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GENEVA TIMBER AND FOREST DISCUSSION PAPER 58

SWEDISH FOREST SECTOR OUTLOOK STUDY

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SWEDISH FOREST SECTOR OUTLOOK STUDY

By

Ragnar Jonsson, Gustaf Egnell

and

Anders Baudin

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Note

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Abstract

In this study, international trends and major drivers of change for forest resources and wood use are reviewed and, together with projections of future developments in the use and supply of wood resources as well as wood-product market developments in Europe for the period 2010 to 2030, analysed as to their impact on the Swedish forest sector. Demand is foreseen to vastly exceed the potential supply of woody biomass in Europe, putting a tremendous pressure on the Swedish forest resource and possibly necessitating trade-offs between different ecosystem services.

Keywords

Bioenergy, biomass, carbon sequestration, climate change, consumption, demand, econometric, EFSOS, Europe, Euwood, export, fellings, forest products, forest resources, future, GDP, globalization, import, increment, IPCC, markets , policy, pulp and paper, roundwood, sawnwood, supply, sustainable , Sweden, wood energy, wood resource balance.

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Preface

Studies reviewing the outlook for the forest and forest products sector in Europe have been produced by the UNECE/FAO Forestry and Timber Section since 1953. The most recent example being the European Forest Sector Outlook Study II (EFSOS II) published in 2011.

This Discussion Paper is based on tributary research into EFSOS II and contained a wealth of valuable analysis which was reflected in a summarized and aggregated state in that study. Thus, this report provides further insight into the increasing role of the forest in servicing the needs of society out into the future, both for Sweden and for Europe. Sweden with its long history of thoughtful forest planning and management has insightful experience to share in this regard.

These results will assist decision makers foresee the implications of policies favouring wood-energy, analysts develop better strategies for forest sector investment, and forest economists to reach a deeper understanding of the linkages across nations and forest industries.

This study is emblematic in that it represents the application of the methodology of the European Forest Sector Outlook Study II to a national context. I would like to invite other member States to follow this example and carry out similar studies for their national forest sector.

The principal authors of this study are Ragnar Jonsson, Future Forests and Gustaf Egnell, Swedish Energy Agency. The study also benefited from the helpful input of Anders Baudin, from Växjö University. The secretariat wishes to express its profound appreciation of the contribution made by all experts, their colleagues and their organisations, to the increasingly relevant task of analysing the outlook for the forest and forest products sector.

Andrey Vasilyev
Officer-in-Charge
United Nations Economic Commission for Europe

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Abbreviations

CEEC Central and Eastern Europe
CBD Convention on Biological Diversity
CIS Commonwealth of Independent States
EFISCEN European Forest Information Scenario model
EFTA European Free Trade Association
EU European Union
EU27 The twenty-seven member states of the EU
FAO Food and Agriculture Organisation of the United Nations
GDP Gross Domestic Product
GIEC Gross inland energy consumption
ICT Information and communication technology
IEA International Energy Agency
IEE Intelligent Energy Europe
IWR Industrial wood residues
JWEE Joint Wood Energy Enquiry
MCPFE Ministerial Conference on the Protection of Forests in Europe
MDF Medium density fibreboard
NAI Net annual increment
PCW Post-consumer wood
RES Renewable Energy Sources
RES Directive EU Directive on the promotion of the use of energy from renewable sources
SEK Swedish krona
UNECE Unites Nations Economic Commission for Europe
UNFCCC United Nations Framework Convention on Climate Change
WRB Wood Resource Balance

Units and prefixes

G Giga (10^9)
J Joule
P Peta (10^{15})
m^3 cubic metre
Mtoe Million Tonnes Oil Equivalent
Odt Oven dry tonnes
SWE Solid wood equivalent

Abbreviations of the Wood Resource Balance

ME Medium – refers to medium mobilisation scenario
C Coniferous - softwood
NC Non-coniferous - hardwood

Country codes – International Organization for Standardization

AT Austria
BE Belgium
BG Bulgaria
CY Cyprus
CZ Czech Republic
DK Denmark
DE Germany
EE Estonia
ES Spain
FI Finland
FR France
GR Greece
HU Hungary
IE Ireland
IT Italy
LT Lithuania
LU Luxembourg
LV Latvia
MT Malta
NL Netherlands
PL Poland
PT Portugal
RO Romania
SI Slovenia
SK Slovakia
SE Sweden
UK (GB) United Kingdom (Great Britain)

Summary

This study reviews international trends and major drivers of change for forest resources and wood use. It also analyses the impact of these on the Swedish forest sector, as well as that of projected future developments in the use and supply of wood resources and wood-product market developments in Europe produced within the *European Forest Sector Outlook Study* (EFSOS) II and EUwood projects.

The report is the result of cooperation between the Swedish research programme *Future Forests* (www.futureforests.se), the United Nations Economic Commission for Europe (UNECE) and Food and Agriculture Organization of the United Nations (FAO), the European Forest Institute, Hamburg University, and several other organizations involved in the EFSOS II and EUwood projects.

The EFSOS II project is carried out under the auspices of UNECE and FAO. Its objective is to provide policymakers with information and analysis on long-term trends and projections for the forest sector. Much of the analysis focuses on the markets for wood products, but forest resources; policies affecting the forest sector; non-wood forest products and forest services are also subjects to analysis.

One of the imminent challenges facing Sweden's and Europe's forest sector is to meet the expected increasing demand for wood raw materials resulting from the promotion of renewable energy sources (see, for example, European Parliament, 2009). Therefore, the objective of the EUwood project, which is being carried out for the European Commission and financed by the Intelligent Energy Europe (IEE) programme, is to provide estimations of the real potential in the use of forests and wood to meet this demand.

When producing the quantitative scenarios for wood-product markets in EUwood and EFSOS II, the downscaled gross domestic product (GDP) projections from the Inter-governmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES) A1 and B2 scenarios were used (source: CIESIN, 2002) to make projections of production, consumption and trade from year 2010 to year 2030.

The A1 scenario describes a highly globalized world with rapid economic and technological development and very limited environmental consciousness. The B2 scenario presents almost the opposite, i.e. a regionalized world with slower economic growth and technological development than in the A1 scenario and pronounced environmental awareness.

The EUwood project and EFSOS scenarios for wood energy use in the EU27 assume that energy efficiency will increase according to the EU RES Directive (20 percent), that the country-specific targets for the share of energy from renewable sources set out in the Directive will be reached, and that the share of wood in renewable energy in the EU27 will decrease to 40 percent from the current 50 percent.

Trends in forest area, growing stock and the relation between net annual increment (NAI) and fellings suggest that forest management in Sweden and the rest of Europe has been sustainable in the strict sense of wood supply. However, the actual volume available for sustainable harvesting is reduced due to, for example, harvest losses and unregistered fellings. This should be taken into consideration when assessing the possibility of increasing the supply of woody biomass, especially in countries like Sweden, already harvesting a substantial share of the NAI. The potential forest biomass supply from forest estimated within the EUwood project is rather stable over time, though it varies between mobilisation scenarios.

Global demand for wood products is expected to continue to grow, mainly in China, India and other developing countries in line with the growth in population and income. In Europe, a

declining and ageing population and slower economic growth (partly resulting from the former two) do not support rapid growth in the demand for wood products. The ageing population also entails a shrinking workforce, accelerating technical progress in the construction industry. Hence, it is vital for the future prosperity of the Swedish forest-products industry to increase its presence in the high growth markets and to speed up technological progress.

Globalization, should it continue, is expected to increasingly shift consumption as well as production of mainly pulp and paper to the southern hemisphere, adversely affecting employment and forest owners (through decreased demand for pulpwood) in Sweden and other European countries. The pulp and paper industry is also foreseen to be affected by the continued expansion of electronic information and communication technology (ICT) through a significantly reduced demand for newsprint and printing and writing paper. However, the demand for woody biomass from the bioenergy sector in the EU, should the targets of the EU RES directive be fulfilled, could more than compensate for shrinking demand for pulpwood, as implied by the EUwood estimations.

As well as being adversely affected through increased competition and resulting rising prices for raw materials, the pulp and paper industry could benefit from the development of the bioenergy sector. Chemical pulp producers could manufacture new, high-value products in integrated bio-refineries. Mechanical pulp producers cannot do this, however, and will thus only suffer from the higher prices for raw materials and electricity.

Overall, the future looks brighter for the Swedish sawmill industry than for pulp and paper, provided it sheds its commodity orientation and increases the value-added by accommodating the growing demand for factory-made, energy-efficient construction components, as expressed by *Green Building,* for instance. Also, the Swedish solid wood-product industry is not facing the same direct threat from globalization as the pulp and paper industry, since the expansion in the southern hemisphere is focused on pulp and paper production.

The development of prominent bioenergy markets should mainly benefit the sawmill industry, by obtaining higher prices for co-products with limited competition from bioenergy markets for raw materials. The sawmill industry is also very important for the mobilisation of small sized stemwood and forest residues. In the future, integrated production units producing construction components, as well as bio-fuel, bioplastics and food ingredients, are conceivable. The wood-based panel industry, on the other hand, already of marginal importance in Sweden, would suffer from intense competition for all its raw materials from the bioenergy sector.

The projections of the econometric models are mostly in line with what can be expected, considering the conclusions that can be drawn from the review of drivers of change in global wood-product markets and the reference future storylines. Consumption of all wood products in Europe is increasing in both of the reference futures, but the rate of growth is, of course, considerably higher in the A1 than in the B2 reference future.

In the B2 reference future, production and consumption growth rates are slowing down over the outlook period, with the exception of sawnwood. The slowing down of consumption is most pronounced for paper products and wood pulp (mechanical pulp in particular), an outcome consistent with a future characterized by heightened environmental concern and thus higher demand for bioenergy and renewable construction materials (see above). In A1, in contrast to the B2 reference future, production and consumption growth rates are increasing for all wood products over the outlook period, with the exception of paper and paperboard.

The slowing down of growth in paper and paperboard production and consumption in the A1 reference future could mainly be understood in the light of progress in ICT. The circumstance that production and consumption of paper is projected to continue to grow in both reference futures, though one could expect a decline in the consumption of newsprint, is a consequence of the absence of a clear declining trend in the historic data as of yet, and estimated income (GDP) elasticities used in the projections are therefore in general positive.

Projections of the structural development of paper consumption in EU and EFTA indicate that newsprint will lose consumption share (of total projected paper consumption) in both reference futures. Printing and writing paper will essentially keep its position, whereas other paper and paperboard will gain consumption shares. This will be in line with the expected impact of progress in electronic ICT on newsprint and printing and writing paper consumption and the expected better prospects for the board and packaging segment of the paper industry.

The composition of the Swedish paper production in the two reference futures follows the projected evolution of consumption in EU/EFTA, suggesting that the Swedish pulp and paper industry is set to adapt to the changing demand patterns resulting from the progress in electronic ICT.

The results from the EUwood projections imply that the wood resources at EU27 level will not suffice to satisfy the demand for wood raw materials by 2030, should the EU RES Directive be realized and given the assumption of a slightly decreasing role for wood-based energy, even if wood production in existing forests is greatly intensified, i.e. in the high mobilization scenario.

Though Sweden most likely could manage to live up to the national RES targets on its own accord, and even considering a potentially decreasing demand for pulpwood resulting from globalization and progress in electronic ICT, the shortage of wood resources relative demand at EU27 level foreseen by the EUwood project would create tremendous demand pressure on Sweden.

Forest owners here and in the rest of the EU stand to gain from an increasing demand and resulting higher prices for woody biomass. However, a number of trade-offs between different needs and interests related to the Swedish forest sector will need to be made. Hence, there is a potential conflict of interest between prioritizing the export revenues generated by the forests-product industry on the one hand and the demand for domestic energy sources on the other. How this potential conflict is resolved largely depends on whether the forest sector or the energy sector will control the future development of bioenergy.

An elevated harvest level and ensuing intensified forest management (e.g. shortened rotation periods and intensified fertilization) in Sweden could compromise non-wood ecosystem services such as biodiversity, water quality, recreation, and carbon sequestration. In particular, the general consideration for biodiversity on all productive forest land, a trait of Swedish forest policy, could be at risk, possibly to be replaced by zoning, i.e. the separation of forest ecosystem services over the forest area so that in some parts management is focused on timber production whereas non-wood ecosystem services are focused on in other parts.

1 Introduction

1.1 Background

Several aspects make decision-making in the forest sector subject to uncertainty. Forestry cannot be isolated from its environment; the sector is shaped by many factors of a political and economic nature that are largely beyond its control. We have to understand the linkages to the environment to be prepared for both external impacts to the sector and the consequences of developments originating within the sector itself.

With international trade in wood products increasing and forest-product companies being multinational an international dimension has been introduced to an industry that has traditionally relied mainly on natural resources and local structures.

In Sweden, the forest-products industry accounts for 15 to 20 percent of the total industrial investments. Together with indirect employment in sectors that supply it with goods and services, it employs around 180,000 people over the entire country, more than a quarter of total industrial employment (Swedish Forest Industries Federation, 2008).

During 2007 the value added by the forest products industry amounted to 11 percent of the total value added by the country's manufacturing industry, and forest products make the largest contribution to net exports (Swedish Forest Agency, 2010a).

Despite being only 0.14 percent of the world population and accounting for 0.32 percent of the world land area, Sweden plays a prominent role in the production and export of forest products (FAO, 2009). It is the world’s second largest exporter overall of paper, pulp and sawn timber (Swedish Forest Industries Federation, 2009). Its forest industry is highly export-oriented, e.g. paper exports amounted to 89% of the production in 2009 (Swedish Forest Industries Federation, 2010), with Europe being by far the most important market (Table 1 below).

Table 1. Swedish exports of selected forest products by importing region in 2009

Assortment	Importing region	Quantity 1000:s m³	Value SEK 1000s	Share of quantity	Share of value
Sawn & planed softwood	Europe	8 455	16 073 871	69%	70%
	EU 27	7 613	14 111 444	62%	61%
	Africa	2 357	4 008 868	19%	17%
	Asia	1 287	2 673 224	11%	12%
	Total	12 252	23 103 596	100%	100%
Wood pulp & waste paper	**Importing region**	**Quantity 1000:s m.t**	**Value SEK 1000s**	**Share of quantity**	**Share of value**
	Europe	2 919	12 133 996	79%	80%
	EU 27	2 778	11 686 253	75%	77%
	Asia	718	2 721 963	19%	18%
	Middle East	71	251 861	2%	2%
	Total	3 718	15 218 645	100%	100%
Paper & paperboard	Europe	7 958	54 909 599	80%	82%
	EU 27	7 438	50 681 656	75%	75%
	Asia	1 402	8 625 401	14%	13%
	Middle East	333	1 936 938	3%	3%
	Total	9 907	67 225 113	100%	100%

Source: Statistics Sweden (Sweden’s statistical databases).

All in all, it may be concluded that international, notably European, developments in the use of wood resources are likely to have far-reaching implications for the Swedish forest-products industry as well as for the forest sector as a whole; affecting land-use, forest policy and forest management, employment and regional development. This study reviews international trends and major drivers of change for forest resources and wood use and, together with projections of future developments in the use and supply of wood resources as well as wood-product market developments in Europe produced within the European Forest Sector Outlook Study (EFSOS) II and EUwood projects, analyses their impact on the Swedish forest sector.

1.2 Cooperation in connection with EFSOS and EUwood

The study is the result of cooperation between the Swedish research programme *Future Forests*, the United Nations Economic Commission for Europe (UNECE) and the Food and Agriculture Organization of the United Nations (FAO), the European Forest Institute, Hamburg University and several other organizations involved in the EFSOS II and EUwood projects.

The objective of EFSOS (European Forest Sector Outlook Study), carried out under the auspices of UNECE and FAO, is to provide policymakers with information and analysis on long-term trends and projections for the forest sector. Much of the analysis does not focus on the markets for wood products, but on forest resources; policies affecting the forest sector; non-wood forest products and forest services are also subjects to analysis (UN, 2005).

One of the imminent challenges facing the forest sector in Sweden and other European countries is to meet the expected increasing demand for wood raw materials resulting from the promotion of renewable energy sources (see European Parliament, 2009). Thus, the objective of the EUwood project, carried out for the European Commission and financed by the Intelligent Energy Europe (IEE) programme, is to provide estimations of real potential in the use of forests and wood in the light of expected growing demand from energy and wood processing uses (Mantau *et al*, 2010a).

Assessing and analysing the status, trends and outlook for forestry is an integrated part of the Swedish research programme *Future Forests* (see http://www.futureforests.se/). The scenario analysis approach of both EFSOS II and EUwood—quantitative and with a shorter time horizon—provides a useful complement to the long-term, qualitative scenario analysis of *Future Forests*.

Future Forests has been represented in the EFSOS II core group, participating in discussions on how to develop the quantitative scenario analysis. Insights gained during core group meetings have in turn provided input to the qualitative scenario analysis process of the *Future Forests* programme.

Future Forests also contributed to EFSOS II and EUwood by providing updated projections, based on econometric analysis, of supply and demand of processed wood products. Inputs used to produce these projections were, besides gross domestic product (GDP) growth projections, price and cost developments derived from the EFORWOOD project (http://87.192.2.62/eforwood/Default.aspx?base). A more detailed account of the modelling is given in chapter 4. The report aims at contributing to EFSOS by providing analysis at country-level for Sweden, one of the major forest product producers and net-exporters within the EFSOS area.

1.3 Scope

1.3.1 Definition of forest sector

In this report, we define forest sector as including wood resources as well as the use of these resources; material uses of wood, i.e., forest products, and energy uses of wood. Forest products include all of the primary wood products manufactured in the forest processing sector (sawnwood, wood-based panels, paper and paperboard) and the main inputs or partly processed products used in the sector (roundwood, wood pulp, wood residues and recovered paper). The report does not cover secondary or value-added forest products (such as wooden doors, window frames and furniture), although we have taken into account the trends in these markets. Non-wood forest products and forest services are not included in this study.

1.3.2 Time horizon

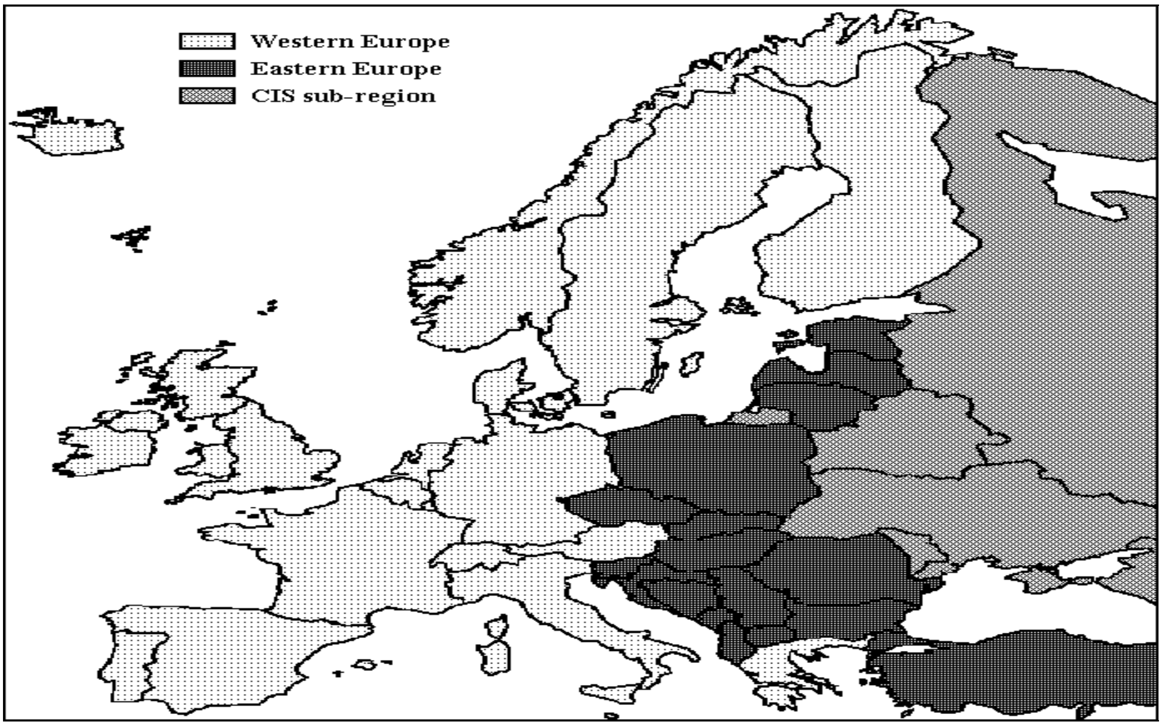
The time horizon for the analysis of past trends is based on the availability of data. In most cases, historical statistics were available back to the year 1961 (e.g. forest products statistics). In other cases, in analysing historical trends we have only looked at the last 20 to 30 years. We selected 2005 as the base-year for the outlook study projections (representing a five-year average of the forest products statistics available at the time, i.e., from year 2003 to 2007), and the projections cover the period from 2005 to 2030. Making projections for a longer period is questionable, as projections of some of the underlying variables used in the study, as, e.g., GDP, become increasingly unreliable over longer periods (Postma and Liebl, 2005).

1.3.3 Geographical scope

The UNECE region comprises fifty-six member countries from Europe (including Turkey and Israel), North America (United States of America and Canada) and the former Soviet Union. For trends in forest resources, and trends in and projections of wood-product markets, we cover 40 of these countries (see Figure 1), including all of the major European countries (including Turkey, but excluding Israel). For the trends in the demand for wood for energy purposes, we focus on the EU.

Some of the very small countries in Europe, with limited forest resources and tiny markets for wood products, are excluded from the study since the UNECE and FAO have limited statistics for these countries. Their exclusion is unlikely to detract from the analysis for the region as a whole.

Figure 1. Geographical scope.



Source: UN (2005).

2 Trends and current situation in Sweden, Europe and globally

2.1 Forest resources

To discuss developments in forest-product markets meaningfully, one needs information about the current situation and trends in forest resources. The following summarizes trends in and the status of a number of aspects of the forest resource in Sweden, Europe and globally.

2.1.1 Forest area

The world's total forest area is just over 4,000 million hectares (ha), 31 percent of the total land area (FAO, 2010). Europe accounts for about 17 percent of global land area but has one quarter of the world’s forest resources, approximately 1, 000 million ha, 81% of which is in the Russian Federation (see Table 2 below).

Sweden's total forest area is 28 million ha, 23 million ha of which is productive forest land. Sweden is to a large part covered with forests. Of the total land area approximately two thirds is forested land area (Source: Statistics Sweden).

Table 2. Distribution of forests by region in 2010

REGION	Forest area	
	Million ha	**% of total forest area**
Total Africa	**674. 4**	**17**
Total Asia	**592.5**	**15**
Europe excl. Russian Federation	195.9	5
Total Europe	**1 005.0**	**25**
Total North & Central America	**705.4**	**17**
Total Oceania	**191.4**	**5**
Total South America	**864.4**	**21**
World	**4 033.1**	**100**

Note: FAO defines forest as land spanning more than 0.5 ha with trees higher than five meters and a canopy cover of more than ten percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use (FAO, 2010). The Swedish definition of forest land differs somewhat from FAO's: Land that is suitable for timber production, i.e., with an average production potential of at least 1 m^3 per hectare and year at 100 years, and not to any substantial extent used for other purposes.

Source: FAO (2010).

For the world as a whole, between the years 2000 and 2010 the forest area decreased by 5.2 million ha per year (FAO, 2010). South America suffered the largest net loss of forests—around 4.0 million ha per year—followed by Africa, which lost 3.4 million ha annually. Oceania also reported a net loss of forest (about 700,000 ha per year).

The forest area in North and Central America remained about the same during this period, whereas Asia, which had a net loss of forest of some 600,000 ha annually in the 1990s, reported a net gain of forest of 2.2 million ha per year, primarily as a result of large-scale afforestation reported by China.

Europe's forest area continued to expand, although at a slower rate (700,000 ha per year) than in the 1990s (900,000 ha per year) (FAO, 2010). In Sweden, the forest area has essentially remained unchanged, with the apparent increase between 2000 and 2005 due to a changed definition of forest land (adapting to the FAO definition).

2.1.2 Standing volume and growing stock

Table 3 depicts trends in growing stock for the period 1990–2010. Growing stock is strongly correlated to forest area. It increased in Asia, North and Central America, and Europe, but decreased in Africa, Oceania and South America. The growing stock for the world as a whole has decreased somewhat since 1990.

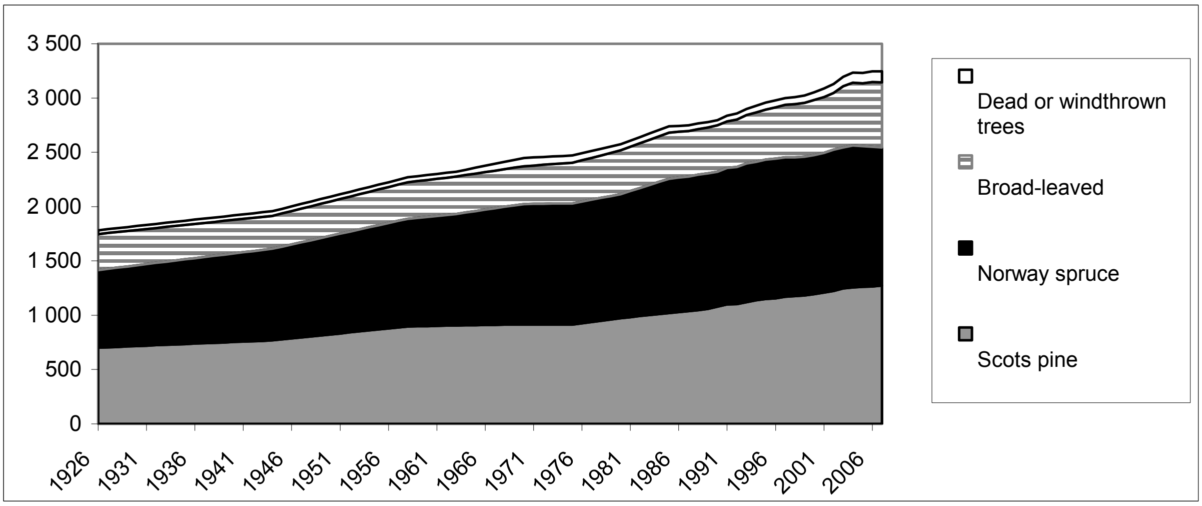
Table 3. Trends in growing stock.

REGION	GROWING STOCK (MILLION M^3)			
	1990	2000	2005	2010
Total Africa	**83 035**	**79 904**	**78 455**	**76 951**
Total Asia	**51 336**	**52 543**	**53 563**	**53 685**
Europe excl. Russian Fed.	23 810	27 487	29 176	30 529
Total Europe	**103 849**	**107 757**	**109 655**	**112 052**
Total North & Central America	**79 141**	**80 708**	**83 564**	**86 416**
Total Oceania	**21 293**	**21 415**	**21 266**	**20 885**
Total South America	**191 451**	**184 141**	**181 668**	**177 215**
World	**530 105**	**526 469**	**528 170**	**527 203**

Source: FAO (2010).

Figure 2 shows the trend for the standing volume in Sweden. As in the rest of Europe, the trend is positive; since the mid-1920s the standing volume has almost doubled. The ratio of growing stock (i.e. standing volume minus the volume of dead trees) between major species, Norway spruce, Scots pine and broad-leaves respectively has not changed much over time.

Figure 2. Total standing volume in Sweden (million m^3)



Source: Swedish National Forest Inventory. Note: Five-year averages

2.1.3 Fellings and increment

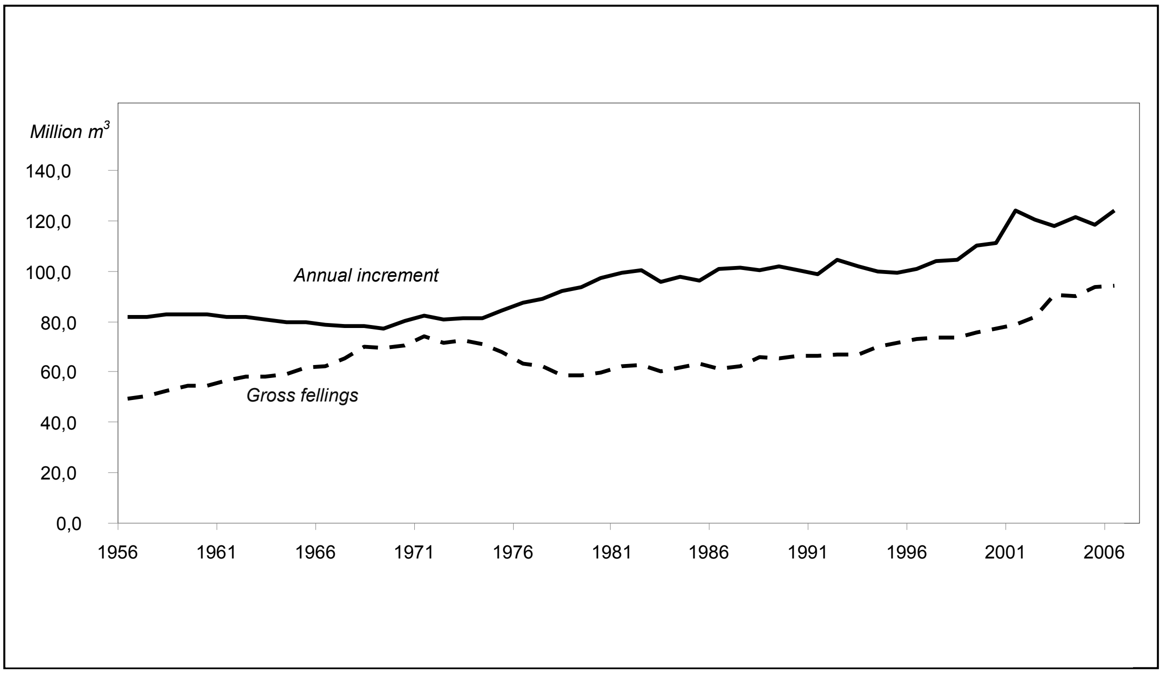
As well as changes in forest area and growing stock/standing volume, annual fellings and annual increment are often compared in order to give an indication of the sustainability of forest management. Table 4 depicts the situation in the EU. Only 60 percent of the net annual increment (NAI) in forests available for wood supply is harvested in the EU as a whole. However, the amount of wood actually available for sustainable harvesting is reduced due to harvest losses, unregistered fellings and unused harvest volume (Mantau, 2007). In Germany, for example, useable stemwood amounts to only about 70% of NAI (ibid.). EU Member States with large forest resources and sizeable forest industries seemingly harvest a higher share of net annual increment. Figure 3 displays historical data of fellings and increment in Sweden.

Table 4. Annual fellings as a share of net annual increment (%) in the EU

	1990	2000	2005
Belgium	84.1	66.7	84.6
Bulgaria	41.6	27.7	40.8
Czech Republic	76.6	80.1	83.9
Denmark	44.4	43.3	35.5
Germany	n.a	40.0	49.8
Estonia	37.1	112.2	52.0
Ireland	n.a	n.a	n.a
Greece	78.1	n.a	n.a
Spain	n.a	62.8	n.a
France	67.0	64.7	55.3
Italy	39.5	33.2	26.4
Cyprus	88.2	42.1	16.0
Latvia	29.2	70.1	68.4
Lithuania	n.a	70.7	73.2
Luxembourg	108.6	47.1	38.3
Hungary	67.4	62.2	55.6
Malta	n.a	n.a	n.a
Netherlands	78.0	58.9	69.6
Austria	71.4	60.1	n.a
Poland	n.a	n.a	55.0
Portugal	n.a	82.1	n.a
Romania	62.3	41.3	46.0
Slovenia	n.a	39.3	44.0
Slovakia	53.7	56.9	74.8
Finland	68.8	84.6	69.5
Sweden	69.5	81.7	85.5
United Kingdom	44.4	45.4	47.8
EU (27 countries)	**62.8**	**61.7**	**59.3**

Source: Eurostat. Note: n.a = Not available

Figure 3. Annual increment and gross fellings in Sweden.



Source**:** The Swedish Forest Agency. Note: Fellings are five-year averages

2.2 Wood use

2.2.1 Wood for material purposes

Processed wood products are commodities produced by the forest processing industry and consumed by other industries outside the sector or by consumers. Included, at the broad level, are sawnwood, wood-based panels; and paper and paperboard (UN, 2005). Trends in prices and the production and consumption of these products are described below.

These commodities have been modelled econometrically, and their use of wood raw materials estimated, in order to produce projections of the supply and demand of wood products and the material use of woody biomass (see section 4.2 of this report). A range of further processed wood products (e.g. wooden furniture) could be considered as part of the forest sector, but information is not readily available about the trends in production and consumption of these products (UN, 2005).

Other traditional material uses of woody biomass include dissolving pulp, mulch, and other industrial roundwood sorted for special purposes (e.g. poles and sleepers). These uses are not modelled econometrically; instead an expansion factor was calculated, based on the econometric projections for solid wood consumption (sawnwood and panels) and applied to the sector other material uses (see section 4.2).

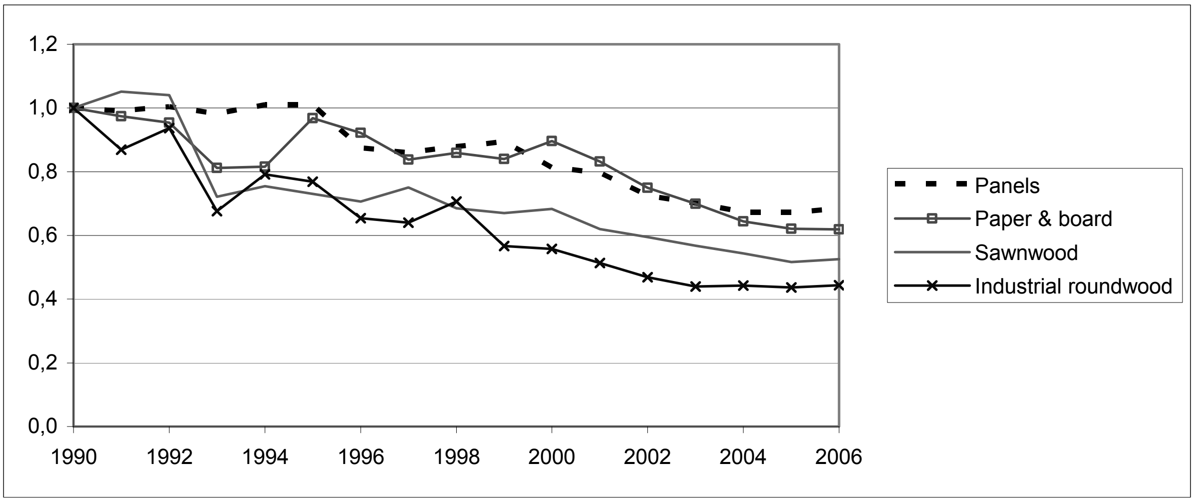
Further, “new products” resulting from technological improvements are dealt with qualitatively only, as regards the impact on the “traditional” wood-product markets mentioned above and the impact on wood fibre demand (see section 3.3 Scientific and technological developments).

Prices of wood products

Globally, historical trends in wood product prices have shown considerable fluctuation. At the time of the first oil crisis, in the early 1970s, prices peaked in nominal terms (i.e. unadjusted for inflation), as did the prices of many other commodities. From this point onwards until the 1990s, trends in prices have varied by product and region.

Since the 1990s, prices have generally remained constant or fallen in nominal terms at the global level, leading to significant falls in real prices, i.e. prices adjusted for inflation (UN, 2005). Figure 4 clearly indicates a falling trend for real prices of wood products in Europe, most noticeable for industrial roundwood and sawnwood.

Figure 4. Relative real price developments in Europe



Sources: FAOSTAT and FAO database (deflators). Note: (i) Based on real price indices (1990=1). (ii) Real export prices are used in case of positive net exports, otherwise real import prices.

The general decline in (real) prices for wood products over time can be understood in the light of increases in plantation forestry, faster growing tree varieties, technological change and cost efficiencies, resulting in a relative abundance of virgin wood fibre (Roberts *et al*, 2004).

Production and consumption of wood products

In general terms, the production and consumption of wood products can be said to be shifting from North America and Western Europe to tropical regions and emerging economies. The growth of the forest-product markets in these regions has slowed considerably but has grown substantially in China, Southeast and South Asia, and Eastern Europe (Aulisi *et al*, 2008). In Western Europe, consumption of wood products has in most cases been inelastic, i.e. estimated income elasticities (sensitivity of quantity demanded to changes in income) are less than one for most wood-products and countries.

<u>Sawnwood</u>

Between 1990 and 2000, long-term annual global growth in production and consumption of sawnwood declined dramatically, chiefly as a result of falling production and consumption in the former Soviet Union and Eastern Europe. Before 1990, Eastern European and Commonwealth of Independent States (CIS) countries had accounted for nearly half of Europe's sawnwood production. But in the 1990s, political changes led to a drastic decline in their production and consumption of sawnwood. With the transition to a market economy, production shifted to more processed products such as wood-based panels (FAO, 2009). Sawnwood production and consumption also declined in Asia during this period.

Since 2000, though not reaching the same level as 1990, sawnwood production and consumption has begun to recover in Europe and Asia as well as globally (Table 5). The prevalent trend, however, has been substitution of wood-based panels for sawnwood (FAO, 2009).

Table 5. Production and apparent consumption of sawnwood

	Amount (million m^3)					Annual change (%)	
	1970	1980	1990	2000	2007	1970-1990	1990-2007
Production							
Africa	5	8	8	8	9	3.0%	0.6%
Asia	77	95	105	62	82	1.5%	-1.5%
Australia & New Zealand	5	5	5	8	9	-0.1%	3.3%
Europe	203	189	193	130	149	-0.2%	-1.5%
Northern America	83	98	126	142	137	2.1%	0.5%
Latin America and the Caribbean	16	26	29	37	45	3.0%	2.7%
World	**389**	**421**	**466**	**386**	**431**	**0.9%**	**-0.5%**
Consumption							
Africa	6	10	10	11	13	3.0%	1.2%
Asia	79	98	112	79	102	1.8%	-0.6%
Australia & New Zealand	6	6	6	7	8	0.1%	1.4%
Europe	204	191	202	121	125	-0.1%	-2.8%
Northern America	79	91	114	136	137	1.8%	1.1%
Latin America and the Caribbean	16	26	28	35	39	3.0%	1.8%
World	**390**	**422**	**473**	**389**	**424**	**1.0%**	**-0.6%**

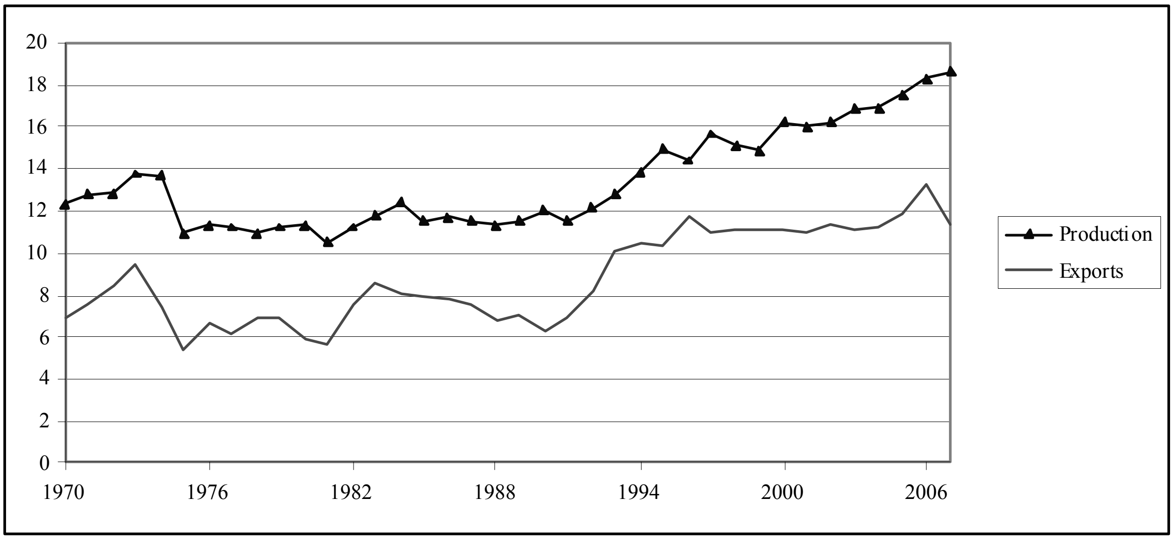
Source: FAOSTAT. Note: Apparent consumption equals production plus imports minus exports

Together, Europe and North America account for about two thirds of global sawnwood production, Asia 19 percent, and Latin America and the Caribbean 10 percent. Europe has changed from being a net importer to a net exporter, and Europe, Latin America and the Caribbean are now the main net exporting regions, while Asia is the main net importing region.

In 2007 Sweden was the world's third largest exporter of sawnwood (nearly all coniferous sawnwood), after Canada and the Russian Federation (Source: FAOSTAT). Europe, in particular EU, dominates as export destination, as we saw in Table 1.

Swedish imports of sawnwood are minor in comparison; around 400,000 m^3 in 2007 (ibid.). While Swedish sawnwood production increased annually by 2 percent between 2000 and 2007, exports increased by less than 0.4 percent (Figure 5), implying that the domestic market has increased in importance.

Figure 5. Swedish production and exports of sawnwood (in million m^3)



Source: FAOSTAT.

Wood-based panels

While production and consumption of wood-based panels were only slightly more than 60 percent of those of sawnwood in 2007, their growth rates are much higher (FAO, 2009). Long-term global annual growth in production and consumption of wood-based panels was around 3 percent between 1970 and 1990, and increased to over 4 percent between 1990 and 2007.

Asian production and consumption increased by over 8 percent per annum between 1990 and 2007; and growth in China has been staggering (see Table 6). In 2007, Asia accounted for around 39 percent of global production and 37 percent of the consumption of wood-based panels (China alone accounted for around a quarter of global production and consumption), Europe for a little less than a third of production and consumption, and Northern America for around a fifth of production and about a quarter of consumption.

Asia, Europe, and Latin America and the Caribbean are the main net exporting regions (Table 6). Sweden is not a major actor when it comes to wood-based panels, neither as a producer nor as a consumer.

Table 6. Production and apparent consumption of wood-based panels

	Amount (million m^3)					Annual change (%)	
	1970	1980	1990	2000	2007	1970 - 1990	1990 - 2007
Production							
Africa	1	2	2	2	3	3.3%	3.2%
Asia	13	19	27	49	105	3.8%	8.3%
Australia & New Zealand	1	1	2	3	4	3.8%	5.3%
Europe	28	44	50	61	84	3.1%	3.0%
Northern America	26	31	43	61	56	2.5%	1.5%
Latin America and the Caribbean	2	4	5	9	15	5.8%	6.9%
World	**70**	**101**	**129**	**185**	**266**	**3.1%**	**4.4%**
Consumption							
Africa	1	2	1	2	3	3.8%	4.6%
Asia	10	17	25	53	95	4.4%	8.2%
Australia & New Zealand	1	1	1	3	3	3.0%	5.0%
Europe	28	45	54	59	81	3.3%	2.5%
Northern America	28	31	43	63	62	2.1%	2.2%
Latin America and the Caribbean	2	4	5	8	12	5.5%	5.9%
World	**70**	**101**	**129**	**188**	**257**	**3.1%**	**4.1%**

Source: FAOSTAT.

Within the category of wood-based panels, there is an increasing shift from plywood to reconstituted panels (particleboard and fibreboard) (FAO, 2009), perhaps due to the introduction of panel products such as medium density fibreboard and other engineered wood products (UN, 2005). This development, which has important implications for wood raw-material requirements, began in Europe, where reconstituted panels have gradually increased in importance, and has continued in North America (FAO, 2009).

Particleboard and fibreboard accounted for around 90 percent of the panel market in Europe in 2007 and about 70 percent in North America. This shift from plywood to particleboard and fibreboard has only recently begun in Asia, where plywood accounted for almost half of the production and around 40 percent of the consumption of wood-based panels in 2007 (ibid.).

Paper and paperboard

In almost all parts of the world, pulp and paper has been the most rapidly expanding forest product (Aulisi *et al*, 2008). Growth has slowed down somewhat the last decades, partly as a result of the expansion of electronic media and the ensuing slowing down of the growth of consumption and production of newsprint (FAO, 2009). Hence, the annual growth rates decreased from 3.3 percent between 1970 and 1990 to 2.8 percent between 1990 and 2007 (Table 7).

Paper and paperboard is also one of the most globalized commodity groups, i.e. a high share of production is exported and a high share of consumption imported (FAO, 2009). International trade grew significantly in the 1990s, particularly in Europe (ibid.).

Table 7. Production and apparent consumption of paper and paperboard

	Amount (million tonnes)					Annual change (%)	
	1970	1980	1990	2000	2007	1970 - 1990	1990 - 2007
Production							
Africa	1	2	3	4	4	5.8%	2.6%
Asia	18	30	57	95	142	6.0%	5.5%
Australia & New Zealand	2	2	3	4	4	3.1%	2.3%
Europe	45	58	77	100	115	2.8%	2.3%
Northern America	57	70	88	107	102	2.2%	0.8%
Latin America and the Caribbean	4	8	11	14	17	5.6%	2.6%
World	**126**	**169**	**239**	**324**	**384**	**3.3%**	**2.8%**
Consumption							
Africa	2	3	4	5	7	4.4%	3.3%
Asia	19	33	62	103	148	6.1%	5.3%
Australia & New Zealand	2	2	3	4	5	3.0%	2.2%
Europe	44	56	75	90	105	2.7%	2.0%
Northern America	53	65	84	103	96	2.3%	0.8%
Latin America and the Caribbean	5	10	12	20	22	4.0%	3.7%
World	**125**	**168**	**239**	**325**	**383**	**3.3%**	**2.8%**

Source: FAOSTAT.

Until 2002, North America dominated global production of paper and paperboard. Then the region was overtaken by both Europe and Asia. Asian growth has been staggering, and in 2007 accounted for almost 37 percent of global production, followed by Europe with 30 percent and North America with 27 percent.

Europe's production growth has been driven to a large extent by expanding exports; Europe is the largest exporter of paper products. (FAO, 2009). Its competitive advantage in paper production is based on close high-demand markets, the availability of recovered paper and technological sophistication for producing high-quality paper. Europe is also one of the largest investors in the pulp and paper sector in Asia and Latin America, where European companies benefit from matching their technological, marketing and managerial skills with the low labour costs, rapidly expanding planted forests and growing demand (ibid.). Over the last decade, the production of pulp and paper in Latin America has expanded rapidly; resulting in a six-fold increase in net exports (Aulisi *et al*, 2008).

North America has also lost its hegemony in consumption terms; Asia became the largest consumer region in 2000, and in 2007 Asian consumption made up almost 37 percent of global consumption, followed by Europe and North America with 28 and 25 percent respectively. In 2007, China alone accounted for one fifth of global production and consumption of paper and paperboard; production and consumption doubled between 2000 and 2007. In sum, the demand for paper has shifted from the mature western markets to the emerging markets in the east and south (Aulisi *et al*, 2008). Differences in growth between the regions reflect the composition of the paper and paperboard market (Table 8).

Table 8. Production in North America, Asia and Europe, share of global production

	1970	1980	1990	2000	2007
Newsprint North America	51.8%	50.6%	46.0%	40.3%	29.1%
Newsprint Asia	11.8%	13.9%	15.9%	21.4%	32.0%
Newsprint Europe	32.5%	30.5%	31.7%	32.8%	33.7%
Other paper and paperboard North America	45.6%	40.9%	36.2%	33.3%	27.1%
Other paper and paperboard Asia	14.7%	18.4%	25.1%	31.5%	39.3%
Other paper and paperboard Europe	34.1%	33.0%	30.8%	27.3%	26.6%
Printing and writing paper North America	39.6%	37.2%	34.1%	29.9%	24.6%
Printing and writing paper Asia	14.6%	17.5%	25.0%	27.9%	33.8%
Printing and writing paper Europe	42.3%	39.3%	35.8%	37.0%	35.7%

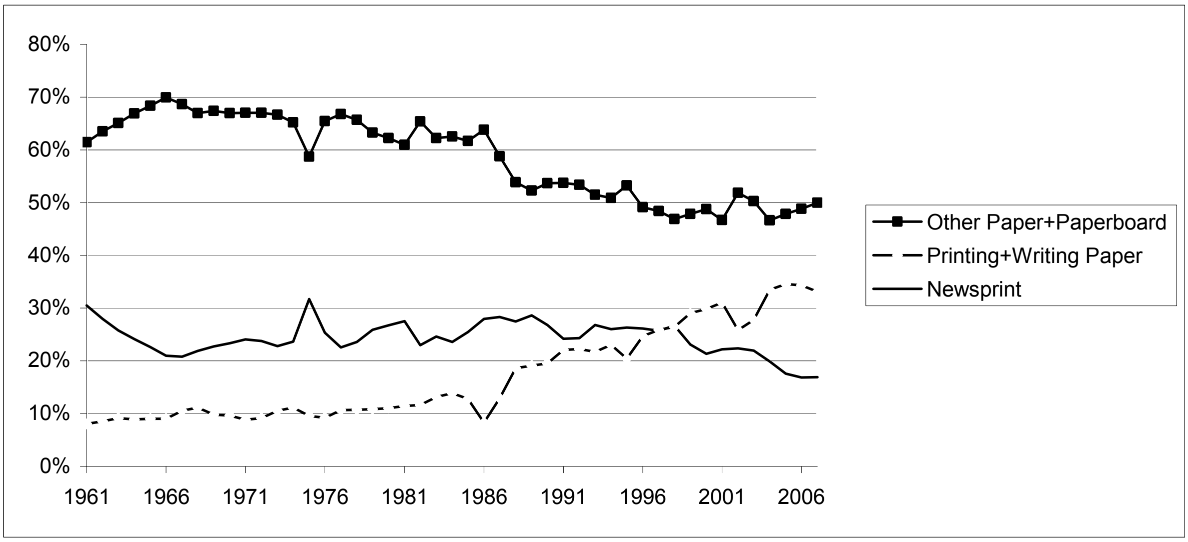
Source: FAOSTAT.

- Currently global newsprint production is fairly evenly distributed among Asia, Europe and North America. Growth is slowing as a result of the rapid expansion of electronic media. Annual long-term global growth of newsprint production was less than one percent between 1990 and 2007, and was even negative between 2000 and 2007; minus half a percent.
- Production of other paper and paperboard is by far the highest in Asia, while Europe and North America produce equal amounts. Annual long-term global growth of other paper and paperboard production was around three percent between 1990 and 2007. The growth rate increased marginally between 2000 and 2007.
- Asia and Europe produce far more printing and writing paper than North America. Long-term annual growth was around three percent between 1990 and 2007, on a global scale. The corresponding figure for the period 2000 to 2007 was about two percent.

In 2007, Sweden, seventh in production terms, was the fifth largest exporter of paper and paperboard in the world, accounting for nine percent of the world total (source: FAO, 2009b). Swedish imports of paper and paperboard are much smaller in comparison. The main market for Swedish paper and paperboard is Europe, particularly EU, which accounted for 75% of Swedish paper exports in 2009 (Table 1).

Figure 6 depicts the composition of the Swedish paper and paperboard exports. The relative importance of other paper and paperboard decreased significantly at the end of the 1980s, but has maintained its position at about 50 percent of paper and paperboard export quantity since then. Newsprint has lost in importance since the late 1990s, whereas printing & writing paper exports show an increasing trend since the mid-1980s.

Figure 6. Structure of Swedish paper exports: the share of total Swedish paper and paperboard export quantity (in percent)



Source: FAOSTAT.

Industrial wood raw material demand

Industrial roundwood demand is derived from demand for, and hence production of, end products: sawnwood, wood-based panels, and paper and paperboard. These products have varying wood requirements depending on the technology used and the potential to use wood and fibre waste. For example, growing sawnwood production increases the demand for industrial roundwood, whereas increased production of reconstituted panels increases the potential to use wood residues and fibre waste, thereby reducing industrial roundwood demand.

In 2005, global derived demand in wood raw-material equivalent (WRME) was about 2,500 million cubic metres: of which 700 million cubic metres were industrial roundwood; 500 million cubic metres came from recovered paper; and the remainder from wood-processing residues, recovered wood products and other sources (FAO, 2009).

In northern countries, notably Canada, Finland and Sweden, the proportion of pulpwood production in total industrial roundwood production has fallen over recent decades. This trend can be explained by improved sawmilling technology, allowing the mills to produce sawnwood from smaller tree sizes. Another effect of this development has been an increase in the production of wood chips for use in the production of reconstituted wood panels, wood pulp, or for bioenergy. Thus, the type of wood used for pulp and paper production has gradually shifted away from pulpwood towards wood chips and residues.

For many countries in the southern hemisphere, on the other hand, the share of pulpwood in total industrial roundwood production has increased in the last decades. This may be partly due to their increasing demand for pulpwood, but it is also a reflection of the fact that the area of forest plantations grown on short-rotations specifically for pulpwood production has increased in recent years in countries such as Brazil, China and, more recently, Indonesia (Whiteman, 2005). In 2007, forest plantations accounted for slightly less than 5 percent of the world's forests, but supplied 50 percent of wood and fibre needs (FAO, 2007)!

Long-term annual global growth in production and consumption of industrial roundwood was 1.4 percent between 1970 and 1990, but declined between 1990 and 2000 as a result of

(a) falling production and consumption in Europe, notably in the former Soviet Union; (b) the substitution of other materials for wood; (c) the global growth of recycling; and (d) the industrialized economies' slowing consumption (Reid *et al*, 2004). Since 2000, global industrial roundwood production and consumption has picked up somewhat, and in 2007 were again at the 1990 level. The main increases in production and consumption of industrial roundwood between 2000 and 2007 took place in Europe, Asia, Latin America, and the Caribbean. Production and consumption in Europe are yet to reach 1990 levels (Table 9).

Table 9. Production and apparent consumption of industrial roundwood

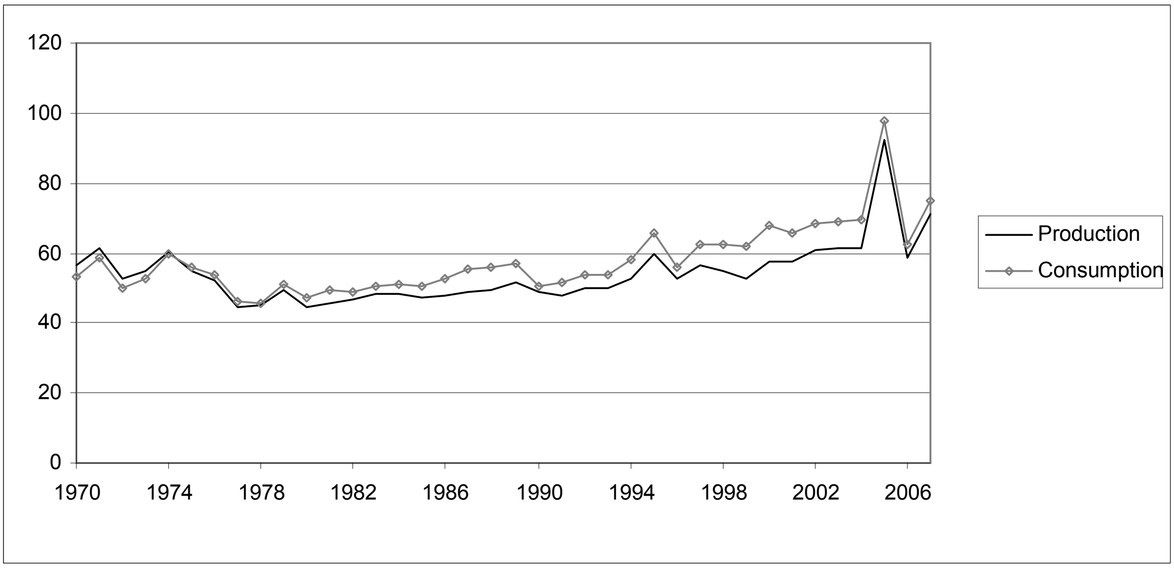
	Amount (million m^3)					Annual change (%)	
	1970	1980	1990	2000	2007	1970 - 1990	1990 - 2007
Production							
Africa	39	50	57	69	69	1.9%	1.2%
Asia	172	233	258	231	240	2.1%	-0.4%
Australia & New Zealand	19	26	29	44	47	2.1%	2.9%
Europe	567	561	645	483	576	0.6%	-0.7%
Northern America	430	478	583	620	586	1.5%	0.0%
Latin America and the Caribbean	49	97	121	159	183	4.7%	2.4%
World	**1 276**	**1 446**	**1 696**	**1 608**	**1 705**	**1.4%**	**0.0%**
Consumption							
Africa	33	45	53	63	66	2.4%	1.3%
Asia	189	253	287	264	294	2.1%	0.1%
Australia & New Zealand	18	25	27	37	40	2.2%	2.3%
Europe	568	564	646	473	547	0.6%	-1.0%
Northern America	418	465	562	614	580	1.5%	0.2%
Latin America and the Caribbean	48	96	118	156	180	4.6%	2.5%
World	**1 274**	**1 448**	**1 696**	**1 609**	**1 707**	**1.4%**	**0.0%**

Source: FAOSTAT.

Sweden, sixth in production as well as in export terms, was the fifth largest importer of industrial roundwood in 2007 (Source: FAOSTAT). Sweden has been a net-importer of roundwood since 1975. The main source of these imports (dominated by pulpwood) during the last decade has been Latvia (source: Statistics Sweden, 2010, "Foreign Trade").

Production and consumption of industrial roundwood in Sweden, which did not vary much between 1970 and 1990, started to grow steadily from 1990, with an annual average growth rate of 3.6 percent between 1990 and 2007. The 2005 peak in production and consumption is due to hurricane Gudrun, which resulted in massive wind throws of timber in southern Sweden (Figure 7).

Figure 7. Swedish production and apparent consumption of industrial roundwood (in million m^3)



Source: FAOSTAT.

Table 10 gives an overview of industrial consumption of wood raw material in Sweden. The steady growth in consumption of wood raw material is apparent, as is the dominance of sawnwood and pulp and paper. And sawnwood has increased its share of industrial consumption of wood raw material at the expense of pulp and paper, possibly reflecting the improvements in sawmilling technology mentioned earlier.

Table 10. Industrial consumption of wood raw material in Sweden

Industrial branch	Million m^3 solid volume under bark			
	1975	1995	2005	2007
Sawnwood	21.7	32.3	37.2	38.2
Pulp & paper	35.0	40.6	46.1	47.9
Plywood	0.3	0.3	0.3	0.3
Fibreboard	1.3	0.4	0.3	0.3
Particle board	1.4	1.0	0.7	0.9
Deducted: Waste products from sawmills consumed in the pulp and wood-based panel industries	8.0	11.4	12.3	12.7
Industrial consumption	**51.7**	**63.0**	**72.3**	**74.9**

Source: The Swedish Forest Agency.

2.2.2 Wood for energy purposes

According to estimates by FAO (2009), roundwood used in energy production is comparable in quantity with industrial roundwood use. However, statistics on energy production from wood are difficult to obtain because of a great diversity of uses – traditional heating and cooking with fuelwood and charcoal; heat and power production in the forest industry (usually using processing wastes such as black liquor from pulp production) for their own use or for sale; and power generation sometimes in combination with heat generation in combined heat and power plants - and extensive informal production. The two main agencies collecting these statistics, FAO and the International Energy Agency (IEA), present different figures on account of different definitions and primary data sources (ibid.).

Trends for biomass energy production estimated from a combination of these two data sources show an increase in global production of bioenergy from about 530 million tonnes of oil equivalent (MTOE) in 1970 to about 720 MTOE in 2005 (Table 11); interpolation suggests a global increase in wood used for energy production from about 2,000 million cubic metres in 1970 to 2,600 million cubic metres in 2005 (FAO, 2009). Most of the increase in wood energy production occurred in developing countries, where wood continues to be a major source of energy. In Asia and the Pacific, however, growth has declined due to a switch to more convenient types of energy as a result of increasing income (ibid.).

Table 11. Production of bioenergy

	Amount (MTOE)			Annual change (%)	
	1970	**1990**	**2005**	**1970 - 1990**	**1990 - 2005**
Africa	87	131	177	2.1%	2.0%
Asia and the Pacific	259	279	278	0.4%	0.0%
Europe	60	70	89	0.7%	1.6%
Latin America and the	70	88	105	1.1%	1.2%
North America	45	64	65	1.8%	0.1%
Western and Central Asia	11	7	6	-2.7%	1.0%
World	**532**	**638**	**719**	**0.9%**	**0.8%**

Source: FAO (2009).

In Europe, the use of wood for energy became relatively minor after the Second World War due to the supply of cheap fossil fuels. The present high-level policy interest in energy security, renewable energies and climate change has stimulated a strong policy interest in encouraging the use of wood as a source of energy (Steierer, 2010b). Hence, ever since the mid-1990s the region has introduced policies to increase the share of renewable energy in total energy consumption (FAO, 2009). One of the more recent is the EU renewable energy directive (European Parliament, 2009). But already before that political initiative the share of biomass and wastes in the *Gross Inland Energy Consumption* (henceforth GIEC) of the 27 EU countries (EU27) more than doubled from 2.7% in 1990 to 5.8% in 2008 (UN, 2010). The development for individual EU27 countries between 2006 and 2008 is shown in table 12. Noteworthy is the circumstance that the four countries with the highest share of renewable energy—Sweden, Latvia, Finland and Austria—all have substantial forest resources.

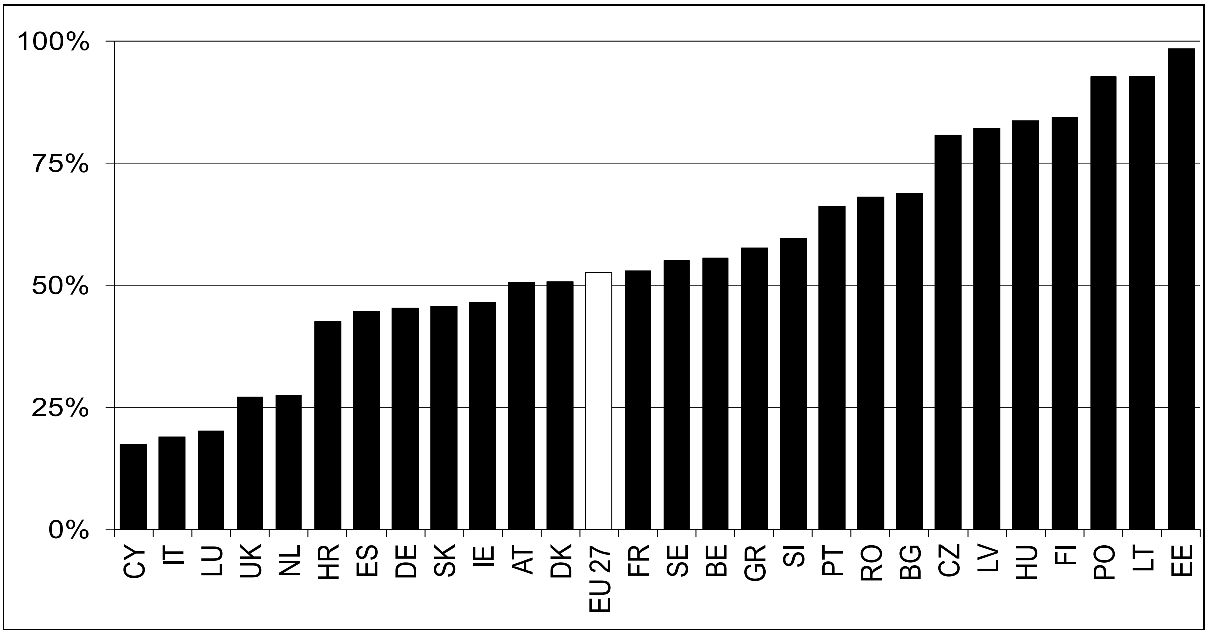
Table 12. Renewable energy as a share of gross final energy consumption (in percent)

	2006	2007	2008
EU 27	8.9	9.7	10.3
Belgium	2.7	3.0	3.3
Bulgaria	9.3	9.1	9.4
Czech Republic	6.4	7.3	7.2
Denmark	16.8	18.1	18.8
Germany	7.0	9.1	9.1
Estonia	16.1	17.1	19.1
Ireland	3.0	3.4	3.8
Greece	7.2	8.1	8.0
Spain	9.1	9.6	10.7
France	9.6	10.2	11.0
Italy	5.3	5.2	6.8
Cyprus	2.5	3.1	4.1
Latvia	31.3	29.7	29.9
Lithuania	14.7	14.2	15.3
Luxembourg	0.9	2.0	2.1
Hungary	5.1	6.0	6.6
Malta	0.1	0.2	0.2
Netherlands	2.5	3.0	3.2
Austria	24.8	26.6	28.5
Poland	7.4	7.4	7.9
Portugal	20.5	22.2	23.2
Romania	17.5	18.7	20.4
Slovenia	15.5	15.6	15.1
Slovakia	6.2	7.4	8.4
Finland	29.2	28.9	30.5
Sweden	**42.7**	**44.2**	**44.4**
United Kingdom	1.5	1.7	2.2

Source: Eurostat.

The share of wood in renewable energy varies by country, but wood accounts for slightly more than 50 percent of GIEC from renewable sources in EU27 (Figure 8), which amounts to approximately 80% of all biomass used for energy (European Commission, 2010). Consequently, policies to increase the share of renewable energy have already stimulated an increasing demand for wood as an energy source (FAO, 2009). Indeed, wood energy was the only forest-related industry sector with steady economic growth in the economically difficult period 2008-2009 (Steierer, 2010b).

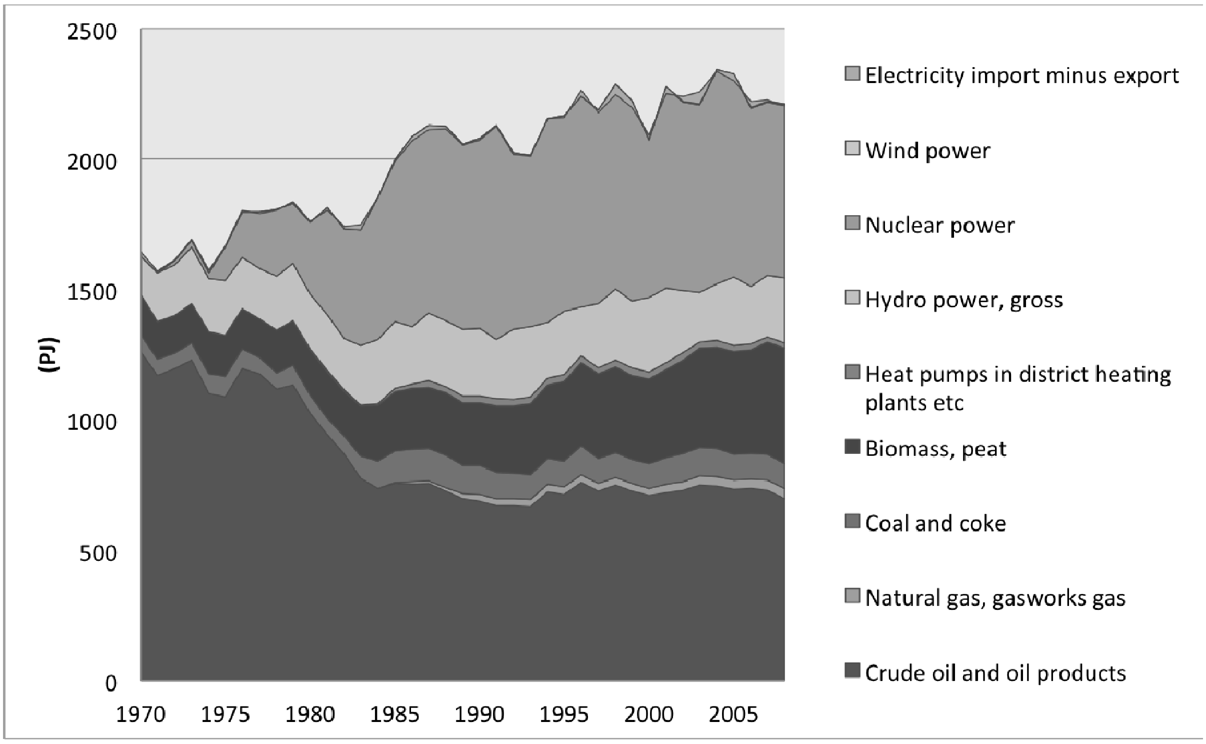
Figure 8. Wood-based energy as a share of total renewable energy



Source: Steierer (2010a). Note: five-year average (2003-2008)

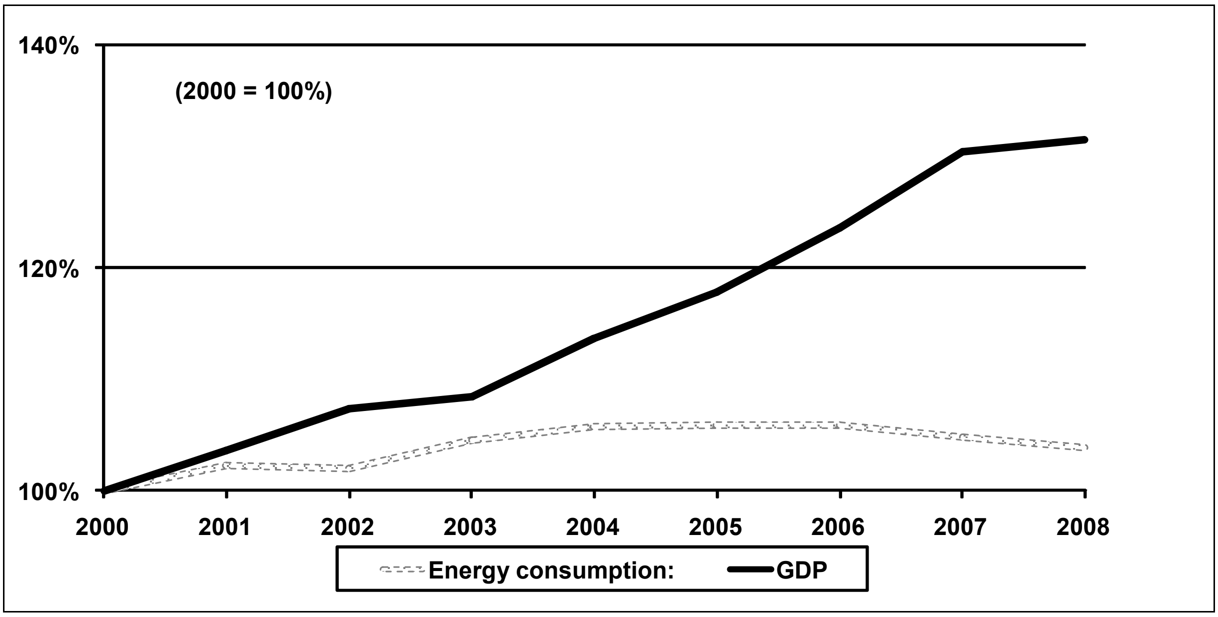
In Sweden, fossil fuels, though still dominating the energy mix, have lost in importance since the 1970s. Biomass as an energy source, on the other hand, has gained market share (Figure 9). The increase in energy supply (and use) has levelled out despite increasing GDP, a trend seen in many developed countries. Indeed absolute values for GIEC started decreasing in the first decade of the twenty-first century in many developed countries, e.g. EU27 (Figure 10).

Figure 9. Total energy supplied in Sweden 1970-2008, by source (PJ)



Source: Statistics Sweden and Swedish Energy Agency.

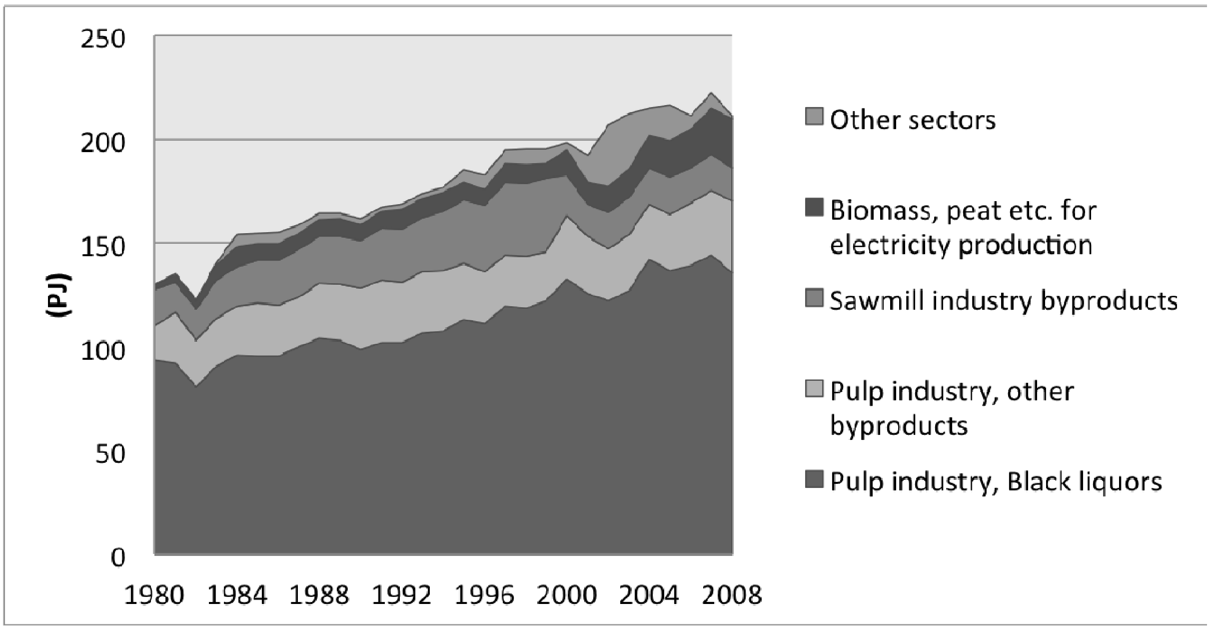
Figure 10. GDP and energy consumption in EU27, indices



Source: Steierer (2010a).

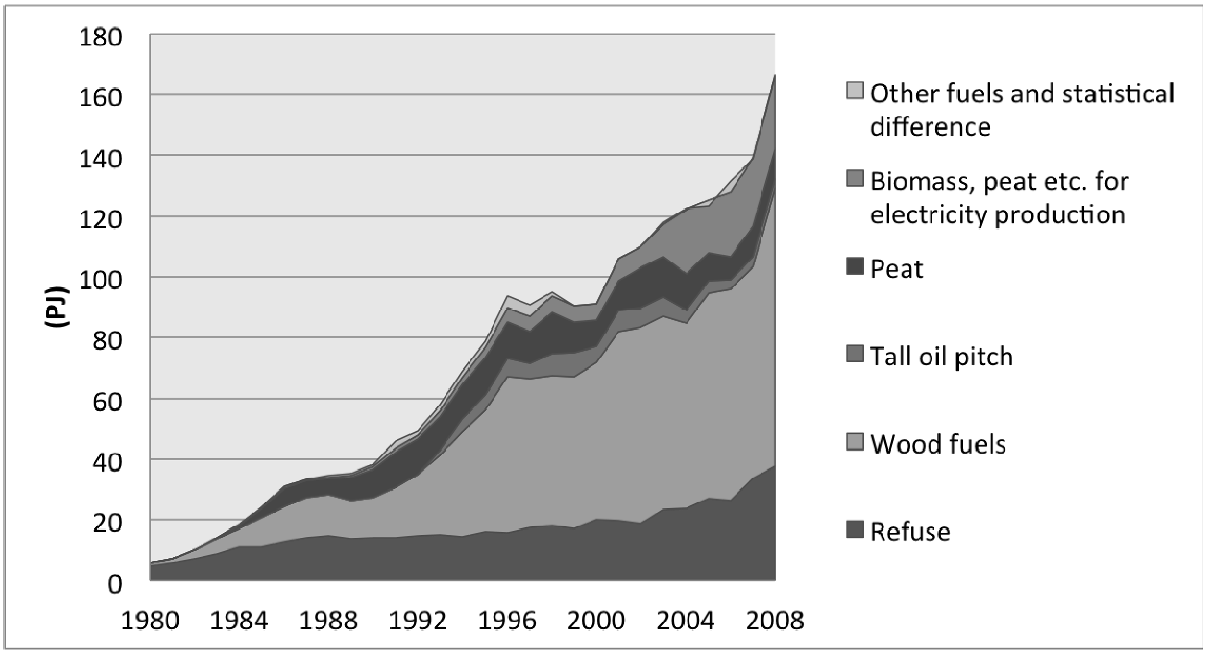
Of the total amount of energy supplied in Sweden in 2008, i.e. 2,204 PJ, biomass, peat, etc. accounted for about 20 percent, i.e. 443 PJ. Out of that, roughly 50 percent was used as process energy in industry (Figure 11) and 40 percent in combined heat and power plants delivering district heating and electricity. This is currently the fastest growing bioenergy sector in Sweden (Figure 12). Wood accounts for more than half of the feed stock supply in district heating. Finally, heating of detached houses accounts for around 10 percent of total biofuel use. Firewood makes up the lion's share, but the use of wood pellets is increasing rapidly (Table 13). In 2009 Sweden was the largest consumer of wood pellets overall within the EU, consuming 1.8 million tonnes (Junginger *et al*, 2011).

Figure 11. Use of biomass, peat, etc. in industry in Sweden 1980-2008 (PJ)



Source: The Swedish Energy Agency. Note: Other sector (than forest products industry) includes food, chemical and manufacturing (engineering) industry among others

Figure 12. Use of biomass, peat, etc. in district heating (incl. electricity generation) in Sweden 1980-2008 (PJ)



Source: Statistics Sweden and Swedish Energy Agency. Note: The term wood fuel represents trees or parts of trees not altered by any artificial chemical process. Statistical difference is due to different sources.

Table 13. Use of wood fuel in one- and two-household dwellings (incl. agricultural properties)

	Firewood		Wood chips. sawdust		Pellets		Total
	million m^3 piled	PJ	million m^3 loose	PJ	1 000 tonnes	PJ	PJ
2005	7.2	32.0	0.8	2.2	329	5.4	39.6
2006	6.4	28.4	0.7	1.8	394	6.5	36.7
2007	6.6	29.5	1.0	2.5	481	7.9	40.0
2008	6.8	30.2	0.9	2.5	470	7.9	40.7

Source: The Swedish Forest Agency, Statistical Yearbook of Forestry.

2.3 Woody biomass demand and supply

The wood resource market can be segmented into four sectors: on the supply side, forest resources and other wood raw material resources; on the demand side, material uses (forest industry) and energy uses. Assessment of the potential for sustainable use of forest resources requires that all the parts of supply (sources) and demand (uses) are brought together in a structured format that integrates all resource flows, including post-consumer wood and forest industry co-products (Mantau *et al*, 2010a). The Wood Resource Balance (henceforth WRB), developed at Hamburg University, is a concept that integrates cross-sectoral information, going beyond existing trade and production classifications of the forest-based sector (Mantau *et al*, 2010b). For details on WRB and other modelling approaches used in EUwood, the reader is referred to Mantau *et al* (2010b) and chapter 4.

Table 14 presents a WRB for EU27, estimated for the year 2010. European forests are by far the largest supply source, accounting for 70.5% of the total supply of wood raw materials.

Forest industry co-products (sawmill co-products, other industrial wood residues and black liquor) constitute the second most important supplier, contributing around 18 percent of total wood fibre supply. Further, as forest industry co-products grow with wood-product output, their overall importance in the resource provision can be regarded as higher than expressed by the market shares (Mantau *et a*l, 2010a).

The total supply of woody biomass in the EU27, about 1,000 million cubic metres or around 500 million oven dry tonnes (odt), corresponds to about 8,500 PJ (ibid.). On the demand side, material uses account for 57 percent of woody biomass consumption, the remaining 43 percent being used for energy purposes.

The sawmill industry and households are the largest consumer groups, accounting for around a quarter and a fifth of total woody biomass consumption respectively. The pulp industry, accounting for around a sixth of total woody biomass consumption, is the third largest consumer.

Table 14. Wood resource balance (WRB) for the EU27 in 2010

SUPPLY			DEMAND		
	million m^3	%	million m^3	%	
Coniferous stemwood (*ME*[(i)])	362	37.2	196	24.4	Sawmill industry
Non-conifer. stemwood (*ME*[(i)])	182	18.7	11	1.4	Veneer and plywood industry
Forest residues (*ME*[(i)])	118	12.1	143	17.8	Pulp industry
Bark (*ME*[(i)])	24	2.4	92	11.5	Panel industry
Landscape care wood	58	6.0	15	1.9	Other material uses[(ii)]
Short rotation plantations[(iii)]	-	-	85	10.6	Forest sector internal use
Sawmill co-products	87	8.9	83	10.3	Biomass power plants
Other industrial residues	30	3.1	23	2.9	Households (pellets and briquettes)
Black liquor	60	6.2	155	19.2	Households fuelwood
Post-consumer wood	52	5.3	0	0.0	Liquid biofuels
Total	**973**	**100.0**	**805**	**100.0**	**Total**

Note: (i) *ME* denotes potential supply of biomass using a medium mobilisation scenario, i.e., projections of theoretically available woody biomass is combined with specific technical and environmental constraints to produce realisable biomass supply potential. (ii) Other material uses include traditional other material uses like dissolving pulp, mulch and other roundwood (pools, sleepers). New, innovative, products are not included. (iii) Short rotation plantations, currently available on about 30 000 ha only, was not quantified in the EUwood project. For details, see Mantau *et al* (2010b). (iv) All calculations in the WRB are based on solid wood equivalents. Thus, the volume of forest resources is reduced to about 92% as bark is converted into solid wood equivalent.

Source: Mantau *et al* (2010a).

The circumstance that potential wood supply in 2010 is considerably higher than demand might be taken to suggest that the wood resources of EU27 are not being overexploited. The same message is conveyed by Table 15, which depicts the WRB for Sweden for 2010; potential supply being once again considerably higher than demand. However, it has to be pointed out that the theoretical supply of woody biomass is only reduced by means of technical and environmental rather than economic constraints (for further details, see section 4.4.2). Consequently, some of the supply potential presented is not yet on the market.

Swedish forests account for 71.5% of the total supply potential of wood raw materials, whereas the potential from forest industry co-products accounts for 25.5%. The pulp industry is the main consumer, followed by the sawmill industry. Together, these consumer groups account for more than two thirds of total wood raw material consumption, in all material uses account for 69.5% of total wood resources demand. The third largest consumer is forest sector internal energy use, accounting for one fifth of total consumption. Comparing the WRB for the EU27 as a whole and for Sweden, the prominence of material uses in Sweden is noticeable. The share of forest sector internal energy use is also considerably higher (Table 15).

Table 15. WRB for Sweden in 2010

SUPPLY			DEMAND		
	million m³	%	million m³	%	
Coniferous stemwood (*ME*)	73.1	48.3	36.1	30.3	Sawmill industry
Non-conifer. stemwood (*ME*)	9.2	6.0	0.2	0.2	Veneer and plywood industry
Forest residues (*ME*)	22.6	14.9	44.9	37.8	Pulp industry
Bark (*ME*)	3.4	2.3	1.0	0.9	Panel industry
Landscape care wood	3.6	2.4	0.4	0.4	Other material uses
Short rotation plantations	-	-	24.0	20.2	Forest sector internal use
Sawmill co-products	18.4	12.1	6.6	5.6	Biomass power plants
Other industrial residues	1.8	1.2	4.0	3.4	Households (pellets and briquettes)
Black liquor	18.3	12.1	1.6	1.3	Households (fuelwood)
Post-consumer wood	1.0	0.7	0.0	0.0	Liquid biofuels
Total	**151.5**	**100.0**	**119.0**	**100.0**	**Total**

Source: Mantau (2010).

2.4 Forest policy in Sweden

Sustainability is at the core of forest policy and forestry in Sweden (see Swedish Government, 2008). Sustainability comprises three dimensions: economic, environmental and social. According to the economic dimension, forests should be managed so as to provide sustainable high yields and good economic returns across the country. The environmental dimension is concerned with issues such as preservation and conservation of endangered species and valuable nature forest land. The social dimension includes aspects such as local acceptance, cultural heritage, etc.

Targets for the forest sector were adopted by the Swedish Forest Agency in 2005 and represent an interpretation of the Government's forest policy. The sectoral targets have been the Forestry Agency's way to give an overview of the Government's forest and environmental policies (Swedish Forest Agency, 2010b). The targets are hierarchically organized, on three levels. At the highest level are two equally important overall objectives set by the Government and parliament: a *production* objective stressing that forest shall be managed efficiently so as to provide sustainable high yields, and an *environmental* objective maintaining that forests must be managed so that the plant and animal species that naturally belong in Swedish forests are equipped to survive under natural conditions and in viable populations.

At the second highest level is a long-term vision that includes clarifications and interpretations of the overall objectives, e.g. that forest management should consider different uses of the forest resource. The timescale here ranges from a few decades to a century.

On the lowest level are the short-term objectives, which are usually quantified and specified in time (Swedish Forest Agency, 2005). The process of formulating new sectoral targets to replace the ones valid until the end of 2010 has started (Swedish Forest Agency, 2010b).

In Sweden, the responsibility for the Government's energy policy lies primarily with the Swedish Energy Agency; but the Swedish Board of Agriculture and the Swedish Forest Agency also work with questions and policies that concern bioenergy. An example of this is provided by the recommendations concerning suitable methods for stump harvesting issued by the Swedish Forest Agency (see, Hektor, 2009).

Large-scale industrial use of wood resources by sawmills and pulp and paper industries emerged in the second half of the nineteenth century. During the 1900s, the use of forests for industrial production was prioritized and regulated at the expense of other uses of the forest resource such as water quality, biodiversity, and cultural and social activities related to forests (Sandström *et al*, 2011). In recent decades, however, forest uses other than industrial have been provided more room in the forest sector within the framework of multiple-use forestry (Ibid.).

Sweden has tackled this concept generally through the application of the so-called "general consideration". Hence, a relatively small share of the forest area is set aside for conservation, about 3.1% of the productive forest area (source: Swedish Environmental Protection Agency. Instead, environmental considerations are made in all stands in all types of forest operations, such as preserving dead wood, old trees, hollow trees and small biotopes. This is sometimes referred to as "the Swedish forestry model" (see, for example, Weslien and Widenfalk, 2009).

Accession to the EU in 1995 changed the conditions for influencing international forest policy, since the EU as a rule speaks with one voice in international negotiations. However, inside the EU Sweden has gained considerable influence on some international negotiations (Holmgren, 2010). It has signed several international agreements that bear on the national forest policy (Swedish Government, 2008; Holmgren, 2010), e.g. the Convention on Biological Diversity (CBD), the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol, and the Ministerial Conference for the Protection of Forests in Europe (MCPFE). There are also regulations within the EU that already have or will have some impact on Swedish forest policy (ibid.). Among these are the Water Framework Directive, the Habitats and Birds Directives, and perhaps the most important of them all, the targets for renewable energy adopted by the Council at the end of 2008 (EU RES Directive). The role of climate change mitigation policies and environmental policies as drivers of change in international wood-product markets are discussed in sections 3.6 and 3.7 below.

3 Drivers of change in forest-product markets

To assess possible future developments in global wood-product markets, one needs to understand how the factors driving change in these markets are likely to evolve. For long-term developments in particular, the factors frequently cited include (see the following, for example, UN, 2005; Kirilenko and Sedjo, 2007; Aulisi *et al*, 2008; FAO, 2009):

- economic development
- demographics
- scientific and technological developments
- globalization
- global climate change, and related policies, regulations and customer preferences
- environmental policies and regulations other than those linked to climate change.

The following review of trends and possible future developments regarding these major drivers of change. It builds on Jonsson (2011).

3.1 Economic development

Economic growth, measured by the rate of change in gross domestic product (GDP), is generally associated with growing demand for products and services, including wood products. According to neo-classical growth theory, it is driven by growth in population (i.e. labour supply), capital and technological change (Solow, 1956; Swan, 1956). Due to diminishing returns to capital, and labour increases, economies will eventually reach a point (steady state) at which no new increase in production factors will create economic growth. In the neo-classical theory, the process by which the economy continues to grow is *exogenous* and represents the creation of new technology (ibid.).

Endogenous growth theory maintains that the development of new forms of technology is driven by enhancing a country's human capital (Rivera-Batiz and Romer, 1991). Further, as personal incomes increase, individuals tend to spend more of their income on pleasure than on basic needs. Hence, with increasing incomes, countries move up the hierarchy towards a pattern of demand that focuses more on less basic needs (Ernst, 1978).

Whereas in the period 1970-2005 developed economies accounted for most of global GDP, the rapid growth of developing economies, especially in Asia, is expected to swing the balance significantly in the future. The rate of economic growth in western Europe, the most important export market for Swedish forest products, is much lower than in developing regions, and is predicted to slow further. For example, real GDP growth in Germany is projected to be slightly less than two percent per annum during the period from 2010 to 2020, and to decrease to about 1.3% during the period from 2020 to 2030 (Jonsson and Whiteman, in press).

The global demand for forest products is thus expected to continue to grow, mainly in China, India, Brazil and other developing countries, in line with the growth in population and income. However, most western European countries have a research and development expenditure of more than two percent of GDP (European Commission, 2007). Hence**,** high investments in science and technology in Europe could favour the transition to a knowledge-based post-industrial "green" economy, based on sustainable use of resources (FAO, 2009).

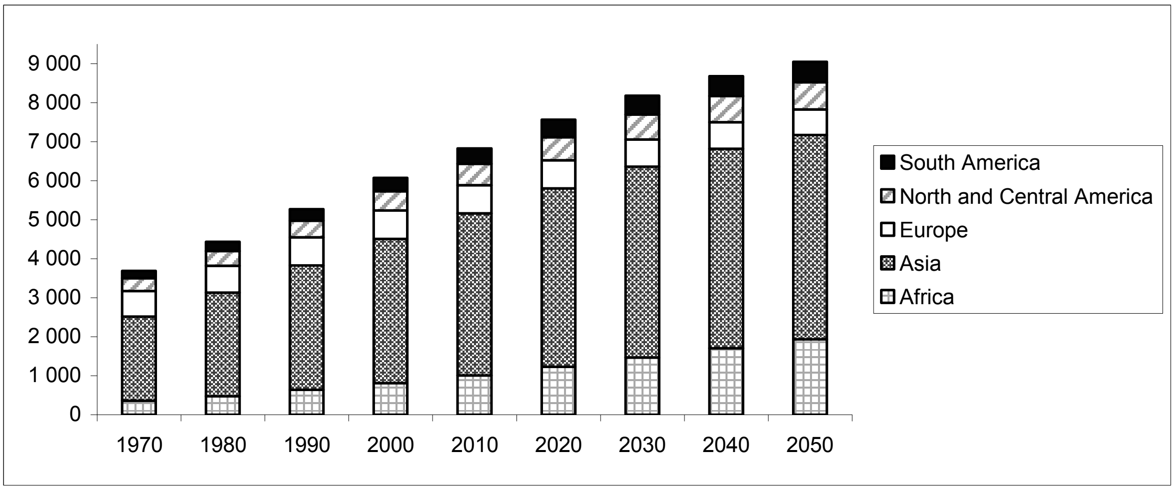
3.2 Demographic developments

3.2.1 Population growth

Demographics affect forest-product markets in several ways. First of all, population increases can lead to economic growth and increased demand. A large population also provides a large domestic market for the economy. Nevertheless, rapid population growth, aside from potential feeding problems, also imposes constraints on the development of savings (and thus, subsequently, on investments)**,** as it leads to more dependent children (Meier, 1995; Cook, 2005).

The world's total population is projected to stabilize at slightly over 9 billion in 2050, whereas Europe's total population is expected to decrease from 730 million in 2005 to around 660 million in 2050, according to United Nations medium fertility forecasts (Figure 13). This projected fall in population could partly explain the expected slow economic growth in Europe. In EUwood and EFSOS II, the IPCC SRES A1 and B2 population projections are used (source: CIESIN, 2002). In the A1 scenario, global population peaks in mid-century and declines thereafter, whereas in the B2 scenario global population is continuously increasing. The European population peaks in 2030 and declines thereafter in the A1 scenario, while in the B2 scenario it peaks in 2010 and declines thereafter.

Figure 13. Historical and projected population figures (in million persons)



Source: United Nations medium fertility variant (United Nations, 2008)

3.2.2 Size and number of households

In terms of housing demand, the number of households is more important than population size (BBR, 2004). In Europe, the number of households is projected to increase by 20 percent from 2005 to 2030, as households are becoming smaller, implying continued rising demand for housing, furniture and (hence) sawnwood and wood-based panel products (EEA, 2005).

Table 16 depicts the development of the distribution of household size in the three largest economies of the EU and Sweden. While the proportion of one-person households has risen in all the countries in question, Sweden stands out with one-person households making up almost half of the total number of households.

Table 16. Distribution of household size (percent)

	1 PERSON		2 PERSONS		3 PERSONS		4 PERSONS		>5 PERSONS	
	1981	**2004**	**1981**	**2004**	**1981**	**2004**	**1981**	**2004**	**1981**	**2004**
France	24.0	32.5	29.0	32.3	18.0	n.a	16.0	n.a	12.0	7.1
Germany	31.0	37.0	29.0	34.0	17.0	14.0	14.0	11.0	9.0	4.0
UK	22.0	29.0	31.0	35.0	17.0	16.0	18.0	13.0	11.0	7.0
Sweden	33.0	46.0	31.0	28.0	15.0	10.0	15.0	11.0	6.0	5.0

Sources: National statistical institutes.

Note: n.a = not available

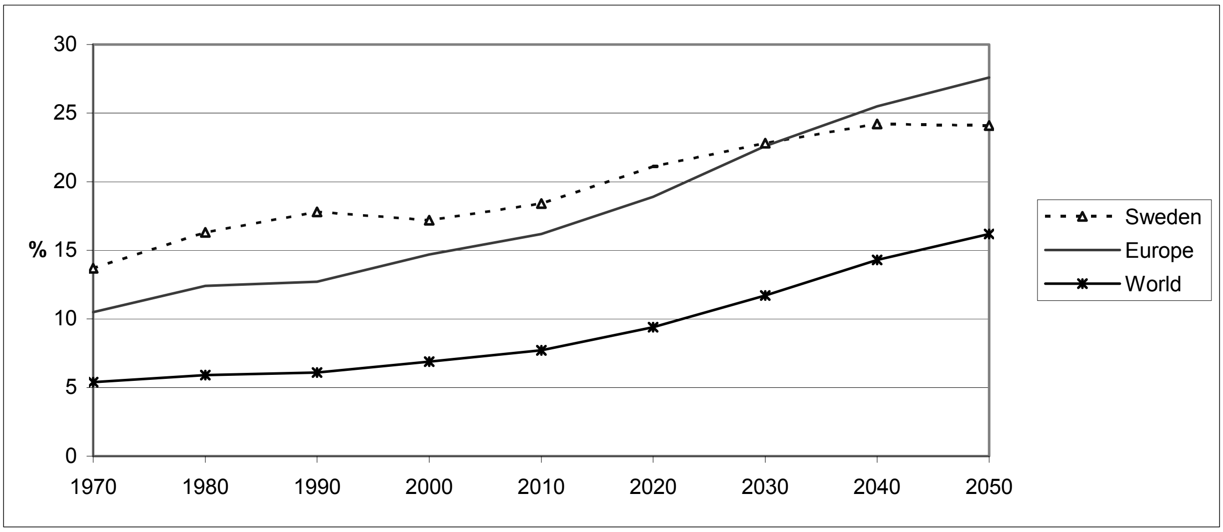
3.2.3 Urbanization

The degree of urbanization also influences forest-product markets. Increased urbanization tends to increase a society's demand for non-wood forest products and services, relative to wood products (United Nations, 2005), while at the same time reducing wood-product harvests, as forest management is affected far beyond the urban boundary (Munn *et al*, 2002; Vickery *et al*, 2009). The effect on net demand for wood products is thus equivocal. Further, by reducing the rural workforce, increased urbanization leads to difficulties in attracting people to work in forestry (Blombäck *et al*, 2003), thereby putting upward pressure on labour costs. Urbanization is expected to increase further in Sweden and Europe as well as globally (United Nations, 2008).

3.2.4 Age structure

Changes in the age structure of the population also have potentially important effects on forest-product markets. The population is ageing, globally as well as in Europe and Sweden (Figure 14). On the demand side, the proportion of the population older than 75 years has been shown to have a significant negative effect on residential construction volumes, due to the increasing burden on the working population (Lindh and Malmberg, 2005). An ageing population also has supply effects, as it entails a shrinking workforce, thereby accelerates technological progress in the construction industry in order to reduce labour costs, i.e. more construction components will be factory-made (Shuler and Adair, 2003).

Figure 14. Historical and projected proportions of Swedish, European and global populations aged 65 years or more.



Source: United Nations medium fertility variant (United Nations, 2008)

3.3 Scientific and technological progress

Scientific and technological developments in silviculture, forest management, harvesting, transport and processing of wood products, and information technology, are expected to be most relevant for forest-product markets (United Nations, 2005; FAO, 2009).

3.3.1 Forest management and silviculture

Research within the areas of forest management and silviculture has focused on planted forests and short-rotation species. Research here aims primarily to identify ways to increase forest growth rates, wood quality and the ability of forests to withstand adverse environmental conditions, pests and diseases. This focus on fast-growing species relates to demand from the pulp and paper industry and reconstituted wood-panel producers.

Enormous productivity gains have been obtained for species such as eucalyptus and tropical pines (FAO, 2009). New possibilities, though controversial, for improving production and quality are provided by research in gene transfer technology and tree genomics; see, for instance, Evans and Turnbull (2004). These developments all contribute to an increase in the supply of roundwood for wood-processing industries.

3.3.2 Wood processing

Technological improvements in wood processing have made the use of small-dimension sawlogs possible. Hence, in recent decades, in a number of northern countries, notably Canada, Finland and Sweden, the proportion of pulpwood production in total industrial roundwood production has fallen. Another effect of these improvements has been an increase in the production of wood chips from sawmills, used in the production of reconstituted wood panels, wood pulp, or for bio-energy (Whiteman, 2005).

Research efforts, mainly in Europe and North America, aim at transforming pulp and paper units into bio-refineries, i.e. integrated industries that produce biofuels, starch, organic acids, polymers, oleochemicals, bioplastics and various food and feed ingredients, from wood-processing residues. By reducing dependence on fossil fuels, these bio-refineries could be key features in the creation of a “green economy” (van Ree and Annevelink, 2007).

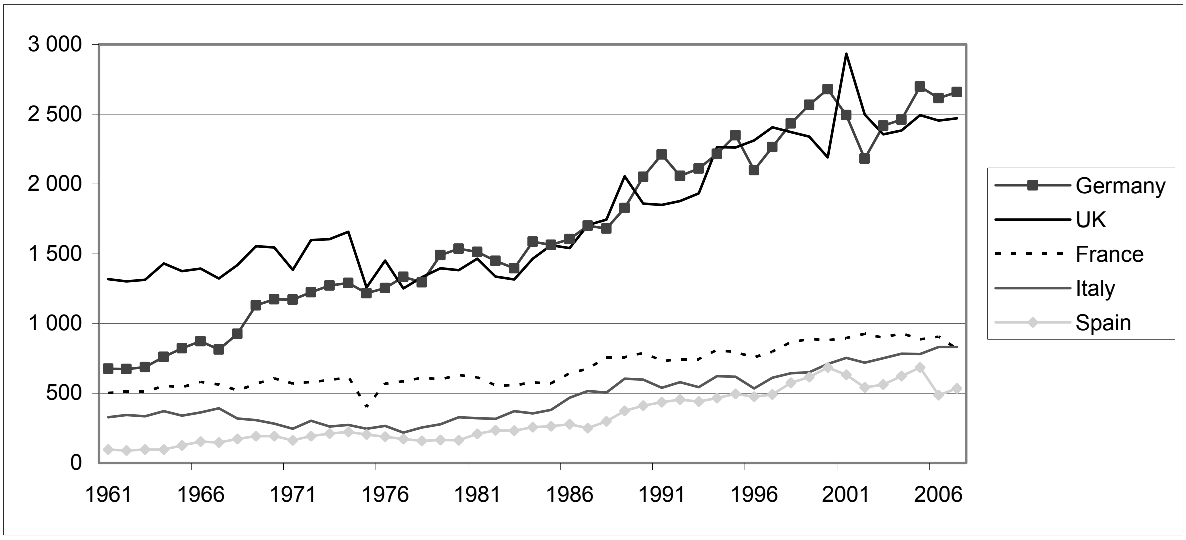
This development should also benefit the profitability of the pulp and paper industry, since the primary goal of converting a given chemical pulp mill into an integrated bio-refinery is to create more value from the bio-based raw material provided by the forestry sector (Söderholm and Lundmark, 2009). Large-scale establishment of integrated bio-refineries should therefore increase the use of forest raw materials as well as the efficiency of raw material use.

In the future, nanotechnology is expected to bring further advances in material and energy efficiency, from production of raw materials to composite and paper products (Roughley, 2005; Reitzer, 2007). This efficiency should dampen global demand for wood fibre. Advances in nanotechnology are also expected to enhance properties of wood products and lead to the creation of new materials, e.g. by injecting ceramic nanoparticles into wood to improve their mechanical properties and fire resistance, and new construction materials based on wood fibre/plastic composites (Roughley, 2005).

3.3.3 Information and communication technology

In the United States, progress in information and communication technology (ICT) has already had an impact on the paper market. Hence, long-run income elasticity (the responsiveness of demand to income changes) for newsprint turned negative after 1987 (Hetemäki and Obersteiner, 2001). Econometric analyses of historical data for western European countries have not yet indicated a general structural shift in newsprint consumption (Bolkesjø *et al*, 2003), as is also indicated by Figure 15, showing no apparent declining trend in newsprint consumption in any of the five largest economies in the EU.

Figure 15. Apparent consumption of newsprint (in 1,000 tonnes)

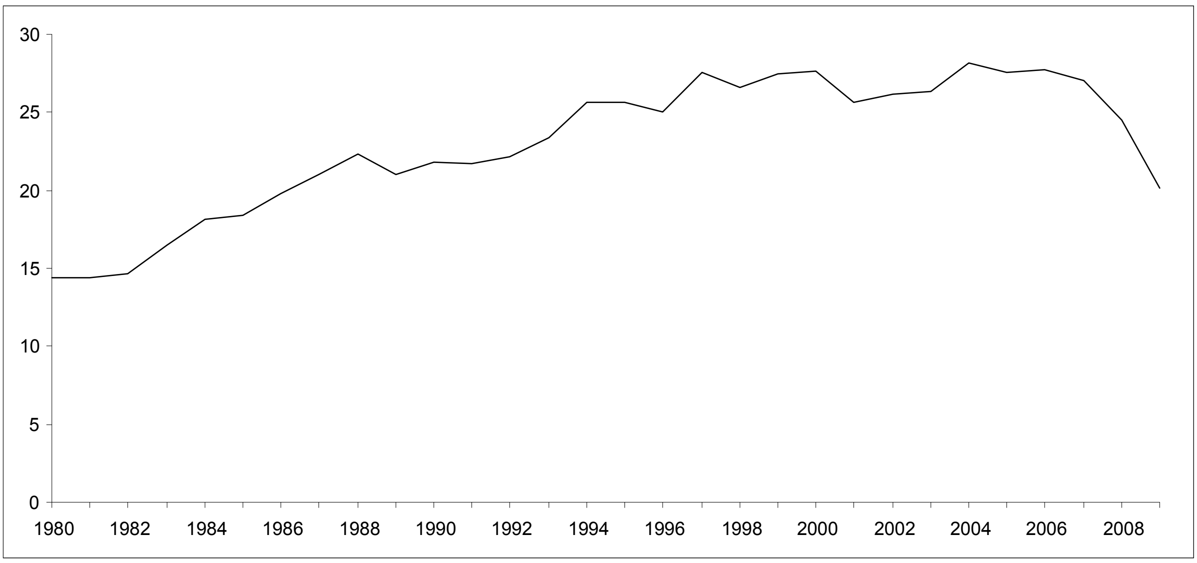


Sources: FAOSTAT

Data from the past decades imply that, contrary to general expectations, ICT development did not create the "paperless office". On the contrary, office paper consumption increased considerably with desktop publishing (Plepys, 2002). Between 1960 and 1997 the increase in the United States was fivefold (EIA, 2002).

However, more recent studies show that this situation is changing. Thus, the market for office paper may have undergone a restructuring – growth in consumption of office paper has slowed down markedly, stopped altogether, or even started to fall in some OECD countries (Hetemäki, 2005). As with newsprint, the change has been most marked in North America (ibid.). Figure 16, depicting consumption of printing and writing paper in the United States, would seem to confirm this finding. The board and packaging segment of the paper industry seems to have a better future, as it is supported by trade, Internet shopping, urbanization, the need to store food properly, and energy prices (Donner-Amnell, 2010; Phillips, 2010).

Figure 16. US printing and writing paper apparent consumption (million tonnes).



Source: FAOSTAT

3.4 Globalization

For the forest sector, the most important aspect of globalization has been reduced transport costs, which has led to increased trade and the creation of a truly global market for forest products (United Nations, 2005). Globalization has reduced the importance of forest resources for the forest industry, and development has been driven predominantly by labour costs, levels of research and technology, and access to capital (Whiteman, 2005).

Intensively managed forest plantations are increasingly replacing natural forests as the raw material resource. These changes eliminate the traditional ties between forest processing and locations with abundant natural forests (Bael and Sedjo, 2006). Hence, forest industry functions have become spatially separated, i.e. companies now utilize materials from various sources, and consequently can site manufacturing plants at different locations along the value chain (United Nations, 2005).

The relative advantage in wood production is thus moving away from countries with large forest resources in the northern hemisphere towards countries where trees grow quickly. The future supply of wood and fibre will increasingly depend on the availability of land for forest plantations, and their environmental and social costs (Whiteman, 2005).

For countries such as Sweden and Finland, succeeding in global competition on a domestic basis alone is not possible. Consequently, Nordic forest companies are expected to continue to invest in forest plantations and pulp mills in South America, whereas paper machines will be located in Asia, where demand is growing most rapidly (Finnish Forest Industries Federation, 2005).

These developments will adversely affect employment in the Swedish forest-product industry. In northern Sweden, raw-material-based industries, such as forest industries, often provide the only means of employment (Jakobsson, 2009). Swedish forest owners will also be affected, as cheap hardwood pulp from the southern hemisphere will exert downward pressure on the price of Swedish softwood pulp. The Swedish sawmill industry, however, should not face the same direct threat, since the forest expansion in the southern hemisphere is mainly focused on pulp and paper production (Whiteman, 2005).

Further globalization could conceivably be halted, and even reversed, by dramatically increasing transport costs and/or by major international conflicts disrupting global trade, arising for example from competition for natural resources in the Arctic region (see, for example, Agrell, 2009). The current tension among certain countries/regions regarding "competitive currency devaluations" and trade imbalances, so called "currency wars", may also hamper global trade as well as global economic recovery (see, e.g., BBC, 2010).

Particularly conspicuous is the dispute between the United States and China. The question is whether currency wars are a short-term phenomenon or something that will have more long-lasting effects. The Great Depression of the 1930s was marked by protectionist trade policies, where the exchange-rate regime and economic policies associated with it were key determinants of trade policies and the breakdown of the multilateral trading system (see, e.g., Eichengreen and Irwin, 2009).

3.5 Global climate change

Changes in the world's climate are likely to substantially affect every aspect of the environment and the economy (Aulisi *et al*, 2008). Expected changes in temperature and precipitation patterns will probably have strong direct effects on both natural and modified forests (Kirilenko and Sedjo, 2007), affecting both the growth rates and optimal locations for tree species (Sohngen and Sedjo, 2005).

Climate change is therefore expected to improve forest productivity on a global scale while increasing regional variability, thereby complicating the relationship between supply and asset appreciation (Aulisi *et al*, 2008). In boreal regions such as Sweden, elevated atmospheric CO_2 concentrations, accompanied by warming and longer growth seasons, are generally expected to increase timber production over the century by inducing a polarward shift in the most important forestry species and accelerating vegetation growth (Cramer *et al*, 2001; Solberg *et al*, 2003; Schroeter, 2004; Scholze *et al*, 2006).

These flow effects could have major economic implications in the long term, e.g. global timber harvests could be six percent greater in 2050 than they might have been without warming (Sedjo, 2010). Up until 2025, timber harvest levels are not expected to change greatly in boreal forests (Sohngen and Sedjo, 2005).

However, stock effects, i.e. changes in frequencies or the nature of disturbances, such as forest fires, pest infestations, severe drought or windthrow, may have potentially important impacts in the near and medium terms (Sohngen and Sedjo, 2005). Increased frequencies of extreme events such as strong winds or droughts, aggravated by insect outbreaks and wildfires, can cause massive losses to commercial forestry (Kirilenko and Sedjo, 2007).

An obvious example is the mountain pine beetle infestation in western Canada. Ensuing salvage logging is projected to increase short-term timber supply and reduce prices; whereas longer-term supply will decrease (Sohngen *et al*, 2001; Perez-Garcia *et al*, 2002; Sohngen and Mendelsohn, 2003).

Modelling results suggest that the decline in the global importance of boreal forests, with global timber harvests shifting towards subtropical plantation regions, will continue over the medium term, as impacts of lower world prices outweigh benefits of rising forest productivity in boreal regions (Sohngen *et al*, 2001; Perez-Garcia *et al*, 2002).

However, no large differences in global warming between different greenhouse gases (GHG) emission scenarios are foreseen until at least 2050 (IPCC, 2007), even if climate changes are ultimately greater than expected due to the inherent inertia of the climate system (see, for example, Hasselmann *et al*, 2003).

3.6 Policies, regulations and customer preferences linked to climate change

3.6.1 Policies promoting material substitution

Policies aimed at mitigating climate change can affect forest-product markets in various ways. One is by encouraging the use of wood products instead of materials that yield more GHG emissions during the course of their production, subsequent use and disposal (Binkley and van Kooten, 1994), i.e. fossil fuel substitution. As an example, public policies promoting the use of energy-efficient, renewable construction materials, e.g. the *Code for Sustainable Homes* (DCLG, 2006) and *Green Building* (EPA, 2010), could boost global demand for construction timber.

But the way in which *Green Building* standards are formulated will greatly influence the strength of preferences for sustainable wood products over competing materials, based on lifecycle carbon emissions (Aulisi *et al*, 2008). Harvested wood products (HWP) also have climate change mitigation value as a form of carbon sequestration (see, for example, Skog and

Nicholson, 1998; and Profft *et al*, 2009). But no agreement on the different approaches for accounting harvested wood product has been reached, and carbon sequestered in HWP is currently not included in climate change mitigation agreements (Kohlmaier *et al*, 2007). The assumption in climate protocols such as the Kyoto Protocol is that all of the carbon contained within trees is released at harvest (see Bowyer *et al*, 2010).

3.6.2 Policies promoting bioenergy

Public policies also affect global forest-product markets by promoting the development and use of bioenergy and biofuel, e.g. the targets for renewable energy in EU (the EU RES Directive): a target of 20 percent for the total energy used in the EU, and a mandatory target of 10 percent for the energy used in petrol and diesel transport, to be from renewable sources by 2020 (European Parliament, 2009).

Sweden's targets are even more ambitious: by 2020 the share of renewable energy shall be at least 50 percent of the total energy consumption (in 2009 the Government voluntarily raised the target for renewable energy for year 2020 from 49 to 50 percent) while in the transport sector the share shall be at least 10 percent (Holmgren, 2010).

These targets have already stimulated an increasing demand for wood as an energy source, e.g. for wood pellets as a substitute for fossil fuel in small-scale heating and electricity production (Peksa-Blanchard *et al*, 2007). Market analysts expect the demand for pellets to continue to grow rapidly in the coming decade (Wild, 2009).

International bioenergy trade is also growing rapidly, not least for wood pellets. Main wood-pellet trade routes are leading from Canada and the United States to Europe, in particular to Sweden, the Netherlands and Belgium (Junginger *et al*, 2011). Biomass co-firing with coal in existing coal-fired power plants represents a considerable near-term potential for increasing the renewable energy share in the EU27 (Hansson *et al*, 2009).

Landowners will benefit from the development of bioenergy as a result of increased competition and ensuing higher prices for wood raw materials (Roberts, 2007). However, the increased costs of raw materials will reduce the competitiveness of the traditional forest-product industry (Aulisi *et al*, 2008; Engelbrecht, 2006); and this is already happening.

For example, during the logging season 2008/2009, Sweden's energy sector successfully competed against the traditional forest-product industry for woody biomass from certain forestry operations such as first thinnings and roadside cleaning in areas far away from pulp mills. This was partly due to the slump in the pulp and paper industry, and resulting lower prices for pulpwood (Hektor, 2009).

However, some representatives of the pulp and paper industry have publicly declared that it will not be possible to increase prices for low-quality pulpwood to match the prices paid by the energy sector. They contend that the industry is experiencing strong international competition in bulk pulp from industries located in areas with abundant cheap wood from high-yielding plantations (ibid.).

In the future, chemical pulp producers will face increased competition for raw materials but may also profit from a growing bioenergy sector since they could manufacture new, high-value products in integrated bio-refineries. Since mechanical pulp producers cannot do this, they will suffer from higher prices for raw materials and electricity (Engelbrecht, 2006).

In solid wood products, the wood-based panel industry will face more competition for all its raw materials—slabs, chips, sawdust and roundwood—and have no secondary products to feed into the energy markets. Sawmills, on the other hand, should mainly benefit from the development of wood-based bioenergy markets, as sawlogs have high value and less competition from energy uses and should attract higher prices for secondary products (slabs, chips, and sawdust) demanded by bioenergy markets (ibid.).

3.6.3 Policies promoting forest-based carbon sequestration

Climate change mitigation policies involving forest-based carbon sequestration raise complex issues; and their effects on forest-product markets therefore have high degrees of uncertainty. Estimates show that the world's forests store 289 gigatonnes (Gt) of carbon in their biomass alone. On a global level, carbon stocks in forest biomass decreased annually by an estimated 0.5 Gt during the period 2005–2010, mainly because of a reduction in the global forest area (FAO, 2010).

Increasing the standing inventory of forest biomass implies a greater sequestration of carbon (Plantinga *et al*, 1999; Stavins, 1999; Sohngen and Mendelsohn, 2003). This can be done by converting non-forest land into forests, by reducing deforestation, and/or through forest management and silviculture emphasizing carbon sequestration.

Management activities promoting increased growth and volume will typically generate additional carbon sequestration (Sedjo *et al*, 1995). Fertilization, for example, could thus increase carbon storage (Huettl and Zoettl, 1992; Nilsson, 1993; Hudson *et al*, 1994; Oren *et al*, 2001). Further, reducing and/or delaying harvests (i.e. lengthening rotations) increases the amount of carbon sequestered (Hoehn and Solberg, 1994; van Kooten *et al*, 1995; Backéus *et al*, 2005).

A model of global forest carbon sequestration suggests that while in the short term global timber supply declines as landowners lengthen rotations, in the longer term (up to 2050 and beyond) the combination of expanding forest area and longer rotations will lead to a dramatic increase in timber supply and a subsequent reduction in global prices (Sohngen and Mendelsohn, 2003).

Reducing tropical deforestation is perhaps the most efficient approach to carbon sequestration. Deforestation in the tropics is still proceeding at a substantial rate (Sedjo, 2001; Santilli *et al*, 2005). Estimations suggest that tropical deforestation accounts for between 10 and 25 percent of global human-induced carbon emissions (Santilli *et al*, 2005); and tropical forests are more efficient engines of carbon sequestration and opportunity costs are lower compared with temperate forests (Newell and Stavins, 2000). These circumstances provide the backdrop for the UN REDD (Reduced Emissions from Deforestation and Forest Degradation) programme—where the basic idea is for rich countries to compensate poor countries for not cutting down forests (Holmgren, 2010).

3.6.4 Customer preferences

De facto climate change, as well as the notion of climate change, is expected to lead to increased consumer preferences for "green products", particularly in the construction sector. Preferences are also expected to shift from fossil fuels to bioenergy and biofuel in the face of rising energy prices (Kirilenko and Sedjo, 2007). At the same time as the climate change issue is high on the political agenda, benefits of sustainable forest products are not widely understood. There is, however, a good opportunity for the industry to improve its consumer relations (Aulisi *et al*, 2008). Paper and wood have the lowest energy consumption and the lowest carbon dioxide emissions of any commonly used packaging or building materials (Frühwald *et al*, 2003).

3.7 Environmental policies and regulations other than those linked to climate change

Environmental policies and regulations have a potentially strong impact on wood supply as well as the production, consumption and trade of wood products. Future developments in environmental policies and regulations deemed most likely by policy experts are a greater emphasis on nature conservation and promotion of biodiversity, as well as on nature-oriented forest management (Thoroe *et al*, 2004).

Various studies on the role of forests show that the preservation of the natural environment and biodiversity, as well as the protective functions of forests, are widely recognized and highly valued by the public in Europe (Rametsteiner and Kraxner, 2003). In Germany, for instance, the aim for 2020 is to increase the share of forest area without interventions to five percent (BMU, 2007). Environmental management, and the image it produces, has also become crucial for forest industry companies (Donner-Amnell *et al*, 2004).

Greater emphasis on nature conservation and promotion of biodiversity is expected to reduce removals and wood production in Europe (Thoroe *et al*, 2004). Estimations of the impacts of biological and landscape diversity protection on wood supply in Europe indicate a reduction in harvest potential of around 70 million cubic meters in the protected areas (Verkerk *et al*, 2008). Policy measures emphasizing nature oriented forest management, including the elimination or reduction of clear-cutting in favour of more selective harvesting, will presumably also lead to a reduction in wood supply (Thoroe *et al*, 2004).

4 Methodology

Projection results as to wood use for material and energy purposes, as well as potential raw material supply from forests and others sources, set out in this report were produced within the frame of the EFSOS and EUwood projects. The following is a brief overview of the different modelling approaches. For a comprehensive description of the methodology, see Mantau *et al* (2010b).

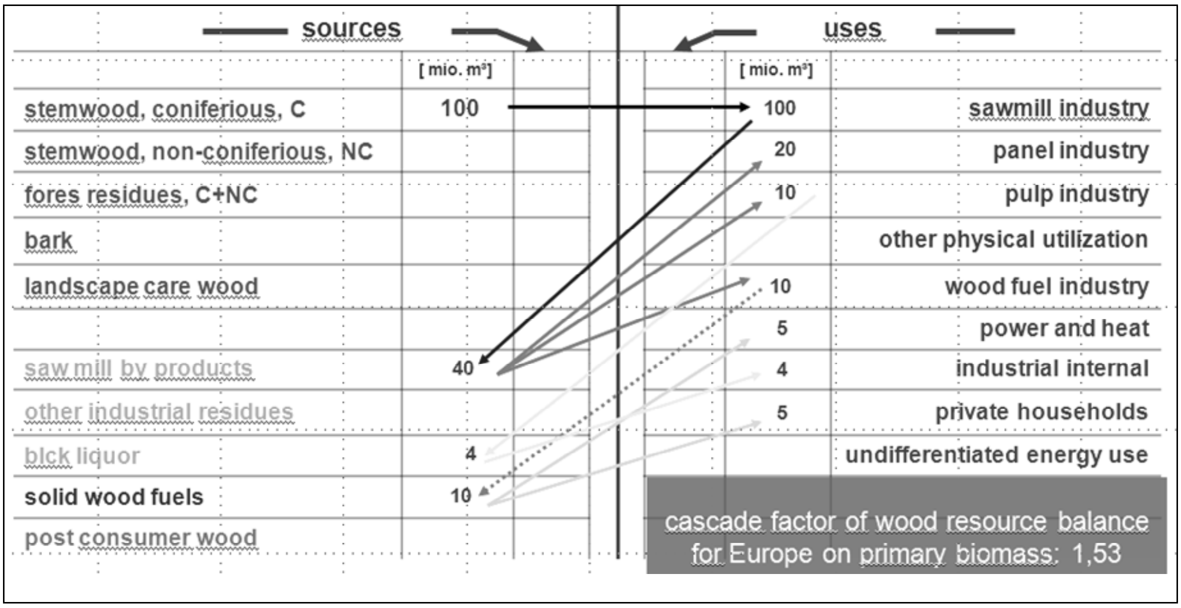
4.1 Wood Resource Balance

The Wood Resource Balance (WRB) brings together in a structured format all parts of wood supply and demand modelling (Mantau *et al*, 2010a). In the WRB approach, available production and trade statistics are supplemented by sector-specific consumption analysis based on empirical field research (e.g. enterprise surveys). Specific conversion factors—considering, for example, average plant sizes, production technologies in the specific sector, or tree species—are used to measure the transferred amount of wood from one sector to another (Mantau *et al*, 2010b).

Wood is a highly versatile material being used and re-used in many different processes. By-products of the wood-processing industry are an important raw material for further processing. They can easily be used directly in on-site integrated processes (e.g. black liquor for energy generation or pellets production by sawmills), or be sold for subordinated processing (e.g. chips from sawmill used for pulp production, or sawdust for panel production).

Wood fibres reappearing as “secondary” raw material increase the overall wood availability on the market (Mantau *et al*, 2010b). This kind of *cascaded use* can be documented by the WRB (Table 17). In the example, the overall cascade factor is 1.53, which means the 100 million m^3 that entered the balance sheet have been used roughly one and a half times (Ibid.).

Table 17. Cascade uses in the WRB



Source: Mantau *et al* (2010b)

Potential wood resource demand is calculated on the right-hand side of the WRB. As for the demand for material use, projections of supply and demand of wood products are based on econometric analysis, using as inputs projections of GDP, commodity price and production cost developments.

Based on projected quantities of produced goods (sawnwood, pulp, and wood-based panels), wood resource biomass requirements and quantities of industrial residues are derived using conversion factors (see Mantau *et al*, 2010b). Traditional other material uses are not modelled econometrically; instead, an expansion factor was calculated based on the econometric projections of solid wood consumption (sawnwood and wood-based panels) and applied to the sector "other material uses". Further, no quantitative calculations have been undertaken for innovative wood products (Mantau and Saal, 2010a). Projections of wood demand for energy use are based on the assumptions that:

- overall energy efficiency in the EU27 increases according to the EU RES Directive.
- targets for the share of energy from renewable sources set out in the EU RES Directive are reached.
- wood-based energy slightly decreases its share in energy from renewable sources to 40 percent in 2020.
- Energy units (TJ) are converted to forest units (cubic metres) using an empirically derived conversion factor (Ibid.)

Potential supply of woody biomass is calculated on the left-hand side of the WRB: first of all wood raw materials from forests: coniferous and non-coniferous stemwood, bark, and forest residues, provided by the European Forest Information Scenario Model (henceforth EFISCEN) based on recent, detailed national forest inventory data on species and forest structure, and combined with specific technical and environmental constraints to produce realizable supply potential.

Other woody biomass sources include:

- industrial residues, estimated based on the production of wood products and empirically derived conversion factors.

- landscape-care wood, i.e. woody biomass from horticulture activities and other landscape-care activities in parks, cemeteries, etc.
- post-consumer wood, comprising all wood that has already been used and is included in the resource stream again via the disposal system or directly, e.g. by households (Mantau *et al*, 2010b).

However, the EUwood project presents quantities of wood use and supply based on given development paths. The identified quantities do not represent equilibriums (or the sums on the supply/sources and uses side would balance out). The calculated potential supply of stemwood, for example, does not correspond to the use of stemwood but to the supply that can be mobilized under given conditions (ibid.).

4.2 Wood demand for material use

The description of the econometric modelling and projections of supply and demand of wood products builds on Jonsson (2010).

4.2.1 Modelling demand, supply and trade of wood products

Applying the approach of Kangas and Baudin (2003), subject to the market characteristics of the country analysed, two different econometric approaches are used:

- A multiple equations approach for demand (two equations: for import demand and demand for domestically produced commodities) and supply (one equation: for export supply). Explanatory variables are real GDP and real prices. Real cost factors used in the supply equations are raw material costs—log prices, chip prices, recovered paper prices and pulp prices—all in constant US$. The functional form is log-linear, allowing for direct interpretation of estimated coefficients as elasticities.
- A time series cross-sectional model for apparent consumption. Explanatory variables are real GDP and real prices. Again, the functional form is log-linear.

Major markets and producers are analysed individually, using the multiple equation approach (Group I in Table 18). Traditional market economies, with minor production and/or relatively low consumption, form a second group of countries, which were subject to time series cross-sectional analysis, as was a third group consisting of countries with economies in transition.

The purpose of sub-groups IIa and IIb is to obtain relatively homogeneous groups. In Group III, the larger (in terms of production and/or consumption of wood products) countries form their own group (IIIa), but they are also included in sub-group IIIb. The reason for this overlapping is the lack of stability of results for group IIIb if the countries in Group IIIa would not have been included. Attempts have been carried out with several alternative groupings among countries, but the classification described above proved to be the one providing the most stable results.

Table 18. Country groupings in the econometric analysis

GROUP I. MULTIPLE EQUATION APPROACH: DEMAND, SUPPLY AND TRADE MODELS ESTIMATED			
Austria	Norway		
Finland	Spain		
France	Sweden		
Germany	United Kingdom		
Italy			
GROUP II. TIME-SERIES CROSS SECTION APPROACH: DEMAND MODELS ESTIMATED			
Group II a		*Group II b*	
Belgium		Greece	
Denmark		Ireland	
Luxembourg		Portugal	
Netherlands		Turkey	
Switzerland			
GROUP III. TIME-SERIES CROSS SECTION APPROACH: DEMAND MODELS ESTIMATED			
Group III a	*Group III b*		
Czech Republic	Albania	Hungary	Serbia
Hungary	Belarus	Latvia	Slovakia
Poland	Bosnia and Herzegovina	Lithuania	Slovenia
Russian Federation	Bulgaria	Montenegro	The Fmr Yug Rp of Macedonia
Ukraine	Croatia	Poland	Ukraine
	Czech Republic	Romania	
	Estonia	Russian Federation	

The products analysed are (a) sawnwood (coniferous and non-coniferous), (b) wood-based panels (plywood, particle board, and fibreboard), and (c) paper and paperboard (newsprint, printing and writing paper, and other paper and paperboard). For wood pulp, other fibre pulp, and recovered paper, consumption is not analysed but derived for projection purposes from the projected production of paper using conversion factors, indicating the input of raw material needed (Jonsson, 2010).

The FAOSTAT database is the main source of data for production, imports and exports, as well as the value of imports and exports of commodities. Based on this information, import and export unit values (in US$) are calculated and subsequently deflated to provide estimates of real (constant) import and export prices. Trade flows were assessed in the UNECE and UN COMTRADE database. Historical macroeconomic data – GDP in constant US$ and deflators – were collected from the FAO database (ibid.).

4.2.2 Projecting demand, supply, and trade

The future developments of GDP, prices and costs used for wood products market projections are based on the IPCC SRES scenarios, as developed for the forest sector by the EFORWOOD project. The scenarios, referred to as reference futures in the analysis, may be briefly characterized as follows (Jonsson, 2010):

- Scenario **A1** describes an open world with steady economic growth, slow population growth, fast technical development in industry, but slow in environment, strong rises in global trade, but less in intra-EU trade, rising consumption, including wood products, faster urbanisation, more road transport and long-distance tourism. It also sees increased profitability of wood-based industries (but not for forest owners). The concentration in the industry proceeds and wood has a stable market share in end-use sectors. Conversion of agricultural land to forest is forecast to rise, and employment in the countryside to fall. Environmental awareness is limited, and thus the area of nature reserves is stable.

- Scenario **B2** describes a less globalized, more environmentally aware future, with slower GDP growth, but higher growth in population, strong increases in the “knowledge society” and technical developments for environment. General consumption would grow more slowly than in scenario A1, but wood consumption for materials and energy would grow faster. Urbanization and the size of mills would progress more slowly. The number of mills in Europe is stable, and multi-functionality is increasing, as is the area of nature reserves. Profitability of wood-based industries would grow more slowly than in scenario A1, but profitability for forest owners would grow (unlike in Scenario A1), as would rural employment. There would be a smaller increase in conversion of agricultural land to forest, while rural employment would grow slightly.

The scenario developments are broken down into GDP growth rates, which, together with (a) future commodity price and production cost developments derived from the EFORWOOD project; and (b) income, price and cost elasticities derived from the econometric analysis, are used to project sawnwood, pulp, and wood-based panels consumption, production and trade (Jonsson, 2010).

These projections form the basis for the wood resource consumption calculations (Mantau and Saal, 2010a). Hence, based on projected quantities of produced commodities (sawnwood, pulp, and wood-based panels), wood resource biomass requirements and quantities of industrial residues are derived using conversion factors (ibid.).

Traditional other material uses are not modelled econometrically; instead an expansion factor was calculated, based on the econometric projections for solid wood consumption (sawnwood and panels) and applied to the sector other material uses (Mantau and Saal, 2010a). Further, no quantitative calculations have been undertaken for innovative wood products, as its future development is highly uncertain at the moment (ibid.)

4.3 Wood demand for energy use

The description of the approach used for projection wood demand for energy uses is derived from (Steierer, 2010a).

4.3.1 The overall energy framework

The EU RES Directive provides guidance for the consumption of renewable energy based on relative figures only (as percentages of total primary energy consumption). Hence, the development of GIEC is crucial for calculating future absolute amounts of energy from renewable sources (Steierer, 2010a). Projections here are based on the development of energy consumption in past years with an added energy efficiency factor.

The EUwood project follows the majority of the country reports and statements made by the Member States in assuming a 20 percent energy efficiency gain. The trend of less energy intensity in combination with higher GDP productivity at the EU level was used to project the energy consumption separately for each Member State (ibid.).

4.3.2 Future energy consumption from renewable sources

Once the future development of GIEC has been calculated, the development of energy consumption from renewable energy sources is given by the country-specific renewable energy targets in the EU RES Directive (Table 19).

Table 19. Country specific renewable energy targets

Country	**Share of energy from renewable sources in gross final consumption of energy in 2005**	**Target for share of energy from renewable sources in gross final consumption of energy by 2020**
Austria	23.3 %	34 %
Belgium	2.2 %	13 %
Bulgaria	9.4 %	16 %
Cyprus	2.9 %	13 %
Czech Republic	6.1 %	13 %
Denmark	17.0 %	30 %
Estonia	18.0 %	25 %
Finland	28.5 %	38 %
France	10.3 %	23 %
Germany	5.8 %	18 %
Greece	6.9 %	18 %
Hungary	4.3 %	13 %
Ireland	3.1 %	16 %
Italy	5.2 %	17 %
Latvia	32.6 %	40 %
Lithuania	15.0 %	23 %
Luxembourg	0.9 %	11 %
Malta	0.0 %	10 %
Netherlands	2.4 %	14 %
Poland	7.2 %	15 %
Portugal	20.5 %	31 %
Romania	17.8 %	24 %
Slovak Republic	6.7 %	14 %
Slovenia	16.0 %	25 %
Spain	8.7 %	20 %
Sweden	**39.8 %**	**49 %**
United Kingdom	1.3 %	15 %

Source: Steierer (2010a).

Besides the starting and target point for each separate country, the EU RES Directive also provides detailed guidance on the trajectory, i.e. how much of the final target should be achieved in every biennium term. The EUwood project applies a slightly different growth path, with the objective of providing a moderate and equilibrated growth rate over the entire time span (for details, see Steierer, 2010a).

4.3.3 The role of wood-based energy

Comparison of datasets of the UNECE/FAO Joint Wood Energy Enquiry (UN, 2009), henceforth JWEE, with corresponding energy data from Eurostat on energy from wood and wood wastes resulted in a conversion factor between energy and cubic metres (8.72 TJ/ 1,000m^3).

EUwood then uses Eurostat data to assess the current role of wood-based energy for each member country (see Figure 9). Due to high variation from one year to another, the calculation was based on a five-year average (2003-2008). In the EUwood project, it is assumed that wood-based energy slightly decreases its share in energy from renewable sources from around 50 percent at present to 40 percent in 2020.

Finally, the total annual wood-based energy consumption per country is obtained by multiplying future amounts of energy from renewable sources by the country-specific average share of wood-based energy. The result in energy units is then converted into cubic metres using the above conversion factor (ibid.).

4.3.4 Wood-based energy — sector specific development

The different wood-based energy sectors are modelled separately in EUwood. Total wood-based energy consumption is distributed between the various users, with the residual assigned to a single user, biomass power plants (Steierer, 2010a).

Industry internal use of wood-based energy

Internal wood-based energy use in the forest industry is split into energy from residues in the pulp and paper industry (liquid) and energy from solid residues from any other wood-processing industry (sawmills and wood-based panels producers mainly). Assessing and calculating the volumes of industrial wood residues in EU27 is based on the general structure of forest industries (Steierer, 2010a).

Modelling approaches for the different sectors are based on production processes in the sawmill industry, the wood-based panel industry and the pulp and paper industry. Estimates of future industry internal use of wood-based energy are based on projected quantities of pulp, sawnwood and wood-based panel production and empirically derived conversion factors (ibid.).

<u>Liquid residues</u>

EUwood calculations for the generation and use of black liquor build on the assumptions that (a) the input to output ratio remains constant and (b) any by-product of the pulping process is entirely used for energy generation (Steierer, 2010a).

<u>Solid residues</u>

Sawmills and wood-based panels producers use solid residues for energy generation, notably for drying of semi-finished products. The JWEE and empirical research by Hamburg University provide indications as to the share of wood used for internal energy generation (for details, see Steierer, 2010a).

Households

Household use of wood-based energy in EUwood is divided into fuelwood consumption and consumption of pellets and briquettes.

<u>Fuelwood</u>

The JWEE provides information on fuelwood consumption by households for 13 EU countries. For the remaining 14, fuelwood consumption is calculated on the basis of an indicator based on the quota of forest area and rural inhabitants, derived from JWEE data.

Different growth rates are then assumed for the five-year periods up to 2030. Finally, it is expected that 10 percent of pellets consumption will substitute fuelwood consumption (for details, see Steierer, 2010a).

<u>Pellets and briquettes</u>

Data on wood-based pellets production, trade and consumption are scarce and there is no official long-term dataset on production and trade of this commodity (Steierer, 2010a). The

EUwood project used data on pellets production and consumption from the Pellets@tlas project (http://www.pelletsatlas.info/cms/site.aspx?p=9170).

Whenever possible, EUwood used existing country specific data to project the future development (Austria, Belgium, Denmark, Finland, Slovenia and Sweden). In countries where data sets did not allow any projections, projections were based on assumed average growth rates until 2030 (for details, see Steierer, 2010a).

Liquid biofuels

The EUwood projection follows the International Energy Agency's reference scenario (IEA, 2009). EUwood further assumes that the raw material needed for second generation biofuels will come primarily from woody biomass, and that these amounts of second generation wood-based biofuels will be produced within the seven EU member countries with the largest raw material procurement basins: Germany, Finland, France, Italy, Poland, Spain and Sweden (for details, see Steierer, 2010a).

Main activity energy producers - biomass power plants

In the EUwood project, wood consumption for energy generation in biomass power plants comprises any heat and electricity producer whose main or sole activity is the production of energy for the market, i.e. similar installations producing heat or electricity for internal use by forest industries are not included.

Further, in EUwood this sector includes consumption of wood by co-firing in large-scale coal plants, large-scale biomass power plants, and mid- and small scale combined heat and power plants. Incineration plants for treated and contaminated wood are similarly included when producing heat and power for the market (Steierer, 2010a).

The amount of energy produced by biomass power plants is calculated as the difference between the total wood-based energy needed to meet the renewable energy targets, estimated by the method outlined above, and the sum of wood-based energy generation from the other sectors (ibid.).

4.4 Biomass supply from forests

In EUwood, the realizable forest biomass supply potential is estimated for the period 2010 to 2030 in three steps (Verkerk *et al*, 2010a):

- The maximum theoretical supply of forest biomass in Europe is estimated using EFISCEN. These projections are based on recent, detailed national forest inventory data on species and forest structure and provided the theoretical biomass potentials from broadleaved and coniferous tree species separately from stemwood, logging residues (i.e., stem tops, branches and needles), stumps and pre-commercial thinnings.
- Multiple constraints that reduce the amount of biomass that can realistically be extracted from forests are identified.
- The theoretical potential is combined with the quantified constraints from the three mobilization scenarios to assess the realizable biomass potential from European forests.

4.4.1 Theoretical biomass supply from forests

EFISCEN modelling framework and data

EFISCEN is a large-scale forest scenario model that assesses potential wood supply from forests and projects forest-resource development. A detailed model description is given by

Schelhaas *et al* (2007). It describes the state of the forest as an area distribution over age- and volume-classes in matrices, based on forest inventory data on the forest area available for wood supply.

Transitions of area between matrix cells during simulation represent different natural processes and are influenced by management regimes and changes in forest area. In each five-year time step, the area in each matrix cell moves up one age-class to simulate ageing. Part of the area of a cell also moves to a higher volume-class, thereby simulating volume increment. Growth dynamics are estimated by the model's growth functions, which are based on inventory data or yield tables (Verkerk *et al*, 2010a).

Management scenarios are specified at two levels in the model. First, a basic management regime defines the period in which thinnings can take place and a minimum age for final felling. Thinnings are implemented by moving area to a lower volume class. Final fellings are implemented by moving area outside the matrix to a bare-forest-land class, from where it can re-enter the matrix, thereby reflecting regeneration. Secondly, the demand for wood is specified for thinnings and for final felling separately and EFISCEN may fell the demanded wood volume if available.

The forest inventory data that were used to initialize EFISCEN were collected by Schelhaas *et al* (2006). Within the EUwood project, new inventory data have been collected from national forest agencies for Austria, Belgium, Czech Republic, Denmark, Finland, Germany, Hungary, Ireland, Italy, Latvia, the Netherlands and Sweden. The data comprise:

- forest area available for wood supply (ha).
- growing stock volume (m^3 over bark/ ha).
- gross annual increment (m^3 over bark/ ha /annum).
- annual mortality (m^3 over bark/ ha /annum).

The data are structured by age classes, tree species, geographic regions, ownership classes, and site classes (Verkerk *et al*, 2010a).

Model simulations and calculations

The theoretical, long-term maximum stemwood harvest potential for the period 2010 to 2030 is assessed iteratively in five-year time-steps, based on the average volume of wood that could be harvested over a 50-year period, taking into account increment, the age-structure, stocking level, and harvesting losses. The maximum, average harvest level is re-estimated for every five-year time-step for the next 50 years to take into account changes in forest area, structure, growth etc. (i.e. 2010 to 2060, 2015 to 2065, etc.). This approach provides direct estimations of the stemwood potentials from thinning and final fellings separately (Verkerk *et al*, 2010a).

Upon harvest, logging residues as well as stumps and coarse roots become available. To assess biomass in branches, coarse roots, fine roots and foliage, stemwood volumes are converted to stem biomass by using basic wood density (dry weight per green volume) and to whole-tree biomass using age- and species-specific biomass allocation functions. In the model, it is possible to define which share of the logging residues and stumps/coarse roots are removed from the forest during thinning and final fellings. The amount of biomass generated during harvest from these tree components is used to derive the theoretical potential of logging residues and stumps/roots from thinning and final fellings separately (ibid.).

EFISCEN outputs do not include estimations of potential biomass supply from pre-commercial thinnings. The theoretical supply potential from pre-commercial thinnings is estimated by assuming 30 percent removal of the stem and crown biomass.

All in all, the following theoretical forest biomass potentials are estimated for coniferous and broadleaved forests separately:

- Stemwood from thinnings and final fellings
- Logging residues from thinnings and final fellings
- Stumps from thinnings and final fellings
- Stem and crown biomass from pre-commercial/early thinnings.

4.4.2 Constraints on biomass supply from forests

The estimated theoretical forest biomass potentials are reduced due to the consideration of various constraints. A long list of constraints was identified, but many are correlated with each other or impossible to quantify. Those finally used in EUwood are described in Table 20.

Table 20. Constraints on wood supply from forests

CONSTRAINT	TYPE	EXPLANATION
Soil and water protection	Environmental	○ The nutritional impact of biomass extraction. More productive soils can tolerate a higher degree of biomass extraction. ○ Removal of forest biomass increases the risk for erosion. Steeper slopes imply less biomass removal. ○ Forests have an important role in the protection of watersheds. Intensive logging and residue extraction may result in the degradation of water quality. ○ Using heavy machinery for extracting biomass can lead to soil compaction, particularly in wet soils
Biodiversity protection	Environmental	○ An increase in protected areas will reduce wood supply potential. ○ Certification schemes include restrictions on harvest in favour of biodiversity. More restrictive rules for harvesting implies reduced wood supply potential
Recovery rate	Technical	○ Part of the woody biomass from forest is lost before reaching the point of utilisation. Technical recovery rate depends on the used harvesting technology.
Soil bearing capacity	Technical	○ On soft soils the bearing capacity can reduce the amount of harvestable biomass. For instance, in soft peat lands the logging residues must be left on the forwarding trail to strengthen the bearing capacity of the soil.
Ownership structure	Social	Where the ownership structure is very fragmented and the forest holdings small, mobilisation of forest biomass may suffer as the forest owners may: ○ be difficult to reach ○ be unmotivated to sell wood as their forests are economically insignificant ○ have other management objectives than wood production

Source: Verkerk *et al* (2010a).

4.4.3 Realistic biomass supply from forests

The constraints depicted in Table 20 are quantified based on assumptions on their development over time in the three different mobilization scenarios: a high mobilisation scenario, a medium mobilisation scenario, and a low mobilization scenario (for details see Verkerk *et al*, 2010a):

High mobilization scenario

There is a strong focus on the use of wood for producing energy and for other uses, and policy measures leading to an increased mobilization of wood have been implemented. Biomass harvesting guidelines will become less restricting, as technologies less harmful for the environment are developed. Furthermore, possible negative environmental effects of intensified use of forest resources are considered less important than the negative effects of alternative sources of energy (i.e., oil, gas, coal) or competing building materials (e.g., steel and concrete).

Medium mobilization scenario

In this scenario – which represents the maximum amount of biomass that can be extracted from forests according to current management guidelines – recommendations to increase the mobilization of wood resources are not all fully implemented, or do not have the desired effect. To maintain biodiversity, forests are being protected, but with medium impacts on the harvests that can take place.

Low mobilization scenario

In this scenario, the use of wood for producing energy and for other uses is subject to strong environmental concerns. Possible negative environmental effects of intensified use of wood are considered very important and lead to strict biomass harvesting guidelines. Forests are set aside to protect biodiversity with strong limitations on harvest possibilities in these areas. Furthermore, forest owners have a negative attitude towards intensifying the use of their forests.

Each of the environmental and technical constraints is quantified separately for the type of biomass (stemwood, logging residues and stumps) and by type of harvesting activity (pre-commercial/early thinnings, thinnings, and final fellings). The theoretical forest biomass potential is then combined with the average reduction factor for each region and constraint. This results in realizable biomass potential from European forests at the regional level. In a next step, these regional estimates were aggregated to the national level (ibid.).

4.5 Landscape-care wood and biomass from other wooded land

Though forests are by far the most important source of primary woody biomass within the EU, wood from trees outside the forest, which becomes available during maintenance operations, landscape care activities, etc. is a non-negligible source of primary woody biomass (Oldenburger, 2010a).

The landscape - care wood potential estimations in EUwood are based on five biomass potential studies at country level from France, Germany, United Kingdom, Netherlands and Slovenia. The relationship derived from these studies —between the volume harvested in the forest area available for wood supply and the landscape care wood volume that is harvested from the non-forest land—is used to calculate total landscape care wood potential for the country in question.

To calculate the potential from other wooded land, area data from the *State of Europe's Forests 2007* (MCPFE, 2007) are combined with data on increment per hectare provided by the countries and an assumed harvest level of 75% of the increment. For countries that reported that no wood is harvested on the other wooded land and that no harvest is expected in the future, the potential is set to 0 m^3 (Oldenburger, 2010a).

4.6 Industrial wood residues

Estimations of the volumes of industrial wood residues (IWR) produced and available in EU27 are based on the production processes in the sawmill industry, the wood-based panel industry and the pulp and paper industry. In addition, the volume of IWR in further processing is derived from the utilization of sawnwood and wood-based panels in construction, furniture industry, packaging and other processing of semi-finished wood products (Saal, 2010a).

4.6.1 Sawmill by-products

Sawmill by-products comprise wood chips, sawdust and particles, as well as sawmill rejects, slabs, edgings and trimmings. The assortments are suitable for material uses such as pulping, particleboard and fibreboard production as well as for energy use (ibid.).

Modelling sawmill by-products, the recovery rate (sawnwood output as a percentage of roundwood input) plays a key role. This rate depends on factors such as wood species and structure (mill size) and technology of the sawmill industry. Based on country-specific information, a recovery rate is assigned to each country. Coniferous and non-coniferous sawmill by-products are modelled separately (Saal, 2010a)

4.6.2 Wood-based panels industrial residues

Estimations of IWR from the production of different types of wood-based panels are based on empirically derived coefficients as to the share of wood residues per cubic meter roundwood input and conversion factors (the ratio of roundwood input and wood-based panel output (ibid.).

4.6.3 Industrial residues from further processing

IWR from further processing derive from the utilisation of sawnwood and wood-based panels in the industry sectors construction, furniture industry, packaging, and other processing of semi-finished wood products. Other IWR, arising during further processing, include dust, shavings, trimmings, rejects or off-cuts (Saal, 2010a).

Estimations of the volumes of other IWR from all four manufacturing processes are based on empirically derived shares of residues in the four sectors mentioned above, and expansion factors, i.e. wood consumption per turnover and wood consumption per employee, for the sector and country in question, derived from EUROSTAT data (ibid.).

4.6.4 Black liquor

Black liquor is a by-product from the production of wood pulp for paper. About 40 to 50 percent of the wood raw material input is recovered as usable fibre in the chemical pulping process, the rest of the wood input along with spent caustic cooking chemicals forms black liquor (ibid.).

The modelling in EUwood is based on the assumption that black liquor is used exclusively for internal energy use in the pulp and paper industry, e.g. process energy for drying chips or black liquor recovery processes. Further, the estimates of black liquor generation assume that the efficiencies of different pulping processes will not change significantly in the given timeframe, and hence the input to output ratio (units of wood needed to produce one unit of pulp) is considered to remain stable. The solid content of black liquor is calculated as a residue volume—the balance between raw material input and pulp output, using conversion factors. Hereby the share of coniferous and non-coniferous roundwood in the raw material input is considered, since the lignin content varies by wood species (Saal, 2010a).

4.7 Post-consumer wood

Post-consumer wood (PCW) includes all kinds of wooden material that is available at the end of its use as a wooden product (Leek, 2010a). PCW can be used in wood-based panel production and for energy. In 2007, about two thirds of the generated PCW was recovered: 18.1 million cubic meters were used for particleboard production and 16.9 million cubic metres were used for energy (ibid.). Primary sources of post-consumer wood are:

- Municipal solid wood waste mainly from households
- Construction waste and demolition wood
- Fractions of used wood from industrial and commercial activities (primarily packaging materials, including pallets).

Data on generated wood waste volumes and amounts of recovered wood were collected from various sources. The share of PCW in total national solid wood consumption (sawnwood and wood-based panels) calculated for all EU27 countries for the year 2007 is used for estimating future PCW supply (Leek, 2010a). The solid wood consumption for the years 2010, 2015, 2020, 2025 and 2030 is provided by the wood-product projections (see section 4.2). Finally, the PCW potential is calculated based on assumptions regarding national developments of the proportion of PCW that is landfilled (ibid.).

5 Outlook: projection results

5.1 Wood for material purposes

The results detailed in section 5.1.1 are based on the econometric modelling by Jonsson (2010).

5.1.1 Projections of demand, supply and trade of wood products

Consumption of wood products

In the EU/EFTA, as well as in the EFSOS area as a whole, consumption growth is slowing down over the outlook period in the B2 reference future, with the exception of sawnwood, which is showing a slight increase (Table 20). The decline in growth rates is most noticeable for paper and paperboard. In the CIS, despite already having the highest growth rates in the EFSOS area, consumption growth is projected to accelerate over the outlook period, continuing the recovery from the slump following the demise of the Soviet Union. In Sweden, where growth rates are lower than in either the EU/EFTA or the EFSOS area, consumption growth rates are decreasing over the outlook period for all wood-product categories (Table 21).

Table 21. Average annual growth rates in the B2 reference future for the consumption of wood products in Europe by product category, period, and region

	2010-2020	2020-2030	2010-2030
EU/EFTA			
Sawnwood	0.4%	0.5%	0.4%
Wood-based panels	1.0%	0.9%	0.9%
Paper and paperboard	1.3%	0.9%	1.1%
CIS			
Sawnwood	1.1%	1.6%	1.3%
Wood-based panels	1.6%	2.6%	2.1%
Paper and paperboard	1.8%	2.7%	2.2%
EFSOS			
Sawnwood	0.5%	0.6%	0.5%
Wood-based panels	1.1%	1.1%	1.1%
Paper and paperboard	1.4%	1.0%	1.2%
Sweden			
Sawnwood	0.4%	0.2%	0.3%
Wood-based panels	0.9%	0.5%	0.7%
Paper and paperboard	0.9%	0.5%	0.7%

Note: EU/EFTA refers to the EU member countries plus Iceland, Norway and Switzerland; CIS refers to Belarus, Republic of Moldova, Russian Federation and Ukraine; EFSOS refers to the geographical area depicted in Figure 1

In contrast to B2, in the A1 reference future consumption growth is generally accelerating in the EU/EFTA as well as the EFSOS area over the outlook period, the only exception being paper and paperboard (Table 22). This decelerating growth in paper and paperboard consumption could mainly be understood in the light of continued progress in information and communication technology (see, for example Hetemäki, 2005). In the CIS, consumption growth is increasing, except for sawnwood. In Sweden, consumption growth is projected to decelerate for panels and, in particular, paper and paperboard over the outlook period, while the growth rate for sawnwood consumption remains chiefly unchanged.

Table 22. Average annual growth rates in the A1 reference future for the consumption of wood products in Europe by product category, period, and region

	2010-2020	2020-2030	2010-2030
EU/EFTA			
Sawnwood	0.9%	1.0%	1.0%
Wood-based panels	1.8%	2.0%	1.9%
Paper and paperboard	2.1%	1.9%	2.0%
CIS			
Sawnwood	2.2%	2.1%	2.1%
Wood-based panels	3.1%	3.5%	3.3%
Paper and paperboard	3.2%	3.7%	3.5%
EFSOS			
Sawnwood	1.1%	1.2%	1.1%
Wood-based panels	2.0%	2.3%	2.2%
Paper and paperboard	2.2%	2.1%	2.1%
Sweden			
Sawnwood	0.5%	0.5%	0.5%
Wood-based panels	1.7%	1.6%	1.6%
Paper and paperboard	1.4%	1.1%	1.3%

In view of the effects of progress in ICT on paper consumption, it is interesting to assess the development of consumption for the different paper categories. Table 23 shows the structure of paper consumption in the EU/EFTA region, by far the most important destination for Swedish paper exports (see Table 1), for the B2 and A1 reference futures. Newsprint is projected to lose consumption shares in both reference futures; printing and writing paper will essentially keep its position in both reference futures (small decrease); and other paper and paperboard is projected to gain consumption shares in the B2 and A1 futures alike.

These patterns of development are in line with the expected impact of progress in ICT on newsprint and office paper consumption, and the assumption that the board and packaging segment of the paper industry have a better future, since it is supported by trade, Internet shopping, urbanization, the need to store food properly, energy prices, etc. (see Donner-Amnell, 2010; Phillips, 2010).

Table 23. Structure of historic and projected paper consumption in the EU/EFTA: shares of total paper and paperboard quantity consumed

	2000	2010	2020	2030
B2				
Newsprint	13.4%	11.9%	11.6%	11.5%
Printing and writing paper	34.9%	34.3%	34.2%	34.1%
Other paper and paperboard	51.7%	53.8%	54.2%	54.4%
A1				
Newsprint	13.4%	11.9%	11.5%	11.3%
Printing and writing paper	34.9%	34.3%	34.3%	34.5%
Other paper and paperboard	51.7%	53.8%	54.2%	54.2%

The countries with economies in transition, i.e. the countries of Group III in Table 18, will answer for a larger share of the consumption of wood products over the outlook period in the B2 reference future; most pronounced in the case of wood-based panels and for the CIS. For sawnwood, however, the CIS consumption share is expected to be smaller in 2030 than in 2000, while EU15 will largely keep its position (Table 24).

Sweden's share of wood-products consumption will decrease, except for sawnwood, where the share will remain fairly constant after an initial increase between 2000 and 2010. The declining trend for Sweden mirrors the lower consumption growth rates.

Table 24. Historical and projected consumption shares for different regions, by product category and period, in the B2 reference future (percentage)

	2000	2010	2020	2030
EU15				
Sawnwood	69.4	68.1	66.5	64.0
Wood-based panels	73.1	61.3	59.9	55.9
Paper and paperboard	83.1	77.3	76.5	73.9
CEEC				
Sawnwood	10.1	14.5	15.6	17.5
Wood-based panels	12.8	17.4	17.8	19.9
Paper and paperboard	7.1	9.7	10.2	11.5
CIS				
Sawnwood	12.3	8.3	8.8	9.7
Wood-based panels	7.5	13.0	13.7	15.8
Paper and paperboard	4.7	7.4	7.7	9.0
Sweden				
Sawnwood	4.3	4.9	4.8	4.7
Wood-based panels	2.3	1.6	1.6	1.5
Paper and paperboard	2.7	2.4	2.3	2.1

Note: EU15 comprise Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden and the United Kingdom; CEEC refers to Albania, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Montenegro, Poland, Romania, Serbia, Slovakia, Slovenia, and the former Yugoslav Republic of Macedonia; CIS refers to Belarus, Republic of Moldova, Russian Federation and Ukraine.

The development patterns displayed in Table 24 are even more pronounced in Table 25. Western Europe (EU15), including Sweden, is losing consumption shares at a faster rate than in the B2 reference future, while countries with economies in transition gain shares rapidly (especially so in the case of wood-based panel consumption). This pattern of development is in line with the A1 reference future theme of rapid economic convergence among regions.

Table 25. Historical and projected consumption shares for different regions, by product category and period, in the A1 reference future (percentage)

	2000	2010	2020	2030
EU15				
Sawnwood	69.4	68.1	65.0	61.5
Wood-based panels	73.1	61.3	57.6	53.1
Paper and paperboard	83.1	77.3	75.2	72.2
CEEC				
Sawnwood	10.1	14.5	16.8	19.6
Wood-based panels	12.8	17.4	19.4	21.9
Paper and paperboard	7.1	9.7	11.1	12.8
CIS				
Sawnwood	12.3	8.3	9.3	10.2
Wood-based panels	7.5	13.0	14.5	16.4
Paper and paperboard	4.7	7.4	8.1	9.6
Sweden				
Sawnwood	4.3	4.9	4.6	4.3
Wood-based panels	2.3	1.6	1.6	1.5
Paper and paperboard	2.7	2.4	2.2	2.0

Production and trade of wood products

Table 26 depicts average annual growth rates for the production of different product categories in the B2 reference future. Comparing tables 21 and 26, it is apparent that, in general, production is projected to grow faster than consumption, particularly in the first half of the outlook period. With the exception of sawnwood, production growth is slowing down over the outlook period, in the EFSOS region as a whole and in EU/EFTA. This trend is most noticeable for paper and paperboard.

These developments are consistent with the reference future B2 storyline describing a future world characterized by heightened environmental concern and ensuing higher demand for bio-energy, driving up the prices of inputs for the wood-based panels and pulp and paper industry, while the sawnwood industry would presumably benefit from a growing demand for energy-efficient and renewable construction materials and higher prices for chips and particles (see, for example, Engelbrecht, 2006).

In the CIS, while paper and paperboard production growth, in accordance with the rest of the EFSOS, will decelerate over the outlook period, sawnwood and wood-based panel production growth will increase significantly. In Sweden, where projected production growth rates for all wood-product categories are below the average for EU/EFTA and the EFSOS area as a whole, growth rates, with the exception of sawnwood, are decreasing further over the outlook period.

Table 26. Average annual growth rates in the B2 reference future for the production of wood products in Europe by product category, period, and region (percentage)

	2010-2020	2020-2030	2010-2030
EU/EFTA			
Sawnwood	0.5%	0.5%	0.5%
Wood-based panels	1.1%	0.8%	0.9%
Paper and paperboard	1.4%	0.9%	1.1%
CIS			
Sawnwood	1.0%	1.5%	1.3%
Wood-based panels	1.5%	2.5%	2.0%
Paper and paperboard	2.9%	2.1%	2.5%
EFSOS			
Sawnwood	0.7%	0.7%	0.7%
Wood-based panels	1.2%	1.1%	1.1%
Paper and paperboard	1.5%	1.0%	1.2%
Sweden			
Sawnwood	0.2%	0.2%	0.2%
Wood-based panels	1.1%	0.3%	0.7%
Paper and paperboard	1.2%	0.7%	0.9%

Table 27 presents average annual growth rates for the production of different product categories in the A1 reference future. Comparing tables 22 and 27, it is apparent that, for the EFSOS area as a whole, production is projected to outgrow consumption as regards sawnwood and paper & paperboard, which could be interpreted as reflecting a comparative advantage for these product groups in the EFSOS area. In the CIS, only for paper & paperboard is production projected to outgrow consumption in the A1 reference future. With the exception of paper and paperboard in EU/EFTA and all wood-product categories in Sweden, production growth is projected to accelerate over the outlook period. Once again, the growth rates for Sweden are lower than in the rest of the EFSOS area.

Table 27. Average annual growth rates in the A1 reference future for the production of wood products in Europe by product category, period, and region (percentage)

	2010-2020	2020-2030	2010-2030
EU/EFTA			
Sawnwood	1.1%	1.3%	1.2%
Wood-based panels	1.8%	2.1%	2.0%
Paper and paperboard	2.2%	2.0%	2.1%
CIS			
Sawnwood	2.0%	2.0%	2.0%
Wood-based panels	2.9%	3.5%	3.2%
Paper and paperboard	4.6%	4.8%	4.7%
EFSOS			
Sawnwood	1.3%	1.4%	1.4%
Wood-based panels	2.0%	2.4%	2.2%
Paper and paperboard	2.4%	2.4%	2.4%
Sweden			
Sawnwood	0.7%	0.6%	0.7%
Wood-based panels	2.6%	1.9%	2.2%
Paper and paperboard	1.8%	1.7%	1.8%

Developments in the composition of Swedish paper production in the B2 and A1 reference futures (Table 28) follow the projected evolution of EU/EFTA paper consumption patterns (Table 23). Thus the projections in both reference futures suggest that the Swedish pulp and paper industry is adapting well to the impacts of progress in ICT. The decrease of the share of newsprint production in total paper and paperboard production is more pronounced in the A1 reference future, which is in concordance with the scenario storyline of more rapid technological progress in the A1 future.

Table 28. Structure of historical and projected paper production in Sweden: shares of total paper and paperboard production quantity (percentage)

	2000	2010	2020	2030
B2				
Newsprint	23.6%	22.5%	21.8%	21.3%
Printing and writing paper	26.3%	25.3%	25.8%	25.8%
Other paper and paperboard	50.1%	52.2%	52.5%	52.9%
A1				
Newsprint	23.6%	22.5%	21.4%	20.4%
Printing and writing paper	26.3%	25.3%	25.8%	26.0%
Other paper and paperboard	50.1%	52.2%	52.8%	53.6%

Following the same pattern as for consumption, the countries with economies in transition, i.e. the countries of Group III in Table 18, will account for a larger share of the production of wood products over the outlook period in the B2 reference future; most noticeably in the case of wood-based panels, and in the CIS. For sawnwood, EU15 will lose production shares to a lesser degree compared to the other wood-product categories, and, unlike for consumption, CIS will increase its production share (Table 29). Like the rest of EU15, Sweden will lose production shares, but at a faster rate, mirroring lower growth rates.

Table 29. Historical and projected production shares for different regions, by product category and period, in the B2 reference future (percentage)

	2000	2010	2020	2030
EU15				
Sawnwood	58.8	57.1	56.1	54.1
Wood-based panels	70.3	60.5	59.7	56.2
Paper and paperboard	83.1	79.7	77.9	76.2
CEEC				
Sawnwood	16.5	17.3	17.6	18.3
Wood-based panels	14.5	17.9	18.1	19.6
Paper and paperboard	5.7	7.4	8.1	8.9
CIS				
Sawnwood	17.7	18.7	19.4	20.9
Wood-based panels	9.2	13.8	14.3	16.3
Paper and paperboard	5.9	7.7	8.8	9.8
Sweden				
Sawnwood	12.0	11.8	11.2	10.7
Wood-based panels	1.6	1.0	1.0	0.9
Paper and paperboard	10.6	10.5	10.2	9.9

The development patterns displayed in Table 29 are accentuated in Table 30. Western Europe (EU15), including Sweden, is in general losing production shares at a faster rate than in the B2 reference future, while countries with economies in transition are gaining shares rapidly. This pattern of development is in line with the A1 reference future theme of rapid economic convergence among regions.

Table 30. Historical and projected production shares for different regions, by product category and period, in the A1 reference future (percentage)

	2000	2010	2020	2030
EU15				
Sawnwood	58.8	57.1	55.2	53.3
Wood-based panels	70.3	60.5	57.6	54.1
Paper and paperboard	83.1	79.7	76.6	72.7
CEEC				
Sawnwood	16.5	17.3	17.9	18.9
Wood-based panels	14.5	17.9	19.3	21.0
Paper and paperboard	5.7	7.4	8.8	10.4
CIS				
Sawnwood	17.7	18.7	20.1	21.2
Wood-based panels	9.2	13.8	15.0	16.7
Paper and paperboard	5.9	7.7	9.5	12.1
Sweden				
Sawnwood	12.0	11.8	11.1	10.2
Wood-based panels	1.6	1.0	1.0	1.0
Paper and paperboard	10.6	10.5	10.0	9.4

Table 31 depicts net exports of different product categories in the B2 reference future, in cubic metres and tonnes. Over the outlook period, the most significant development in Western Europe (EU15) is the move from substantial net importer to small net exporter of solid wood products. For paper and paperboard, developments are less obvious; an initial decrease is followed by an increase between 2010 and 2030. In Sweden, net exports of sawmill are foreseen to be rather stable over the outlook period, whereas paper and paperboard exports are projected to increase significantly.

For the CEEC, imports are projected to outgrow exports for all product categories; solid wood products net exports will diminish while net imports of paper & paperboard are foreseen to increase over the outlook period. For the CIS, net exports of sawnwood are projected to increase significantly over the outlook period while net exports of wood-based panels will remain virtually unchanged. Paper and paperboard net exports are foreseen to increase significantly from 2010 to 2020 and decline somewhat thereafter. All in all, for the EFSOS area as a whole, sawnwood appears to enjoy a competitive advantage in the B2 reference future.

***Table 31. Net exports in the B2 reference future in Europe by product, period, and region* (m^3)**

	2000	2010	2020	2030
EU15				
Sawnwood	-8 476 247	-2 052 297	-389 855	943 848
Wood-based panels	-757 013	672 400	1 393 286	1 422 229
Paper and paperboard	7 586 362	5 147 868	6 091 503	7 071 728
CEEC				
Sawnwood	9 490 237	7 242 086	7 077 701	6 253 647
Wood-based panels	1 245 779	808 974	698 455	175 195
Paper and paperboard	-827 467	-2 188 881	-2 043 420	-2 984 317
CIS				
Sawnwood	8 373 616	17 374 031	19 147 448	22 015 378
Wood-based panels	1 201 452	920 969	903 728	896 730
Paper and paperboard	1 622 321	556 703	1 832 314	1 490 590
Sweden				
Sawnwood	10 699 909	11 402 780	11 470 636	11 597 307
Wood-based panels	-402 270	-527 995	-567 564	-613 397
Paper and paperboard	8 277 446	8 994 491	10 143 400	10 985 391

Note: net exports equals production minus apparent consumption

Table 32 depicts net exports in the A1 reference future. There, development patterns displayed in Table 31 are even more marked. Therefore, over the outlook period, Western Europe (EU15) is evolving from a substantial net importer to a substantial net exporter of solid wood products. However, in this scenario net exports of paper and paperboard are also projected to increase notably. Developments in Sweden follow these trend patterns, with the increase in net exports most marked for paper and paperboard.

For the CEEC, imports are once again projected to outgrow exports for all product categories; in this reference future CEEC will even turn from a net exporter to a net importer of wood-based panels. In the CIS, net exports of all product categories are projected to show dramatic increases. Taken as a whole, EFSOS appears to enjoy a competitive edge when it comes to sawnwood and paper and paperboard.

Table 32. Net exports in the A1 reference future in Europe by product, period, and region (m^3)

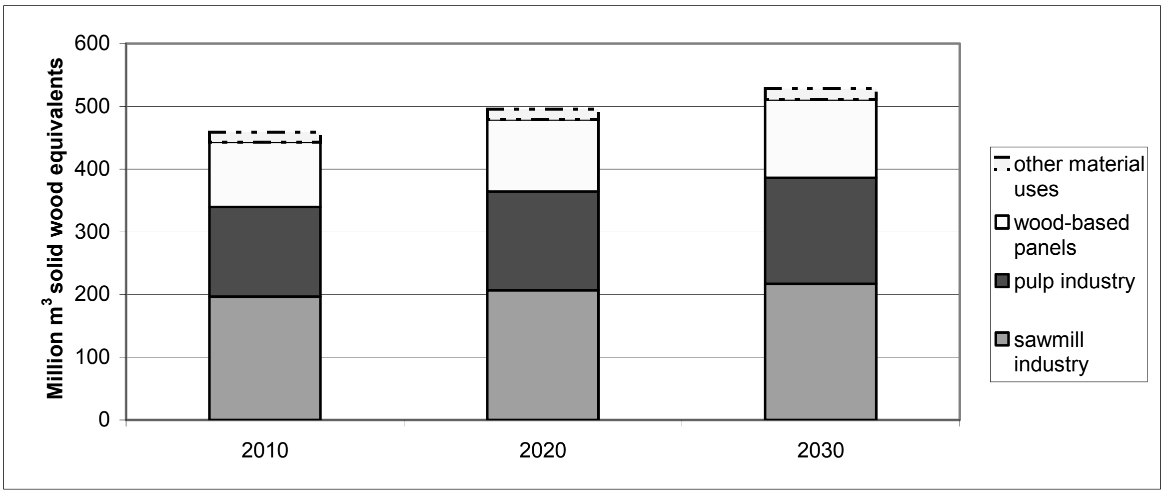
	2000	2010	2020	2030
EU15				
Sawnwood	-8 476 247	-2 052 297	1 337 828	6 124 796
Wood-based panels	-757 013	672 400	1 620 921	3 558 713
Paper and paperboard	7 586 362	5 147 868	6 976 882	10 223 072
CEEC				
Sawnwood	9 490 237	7 242 086	6 543 377	5 747 364
Wood-based panels	1 245 779	808 974	441 103	-204 652
Paper and paperboard	-827 467	-2 188 881	-2 437 332	-2 470 760
CIS				
Sawnwood	8 373 616	17 374 031	21 031 457	25 345 044
Wood-based panels	1 201 452	920 969	943 054	1 151 549
Paper and paperboard	1 622 321	556 703	2 458 060	5 609 842
Sweden				
Sawnwood	10 699 909	11 402 780	12 321 628	13 230 792
Wood-based panels	-402 270	-527 995	-547 212	-596 330
Paper and paperboard	8 277 446	8 994 491	10 850 035	13 106 304

5.1.2 Material uses of wood resources

The developments in material uses of wood resources are calculated based on the econometric modelling by Jonsson (2010). This projects the quantities of goods consumed and produced but not the quantities of wood raw materials needed, which have been calculated using conversion factors (see Mantau and Saal, 2010a and section 4.2 of this report).

In the year 2010, the wood consumption in solid wood equivalents (henceforth SWE) for all material uses in EU27 is estimated to be about 458 million cubic metres (Mantau and Saal, 2010b). According to projections, in the B2 reference future, by 2020 overall material use will increase by 8 percent to an equivalent of 495 million cubic metres. From 2020 to 2030, the growth is projected to decelerate to 6.8 percent, overall use of wood resources in 2030 foreseen to be 528 million cubic metres SWE (Figure 17).

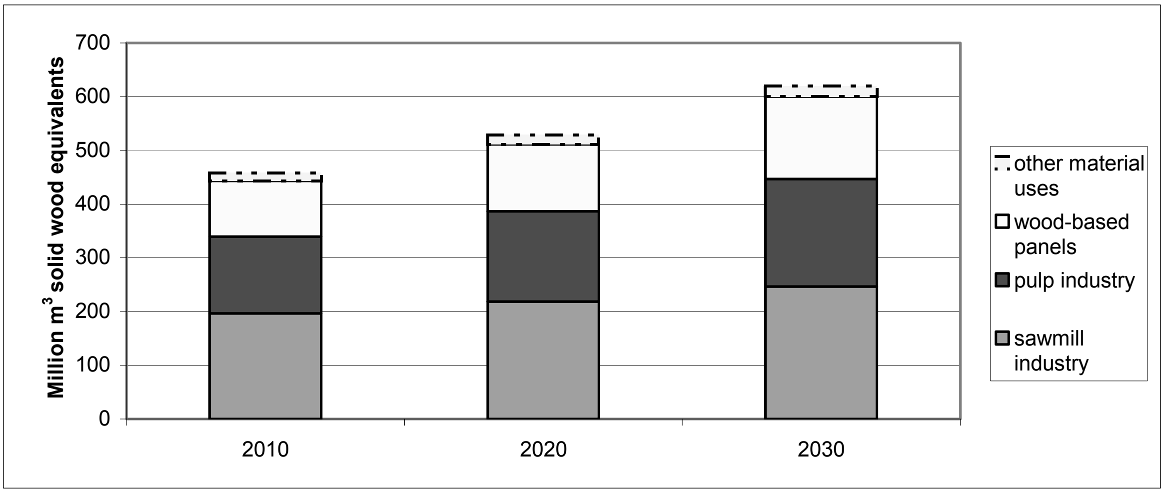
Figure 17. Material uses of wood resources in EU27 in the B2 reference future



Source: Mantau and Saal, (2010b).

In the A1 reference future, wood consumption for material uses in EU27 is estimated to increase by 15.4 percent between 2010 and 2020, to 529 million cubic metres SWE. From 2020 to 2030, the growth is projected to accelerate to 17.2 percent; the projection of overall use of wood resources in 2030 is 620 million cubic metres SWE (Figure 18).

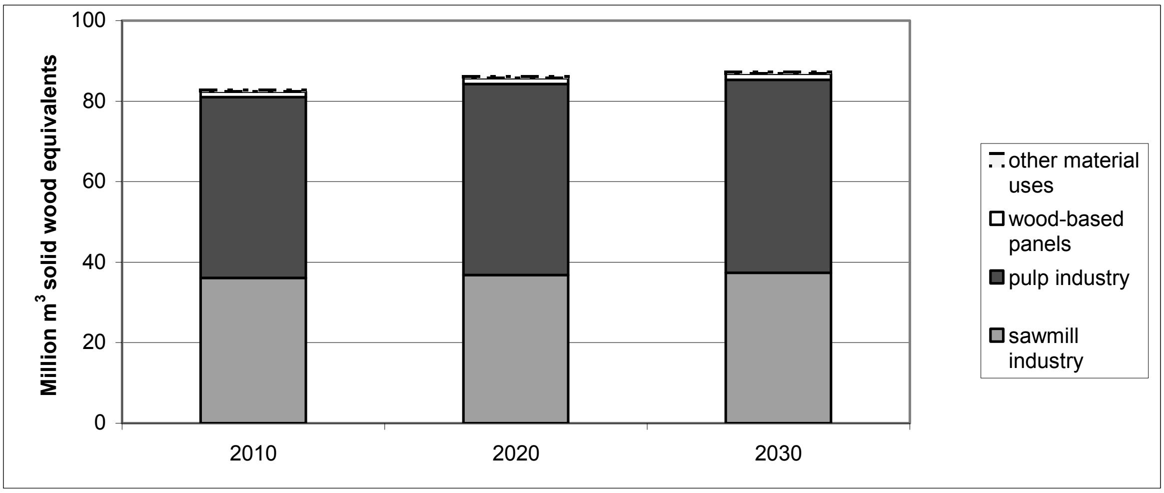
Figure 18. Material uses of wood resources in EU27 in the A1 reference future



Source: Mantau and Saal (2010b).

In Sweden, material use of wood resources is completely dominated by the sawmill and pulp and paper industries. In 2010, wood consumption in SWE for all material uses in Sweden is estimated to be about 83 million cubic metres. Overall material use is projected to increase by 4.1 percent to an equivalent of 86 million cubic metres by 2020 in the B2 reference future. From 2020 to 2030, the growth is projected to decelerate to 1.3 percent, with overall use of wood resources in 2030 estimated at 87 million cubic metres SWE (Figure 19).

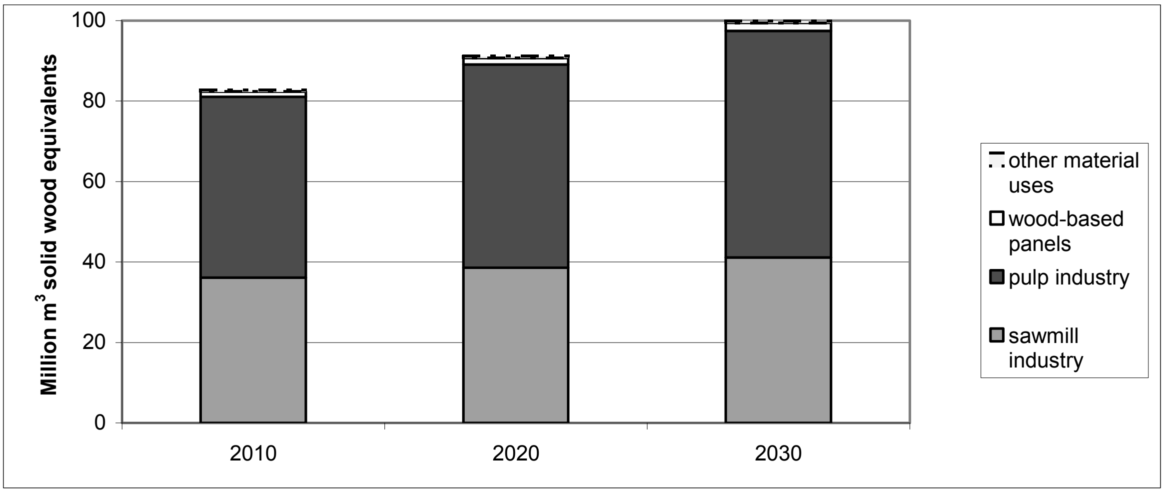
Figure 19. Material uses of wood resources in Sweden in the B2 reference future



Source: Mantau (2010).

In the A1 reference future, wood consumption for material uses in Sweden is estimated to increase by 10.2 percent between 2010 and 2020, to 91 million cubic metres SWE. From 2020 to 2030, growth is projected to decelerate somewhat to 9.6 percent, with overall use of wood resources in 2030 foreseen to be 100 million cubic metres SWE (Figure 20).

Figure 20. Material uses of wood resources in Sweden in the A1 reference future



Source: Mantau (2010).

The shares of the different wood resource user segments remain relatively stable in both reference futures in EU27. The sawmill industry, accounting for about 40 percent, is the biggest material user of wood resources. However, more than one third of the consumed stemwood flows back as a resource of high value, in the form of sawmill co-products (Mantau and Saal, 2010b). In addition, the sawmill industry is very important for the mobilization of small-sized stemwood and forest residues (ibid.).

In Sweden, as is already apparent from Table 10, the pulp industry accounts for the largest share of wood use for material purposes, estimated at around 54 percent in 2010. The sawmill industry, accounting for about 44 percent, is the second largest material user of woody biomass. The same as for the rest of EU27, the shares for different material uses remain essentially stable regardless of reference future.

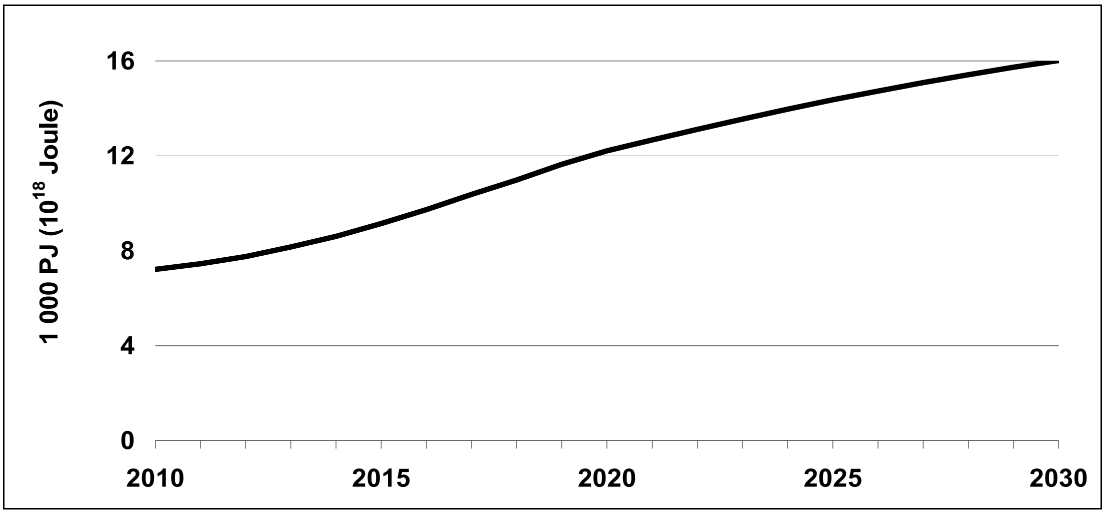
5.2 Wood for energy

5.2.1 Total future energy demand and demand for renewable energy

The EUwood project estimates a GIEC in EU27 of 61.6 EJ in year 2020 and 51.8 EJ in 2030. Twelve Member States, among them Sweden, included such information in their forecast documents on the transparency platform of the European Commission. EUwood calculations for these countries are about 13 percent higher than national projections (Steierer, 2010b).

The EU RES Directive sets country-specific targets for the share of energy from renewable sources in each Member State (see European Parliament, 2009). Thus, energy from renewable sources in the EU27 is expected to increase as a share of GIEC from 8.5 percent in 2008 to 20 percent in 2020. The EUwood assumptions (notably energy efficiency gains of 20 percent) and calculations project energy consumption from renewable sources in EU27 to increase from 7.2 EJ in 2010 to 12.2 EJ in 2020 and 16 EJ in 2030 (Figure 21).

Figure 21. Gross inland consumption of energy from renewable sources in EU27



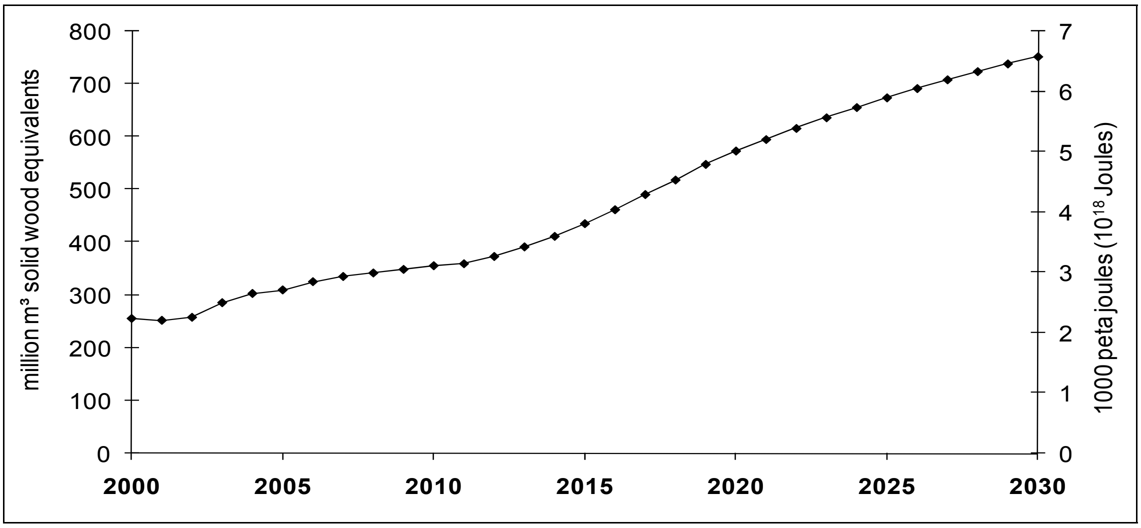
Source: Steierer (2010a).

5.2.2 Future demand for wood-based energy

The European Commission and the Member States support research and development in other renewable energy technologies, whereas technology for wood combustion is relatively mature. EUwood assumes that these efforts will facilitate the realization of the technological potential of other forms of renewable energy source, such as solar heat and power, geothermal, wind and hydropower (Steierer, 2010b).

Hence, on the basis of assumptions of 20 percent energy efficiency gains by 2020, achieved renewable energy targets, and wood-based energy decreasing its share in energy from renewable sources from 50 percent in 2008 to 40 percent in 2020 (see chapter 4.3), EUwood estimates that wood volumes for energy generation will increase by 66 percent between 2010 and 2020 and by a further 31 percent between 2020 and 2030 (Figure 22). According to the EUwood projections, wood volumes for energy generation in Sweden will remain essentially unchanged from 2010 to 2020, but will increase from about 36 to 48 million cubic metres SWE between 2020 and 2030 (source: Mantau, 2010).

Figure 22. Current and future amounts of wood-based energy in EU27



Source: Steierer (2010b)

Both the JWEE and the EurObserv'ER's solid biomass barometer (EurObserv'ER, 2009) indicate a steadily growing trend for wood energy in general and heat and power generation by main activity producers in particular (Steierer, 2010b). The results of the EUwood study also indicate that wood energy generation by main activity producers is expected to see the biggest increase in absolute and relative terms, which could be regarded as a relevant reflection of the significant near-term potential for biomass co-firing with coal (see, for example, Hansson *et al*, 2009).

Main activity producers are thus expected to replace private households as the single biggest wood-based energy consumer in EU27 around 2020. The consumption of around 83 million cubic metres SWE of wood raw materials in 2010 is expected to almost triple to 242 million cubic metres in 2020 and increase further to 377 million cubic metres in 2030 (Steierer, 2010b).

Total household use of wood-based energy is projected to increase from 178 million cubic metres SWE in 2010 to 232 million cubic metres in 2020 and then remain stable up to 2030 (source: Mantau, 2010). Traditional fuelwood use for heat and hot water production by private households, still the most important sector of wood consumption for energy generation in EU27, is expected to increase from 155 million cubic metres SWE in 2010 to 163 million in 2020 and then decrease to 151 million in 2030 (Steierer, 2010b).

According to EUwood estimations, consumption of wood pellets and briquettes by private households will increase from 23 million cubic metres SWE (12 million tonnes) in 2010 to 69 million (35 million tonnes) in 2020 and then to 82 million (41 million tonnes) in 2030.

Though this certainly represents a rapid development, it remains significantly below the projection made by the European Biomass Association (AEBIOM, 2008). According to AEBIOM estimations, the use of pellets for heating purposes in the residential, services and industrial sectors might reach 50 million tonnes in 2020. This figure still excludes possible additional use of wood pellets for electricity production in power plants, whether co-firing or biomass only (Steierer, 2010b).

Internal wood-based energy use in the forest industry is expected to increase from around 85 million cubic meters SWE in 2010 to 98 million in 2020 and further to 114 million in 2030 in the A1 reference futures; in the B2 reference future to 100 and 117 million cubic metres respectively (source: Mantau, 2010).

In the EUwood project, it is assumed that the production of liquid biofuels will not have any significant impact on wood raw material markets before 2020, despite the political support and intensive research and development activities in this field. It is assumed that the production of liquid biofuels could account for about one million cubic metres SWE in 2020 and up to 29 million cubic metres in 2030, which would represent about 4 percent of the wood raw material volumes used for energy generation (Steierer, 2010b).

Whereas EUwood in general, and in particular for EU27 as a whole, yields plausible projections, in a few countries, among them Sweden, projections show a decline in wood raw material demand from biomass power plants between 2010 and 2020, followed by an increase between 2020 and 2030. These apparent declines are, however, purely artefacts of the estimation procedure.

Thus, wood consumption by biomass power plants has been calculated as a residual: overall energy consumption is based on EU RES targets (energy efficiency, share of renewables) and assumptions as to the future role of wood-based energy, whereas the individual components of biomass energy supply (other than biomass power plants) have each been estimated according to its own methodology (Mantau *et al*, 2010a).

5.3 Potential supply of wood raw materials

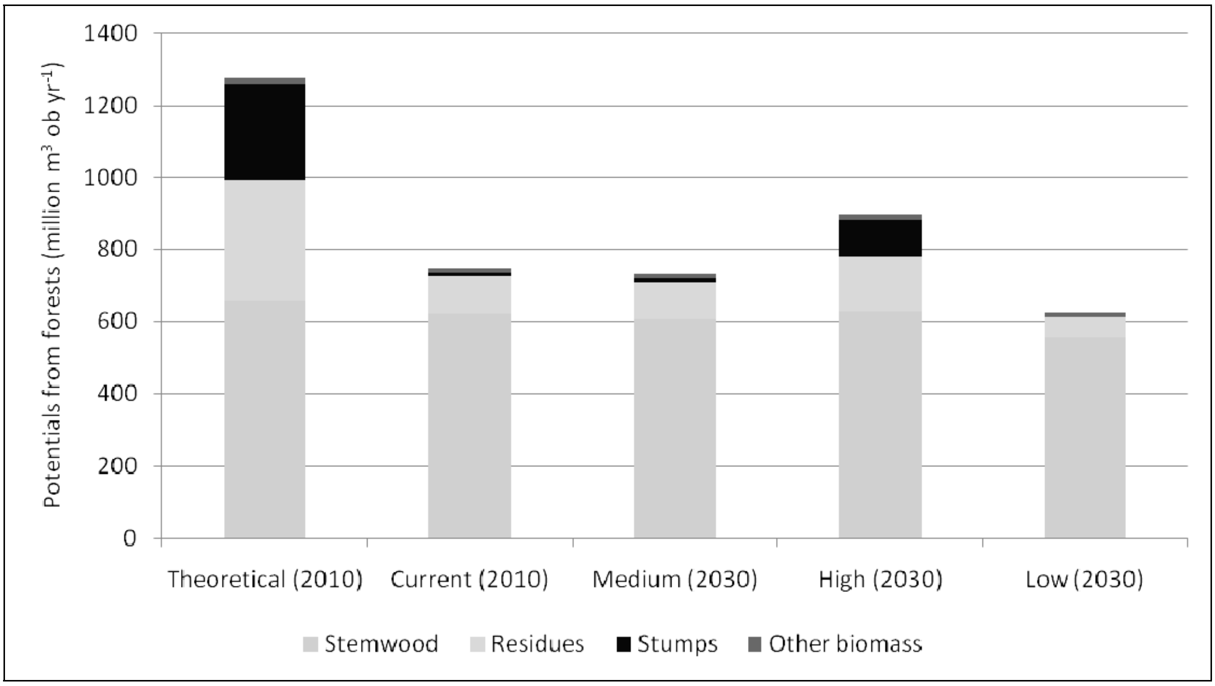
5.3.1 Biomass supply from forests

The theoretical biomass potential from European forests in 2010 is 1,277 million cubic metres over bark, according to EFISCEN projections. This figure is based on the average volume of wood that can be harvested over a 50-year period, taking into account increment, the age-structure, stocking level and harvesting losses. The potential is rather stable over time, as the potential for each year is based on the average maximum harvest level that can be maintained throughout the next 50-year period. However, in 2030 it is expected to decrease somewhat—to 1,254 million cubic metres per year.

Stems make up about 52 percent of the theoretical potential, while logging residues account for 26 percent and stumps for 21 percent. Other biomass, i.e. stem and crown biomass from early (pre-commercial) thinnings, represent only 1 percent of the total potential (Verkerk *et al*, 2010b).

The realistic potential from European forests under the medium mobilization scenario is estimated at 747 million cubic metres over bark per year in 2010, which represents 58 percent of the estimated theoretical potential. Hence, the environmental, technical and social constraints implemented in the EUwood analysis have a large impact on the biomass potential from European forests. In particular, the potentials from logging residues and stumps are strongly reduced (ibid.). The projections suggest that the realizable biomass potential in 2030 could range from 625 cubic metres over bark per year in the low mobilization scenario to 898 million cubic metres per year in the high mobilization scenario (Figure 23).

Figure 23. Biomass potentials from forests in EU27 in 2010 and 2030

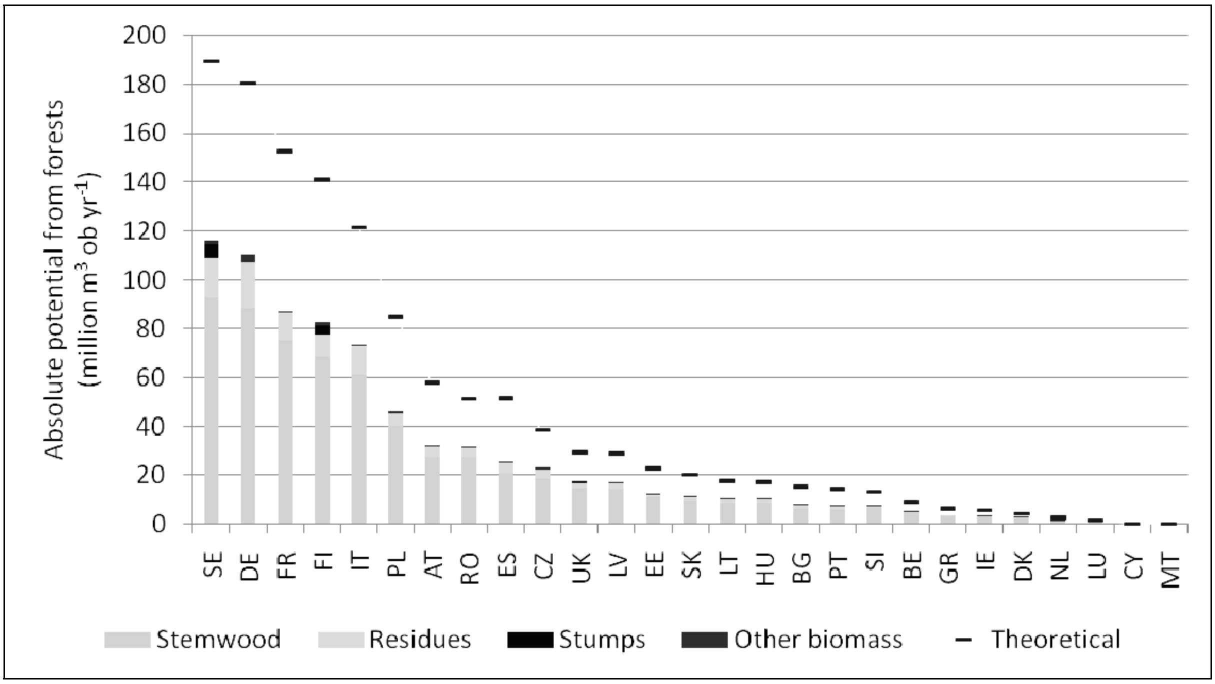


Source: Verkerk *et al* (2010b)

According to estimates by FAO (2006), around 449 million cubic metres per year (over bark) were removed from forests in EU27 in 2005. This estimate likely underestimates the level of removals due to, for example, unregistered use of wood for household heating. Nevertheless, to mobilize the biomass potentials from forests estimated in all EUwood mobilization scenarios requires a significant increase in the harvest level compared to the current situation. This also implies a far more intensive use of the European forest resources than at present and may involve trade-offs in relation to other forest functions, e.g. biodiversity (Verkerk *et al*, 2010b).

The realistic potentials are not equally distributed between EU Member States. Figure 24 shows the distribution of the biomass potentials from forests across Europe. The five countries with the largest forest biomass potentials – Sweden, Germany, France, Finland and Italy – account for 62% of the EU27 forest biomass potentials (Verkerk *et al*, 2010b).

Figure 24. Distribution of forest biomass potentials from forests across EU member states in 2010



Source: Verkerk *et al* (2010b)

All three mobilization scenarios are sustainable from a strict wood-supply point of view, in the sense that the projected level of supply can be maintained for at least 50 years (Verkerk *et al*, 2010b). Furthermore, in all three scenarios it is assumed that areas currently protected for conservation of biodiversity are maintained and not converted to forests available for wood supply.

It is further assumed that there is no change in species composition, i.e. each type of forest is replaced by the same type of forest after final harvest. Consequently, slower growing species are not replaced by faster growing species even in the high mobilization scenario. Finally, constraints or corrective measures (e.g. fertilization) preventing site degradation through loss of nutrients or by physical processes such as compaction or erosion, are assumed (ibid.).

However, as a greater part of the forest biomass is harvested in each of the mobilization scenarios than at present, less deadwood will be left in the forests (Verkerk *et al*, 2010b); with possible negative impacts on biodiversity (Verkerk *et al*, 2011). Extracting more wood from forests may also affect other forest functions (Verkerk *et al*, 2010b). Thus, though the effects of stump extraction are still not well understood (Walmsley and Godbold, 2010), some studies suggest that stump extraction might have negative impacts on biodiversity, e.g. on the diversity of saproxylic beetles (Hjältén *et al*, 2010).

5.3.2 Supply of wood raw materials from other sources

Landscape care wood and other wooded land

The potential of landscape care wood within the EU27 is estimated to be about 87 million cubic metres SWE each year. This potential is expected to remain stable until 2030. Instead, the major changes are expected to take place in the share of the potential that is actually used for energy production or in the wood-based industry (Oldenburger, 2010b).

Due to rather high procurement costs for landscape care wood, a large share of the potential is not utilized. The high procurement costs are due to the nature of this biomass source: a large share of the landscape care wood becomes available in small volumes, at scattered locations and with a low density (e.g. branches instead of roundwood). Increasing demand for raw materials from the energy and wood processing sectors is expected to lead to reduced procurement, as a result of new technologies and a better organization of the collection chain (ibid.).

According to a medium scenario, the use of wood raw material from landscape care wood and other wooded land is expected to increase from 58.5 million cubic metres SWE per year in 2010 to 73.5 million cubic metres SWE per year by 2030 in EU27, and in Sweden from 3.6 million cubic metres SWE to 4.5 million cubic metres SWE (source: Mantau, 2010).

Industrial wood residues

Industrial wood residues (IWR) (sawmill co-products, other industrial wood residues, and black liquor) is the second largest supplier of wood raw materials in EU27 after the forests. The importance of IWR is augmented by the circumstance that this resource grows with the output of the wood-product industry (Saal, 2010b). The significance of IWR is projected to increase, from around 18 percent of total wood fibre supply in 2010 to 20 and 22 percent in the B2 and A1 reference futures respectively by 2030, or from 177 to 202 and 232 million cubic meters SWE in the B2 and A1 reference futures respectively.

Sawmill by-products is estimated to account for about 49 percent of IWR in 2010, and projected to decrease somewhat to around 47 and 46 percent by 2030 in the B2 and A1 reference futures respectively. Black liquor, on the other hand, is foreseen to increase its share of IWR from about 34 percent to around 36 percent by 2030 in both reference futures (source: Mantau, 2010).

In Sweden, mirroring the prominence of the Swedish wood-product industry, IWR is even more important as a wood fibre supply source than in the EU as a whole. It is estimated to represent 25.5 percent of total wood fibre supply in Sweden in 2010. In the B2 reference future, this share is projected to decrease marginally to 25.0 percent by 2030, while in the A1 reference future the share is instead estimated to increase to 27.5 percent.

In absolute numbers, IWR is projected to increase from 38.6 million cubic metres SWE in 2010 to 40.6 and 46.2 million cubic metres SWE in the B2 and A1 reference futures respectively. Sawmill by-products share of IWR, estimated at 47.5 percent of IWR in 2010, is projected to decrease marginally in the B2 reference future to 47.0 percent by 2030.

The projected decrease in the B2 reference futures is more significant, to 45.4 percent by 2030. The same as for EU as a whole, black liquor is estimated to increase its share of IWR in both reference future, from about 34 percent to around 36 percent in both reference futures, from 47.5 percent in 2010 to 48.3 percent in the B2 reference future and 49.9 percent in the A1 (source: Mantau, 2010).

Post-consumer wood (PCW)

The relation between the solid wood consumption per capita and the share of post-consumer wood in the total national solid wood consumption in 2007 is used for estimating the future post-consumer wood supply in the EU27 countries (see section 4.7). The national solid-wood (sawnwood and wood-based panels) consumption is provided for the years 2010, 2015, 2020, 2025 and 2030 by the wood-product projections (see section 4.2). The volume of landfilled post-consumer wood will most likely decrease strongly in the coming years.

The EU Landfill Directive 1999 sets targets for the quantity of bio-degradable municipal waste each EU Member State can landfill. However, the process has been delayed; some countries are only now starting to reduce their share of land-filled waste. For this reason, and the circumstance that the wooden parts in municipal waste are not easily separated from the rest of this waste stream, the share that goes to disposal is not set to zero in 2030, it is assumed that 5 percent of post-consumer wood is still land filled.

The supply of post-consumer wood for the EU27 in 2030 then is estimated at 58.6 million cubic metres SWE for reference future B2 and at 67.3 million cubic metres for the A1 reference future, corresponding to a growth of 13 and 29 percent respectively, compared with the situation in 2010 (Leek, 2010b). In Sweden, the supply potential for post-consumer wood is projected to increase from 1.0 million cubic metres SWE in 2010 to 1.1 and 1.2 million cubic metres by 2030 in the B2 and A1 reference futures respectively (source: Mantau, 2010).

Sizeable quantities of post-consumer wood (recovered wood and demolition wood) are imported into Sweden, mainly to be used in boilers with efficient flue gas cleaning systems meeting the stringent emission demands (Junginger *et al*, 2011). As considerable increases in this capacity are planned, these boilers are seen as a technological driver for bioenergy imports in Sweden (ibid.).

5.4 Future Wood Resource Balances

Forest resources represent a relatively stable potential supply of woody biomass in the medium mobilization scenario (Mantau *et al*, 2010a). Other wood fibre supply increases over time as most of these potentials are industrial residues that grow along with the production of wood products. Hence, the growth of potential wood raw material supply is highly linked to the development of the wood-product industry (ibid.). This circumstance explains why potential supply is higher in the A1 reference future.

In the medium wood mobilization scenario, future demand for wood raw material will overtake potential supply before 2020 in EU27, in both of the reference futures (Table 33). Most noteworthy is the rapidly increasing demand for wood-based energy necessary to achieve the targets of the EU RES directive. The demand for wood for energy uses is thus expected to overtake material uses of wood by 2020, regardless of reference future. The overall demand for wood fibre does not differ a lot between the reference futures, which is due to the fact that projected consumption of wood for energy purposes depends on the energy policy objectives, which are the same in both reference futures (Mantau *et al*, 2010a). Only if wood production is intensified to a great extent, i.e., in the high mobilisation scenario, can the demand for wood fibre be met by 2020 (Ibid.). However, by 2030 the demand for wood fibre will exceed potential supply in both reference futures even in the high mobilization scenario (source: Mantau, 2010).

Table 33. Wood resource balances for EU27 (million m^3 SWE).

Reference future B2							
potential	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**	**demand**
forest fibre	686	678	680	458	495	528	material uses
other fibre supply	287	311	334	346	573	752	energy uses
total	**973**	**989**	**1015**	**805**	**1068**	**1280**	**total**
Reference future A1							
potential	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**	**demand**
forest fibre	686	678	680	458	529	620	material uses
other fibre supply	287	327	375	346	573	752	energy uses
total	**973**	**1005**	**1055**	**805**	**1102**	**1372**	**total**

Source: Mantau (2010). Note: Medium mobilisation scenario for supply of wood raw materials from forests

Different regions of the EU show considerable differences as regards the outlook for the balance between the supply potential and demand (Mantau *et al*, 2010a). Thus, in the northern region, comprising Estonia, Finland, Lithuania, Latvia and Sweden, the potential supply of wood raw materials exceed demand, irrespective of mobilization scenario and reference future, by 2020 according to EUwood projections (source: Mantau, 2010).

By 2030 demand exceeds potential supply in the low mobilization scenario by around 6 million cubic metres SWE in the B2 reference future and 31 million in the A1 reference future. However, in the medium and high mobilization scenarios, potential supply remains considerably higher than potential demand all through the period 2010 to 2030; from about 43 and 109 million cubic metres SWE respectively in 2020 to around 13 and 83 million cubic metres respectively by 2030 in the A1 reference future (Mantau *et al*, 2010a).

In western EU, i.e. the region comprising Austria, Belgium, Germany, Denmark, France, Ireland, Luxembourg, Netherlands and United Kingdom, potential demand is foreseen to be higher than potential supply even in the high mobilisation scenario (Mantau *et al*, 2010a). This is due to the circumstance that in these densely populated and relatively sparsely forested countries, the potential is already intensively used (Ibid.). Thus, according to EUwood estimations the supply deficit by year 2020 in this region amounts to about 115 and 125 million cubic metres SWE for the medium mobilisation scenario in the B2 and A1 reference futures respectively, and the deficit increases further to around 200 and 230 million cubic metres respectively by 2030 (source: Mantau, 2010).

The supply situation in eastern EU countries Bulgaria, Czech Republic, Hungary, Poland, Romania, Slovenia and Slovakia remains largely stable in the medium mobilization scenario until 2020 (Mantau *et al*, 2010a), i.e., projected potential supply is larger than projected demand. However, by 2030, potential demand will be more than fifteen million cubic metres SWE higher than potential supply in the B2 reference future, and more than 40 million cubic metres higher in the A1 reference future (source: Mantau, 2010).

In southern EU, i.e., Cyprus, Greece, Italy, Malta, Portugal, and Spain, a potential supply surplus in 2010 in the medium mobilization scenario is expected to be replaced by a minor deficit by 2020 of 13 and 17 million cubic metres SWE in the B2 and A1 reference futures respectively. By 2030, the deficit is foreseen to grow to around 40 and 50 million cubic metres respectively (source: Mantau, 2010).

In Sweden, projected potential supply of wood raw materials will exceed projected demand, regardless of reference future and mobilisation scenario, by 2020. EUwood projections imply that potential supply will still be greater than potential demand by 2030 for all combinations of mobilisation scenarios and reference futures, except for the combination of a low mobilisation scenario and the A1 reference future, indicating a deficit of four million cubic metres SWE (source: Mantau, 2010). Table 34 depicts the projections for reference futures B2 and A1 in Sweden, assuming a medium mobilisation scenario. Though energy demand for wood is expected to increase, the material use of wood is expected to continue to dominate in the future in Sweden.

The share of material use of wood is thus expected to decrease from 69.5% in 2010 to 64.6 and 67.6% by 2030 in the B2 and A1 reference futures respectively. The supply of forest fibre is rather stable, increasing by about seven percent between 2010 and 2030. Thus, a simulation study of the effect of intensive forest management on forest production in Sweden indicate that it takes a relative long time, forty to sixty years, for an intensive forest management regime to result in a significant increase in stem volume production (Nilsson *et al*, 2011). Other fibre supply, dominated by industrial residues (over 89% in 2010) is foreseen to increase by seven percent in the B2 reference future and by more than twenty percent in the A1 reference future between 2010 and 2030.

Table 34. Wood resource balances for Sweden (million m^3 SWE).

Reference future B2							
potential	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**	**demand**
forest fibre	108	110	116	83	86	87	material uses
other fibre supply	43	45	46	36	36	48	energy uses
total	**151**	**155**	**162**	**119**	**123**	**135**	**total**
Reference future A1							
potential	**2010**	**2020**	**2030**	**2010**	**2020**	**2030**	**demand**
forest fibre	108	110	116	83	91	100	material uses
other fibre supply	43	47	52	36	36	48	energy uses
total	**151**	**158**	**168**	**119**	**128**	**148**	**total**

Source: Mantau (2010). Note: Medium mobilisation scenario for supply of wood raw materials from forests

6 Discussion and conclusions

The Swedish forest sector is apparently facing many diverse challenges in the future. Some of the major trends and drivers of change are working in the same direction, reinforcing each other, whereas others are working in opposite directions.

Trends in forest area, growing stock and the relation between net annual increment (NAI) and fellings suggest that forest management in Sweden and the rest of Europe has been sustainable in a strictly "wood supply" sense. However, the actual volume available for sustainable harvesting has fallen due to, for example, harvest losses and unregistered fellings.

This should be taken into consideration when assessing the possibility of increasing the supply of woody biomass, especially in countries like Sweden, which are already harvesting a substantial share of NAI. The potential forest biomass supply from forest estimated within the EUwood project is fairly stable over time, though it varies between mobilization scenarios.

Global demand for wood products is expected to continue to grow, in line with the growth in population and income, mainly in China, India and other developing countries. In Europe, the declining and ageing population and slower economic growth (partly resulting from the former two) will not support rapid growth in the demand for wood products. The ageing population also entails a shrinking workforce, accelerating technical progress in the construction industry. It is therefore vital for the future prosperity of the Swedish forest-products industry to increase its presence in the growing markets and to speed up technological progress.

Globalization—should it continue—is expected to increasingly shift both consumption and production mainly of pulp and paper to the southern hemisphere, thus (through decreased demand for pulpwood) affecting employment and forest owners in Sweden and other European countries.

The pulp and paper industry is also foreseen to be mainly negatively affected by continued expansion of electronic ICT through greatly reduced demand for newsprint and printing and writing paper. Should the targets of the EU RES directive be fulfilled, the demand for woody biomass from the bioenergy sector in the EU could however more than compensate for a shrinking demand for pulpwood, as implied by the EUwood estimations. As well as being adversely affected—through increased competition and resulting rising prices for raw materials—the pulp and paper industry could benefit from the development of the bioenergy sector. Hence, chemical pulp producers could manufacture new, high-value products in integrated bio-refineries. Mechanical pulp producers cannot do this, however, and will thus only suffer from higher prices for raw materials and electricity.

Overall, for the Swedish sawmill industry the future looks brighter than for pulp and paper, provided this industry sheds its commodity orientation and increases the value-added by accommodating the growing demand for factory-made, energy-efficient construction components, as expressed by, e.g., *Green Building*. In this context timber-frame in multi-storey house building deserves mentioning. Though a niche market, using relatively small quantities of wood (see, e.g., Dackling, 2002), it is of interest in terms of value-added and employment opportunities in the wood-working industry. In addition, the Swedish solid wood-product industry is not facing the same direct threat from globalization as the pulp and paper industry.

Furthermore, the development of prominent bioenergy markets should mainly benefit the sawmill industry, by obtaining higher prices for co-products with limited competition from bioenergy markets for raw materials. The sawmill industry is also very important for the mobilization of small-sized stemwood and forest residues. In the future, integrated production units producing construction components—as well as bio-fuel, bioplastics and food ingredients—are conceivable.

The wood-based panel industry, on the other hand, already of marginal importance in Sweden, would suffer from intense competition for all its raw materials from the bioenergy sector.

The projections of the econometric models are mostly in line with what can be expected, considering the conclusions that can be drawn from the review of drivers of change in global wood-product markets and the reference future storylines. Overall consumption of all wood products in Europe is increasing in both of the reference futures, but the rate of growth is considerably higher in the A1 than in the B2 scenario. In the B2 reference future, production and consumption growth rates are slowing down over the outlook period, with the exception of sawnwood.

The slowing down of consumption growth is most pronounced for paper products and wood pulp (mechanical pulp in particular), which is consistent with a future characterized by heightened environmental concern and thus higher demand for bioenergy and renewable construction materials (see above). In the A1, in contrast to the B2, reference future, production and consumption growth rates are increasing for all wood products over the outlook period, with the exception of paper and paperboard.

The slowing down of growth in paper and paperboard production and consumption in the A1 reference future could mainly be understood in the light of progress in ICT. The circumstance that production and consumption of paper is projected to continue to grow in both reference futures, albeit at lower growth rates— though one could expect a future decline in the consumption of newsprint in particular—is a consequence of the absence of a clear declining trend in the historic data, and hence estimated income (GDP) elasticities used in the projections are in general positive.

Projections of the structural development of paper consumption in EU and EFTA indicate that newsprint will lose consumption shares (of total projected paper consumption) in both reference futures, printing and writing paper will essentially keep its position, whereas other paper and paperboard will gain consumption shares. These patterns of development once again are in line with the expected negative impact of progress in electronic ICT on newsprint and printing and writing paper consumption and the expected better prospects for the board and packaging segment of the paper industry.

The composition of the Swedish paper production in the two reference futures follows the projected evolution of consumption in EU/EFTA, suggesting that the Swedish pulp and paper industry will adapt well to the changing demand patterns resulting from the progress in electronic ICT.

Further, according to projections, the eastern parts of Europe will increase in importance over the next two decades: eastern European countries will answer for a larger share of the production and consumption of solid wood as well as pulp and paper products in Europe in both of the reference futures. At the same time, Sweden will decrease in importance in production as well as consumption terms, a result of lower production and consumption growth rates in Sweden compared with the average for the EU/EFTA as well as the EFSOS area as a whole, for all wood products and in both reference futures.

The importance of the eastern European countries is projected to be highest in the A1 scenario, in accordance with the A1 theme of rapid economic convergence among regions. This development can be considered as highlighting the need for the Swedish forest-products industry to invest in technological development and the production of value-added products rather than producing basic (bulk) commodities, in order to compete with countries that have lower production costs.

The results from the EUwood projections imply that the wood resources at EU27 level will not suffice to satisfy the demand for wood raw materials by 2030, should the EU RES Directive be realized and given the assumption of a slightly decreasing role for wood-based energy (from around 50 to 40 percent by 2020), even if wood production in existing forests is intensified to a great extent, i.e., in the high mobilisation scenario. There are number of thinkable means to address this shortfall.

One way to increase the supply would be to import bioenergy from other regions. When considering the option of large-scale bioenergy imports to mitigate domestic biomass scarcity in EU, however, the question of potential global biomass scarcity relative to the future required levels of climate neutral energy in a world undertaking ambitious climate change mitigation efforts (Berndes and Hansson, 2007) comes to the fore. Factors that might result in global scarcity of wood fibre are, above all, continued rapid economic growth in Asia, major calamities such as insect outbreaks, and the development of large-scale bio-energy markets (Roberts, 2007).

Another way to increase the supply of woody biomass would be to use more parts of the harvested tree. The environmental, technical and social constraints implemented in the EUwood estimations significantly reduce potentials from logging residues and stumps in particular. However, extracting more wood from forests may entail negative impacts on other forest functions, such as biodiversity.

Although no economic constraints were included in the EUwood estimations of realizable biomass supply from forests, a case study of procurement costs for logging residues in the province of North Karelia in Finland indicates that the supply of logging residues is highly price elastic. Ultimately, the amount of logging residues that can be mobilized depends on how much the market is willing to pay for this energy source relative to the competing sources of energy.

Improved efficiency in the use of those resources—residues and co-products from the wood-product industry and post-consumer wood—that grow along with the material use of wood is another option. The sawmill industry is of particular importance, both as a supplier of co-products that can be used for material as well as energy purposes and for mobilizing small sized stemwood and forest residues. Promoting the market for sawmill end-use products is thus vital for wood mobilization (Prins, 2010), underlined by the already emerging shortage of sawmill by-products in northern Europe (Hektor, 2009). Improved recovery and use of wood from landscape care activities and other wooded land would also increase the total supply of woody biomass.

Changing the species composition in the forests—replacing slow growing species with faster growing ones—represents another option to increase the supply of woody biomass. Hence, in a simulation study of the effect of intensive forest management on forest production in Sweden, the treatment that resulted in the highest increases in yield relative the reference scenario was planting of lodgepole pine (Nilsson *et al*, 2011). This could, however, like other forms of intensive forest management, be questionable from a biodiversity perspective, and in Sweden the use of tree species other than indigenous ones is as of yet not allowed more than on a quite limited scale.

Establishing short rotation plantations with tree species such as, for instance, willow and poplar represents yet another, potentially major, addition to wood supply within EU27. However, the land area needed to fill the expected gap between supply and demand of wood raw materials is considerable (see Leek, 2010c), Thus, this means is questionable from a food supply point of view, as it would entail increased competition with agriculture for land. In addition, the consequences for other ecosystem services like, e.g. biodiversity are not well understood (Prins, 2010).

In the EUwood base scenario, no assumptions of changes in the overall efficiency of wood use are made, whether in the wood-products industry or for energy generation. However, increased efficiency in the use of wood could contribute significantly to cutting the expected wood deficit, not the least in the energy sector (Prins, 2010). Thus, estimations suggest that every 1 percent increase in combustion efficiency could save up to 7.5 million cubic metres SWE at EU27 level (Steierer, 2010b). Hence, it makes a difference whether wood is burnt in a conventional power plant co-firing with coal or in an efficient combined heat and power plant (Ibid.).

Increasing overall energy efficiency is a most efficient way to decrease the demand pressure on wood resources. On the other hand, the demand for wood for energy purposes could increase by as much as 130 million cubic metres SWE by 2030 at the EU27 level, should countries fail to meet the 20 percent energy efficiency target. Seeing that this target is quite ambitious, it does not seem realistic to expect energy efficiency gains beyond that. The circumstance that overall energy consumption in EU27 seems to have levelled out, as indicated by Figure 10, is encouraging though.

Yet another efficient way to decrease the demand for wood is to develop other renewable energy sources like wind, hydro, solar, tide, and non-wood biomass. Should the share of wood-based energy in renewable energy decrease to 75% of its 2010 value (i.e. 37.4% instead of 50 percent), wood demand could decrease by another sixty-three million cubic metres SWE by 2030 for EU27 compared to the 40 percent assumed in EUwood. Conversely, should wood-based energy account for the same share in renewable energy as in 2010, i.e. 50 percent, 167 million cubic metres SWE more wood could be needed by 2030 compared to a 40 percent share (Steierer, 2010b).

All in all, it appears more than likely that the Swedish forest sector will face a mounting demand for wood. Thus, though Sweden would probably manage to live up to the national RES targets of its own accord, and even considering a potentially decreasing demand for pulpwood resulting from globalization and progress in electronic ICT, the shortage of wood resources relative demand at EU27 level foreseen by the EUwood project would create a tremendous demand pressure on Sweden and the other countries in the northern region, the "woodshed of the EU". Forest owners in Sweden and the rest of the EU stand to gain from resulting higher prices for woody biomass. However, a number of trade-offs between different needs and interests related to the Swedish forest sector are also brought to the fore.

Hence, there is a potential conflict of interest between prioritizing the export revenues generated by the forests-product industry on the one hand and the demand for domestic energy sources on the other. How this is resolved depends to a large extent on whether the forest sector or the energy sector will control the future development of bioenergy. The involvement of Stora Enso in the expansion of wind energy in Sweden could be regarded as part of a strategy to take the initiative by moving more decisively into the energy sector.

Further, an elevated harvest level and ensuing intensified forest management (e.g. shortened rotation periods and fertilisation) in Sweden could compromise non-wood ecosystem services such as biodiversity, water quality, reindeer husbandry, and recreation. In particular, the general consideration for biodiversity on all productive forest land, a trait of Swedish forest policy, could be at risk, possibly to be replaced by zoning, i.e. the separation of forest ecosystem services over the forest area so that in some parts management is focused on timber production whereas non-wood ecosystem services are focused elsewhere (see, e.g. Montigny and MacLean, 2006). The objective of maximizing wood supply also conflicts to some extent with the objective of increasing carbon sequestration in forests (Jonsson, 2011).

7 References

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Some facts about the Timber Committee

The Timber Committee is a principal subsidiary body of the UNECE (United Nations Economic Commission for Europe) based in Geneva. It constitutes a forum for cooperation and consultation between member countries on forestry, the forest industry and forest product matters. All countries of Europe, the Commonwealth of Independent States, the United States, Canada and Israel are members of the UNECE and participate in its work.

The UNECE Timber Committee shall, within the context of sustainable development, provide member countries with the information and services needed for policy- and decision-making with regard to their forest and forest industry sectors ("the sector"), including the trade and use of forest products and, when appropriate, will formulate recommendations addressed to member governments and interested organisations. To this end, it shall:

1. With the active participation of member countries, undertake short-, medium- and long-term analyses of developments in, and having an impact on, the sector, including those offering possibilities for the facilitation of international trade and for enhancing the protection of the environment;
2. In support of these analyses, collect, store and disseminate statistics relating to the sector, and carry out activities to improve their quality and comparability;
3. Provide the framework for cooperation e.g. by organising seminars, workshops and ad hoc meetings and setting up time-limited ad hoc groups, for the exchange of economic, environmental and technical information between governments and other institutions of member countries required for the development and implementation of policies leading to the sustainable development of the sector and to the protection of the environment in their respective countries;
4. Carry out tasks identified by the UNECE or the Timber Committee as being of priority, including the facilitation of subregional cooperation and activities in support of the economies in transition of central and eastern Europe and of the countries of the region that are developing from an economic perspective;
5. It should also keep under review its structure and priorities and cooperate with other international and intergovernmental organizations active in the sector, and in particular with the FAO (Food and Agriculture Organization of the United Nations) and its European Forestry Commission, and with the ILO (International Labour Organisation), in order to ensure complementarity and to avoid duplication, thereby optimizing the use of resources.

More information about the Committee's work may be obtained by writing to:

UNECE/FAO Forestry and Timber Section
Trade and Sustainable Land Management Division
United Nations Economic Commission for Europe
Palais des Nations
CH-1211 Geneva 10, Switzerland

Fax: +41 22 917 0041
E-mail: info.timber@unece.org
www.unece.org/forests/welcome.html

UNECE/FAO Publications

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In the interests of economy, Discussion Papers are issued in the original language, with only minor language editing and final layout by the secretariat. They are distributed automatically to nominated forestry libraries and information centres in member countries.

This Discussion Paper is available on the Forestry and Timber Section website at: www.unece.org/forests-welcome/publications.html .

The Discussion Papers are available on request from the secretariat. Those interested in receiving them on the continuing basis should contact the secretariat as well. Your comments are most welcome and will be referred to the authors:

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Trade and Sustainable Land Management Division
United Nations Economic Commission for Europe
Palais des Nations
CH-1211 Geneva 10, Switzerland
Fax: +41 22 917 0041
E-mail: info.timber@unece.org
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In this study, international trends and major drivers of change for forest resources and wood use are reviewed and, together with projections of future developments in the use and supply of wood resources as well as wood-product market developments in Europe, analysed as to their impact on the Swedish forest sector. Demand is foreseen to vastly exceed the potential supply of woody biomass in Europe, putting a tremendous pressure on the Swedish forest resource and possibly necessitating trade-offs between different ecosystem services.

UNECE Timber Committee and FAO European Forestry Commission

Further information about forests and forest products, as well as information about the UNECE Timber Committee and the FAO European Forestry Commission is available on the website: http://live.unece.org/forests/welcome.html

Information about the UNECE may be found at www.unece.org and information about FAO may be found at www.fao.org

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