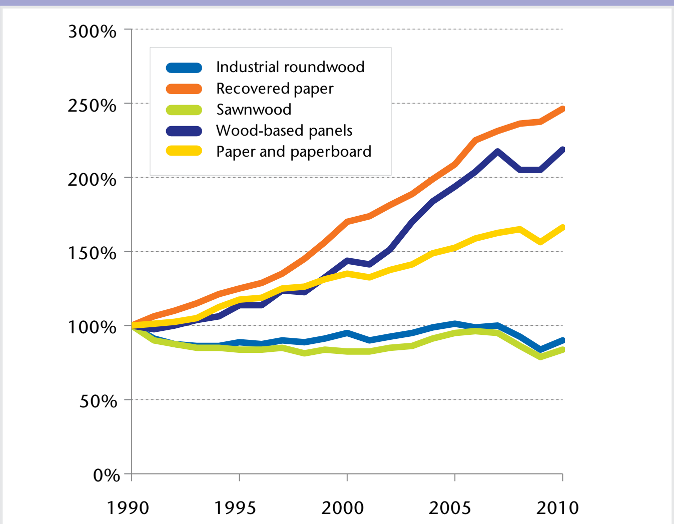
Industrial roundwood (10^6 m^3)		Sawn wood (10^6 m^3)		Wood-based panels (10^6 m^3)		Paper and paperboard (10^6 metric tons)	
U.S.A.	300	U.S.A.	58.6	China	104	China	96.5
Russian Fed.	133	Canada	38.7	U.S.A.	33.3	U.S.A.	75.8
Canada	130	China	37.7	Germany	14.5	Japan	27.4
Brazil	128	Russian Fed.	28.3	Russian Fed.	10.2	Germany	23.2
China	102	Brazil	25.1	Canada	9.9	Canada	12.7
Sweden	64.3	Germany	22.4	Brazil	9.6	Finland	11.8
Indonesia	54.1	Sweden	17.1	Poland	8.1	Indonesia	11.5
Finland	46.0	India	14.8	Malaysia	6.9	Sweden	11.4
Germany	45.4	Austria	9.6	Turkey	6.6	Rep. of Korea	11.1
Chile	34.6	Finland	9.5	Thailand	5.4	India	10.3
World	1,540	World	391	World	283	World	400

Source: Data in FAO 2012

- Both the supply and demand for forest biomass are significantly affected by technological change, economics and public policies, making supply and demand predictions inherently uncertain (see Mantau et al.2010, Ince et al. 2011 and IPCC 2012).
- It is possible to construct a number of plausible scenarios wherein, between now and 2030, producers of electricity and other energy products will be competing for biomass normally used by the forest products industry, perhaps most notably manufacturing residuals from saw mills and roundwood normally used to produce wood pulp (for instance, see Mantau et al. 2010 and Ince et al. 2011).

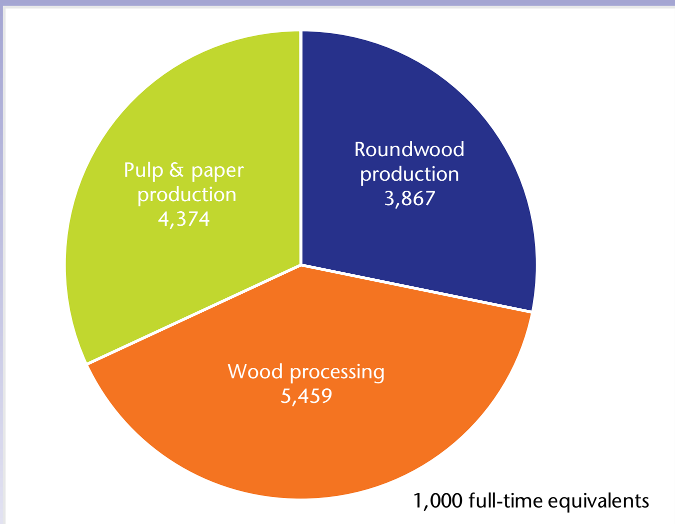
The forestry sector employs almost 14 million people (full-time equivalents) around the world in roundwood production, wood processing and pulp and paper production. This direct employment amounts to approximately 0.4% of the global labor force. In some regions, however, the forest sector has a much larger impact on employment, with the sector employing over 3% of the labor force in countries like Estonia, Finland and Latvia. The forest sector contributes approximately 1% of global GDP, but the economic importance of the sector is highly variable among countries, with the sector contributing over 10% of GDP in some developing countries (e.g., the Central African Republic, Liberia and the Solomon Islands (FAO 2011).

Figure 2: Trends in industry input and output



Source: Data in FAO 2012.

Figure 3: Global forest sector employment



Source: Data in FAO 2011.

Facts and Trends 2

The forest carbon cycle

In 2005, the Food and Agriculture Organization of the United Nations (FAO) estimated that the world's forests store 283 Gt C in their biomass and, when other forest carbon pools (e.g., soils) are considered, 638 Gt C in total (FAO 2005). More recently, a group of 18 leading forest carbon experts from government, research and academic organizations around the world estimated global forest carbon stocks to be 861 Gt (363 Gt in live biomass). These experts also determined that although deforestation is causing net losses of forest carbon in the tropics, the rate of deforestation is slowing, and in recent years the amount of carbon stored in forest

The carbon stocks in global forests are currently increasing by about 1 gigaton carbon (Gt C) per year due to reduced rates of deforestation and forest growth and expansion. About one-half of the wood removed from global forests is used for traditional heating and cooking and most of the rest is used by the forest products industry. Some of the carbon removed from the atmosphere in the forest is transferred into forest products where it is accumulating at a rate of almost 0.2 Gt C per year.

Table 2: The global forest carbon budget (Gt C per year)

Positive values indicate growth in carbon stocks and negative values indicate a loss of carbon stocks.

Carbon source	1990-1999	2000-2007	1990-2007
Boreal forest	0.50 ± 0.08	0.50 ± 0.08	0.50 ± 0.08
Temperate forest	0.67 ± 0.08	0.78 ± 0.09	0.72 ± 0.08
Tropical intact forest	1.33 ± 0.35	1.02 ± 0.47	1.19 ± 0.41
Total stock change in global established forests	2.50 ± 0.36	2.30 ± 0.49	2.41 ± 0.42
Tropical regrowth forest	1.57 ± 0.50	1.72 ± 0.54	1.64 ± 0.52
Tropical gross deforestation emissions	- 3.03 ± 0.49	- 2.82 ± 0.45	- 2.94 ± 0.47
Tropical land-use change emissions	- 1.46 ± 0.70	- 1.10 ± 0.70	- 1.30 ± 0.70
Global gross forest stock change	4.07 ± 0.62	4.02 ± 0.73	4.05 ± 0.67
Global net forest stock change	1.04 ± 0.79	1.20 ± 0.85	1.11 ± 0.82
Global net forest stock change, without considering growth in harvested wood products carbon pool		1.01	
Global net growth in harvested wood products carbon pool		0.189	

Source: Pan et al. 2011.

ecosystems has been increasing globally (Pan et al. 2011). The amount of carbon in global forest ecosystems is comparable to the amount in the atmosphere, estimated by the Intergovernmental Panel on Climate Change (IPCC) to be 762 Gt in the 1990s (IPCC 2007).

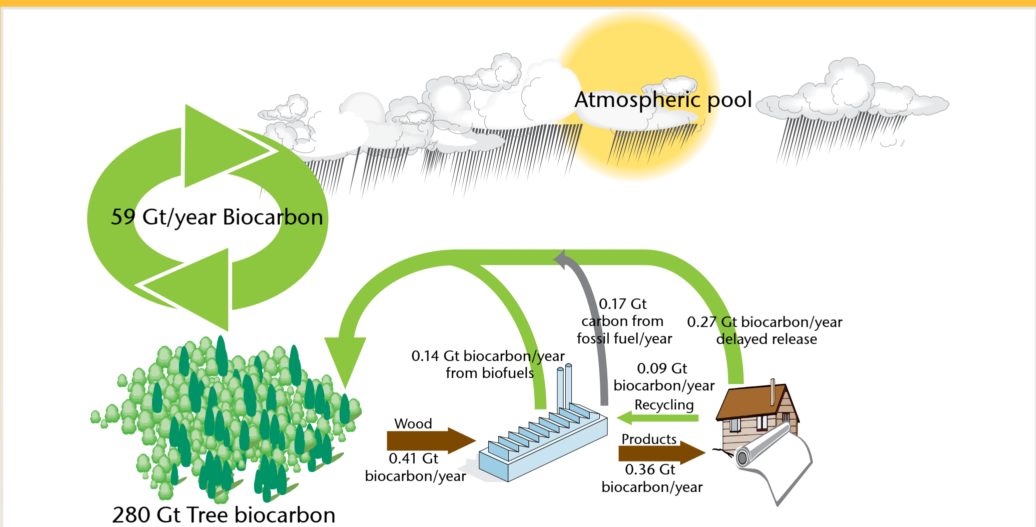
Compared to the amounts of carbon in the forest, and the amounts of carbon that cycle between the atmosphere and the forest, the amounts removed by the forest products industry in harvested wood are small. Annual harvesting of industrial roundwood removes about 0.41 Gt C per year from the world's forests, compared to global carbon stocks in forest biomass of at least 280 Gt. Industrial harvesting accounts for approximately one-half of the wood removals from the world's forests, with most of the remainder associated with wood removals for traditional heating and cooking in developing countries. Increasing the efficiency with which biomass is used for traditional heating and cooking would help extend this resource while addressing a range of health issues attributable to emissions associated with inefficient combustion (WBCSD 2011, FAO 2010a, IEA 2012 and Wilkinson et al. 2009).

At the global level, forest carbon stocks are now increasing by over 1 Gt per year, indicating that growth and expansion of forests more than compensates for the losses of carbon attributable to deforestation, natural disturbances, industrial harvesting, wood removals for traditional heating and cooking, and other phenomena (derived from data in Pan et al. 2011 and WBCSD 2011).

The carbon stored in products remains out of the atmosphere for varying lengths of time, depending on the product. In parallel to the increasing amount of carbon stored in forest ecosystems (as per the recent estimate of 1.01 Gt per year shown in Table 2), the amount of carbon stored in products is also growing, resulting in net transfers of carbon from the atmosphere into the product-carbon pool every year. The net removals of carbon from the atmosphere attributable to carbon storage in products are significant, amounting to 189 million metric tons of carbon per year (Pan et al. 2011). To put this in perspective, the direct and indirect emissions attributable to fossil fuel combustion in the global forest products industry value chain are estimated to be approximately 170 million metric tons of carbon per year (calculations based on data in FAO 2010b).

It is important to note that it is not possible to quantitatively determine the forest product industry's contribution to changes in global forest carbon stocks. Some of the industry's activities (e.g., establishing plantations on degraded pastureland) can increase forest carbon stocks while other activities (e.g., converting high-carbon density natural forests to more productive managed forests with lower carbon density) can decrease forest carbon stocks. Due to the commitment to sustainable forest management practices among forest product industry companies (discussed elsewhere in this report), it is normally assumed that the industry obtains wood using practices that allow long-term forest carbon stocks in the supply area to remain stable.

Figure 4: The forest products industry in the global carbon cycle



Source: NCASI calculations based on FAO 2010b and 2011, Beer et al. 2010 and IPCC 2003 and 2007

The carbon removed from the forest by the forest products industry represents only about 0.7% of the carbon that is recycled between the forest and the atmosphere annually, and less than 0.14% of the carbon stored in trees in the world's forests.

Energy use

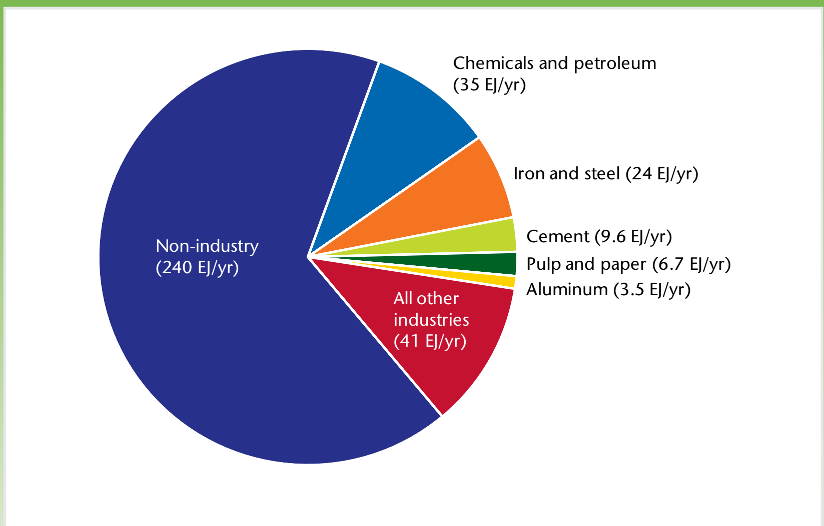
The pulp and paper sector is the fourth largest industrial sector in terms of energy use. In 2006, it consumed 6.7 exajoules (EJ) of energy, representing approximately 6% of total global industrial energy consumption and between 1.5% and 2% of total global final energy use. Approximately one-half of the energy needed by the sector is self-generated from biomass (IEA 2009).

The amount of energy required to manufacture forest products depends on many things. First, it depends on the type of product, the raw materials being used and the manufacturing processes employed. On a per-metric ton of product basis, wood products such as sawn wood and wood-based panels are generally far less energy intensive than paper and paperboard products because paper and paperboard require that wood be separated into individual fibers, an energy-intensive process. The types of energy required are also highly variable. Undried sawn wood manufacturing is reliant primarily on electrical energy while some market pulp mills are entirely reliant on biomass fuels, producing enough electricity for their own needs and excess amounts to sell. Many forest products manufacturing facilities purchase both electricity and fuel, often using the fuel to produce both steam and electricity via combined heat and power (CHP) systems.

Energy requirements can also be affected by water use because some measures that reduce water use also reduce energy consumption. The effects are usually small, however, compared to the differences between mills due to other factors. The relationship between water use and energy consumption is also dependent on climate. In temperate climates, water losses via cooling towers can be up to 8% of the total mill water use during the summer months, while in tropical climates, cooling tower water losses can reach 20% of total mill water use. The opportunities for reducing energy consumption through reduced water use are site-specific (NCASI 2009).

Energy consumption by the forest products industry represents about 1.5% to 2% of global final energy use. Approximately one-half of the energy required by the industry is supplied by biomass. The sector continues to improve its energy efficiency and already is among the leaders in the use of combined heat and power.

Figure 5: Global final energy use (total of approximately 360 EJ/yr)



Source: Data in IEA 2009.

Table 3: Example energy requirements for manufacturing forest products[§]

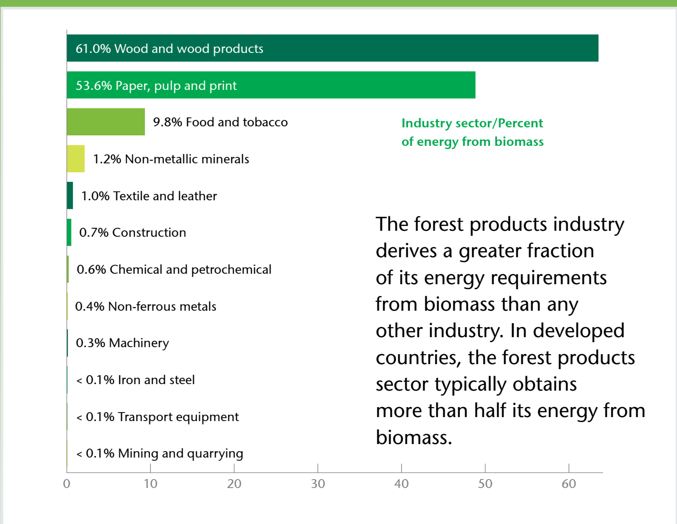
Product	Process heat energy required*	Electrical energy required*	Source
Bleached kraft market pulp	14.4 GJ/t	760 kWh/t	(IPTS 2001)
Paperboard produced at an unbleached kraft mill (includes pulp and paper production)	16.4 GJ/t	959 kWh/t	(IPTS 2001)
Uncoated fine paper produced at a bleached kraft mill (includes pulp and paper production)	17.5 GJ/t	1218 kWh/t	(IPTS 2001)
Newsprint from thermomechanical pulp (includes pulp and paper production)	5.5 GJ/t	2974 kWh/t	(IPTS 2001)
Chemi-thermo-mechanical pulp (CTMP)	2.9 GJ/t	1800 kWh/t	(IPTS 2001)
Newsprint from old newsprint	5.5 GJ/t	917 kWh/t	(IPTS 2001)
Coated fine paper from purchased market pulp	8.0 GJ/t	674 kWh/t	(IPTS 2001)
Sawn wood, not dried**	0 - 0.1 GJ/t	25 - 56 kWh/t	(NREL 2008)
Sawn wood, dried and planed**	2.8 - 3.4 GJ/t	91 - 156 kWh/t	(NREL 2008)
Plywood**	2.5 - 3.5 GJ/t	171 - 220 kWh/t	(NREL 2008)
Oriented strand board**	5.4 GJ/t	319 kWh/t	(NREL 2008)

§ These are provided only to illustrate the variability in requirements for process heat and electricity among different sectors of the industry. Energy requirements for individual mills may be significantly above or below these values depending on a range of site-specific factors.

* At most forest products manufacturing facilities, much of the process heat energy is generated from biomass, and at pulp and paper mills much of the electricity is commonly produced from biomass in on-site CHP systems.

** Process heat estimated using efficiency of 80% for natural gas combustion and 65% for biomass combustion.

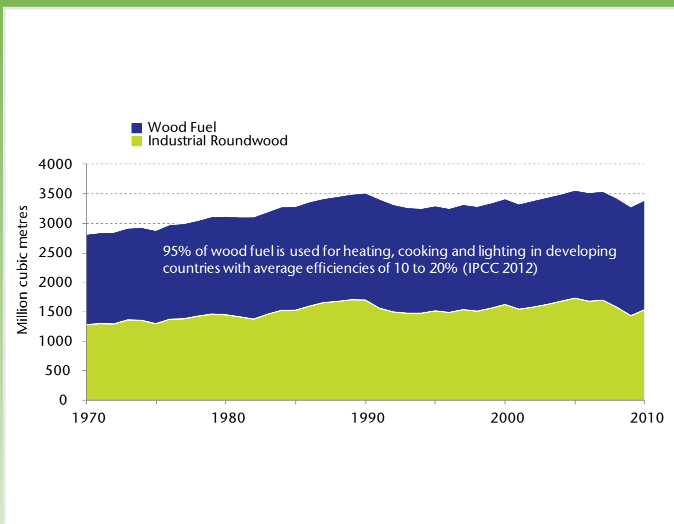
Figure 6: The forest products industry leads all industries in the use of biomass for energy[2]



Source: Based on data from Energy statistics of OECD Countries: 2008-2009, Paris, France: OECD/IEA

2. Data do not include purchased electricity

Figure 7: Wood removals from global forests



Source: Data in FAO 2012.

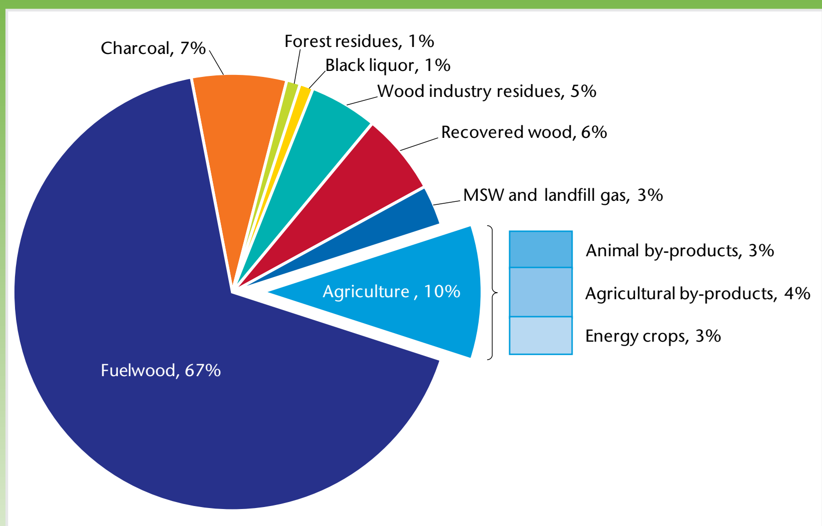
In 2008, biomass-derived energy provided about 10% (50.3 EJ/yr) of the global primary energy supply. Two-thirds of this was derived from fuel wood (wood harvested specifically for use as fuel) and 95% of fuel wood was used in developing countries for indoor heating, cooking and lighting. Forest residues, black liquor and residues from forest products operations comprised 1%, 1% and 5%, respectively, of the total biomass energy generation in 2008 (IPCC 2012).

The global pulp and paper industry has made steady progress in reducing its energy consumption, with the amounts of energy now required to produce a metric ton of paper being 10% to 20% lower than the amounts required in 1990.

The paper industry is a world leader in using combined heat and power (CHP) technology (also known as co-generation technology), which allows both heat and electricity to be generated from the same fuel. Pulp and paper mills require significant amounts of steam, making them excellent hosts for CHP systems. By using CHP systems to first produce electricity from the steam needed for pulping and papermaking, mills reduce the need to purchase electricity and sometimes generate excess electricity for sale. This, in turn, reduces societal energy consumption and greenhouse gas emissions by reducing the amounts of electricity that must be generated at electric power plants. The International Energy Agency (IEA) notes that “the food, pulp and paper, chemical, and petroleum refining sub-sectors represent more than 80% of the total electric capacities at existing CHP installations” (IEA 2007).

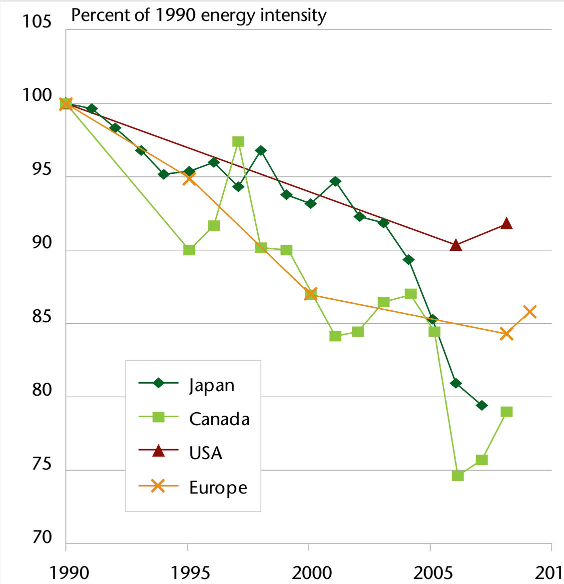
In the pulp and paper industry, most CHP systems employ biomass as fuel, allowing the industry to maximize the greenhouse gas (GHG) mitigation benefits obtained from this renewable fuel. If the pulp and paper industry purchased electricity rather than generating it in highly efficient CHP systems, emissions from the electricity sector might increase by as much as 95 million metric tons of CO_2 per year (Miner and Perez-Garcia 2007).

Figure 8: Shares of global primary biomass sources for energy



Source: IPCC 2012.

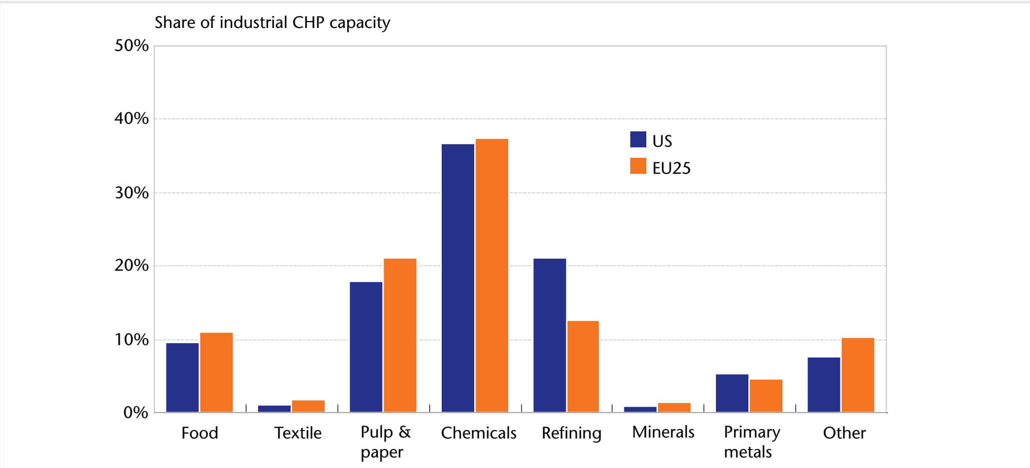
Figure 9: Progress in reducing the energy required to produce pulp, paper and paperboard



The major paper and paperboard producing regions of the world have reduced energy intensity by approximately 10 to 20 percent since 1990. Recent upturns in energy intensity are probably due to lower operating rates, attributable to the global economic slowdown. Comparisons between regions must be carried out with caution, because the 1990 energy intensity varied between countries, and different countries may use different calculation methods to determine energy intensity.

Source: Based on data from Energy statistics of OECD Countries: 2008-2009, Paris, France: OECD/IEA

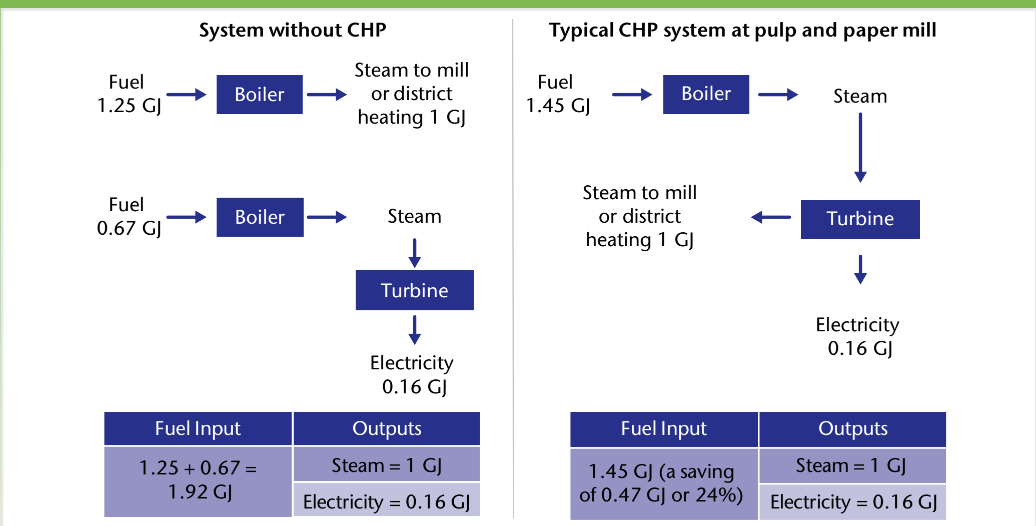
Figure 10: Distribution of CHP capacity in the European Union and the United States[3]



Source: IEA 2007.

3. Utility-owned units at industrial sites are classified as public supply, which may affect the distribution shown in the figure.

Figure 11: CHP meets society's need for electricity and steam while saving fuel



Source: Provided by NCASI

Facts and Trends 4

Greenhouse gas emissions

The World Resources Institute has estimated that Scope 1 emissions (attributable to combustion of fossil fuels at mills) and Scope 2 emissions (attributable to purchased electricity)[4] from the pulp, paper and printing sectors of the forest product industry represent about 1.1% of global greenhouse gas emissions, not including biogenic CO_2 (Baumert, Herzog and Pershing 2005). This is consistent with estimates derived from data published by FAO, which indicate that the global pulp and paper industry's Scope 1 and 2 emissions represent 0.9% percent of global greenhouse gas emissions (1.2% if the wood products sector is included) (FAO 2010b).

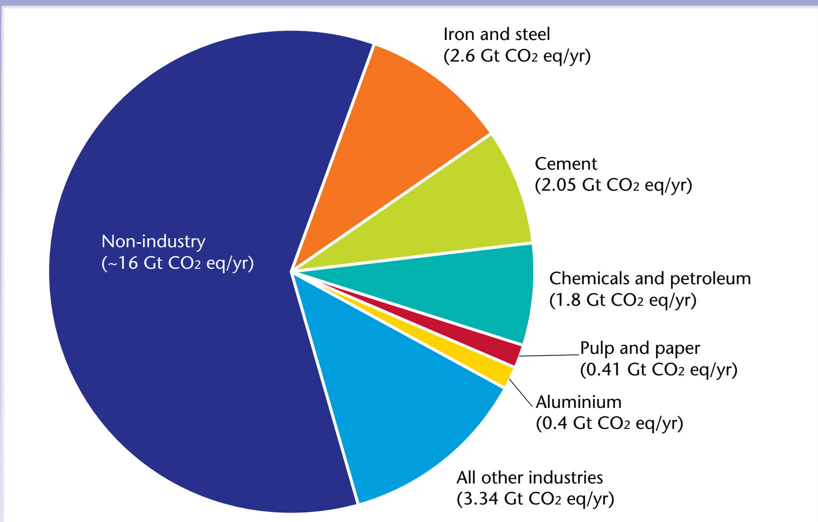
Although the pulp and paper industry accounts for approximately 5.6% of primary energy consumption by industry, it emits only about 3.9% of emissions of greenhouse gases from industrial sources estimates derived from data and figures in IEA 2009. This is primarily due to (a) the industry's reliance on biomass fuels, which emit biogenic CO_2, a gas that is not included in greenhouse gas emissions totals, (b) the use of CHP, which greatly reduces the need for purchased electricity (also discussed above), and (c) the fact that the industry has few direct emissions other than those associated with fossil fuel combustion.

Figure 13 from Herzog 2009 provides a comprehensive overview of (a) the relative importance of emissions related to energy, industrial processes, land-use change, agriculture and waste management; (b) the end-use sectors responsible for the emissions; and (c) the particular greenhouse gases involved. The pulp and paper industry, shown in the middle of the figure, contributes 1.1% of global emissions of greenhouse gases, not including biogenic CO_2, which is accounted for in the land-use change category. It should be noted, however, that the net contribution of forests to global greenhouse gas emissions is less than suggested in the figure (which is limited to activities in the tropics) because recent analysis has shown that growth in global forests more than offsets deforestation-related emissions (Pan et al. 2011).

4. Scope 1, Scope 2 and Scope 3 as defined by the Greenhouse Gas Protocol

The direct use of fossil fuels and purchased electricity by the forest products industry is responsible for approximately 1% of global greenhouse gas emissions (or approximately 2% if all emissions in the value chain are included). The annual net growth in the stocks of carbon in forest products represents removals of carbon from the atmosphere large enough to offset one-half or more of the emissions from the forest products value chain. Due to lack of data, it is not possible to quantify the net impact of the industry on forest carbon stocks.

Figure 12: Global CO_2 emissions 2006



Source: Data in IEA 2009.

Table 4: Greenhouse gas emissions from the forest products industry, in a global context (including pulp, paper and wood-products sectors)

Forest products industry emissions in 2006-2007*	Million metric tons CO_2 eq./yr	Percent of global emissions
Pulp and paper industry Scope 1 and 2 emissions including wood procurement	385	0.9%
Wood products industry Scope 1 and 2 emissions including wood procurement	124	0.3%
Forest products industry Scope 1 and 2 emissions, including wood procurement	509	1.2%
Forest products industry value chain emissions, not including carbon sequestration	890	2.0%
Removals of CO_2 eq. from the atmosphere as a result of long-term storage of carbon associated with products manufactured in 2007 to 2006§	424	
Forest products industry value chain emissions, including carbon sequestration associated with long term carbon stored in products^λ^	467	1.1%
Global greenhouse gas emissions, 2005**	44,153	100.0%
Biogenic CO_2, not included in greenhouse gas emissions totals***	~ 500	

* Derived from data in FAO 2010b. Some values may be affected by rounding.

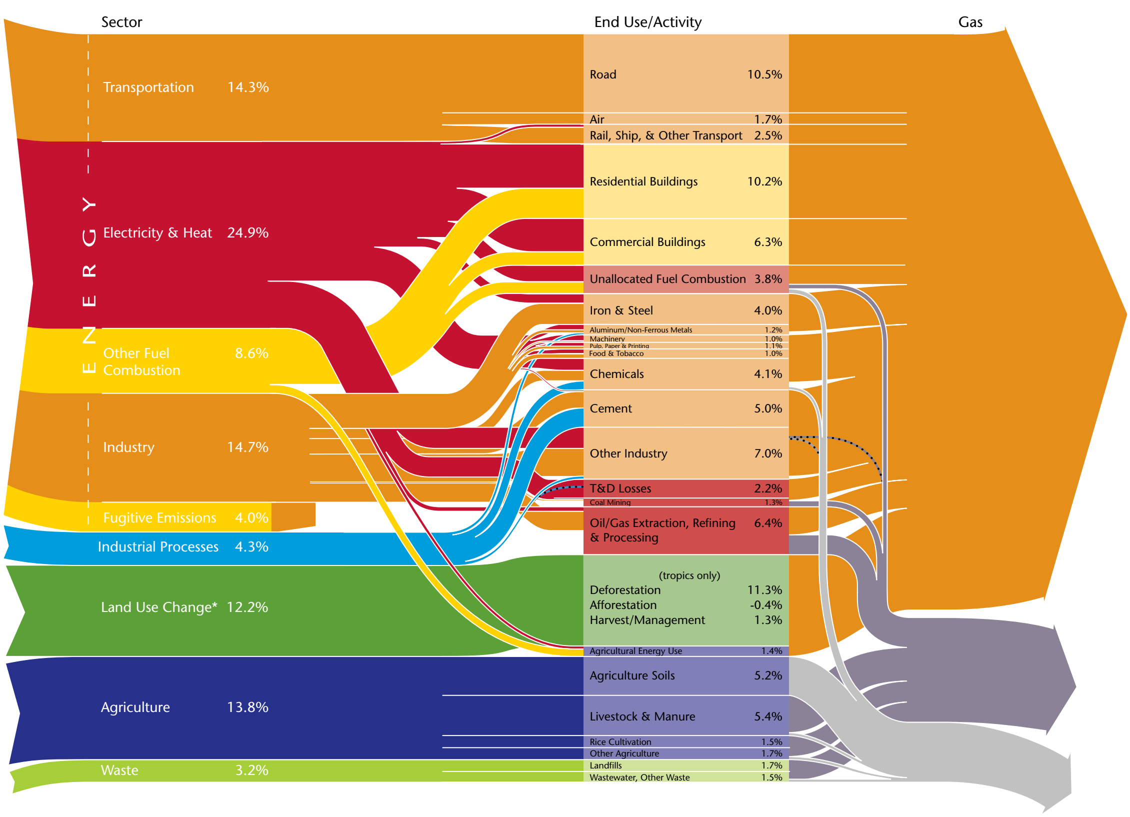
§ This value is different from the value that can be calculated from the carbon storage estimate shown in Table 2 because the two numbers reflect different measures of carbon storage. The value in Table 2 is a measure, at a given point in time, of the annual change in stocks of carbon stored in products. It represents the net current impact of products manufactured in the current year and all past years. The value in Table 4 is a measure of the storage that is predicted to occur in the long term as a result of products manufactured in a given year, in this case 2006.

λ Assumes the wood for the industry is obtained from forests where carbon stocks are stable over time; an attribute consistent with the use of sustainable forest management practices

** Herzog 2009

*** Estimated from data in FAO 2010b indicating that fossil fuel-related emissions from manufacturing are approximately 230 million metric tons of CO_2 per year and data in IEA 2011b that suggest biogenic CO_2 emissions are approximately twice fossil fuel CO_2 emissions from forest products industry facilities.

Figure 13: World greenhouse gas emissions 2005, Total: 44,153 $MtCO_2$ eq.



Sources & Notes: All data are for 2005. All calculations are based on CO_2 equivalents, using 100-year global warming potentials from the IPCC (1996), based on a total global estimate of 44,153 $MtCO_2$ equivalent. See Appendix 2 of Navigating the Numbers: Greenhouse Gas Data & International Climate Policy (WRI, 2005) for a detailed description of sector and end use/activity definitions, as well as data sources. Dotted lines represent flows of less than 0.1% percent of total GHG emissions.

* Land Use Change includes both emissions and absorptions, and is based on analysis that uses revised methodologies compared to previous versions of this chart. These data are subject to significant uncertainties.

Source: Herzog 2009.

Facts and Trends 5

Emissions along the value chain

A detailed analysis of greenhouse gas emissions and sinks from the forest products industry value chain in 2006/2007 yielded the results shown in table 5.

The FAO analysis reveals several important features of the value chain carbon footprint. One is the significance of end-of-life management for forest products, especially paper products. End-of-life management options that reduce the quantities of paper going to landfills can significantly improve this element of the footprint. Indeed, it has been estimated that the current levels of recycling are avoiding the release of approximately 300 million metric tons of CO_2 equivalents in landfill methane per year (FAO 2010b).

Another important feature of the value chain footprint made clear in the FAO report is the importance of carbon storage in products. The FAO analysis indicates that the quantities carbon destined for long-term storage in forest products manufactured in 2007 were the equivalent of removing over 424 million metric tons of CO_2 from the atmosphere. Pan et al. (2011) use a different approach to examine the carbon benefits of forest products. Instead of considering the long-term carbon storage in a single-year's production, they calculate the actual year-to-year changes in the amounts of carbon stored in forest products manufactured in the past and present. Their analysis indicates that this pool of carbon in harvested wood products is currently growing at an annual rate of 189 million metric tons of C per year, representing a net removal from the atmosphere of 693 million metric tons of CO_2 per year, a significant amount considering that the total cradle-to-grave emissions from the forest industry value chain have been estimated to be 890 million metric tons of CO_2 eq. per year (FAO 2010b).[5]

5. It is normally assumed that carbon storage in products is accomplished while maintaining stable forest carbon stocks in the supply area, an assumption consistent with both current trends in global forest carbon stocks and sustainable forest management practices. This assumption is equivalent to assuming that the net biomass carbon emissions from the forest ecosystem are zero. The question of whether this is the most appropriate way to estimate net carbon storage benefits remains a matter of debate.

Most of the emissions from the forest products value chain are associated with fossil fuel combustion (Scope 1), purchased electricity (Scope 2) and methane attributable to the decomposition of discarded forest products in landfills (Scope 3). Recycling reduces methane emissions from landfills by approximately 300 million metric tons CO_2 eq. per year. Growth in the pool of carbon in products is adequate to offset over one-half of the industry's value chain emissions.

Table 5: Estimated emissions and sequestration in the global forest products industry value chain, circa 2006/2007

Process	Emissions (million metric tons CO_2 equivalent/year)
Direct emissions from manufacturing (Scope 1)	
Fuel combustion: pulp and paper	207.0
Fuel combustion: wood products	25.6
Fuel combustion: converting	38.7
Methane from manufacturing waste	26.2
Total	**297**
Emissions associated with electricity purchase (Scope 2)	
Pulp and paper	106.0
Wood products	48.8
Converting	38.7
Total	**193**
Wood production	18.2
Upstream emissions associated with chemicals and fossil fuels	
Non-fibre inputs: pulp and paper	34.9
Non-fibre inputs: wood products	22.4
Fossil fuels: pulp and paper	30.5
Fossil fuels: wood products	4.6
Total	**92.4**
Transport	
Cradle-to-gate	21.0
Gate-to-consumer	26.7
Consumer-to-grave	3.6
Total	**51.2**
Product use	
Emissions	0.0
Effect of additions to carbon stocks in paper products in use	-20.0
Effect of additions to carbon stocks in wood products in use	-243.0
Total	**-263.0**
End-of-life	
Burning used products	3.0
Paper-derived methane	176.0
Effect of additions to carbon stocks in paper products in landfills	-67.0
Wood-derived methane	58.6
Effect of additions to carbon stocks in wood products in landfills	-93.6
Total	**77.1**

Source: FAO 2010b.

Note: Data are subject to rounding.
Total cradle-to-gate emissions = 622 million metric tons of CO_2 equivalent per year (not considering sequestration).
Total cradle-to-grave emissions = 890 million metric tons of CO_2 equivalent per year (not considering sequestration).
Value chain sequestration = net uptake of 424 metric tons of CO_2 equivalent per year, based on estimates of the accumulation of carbon stocks in product pools and an assumption that globally, regeneration and regrowth are keeping carbon stocks stable in the forests the industry relies on.
Net value chain emissions, cradle-to-grave = 467 million metric tons of CO_2 equivalent per year.

Facts and Trends 6

Understanding forests and forest carbon

Forests cover almost one-third of the world's land surface. Although global forest carbon stocks are increasing, net forest area continues to decline primarily due to continuing, albeit slowing, deforestation in the Southern Hemisphere. The area of planted forest, however, is growing rapidly. High productivity planted forests provide a large and growing share of the wood required by the forest products industry. Sustainable forest management and wood procurement certification programs continue to grow, with about one-quarter of industrial roundwood now coming from certified forests.

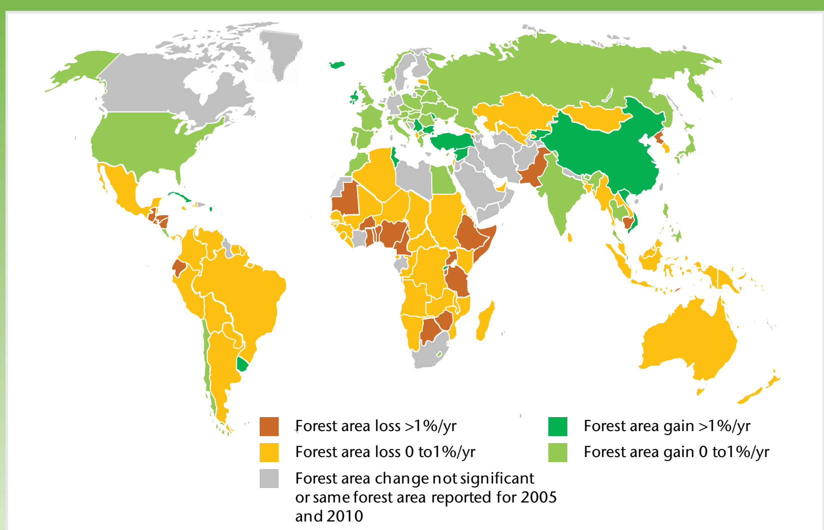
Forests cover approximately 4,000 million hectares or 31% of the world's land area. From 2000 to 2010, total forested area decreased by 5.2 million hectares (ha) per year, a significant loss but an improvement over the previous decade when 8.3 million ha of forest were lost each year. In the decade beginning in 2000, the net rate of forest lost (5.2 million ha per year) consisted of forest area losses of 13 million ha per year offset by gains in forested area (via planting or natural expansion) of 7.8 million ha per year. Forested areas are expanding in parts of Asia and North America while they continue to decline in much of the Southern Hemisphere. However, within individual countries, some regions may be losing forests while other regions are gaining forest area (FAO 2010a; Carle and Holmgren 2008).

Due to a lack of data and highly variable wood procurement practices from one nation to another, it is impossible to precisely characterize the impact of the forest products industry on forests globally. It is important to note, however, that according to FAO statistics, forest area is stable or increasing in 8 of the 10 nations producing the largest amounts of industrial roundwood globally (FAO, 2012 and FAO 2010a).

The forests of the world are highly variable, and experience a range of human influences. Primary forests, which consist of native species and show no clearly visible indications of human activity, account for 36% of the world's forested area. Planted forests comprise 7% of forested area, with the remaining 58% of the world's forests classified as "other naturally generated" forests consisting of modified natural forests, or assisted natural generation forests (FAO 2010a; Carle and Holmgren 2008).

FAO reports that in 2010, approximately one-half of global forests were managed, at least in part, for wood production. Industrial roundwood accounted for 71% of the value of all forest products in 2005 (FAO 2010a).

Figure 14: Changes in forest area 2005 to 2010[6]



Source: FAO 2010a.

6. The figure is based on percent changes in forested area instead of absolute changes in forested area in order to properly characterize the trends in regions comprised of many small countries.

Table 6: Description of forest types and characteristics

Continuum of Forest Characteristics						Non-forest
Primary	**Modified natural**	**Semi-natural**		**Plantation**		**Trees outside forests**
		Assisted natural regeneration	**Planted**	**Productive**	**Protective**	
Forest of native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed	Forest of naturally regenerated native species where there are clearly visible indications of human activities	Silvicultural practices for intensive management (weeding, fertilizing, thinning, selective logging)	Forest of native species, established through planting, seeding or coppice of planted trees	Forest of introduced species and in some cases native species, established through planting or seeding mainly for production of wood or non-wood goods	Forest of native or introduced species, established through planting or seeding mainly for provision of services	Stands smaller than 0.5 ha; trees in agricultural land (agroforestry systems, home gardens, orchards); trees in urban environments; and scattered along roads and in landscapes
			⇦ Planted forests ⇨			

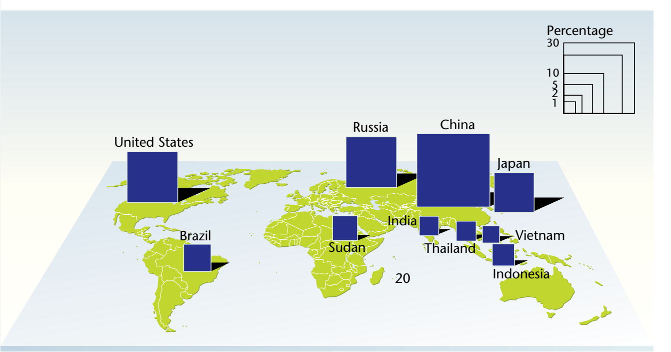
Source: Carle and Holmgren 2008.

The role of planted forests

From 2000 to 2010, planted forest area increased by about 5 million hectares per year, with much of this increase occurring in China. Three-quarters of planted forests consist of native species. Approximately three-quarters of planted forests have production of wood and non-wood products as their primary function (FAO 2010a). Although it is not known what fraction of industrial roundwood comes from planted forests, estimates in 2005 indicated that planted forests were capable of producing two-thirds of industrial roundwood (Carle and Holmgren 2008). FAO (2010a) observes that "in spite of data limitations it is evident that wood supply (particularly industrial roundwood) is shifting from natural forests to planted forests". It is estimated that 76% of planted forests have wood production as their primary function (FAO 2010a).

Because they are more productive than natural forests, planted forests allow the demand for wood to be met while using less land than would otherwise be the case. The gains in productivity that have already been accomplished in planted forests are significant. Over recent decades, for instance, the productivity of pine plantations in the Southeastern US has been increasing by 50% every twenty years (estimated from information in Rauscher and Johnsen 2004). Were it not for these improvements, the area of land needed for wood production in the US would be much larger than currently used, equal to the size of the US state of South Carolina (estimated from area data from the Southern Forest Futures Project (USFS 2012) and productivity data from Rauscher and Johnsen 2004.)

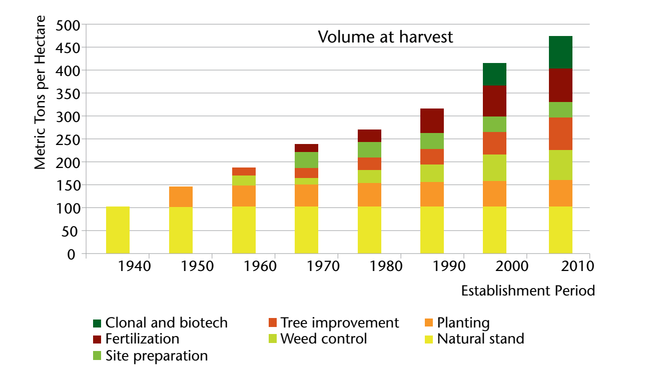
Figure 15: Countries with the largest areas of productive plantations



Source: FA Source: UNEP 2009[7]

Figure 16: Productivity gains in US southern pine plantations

The industry can help supply society by increasing amounts of sustainably produced fiber for use as a raw material and for bioenergy. The forest-based industry is finding ways to increase forest productivity, while protecting forests' environmental values. New and improved management techniques will further increase the amount of biomass that can be produced on a given area.



Source: USDA 2004.

7. Design credit to Philippe Rekacewicz assisted by Cecile Marin, Agnes Stienne, Guilio Frigieri, Riccardo Pravettoni, Laura Margueritte and Marion Lecoquierre. Available at http://www.grida.no/graphicslib/collection/vital-forest-graphics

Plantation development requires attention to issues besides wood production and carbon. Questions have been raised regarding potential impacts on soil productivity, water availability, biodiversity and pest and disease susceptibility and societal costs (e.g., see van Bodegom 2008). The ramifications of these issues vary significantly from one location to another. There is a large and growing body of research available to assist forest users in mitigating any potential impacts.

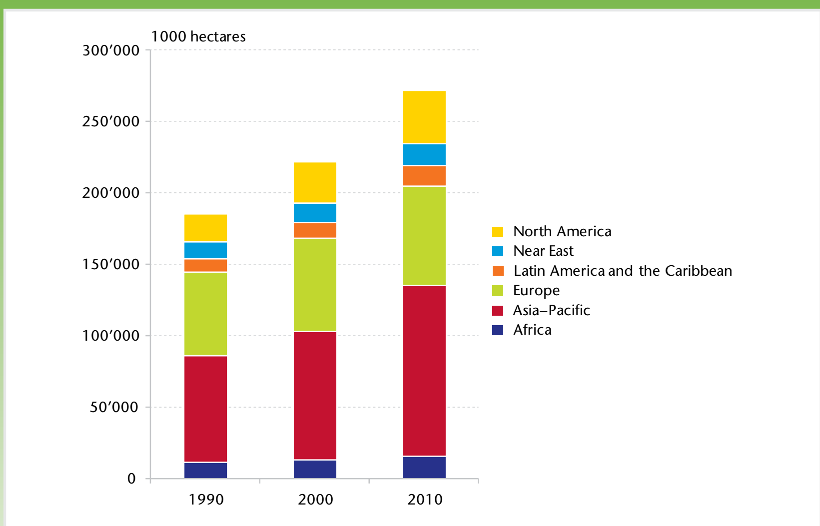
WBCSD's Vision 2050 envisions a world in which the area of planted forest has increased by 60% from current levels and the amounts of wood from planted forests have increased three-fold (WBCSD 2010). The importance of investments in increased productivity of planted forests is clear. Without the productivity improvements expected by 2050, the area of land needed for producing wood would have to be larger by an area the size of India.

Carle et al. (2008) estimate that planted forests sequester about 1.5 Gt of carbon per year, not counting carbon stored in long-lived products. This is six times the gross value chain emissions of GHGs from the global forest products industry (FAO 2010b; Carle and Holmgren 2008).

The role of sustainable forest management

Although the benefits of sustainable forest management are widely understood by the forest products industry and its customers and stakeholders, adherence to sustainable management practices has proven difficult to quantify at the global level. A recent effort by FAO to characterize the extent of use of sustainable forest management practices found that country-to-country differences in definitions made it impossible to generate regional or global totals of forest area under sustainable forest management. Nonetheless, considering the 121 countries responding to FAO's survey, encompassing 79.4% of the world's forested area, about half (52.3%) of the forest was covered by a "management plan" of some type. Ninety-four (94) of the countries were able to provide data back to 1990, and these data clearly indicate a growth in the use of forest management plans over

Figure 17: Area of planted forests



Source: Data in FAO 2011.

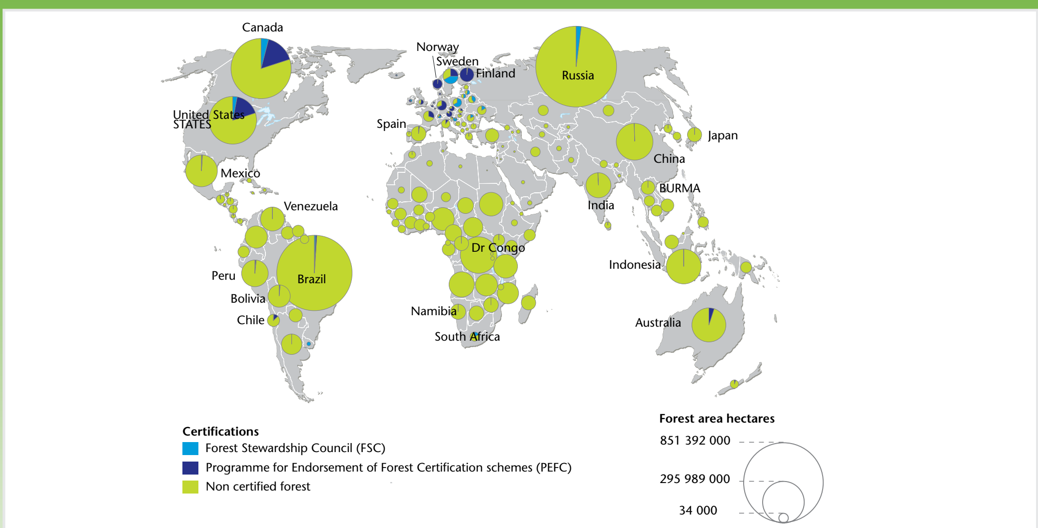
time, with the area under a management plan increasing by over 1% per year (almost 16 million ha per year) in the decade beginning in 2000 (FAO 2010a).

Forest certification rates vary by country as illustrated in figure 19. Approximately 90% of certified forest area is in developed countries (UNECE, FAO 2011).

Other studies have focused specifically on certification programs for sustainable forest management. One of these studies determined that in 2011, 375 million hectares, or over 9% of the world's forests, had been certified by independent third parties. The proportion of global industrial roundwood supply from certified forests is estimated at 25.3%. The area of certified forest is growing by about 7% per year. The largest certification program in terms of certified forest area is the Programme for the Endorsement of Forest Certification (PEFC), which includes the Sustainable Forestry Initiative (SFI), the Canadian Standards Association certification scheme and several other programs. In May 2011, PEFC covered 236 million hectares. The next largest system is the Forest Stewardship Council (FSC) certification program covering 143 million hectares (UNECE, FAO 2011). In addition, the sourcing of forest products is also covered by strict legal requirements in some countries (e.g., the European Union's Timber Regulation and the USA's Lacey Act).

Since 2007, forest product companies that are members of the WBCSD – representing nearly a third of global annual sales of forest, paper and packaging products – have agreed to "progressively and systematically introduce credible forest certification in the forests [they] own, lease or manage" (see membership principles and responsibilities).

Figure 18: The use of sustainable forestry management certification programs varies among countries



Source: UNEP 2009[8].

8. Design credit to Philippe Rekacewicz assisted by Cecile Marin, Agnes Stienne, Guilio Frigieri, Riccardo Pravettoni, Laura Margueritte and Marion Lecoquierre. Available at http://www.grida.no/graphicslib/collection/vital-forest-graphics

Facts and Trends 7

The greenhouse gas and carbon attributes of industry products

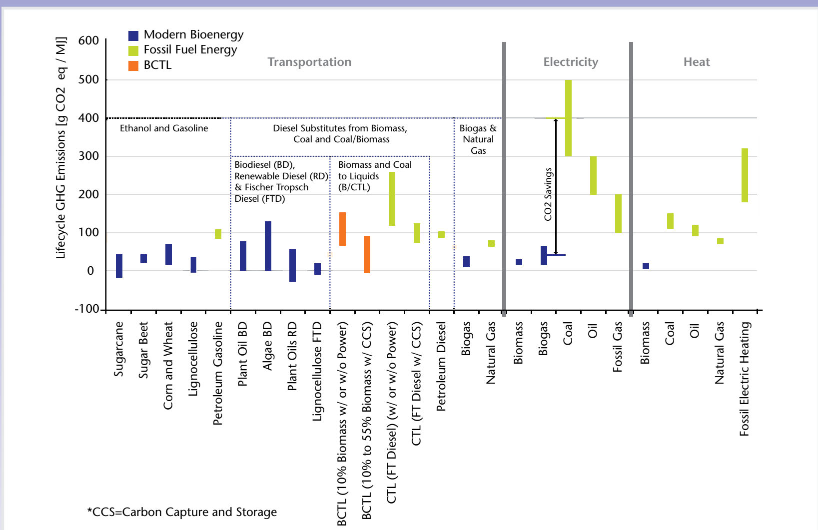
Forest products store carbon. The growth in the amounts of carbon stored in forest products represents removals of CO_2 from the atmosphere amounting to almost 700 million metric tons of CO_2 per year. Sustainable forest management practices allow this to occur without causing forest carbon stocks to decline. Forest products also reduce societal emissions of greenhouse gases when they displace more greenhouse gas-intensive products in commerce. The benefits of substituting wood-based building materials for alternative materials are especially significant. As population and standards of living increase, these carbon storage and product substitution benefits are expected to grow.

One of the benefits of wood-based products is that they store carbon. Indeed, much of the carbon in harvested wood products remains out of the atmosphere for long enough periods to benefit the atmosphere. Pan et al. (2011) have estimated that in recent years, the global pool of carbon in harvested wood products has been growing at a rate of 189 million metric tons of carbon per year, equivalent to removing 693 million metric tons of CO_2 from the atmosphere per year[9]. This has been accomplished without causing global forest carbon stocks to decline. Indeed, their analysis shows that during this same period, global forest carbon stocks have been increasing at a rate of 920 million metric tons of carbon per year. This increase is not, for the most part, due to the activities of the forest products industry but rather to the natural return and growth of forests in areas that were deforested many years ago to make room for cropland and pastures. Many of these areas are in countries in North America and Europe that also produce large industrial roundwood harvests. The fact that these forests continue to accumulate carbon reaffirms the view that the carbon storage benefits of forest products can co-exist with stable, or even increasing, forest carbon stocks.

However, the carbon and greenhouse gas benefits of forest products extend well beyond carbon storage. When used to produce fuels, sustainably produced biomass results in far lower life cycle greenhouse gas emissions than those emitted by fossil fuels. In most cases, as shown in figure 20, the life cycle greenhouse gas emissions for biomass-based fuels are much less than 100 g CO_2 eq. per MJ compared to life cycle emissions for fossil fuels of 100 to 500 g CO_2 eq. per MJ (not including stock changes due to land-use change and land management). The benefits of using biomass to produce heat and electricity are especially significant, particularly when electricity and

9. This value is different from the value shown in Table 4 because the two numbers reflect different measures of carbon storage. This value is a measure, at a given point in time, of the annual change in stocks of carbon stored in products. It represents the net current impact of products manufactured in the current year and all past years. The value in Table 4 is a measure of the storage that is predicted to occur in the long term as a result of products manufactured in a given year, in this case 2006.

Figure 19: Biomass-based energy system life cycle emissions compared to fossil fuels



Source: IPCC 2012[10].

10. Although life cycle greenhouse gas emissions from biomass-based energy systems vary, they are lower than those from fossil-fuel based systems

heat are co-generated in a CHP system, although these benefits can be reduced if transport distances are long (IPCC 2012).

Where biomass production involves land-use change, the impacts can be positive or negative. The impacts can be positive where the land-use change results in higher carbon stocks on the land (e.g., converting degraded grassland to managed forest). In other cases, however, where carbon stocks are reduced in order to produce biomass (e.g., converting land from forest to annual energy crop production), the benefits of using biomass are delayed, resulting in a "carbon payback time" ranging from a few years to centuries, depending on type of changes involved.

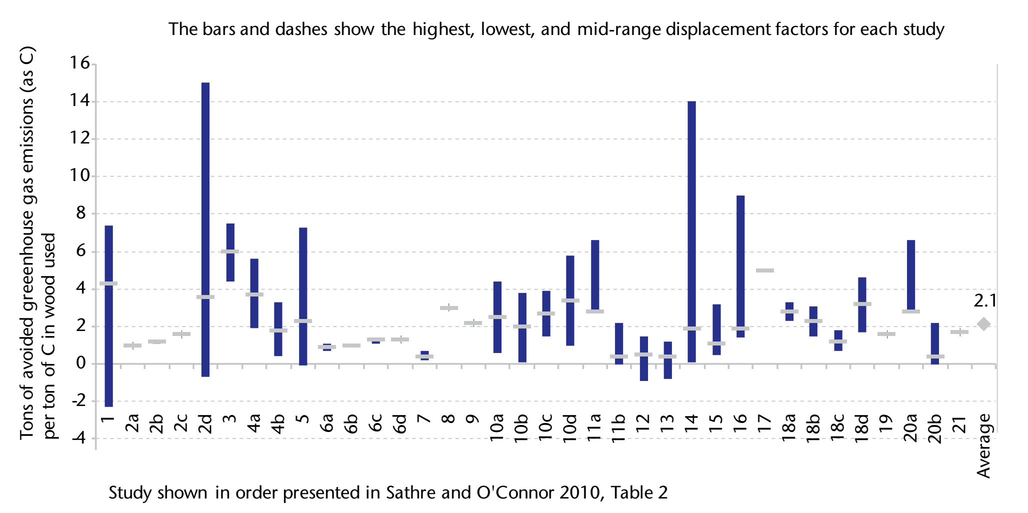
Additional carbon benefits could be obtained from the biomass in forest products if, after recycling, the non-recyclable fiber were not disposed of, but rather used to produce biomass energy. For example, if products made in 2007 are burned as a source of biomass energy to displace natural gas instead of being sent to landfills, the expected global benefit would be a reduction in greenhouse gas emissions of 135 million metric tons of CO_2 equivalent per year (FAO 2010b).

The greenhouse gas and carbon attributes of wood-based construction materials are also noteworthy. Wood as a material has an inherent low-carbon intensity because the energy required for its creation is supplied by the sun. In almost all cases, the long-term benefits of sustainably growing, harvesting and using wood for construction are much greater than the benefits that would have accrued if the wood had been left in the forest.

Sathre and O'Connor (2010) recently reviewed 48 North American and European studies of the substitution effects associated with using wood-based building materials instead of alternatives. The results of the review are presented in figure 21, with each study presented in terms of the life cycle greenhouse gas reduction accomplished using wood, expressed as metric tons of avoided carbon emissions per metric ton of carbon in wood used. This review, which included studies using a range of accounting approaches for biomass carbon, suggests that for each metric ton of carbon in wood products substituted for non-wood products, an average greenhouse gas emission reduction (shown at the right of the figure) of approximately 2 metric tons of carbon can be expected. Using this factor, it has been estimated that the wood used in home construction globally in 2007 avoided emissions of 483 million metric tons CO_2 equivalents by displacing more greenhouse gas-intensive construction materials (FAO 2010b).

An example of these studies is the work by Gustavsson and Sathre (2006). In that study, the authors examined the changes in energy and CO_2 balances caused by variation of key parameters in the manufacture and use of the materials for a wood- and a concrete-framed 4-story apartment building containing 16 apartments. The results indicated that materials of the wood-framed building had lower energy and CO_2 balances than those of the concrete-framed building in all cases but one, involving the worst-case combination of parameters for the wood-frame building. Although "the precise values of the energy and CO_2 balances of building materials depend upon many factors," the authors conclude "that the use of wood construction material will, in general, result in lower energy and CO_2 balances then when concrete is used."

Figure 20: Displacement ratios from 21 studies comparing wood-based building materials to alternatives[11]



Source: Data in Sathre and O'Connor 2010.

11. Data shown as metric tons of avoided GHG emissions (as carbon) per metric ton of carbon in wood products in applications where other materials could have been used.

Additional information

A large and persistent carbon sink in the world's forests

About the authors Pan et al. (2011)

The authors of "A large and persistent carbon sink in the world's forests," represent a group of 18 outstanding scientists from Canada, China, Finland, France, Spain, Ukraine, the United Kingdom and United States. Led by Yude Pan from the US Department of Agriculture Forest Services, their research is highly interdisciplinary and covers numerous focus areas such as: Environmental science and policy, climate change, terrestrial ecology, ecosystem services, biodiversity, forest and watershed management, land-use change, evolutionary biology, biological and agricultural engineering, forest carbon budget, carbon cycle sciences and carbon sequestration. Out of this distinguished group of scientists, most have contributed to the reports of the Intergovernmental Panel on Climate Change (IPCC) and/or the Millennium Ecosystem Assessment.

Conversion factors

Energy

1 GJ = 0.9478 Million BTUs , where GJ is gigajoule and BTU is British thermal unit
1 Million BTUs = 1.0546 GJ
1000 MJ = 1 GJ, where MJ is megajoule
1,000 GJ = 1 TJ, where TJ is terajoule
1,000,000 GJ = 1 PJ, where PJ is petajoule
1,000,000,000 GJ = 1 EJ, where EJ is exajoule
1 GJ = 277.8 kWh, where kWh is kilo watt hour

Mass

1 metric ton = 1.10231 short ton
1 petagram (Pg) = 1,000,000,000 metric tons
1 Gt = 1,000,000,000 metric ton

Area

1 hectare (ha) = 2.471 acres

The Forest Solutions Group's Membership Principles and Responsibilities

As evidence of our ongoing commitment to sustainable development and balancing our efforts between economic growth, ecological responsibility and social progress, members of the Forest Solutions Group will, in accordance with the following principles (agreed in March 2007):

1 Management and Governance

1. Apply corporate policies and procedures to meet all applicable legal requirements and other company commitments, including these membership principles and responsibilities.
2. Seek cost-effective opportunities to continuously improve and be industry leaders in sustainable development.
3. Work against corruption and illegal practices, in all their forms.

2 Resource Management

1. Use sustainable forest management in forests we own, lease or manage to provide fiber, timber and other forest products and valuable ecosystems services.
2. Seek to conserve important biodiversity and cultural values and to optimize the social, environmental and economic benefits of managed forests.
3. Respect the lawful access and tenure rights of indigenous peoples and other community members directly affected by our forestry operations. Proactively seek to resolve any potential land disputes through dialogue, independent arbitration or the legal system.
4. Recognize as credible forest certification systems that are based on third party verification, independent accreditation, good governance and transparency, and support efforts to expand their use.
5. Progressively and systematically introduce credible forest certification in the forests we own, lease or manage.

3 Fiber Sourcing

1. Manage supply chains to obtain purchased fiber from acceptable sources, using contract requirements and education and outreach programs, as appropriate to the nature and scale of the fiber supply activities.
2. Ensure legal ownership of all fiber and wood utilized and comply with all applicable laws in forestry operations.
3. Introduce credible, independently certified wood-tracing systems where needed to address significant risks.

4 Eco-efficiency and Emissions Reduction

1. Promote efficiency and innovation in the use of key resources (raw materials, water, energy and chemicals) and foster continuous improvement based on setting and reporting on appropriate reduction targets.
2. Promote the use of new and innovative technologies whenever economically and environmentally feasible.
3. Promote the recyclability and recovery of forest products and the appropriate reuse of materials.

5 Climate Change Mitigation

1. Improve energy efficiency and the use of renewable energy whenever economically and environmentally feasible.
2. Track and report on carbon dioxide (CO_2) emissions and progress on managing the reduction of greenhouse gas (GHG) emissions.
3. Promote sustainable forest management, including afforestation and reforestation, and the use of forest products as important climate mitigation strategies.

6 Health and Safety

1. Strive for continuous improvement in occupational health and safety and report accidents and injuries in the workplace.

7 Community Well-being & Stakeholder Engagement

1. Contribute to economic health, employment and community service in the communities in which we operate.
2. Engage in, listen to and respond to local sustainability expectations and concerns related to our operations.
3. Cooperate with other organizations, governments and stakeholders to promote and develop sustainability in the forest products industry, including sharing best practices and lessons learned.

8 Human Rights and Labor Standards

1. Respect all national laws for human rights and labor standards and, where these are lacking, use internationally agreed standards.

9 Reporting

1. Publish a periodic report reflecting progress on these principles and responsibilities according to international reporting standards.

References

Baumert, K., Herzog, T., and Pershing, J. *Navigating the Numbers: Greenhouse Gas Data and International Climate Policy* (data updated in 2012). Washington DC: World Resources Institute, 2005.

Beer, C., Reichstein, M., Tomelleri, E., Ciais, P., Jung, M., Carvalhais, N., Rödenbeck, C. , Arain, M.A., Baldocchi, D., Bonan, G.B., Bondeau, A., Cescatti, A., Lasslop, G., Lindroth, A., Lomas, M., Luyssaert, S., Margolis, H., Oleson, K.W., Roupsard, O., Veenendaal, E., Viory, N., Williams, C., Woodward, F.I. and Papake, D. "Terrestrial Gross Carbon Dioxide Uptake: Global Distribution and Covariation with Climate". Science, Vol. 329, August 2010: 834-838.

Carle, J. and Holmgren, P. "Wood from planted forests: A global outlook 2005-2030". *Forest Products Journal* , Vol. 58, 2008: 6-18.

Food and Agriculture Organization of the United Nations (FAO). FAOStat, 2012. http://faostat.fao.org (accessed March 2012).

Food and Agriculture Organization of the United Nations (FAO). *Global Forest Resource Assessment 2005*. Rome: Food and Agriculture Organization of the United Nations, 2005.

Food and Agriculture Organization of the United Nations (FAO). *Global Forest Resources Assessment 2010.* Rome: Food and Agriculture Organization of the United Nations, 2010a.

Food and Agriculture Organization of the United Nations (FAO). Impact of the global forest industry on atmospheric greenhouse gases. FAO Forestry Paper 159. Rome: Food and Agriculture Organization of the United Nations, 2010b.

Food and Agriculture Organization of the United Nations (FAO). *State of the World's Forests.* Rome: Food and Agriculture Organization of the United Nations, 2011.

Gustavsson, L. and Sathre, R. "Variability in energy and carbon dioxide balances of wood and concrete building materials". *Building and Environment,* Vol. 41, 2006: 940-951.

Herzog, T. *World Greenhouse Gas Emissions in 2005.* WRI Working Paper. World Resources Institute, 2009. Available online at http://pdf.wri.org/working_papers/world_greenhouse_gas_emissions_2005.pdf.

International Council of Forest and Paper Associations (ICFPA). 2011 ICFPA Sustainability Progress Report. International Council of Forest and Paper Associations, 2011.

International Energy Agency (IEA). *Co-generation and Renewables: Solutions for a low-carbon energy future.* Rome: International Energy Agency, 2011a.

International Energy Agency (IEA). *Energy Statistics of OECD Countries.* Paris: International Energy Agency, 2011b.

International Energy Agency (IEA). *Energy Technology Transitions for Industry.* Rome: International Energy Agency, 2009.

International Energy Agency (IEA). *Technology Roadmap: Bioenergy for Heat and Power.* Paris: International Energy Agency, 2012.

International Energy Agency (IEA). *Tracking Industrial Energy Efficiency and CO_2 Emissions.* Paris: International Energy Agency, 2007.

Ince, P., Kramp, A.D. , Skog, K.E. , Yoo, D. V., Sample, A. "Modeling future U.S. forest sector market and trade impacts of expansion in wood energy consumption". *Journal of Forest Economics*, Vol. 17, 2011: 142-156.

Intergovernmental Panel on Climate Change (IPCC). Good *Practice Guidance for Land Use, Land Use Change and Forestry.* Published by the Institute for Global Environmental Strategies for the IPCC. Hayama, Kanagawa, Japan, 2003.

Intergovernmental Panel on Climate Change (IPCC). *IPCC Fourth Assessment Report,* WG1, Chapter 7. Cambridge: Cambridge University Press, 2007.

Intergovernmental Panel on Climate Change (IPCC). *Renewable Energy Sources and Climate Change Mitigation.* Cambridge: Cambridge University Press, 2012.

Institute for Prospective Technological Studies (IPTS). *Integrated Pollution Prevention and Control Reference Document on Best Available Techniques in the Pulp and Paper Industry.* Seville: European Commission Joint Research Centre, 2001.

Mantau, U., Saal, U., Prins, K., Steierer, F., Lindner, M., Verkerk, H., Eggers, J., Leek, N., Olderburger, J., Asikainen, A., and Anttila, P. *EUwood - Real potential for changes in growth and use of EU forests.* Hamburg: EUwood, 2010.

Miner, R. and Perez-Garcia, J. "The Greenhouse gas and carbon profile of the global forest products industry". *Forest Products Journal,* Vol. 57, 2007: 81-90.

National Council for Air and Stream Improvement (NCASI). *Effects of decreased water use.* 2009. http://www.paperenvironment.org/PDF/water/Water_Full_Text.pdf (accessed March 2012).

National Renewable Energy Laboratory (NREL). "U.S. LCI Database, updated 2010". U.S. Department of Energy National Renewable Energy Laboratory, 2008.

OECD/IEA. *Energy Statistics for OECD Countries.* Paris: OECD, 2010.

Pan, Y., Birdsey, R.A., Fang, J., Houghton, R., Kauppi, P.E., Kurz, W.A., Phillips, O.L., Shvidenko, A., Lewis, S.L., Canadell, J.G., Ciais, P., Jackson, R.B., Pacala, S.W., McGuire, A.D., Piao, S., Rautiainen, A., Sitch, S. and Hayes, D. "A Large and Persistent Carbon Sink in the World's Forests". *Science* Vol. 333, 2011: 988-993.

Rauscher, H. M. and Johnsen, K. *Southern Forest Science: Past, Present and Future* - Southern Research Station General Technical Report SRS-75. Asheville, NC: U.S. Forest Service Southern Research Station, 2004.

Sathre, R. and O'Connor, J. *A synthesis of research on wood products and greenhouse gas impacts* - 2nd edition. Vancouver BC: FPInnovations, 2010.

United Nations Economic Commission for Europe (UNECE), Food and Agriculture Organization of the United Nations (FAO). *Forest Products Annual Market Review 2010-2011.* Geneva: United Nations Economic Commission for Europe, Forestry and Timber Section, 2011.

United Nations Environment Programme (UNEP), Food and Agriculture Organization of the United Nations (FAO), United Nations Forum on Forests (UNFF). "Vital Forest Graphics". 2009.

United States Department of Agriculture (USDA) Forest Service, Southern Research Station. *General Technical Report 75.* October 2004.

United States Forest Service (USFS). Southern Forest Futures Project. 2012. http://www.srs.fs.usda.gov/futures (accessed April 2012).

van Bodegom, A.J., van de Berg, J. and van der Meer, P. *Forest Plantations for Sustainable Production in the Tropics: Key Issues for Decisions-Makers.* Wageningen, Netherlands: Wageningen University and Research Center, 2008.

World Business Council for Sustainable Development (WBCSD). *Changing Pace: Public Policy Options to Scale and Accelerate Business Action Towards Vision 2050.* Geneva: World Business Council for Sustainable Development, 2012.

World Business Council for Sustainable Development (WBCSD). *The Sustainable Forest Products Industry: Carbon and Climate Change - Key Messages for Policy Makers* (third edition). Geneva: World Business Council for Sustainable Development, 2011.

World Business Council for Sustainable Development (WBCSD). *Vision 2050: The new agenda for business.* Geneva: World Business Council for Sustainable Development, 2010.

Wilkinson, P., Smith, K.R., Davies, M., Adair, H., Armstrong, B.G., Barrett, M., Bruce, N., Haines, A., Hamilton, I., Oreszczyn, T., Ridley, I., Tonne, C., Chalabi, Z. "Public Health Benefits of Strategies to Reduce Greenhouse-Gas Emissions: Household Energy". Lancet 374, December 2009: 1917-1929.

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The National Council for Air and Stream Improvement (NCASI) is an independent, non-profit research institute that focuses on environmental topics of interest to the forest products industry. Established in 1943, NCASI is recognized as a leading source of technical and scientific information on environmental issues affecting this industry. Although NCASI receives most of its funding from forest products companies, it also receives funding from government agencies, associations and other organizations interested in better understanding the connections between the forest products industry and the environment.
For more information visit www.ncasi.org

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