The European Forest Sector Outlook Study II

2010-2030

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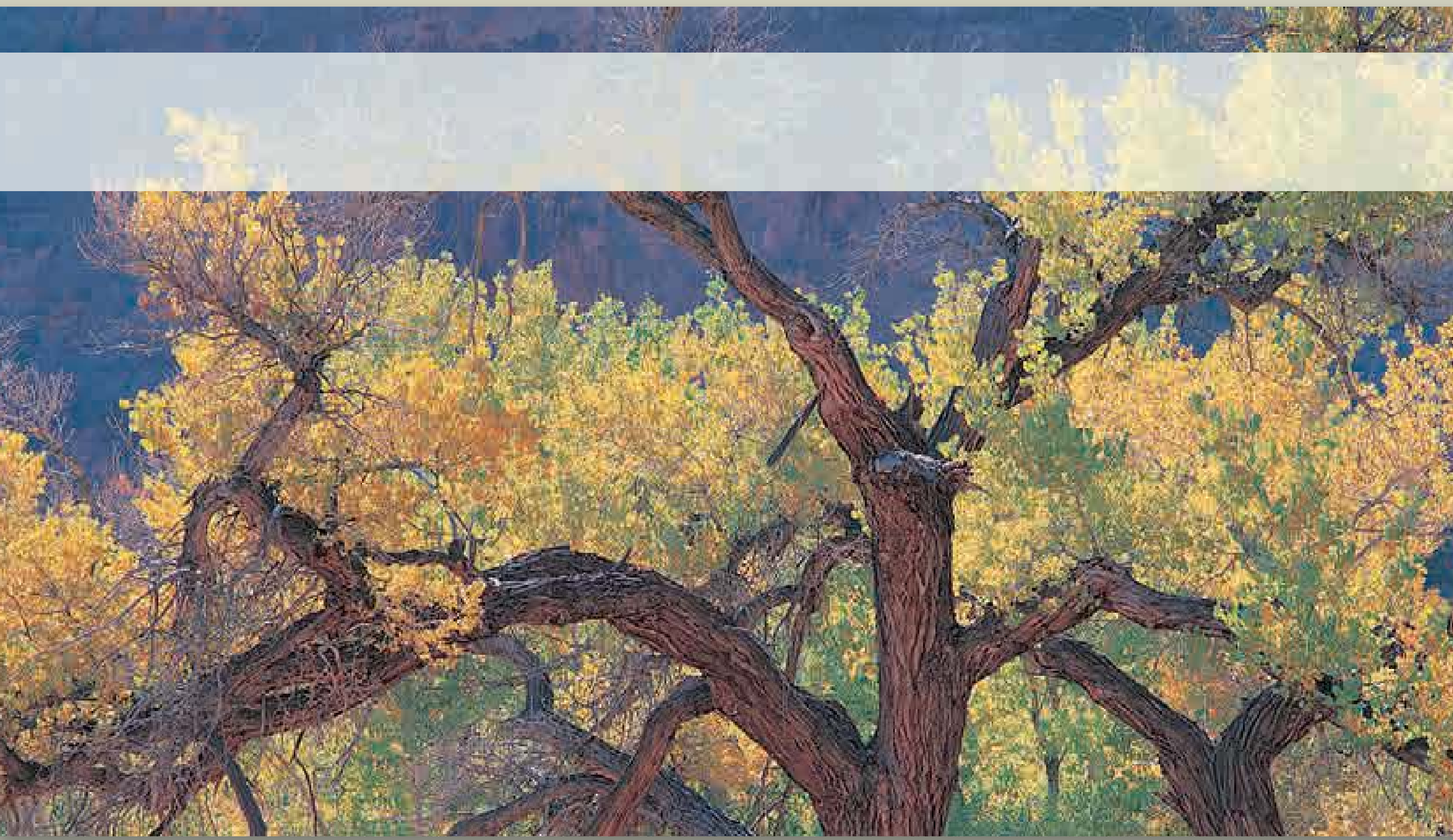

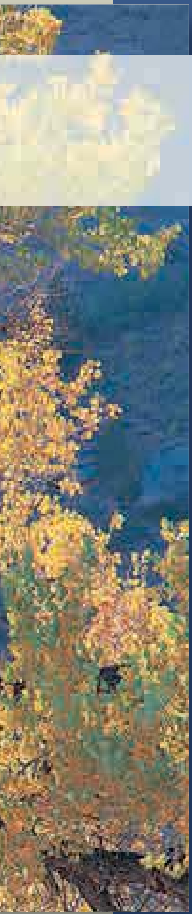

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Foreword

European forest sector policy makers are under increasing pressure.

Expectations of the region's forests to meet increasing environmental, social and economic demands have never been higher. European forest sector policy makers must grapple with complex, imperfectly understood challenges to meet these demands when designing forest policies. These policies will have to address challenges such as climate change, protection of biodiversity, space for recreation and leisure, and energy and raw material needs.

Forests and wood play an important role in climate change mitigation and adaptation strategies. Forests in Europe serve as a carbon sink, mitigating to the extent possible the effects of climate change. Furthermore, forest management needs to be increasingly applied to support adaptation to climate change. At the same time, policies and institutional responses have to adapt to address the consequences of climate change impacts, such as pests, diseases, storms and forest fires. There is also a rising demand for the use of wood for energy and raw material inputs. Forest-based industries continue to demand a reliable supply of raw material inputs. At the same time, the use of wood for energy is intensifying to meet ambitious renewable energy targets. However, mobilising enough wood to satisfy this growing need could come at a significant environmental, financial and institutional cost. Innovation has the potential to introduce wood-based products with novel uses and applications. Growth in the use of wood for new industrial needs and renewable energy demands will need to be balanced with the other functions and uses of forest resources.

At the same time, forest management approaches will need to continuously ensure that forest ecosystems are able to continue to conserve biodiversity. Forests also need to be managed in a manner that guarantees the provision of a range of other environmental and social services, namely supporting and regulating clean air and water quality while providing the cultural and recreational services important to the daily life of many citizens.

The European Forest Sector Outlook Study II (EFSOS II) addresses and discusses these demanding challenges. Through scenario analysis, policy makers are presented with the long-term consequences of possible policy choices. These choices are assessed according to their sustainability and recommendations are proposed based on the trade-offs facing policy makers. Decision makers are encouraged to reflect upon these analyses and to consider them when taking possible future policy actions.

We would like to express our sincere thanks to the team of forestry, climate change, competitiveness and trade experts as well as the country correspondents who have contributed to this comprehensive, new and innovative study.

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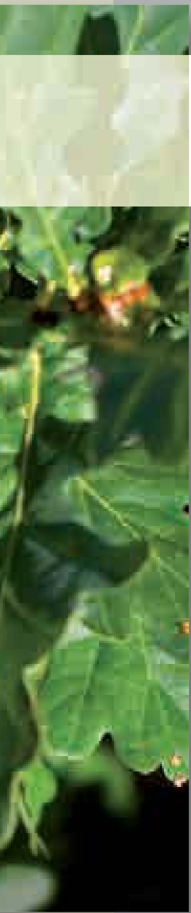


Executive Summary

Policy challenges

The intention of EFSOS II is to help policy makers and other actors to make well-informed choices, by providing them with objective analysis on which they can base these choices. Allowing policy makers to see the possible consequences of their choices, presented in a structured and objective way, should help them to make more informed, and presumably better, decisions.

EFSOS II focuses on seven major challenges, which could all have significant consequences and could interact with each other. They are complex, international, and long term in nature. The issues chosen are the following:

- Mitigating climate change;
- Supplying renewable energy;
- Adapting to climate change and protecting forests;
- Protecting and enhancing biodiversity;
- Supplying renewable and competitive forest products;
- Achieving and demonstrating sustainability, and;
- Developing appropriate policies and institutions.

Methods

EFSOS II is based on scenario analysis. A reference scenario and four policy scenarios have been prepared for the European forest sector between 2010 and 2030, covering the forest resource (area, increment, harvest, silviculture) and forest products (consumption, production, trade). All calculations are at the national level aggregated into five country groups.

The starting point of the analysis is a *Reference scenario*, which provides a picture of a future without major changes from the past: current policies remain unchanged, and current trends continue. For developments outside the forest sector, the Intergovernmental Panel on Climate Change (IPCC) B2 scenario is used. The four policy scenarios help policy makers gain insights into the consequences of certain policy choices. These 'what-if?' scenarios are not meant to give predictions of what will happen in the future, but to give insights into the behaviour of the system and how it could be influenced.

The four policy scenarios are as follows:

- *Maximising biomass carbon:* explores how much carbon could be stored in the European forest by changing silvicultural methods, without affecting the level of harvest.
- *Priority to biodiversity:* assumes that decision makers give priority to the protection of biological diversity.
- *Promoting wood energy:* explores what would be necessary for wood to contribute to achieving the ambitious targets for renewable energies adopted by most European countries.
- *Fostering innovation and competitiveness:* explores the consequences for the sector of a successful strategy of innovation, leading to improved competitiveness. This scenario is treated in a qualitative way.

The scenarios are based on the results of several different modelling approaches, and in particular of econometric projections of production and consumption of forest products, the Wood Resource Balance, the European Forest Information Scenario model (EFISCEN), the European Forest Institute - Global Forest Sector Model (EFI-GTM), and competitiveness analysis. These are all described in detail in the study and its accompanying Discussion Papers.

Conclusions

If no major policies or strategies are changed in the forest sector and trends outside it follow the lines described by the IPCC B2 scenario, consumption of forest products and wood energy will grow steadily and wood supply will expand to meet this demand (see Figure 24). All components of supply will have to expand, especially harvest residues (*Reference scenario*).

To maximise the forest sector's contribution to climate change mitigation, the best strategy is to combine forest management focused on carbon accumulation in the forest (longer rotations and a greater share of thinnings) with a steady flow of wood for products and energy (*Maximising biomass carbon scenario*). In the long term however, the sequestration capacity limit of the forest will be reached, and the only potential for further mitigation will be regular harvesting, to store the carbon in harvested wood products or to avoid emissions from non-renewable materials and energy sources.

If wood is to play its part in reaching the targets for renewable energy, there would have to be a strong mobilisation of all types of wood. Supply would have to increase by nearly 50% in twenty years (*Promoting wood energy scenario*). However the mobilisation of such high volumes would have significant environmental, financial and institutional costs.

To increase European wood supply from outside the existing forest sector, it would be necessary to establish short rotation coppice on agricultural land. This could significantly reduce the pressure on the existing European forest and help to build the share of renewables in energy supply, but at the cost of trade-offs with other land uses and, depending on site selection processes, landscape and biodiversity.

Demand for energy wood is directly determined by the efficiency with which it is used. Use efficiency is improved if wood is used for heat production or combined heat and power (CHP). Efficient wood burning installations equipped with the necessary filters prevent the emission of fine particles which are harmful to human health.

If biodiversity were given priority, for instance by setting aside more land for biodiversity conservation and changing forest management to favour biodiversity, the supply of wood from European forest would be 12% less than in the *Reference scenario*. This would necessitate reduced consumption of products and energy, and/or increased imports from other regions and/or intensified use of other sources like landscape care wood and wood originating from conservation management and short rotation coppice (*Priority to biodiversity scenario*).

A more innovative approach in all parts of the sector could create, defend or expand markets, create new opportunities, reduce costs and increase profitability (*Fostering innovation and competitiveness scenario*). Forest management also needs innovative approaches. Developing a culture of innovation is a complex challenge, going far beyond the boundaries of the forest sector.

Europe is, and will remain in all scenarios, a net exporter of wood and forest products: significant net exports of products outweigh relatively minor net imports of wood, even in the *Promoting wood energy scenario*.

Supplies of landscape care wood (e.g. from urban and highway trees, hedges, orchards and other wooded land) and post-consumer wood have the potential to increase by about 50%, reducing waste disposal problems for society as a whole.

Projections show a steady rise in prices of forest products and wood over the whole period, driven by expanding global demand and increasing scarcity in several regions.

A method developed for EFSOS II, which builds on the sustainability assessment of the State of Europe's Forests 2011 (SoEF 2011) report (FOREST EUROPE, UNECE and FAO, 2011), has been used to review the sustainability of the *Reference scenario* and all three quantified policy scenarios. Most parameters, in this experimental method, are relatively satisfactory. The main concern is for biodiversity, as increased harvest pressure in all scenarios, except for the *Priority to biodiversity scenario*, lowers the amount of deadwood and reduces the share of old stands. The *Promoting wood energy scenario* shows a decline in sustainability with regards to forest resources and carbon, due to the heavy pressure of increased wood extraction to meet the renewable energy targets.

The European forest will have to adapt to changing climate conditions, whose effects will vary widely by geographic area and forest type. Forest management needs to support the adaptation process either by increasing the natural adaptive capacity (e.g. by enhancing genetic and species diversity) or

with targeted planned adaptation measures (e.g. introducing an adapted management system or other species). To manage this adaptation process, more scientific and forest monitoring information is needed. For decisions now, the further development of existing regional forest management guidelines is important, as well as the implementation of decision-support systems.

Forest sector policies, institutions and instruments in Europe are in general stable, recent and effective, and increasingly enjoy public support through the participatory nature of national forest programme (NFP) processes. However the challenges posed by climate change, energy and biodiversity issues are exceptionally complex and long term, and require quite profound changes if they are to be satisfactorily resolved. It will require a very high level of sophisticated cross-sectoral policy making, sharply focused policy instruments and strong political will to mobilise enough wood for energy, to implement the right balance between carbon sequestration and substitution and to conserve biodiversity without sacrificing wood supply, and thereby to make the best possible contribution to the sustainable development of society as a whole.

Recommendations

For policy makers

Climate mitigation: policy measures should be put in place to encourage the optimum combination of carbon sequestration and storage with substitution, as well as systems to monitor trends for this, to enable adjustment of the incentive system in the light of results attained.

Carbon stock in forests: prevent any reduction of the carbon stock in forests, for instance due to fire, pests and insects or pollution.

Adaptation to climate change: guidelines, by region and forest type, based on the best available scientific knowledge, should be developed to support practitioners in their decisions, and to build resilience in European forests.

Wood energy: a strategy should be drawn up, at the national level, which integrates the needs of the energy sector with those of the forest sector, and is produced after a scientifically based dialogue between forest sector and energy sector policy makers.

Wood supply: guidance, based on best available scientific knowledge, should be prepared on what levels of extraction of harvest residues and stumps are sustainable, in what forest types.

Short rotation coppice: develop national strategies for rural land use, integrating concerns related to sustainable supply of food, raw material and energy, as well as the other functions of forests, and all aspects of rural development.

Wood energy use: ensure that wood, like other energy sources, is used as efficiently and cleanly as possible.

Wood mobilisation: implement the existing wood mobilisation guidance, monitoring success/lack of success, and modifying the guidance in the light of experience.

Post-consumer wood: remove constraints on the mobilisation of post-consumer wood.

Biodiversity: identify win-win areas and forest management techniques where biodiversity, wood supply and carbon sequestration can be combined, and then implement measures to promote these practices.

Innovation: governments should work to develop good conditions for innovation.

Forest ecosystem services: provide positive framework conditions for payment for forest ecosystem services. Move from the pilot phase to implementation of schemes which have proved their effectiveness and are applicable to local circumstances.

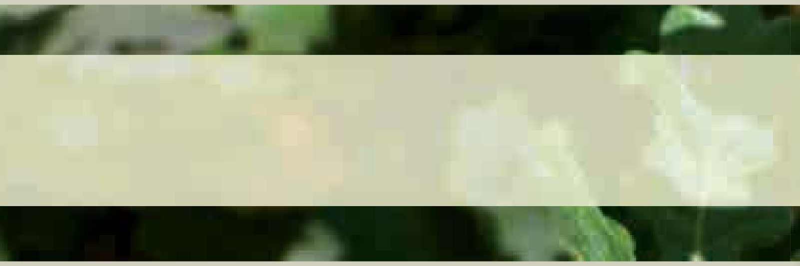
Policies and institutions: countries should review whether their forest sector policies and institutions are equipped to address the challenges of climate change, renewable energy and conserving biodiversity, and whether intersectoral coordination in these areas is functioning properly.

Assessment of sustainability: countries should develop objective methods of assessing the present and future sustainability of forest management, preferably linked to the regional systems under development.

Outlook studies: develop national/regional outlook studies, possibly based on EFSOS II, and use them as the basis for policy discussions.

For international organisations

Adaptation of forest management to climate change: encourage the sharing of knowledge and experience between countries, on strategies to increase resilience of forests to climate change, promote the preparation of guidance for regions/forest types.



Wood energy: use existing forums to discuss strategic options for increasing the contribution of wood to renewable energy, identifying constraints, and developing precisely targeted policy instruments.

Biodiversity: forest sector organisations should communicate the EFSOS II analysis to regional and global organizations focused on biodiversity, and encourage the exchange of analysis and information between the two sectors.

Innovation in forest management: there is a need to share innovative ideas and approaches in forest management. An informal structure, centred on periodic forums and exchanges, could be initiated by an existing international organisation.

Competitiveness: review factors underlying results of the competitiveness analysis in EFSOS II, bringing together analysts and the private sector to identify what lessons can be learnt from this analysis, and whether there are implications for policy.

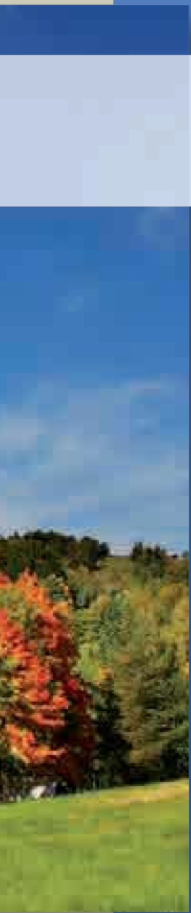
Knowledge base: international organisations should continue to work together to maintain and improve the knowledge infrastructure needed to carry out reliable analysis of the European forest sector and of the outlook for the sector.

Assessing sustainable forest management in Europe, now and in the future: the experimental approaches developed for SoEF 2011 and EFSOS II should be the subject of widespread consultation and review. Approaches, methods and data need to be defined and regularly implemented.

Outlook studies: review EFSOS II, with a view to improving methods and impact in future outlook studies. Communicate analysis to other regions and the global level, to improve consistency between the outlooks.

For research

EFSOS II formulates specific recommendations for research in the fields of soil carbon, strategies for adaptation to climate change, forest monitoring for adaptation to climate change, ecological / physiological range of forest trees, sustainability of wood supply, drivers of wood supply, short rotation coppice and rural land use, non-forest wood supply, wood for energy and models.



1 Introduction

1.1 Objectives of the outlook study

Sector outlook studies are a major component of the integrated programme of work of the UNECE Timber Committee and the FAO European Forestry Commission. UNECE/FAO analyses structural developments in the forest sector and periodically produces studies of the long term outlook for supply and demand for wood and the other forest goods and services, to support policy makers and analysts, as well as civil society and private sector decision makers. The European Forest Sector Outlook Study II (EFSOS II) is the latest in a series of studies, which started in 1952, to provide a regular outlook report for the European forest sector. All these studies have aimed to map out possible or likely future developments, on the basis of past trends, as a contribution to evidence-based policy formulation and decision making.

In accordance with its mandate, the objectives of EFSOS II are to:

- Analyse structural developments in the forest sector and project these trends into the future through reference scenarios;
- Construct scenarios projecting the possible long term consequences of major policy choices, as a support to decision making;
- Supply information and analysis which will make it possible to estimate whether future likely or proposed policy choices will lead to the sustainable development of the forest sector;
- Provide information and analysis which can be used by all those who wish to analyse sustainable forest management in Europe;
- Provide information and analysis on the forest sector in Europe which may be used by those analysing other sectors or multi-sector issues such as climate change, energy or land use.

EFSOS II presents possible futures for the European forest sector up to 2030, based on differing assumptions about priorities and policy choices. Compared to its predecessors, EFSOS II has some improved features:

- It identifies specific policy issues, and focuses the analysis on them, as opposed to a more general description of possible futures;
- It analyses the sustainability of all the dimensions of the sector, not only those concerned with wood supply and demand, using the structure of the pan-European criteria and indicators of sustainable forest management;
- It gives more detailed consideration to trends for energy, climate change and biodiversity, how they influence the environment for forest sector decision making, and how the forest sector can contribute to achieving related wider goals.

1.2 Approach and methods

This study is structured into 5 main sections.

Chapter 2, after a brief overview of the situation around 2010, identifies six major policy issues and outlines the challenges facing policy makers.

Chapter 3 describes the reference scenario and the policy scenarios, notably the assumptions on which they are based and the long term development of all parts of the sector.

Chapter 4 assesses the sustainability of each of the scenarios, by estimating projected changes in a number of sustainability indicators.

Chapter 5 analyses the main policy issues in the light of the scenario results.

Chapter 6 presents conclusions and policy recommendations.

EFSOS II is built on the construction and interpretation of scenarios. Scenarios use what is known about the past and the present to create a series of possible futures, demonstrating the possible consequences of defined choices or external events. To do this, relationships, often quantified, are established between external 'drivers' (e.g. economic growth, population, climate) and the parameters on which the analysis is focused (e.g. consumption of forest products, removals from forests), as well as the interactions of the parameters. The usefulness of a set of scenarios depends on the robustness and realism of the relationships chosen to explain trends, the relevance of the assumptions used to construct the scenarios, and the ability to construct internally consistent outlooks which could each result from specific policy choices.

The scenarios in EFSOS II are based on a number of different approaches and models, each with its own strengths and weaknesses. The main models used are: the European Forest Information Scenario Model (EFISCEN); the Global Forest Sector Model (EFI-GTM); market models developed for earlier outlook studies; and, the Wood Resource Balance (WRB). The approaches were developed for earlier outlook studies, or in other contexts, and have been brought together in a major cooperative approach by analysts and modellers from different backgrounds. The methods used are summarised in Chapter 3, and fully presented in the references quoted, including a series of Discussion Papers[1] that will follow EFSOS II.

This approach brings robustness, in that the outputs of the different models can be compared and contrasted, as well as the ability to address a wide variety of issues in some detail.

1.3 Scope and definitions

1.3.1 The forest sector

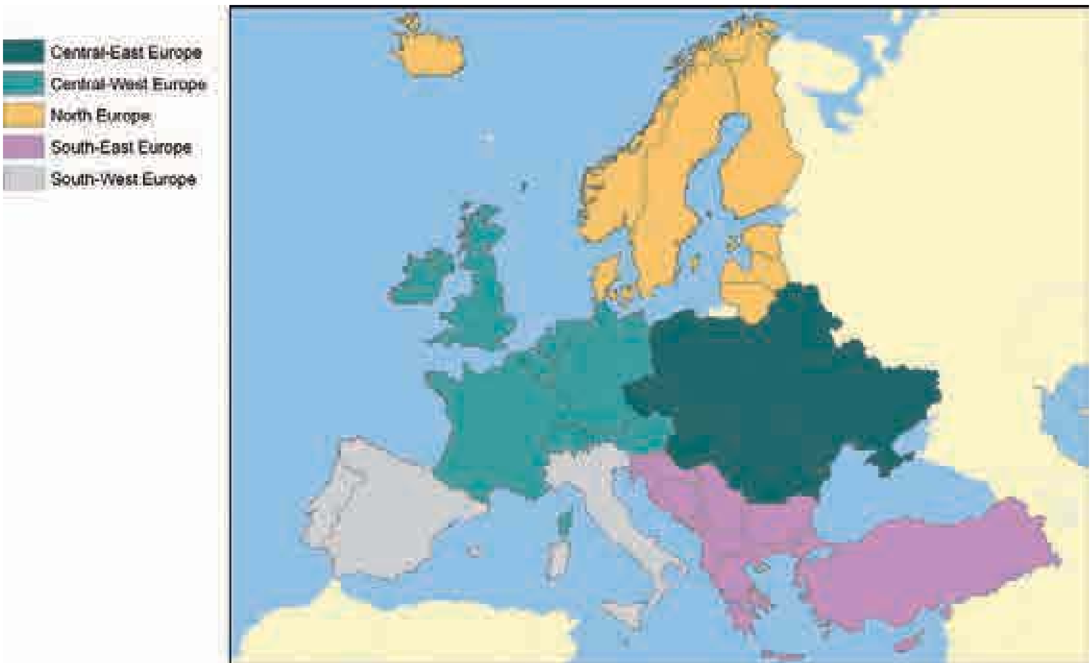
In EFSOS II the forest sector includes the forest resource, as well as the production, trade and consumption of forest products.

1.3.2 Geographical scope

The UNECE region comprises 56 member countries from Europe, North America and the countries of the Caucasus and central Asia. EFSOS II analyses trends for all UNECE members, except Canada, the Caucasus and central Asia, Israel, Russia and the United States. Outlook studies for Russia and for North America are under preparation and will be presented alongside EFSOS II. The outlook for the countries of the Caucasus and central Asia was analysed in the FAO Forest Sector Outlook Study for Western and Central Asia (FOWECA). The country groups within Europe (Figure 1) are the same as in SoEF 2011:

[1] *in preparation see list in section 7.3*

Figure 1: Country groups



Source: adapted from SoEF 2011

- North Europe: Denmark, Estonia, Finland, Iceland, Latvia, Lithuania, Norway, Sweden.
- Central-West Europe: Austria, Belgium, France, Germany, Ireland, Luxembourg, the Netherlands, Switzerland, United Kingdom.
- Central-East Europe: Belarus, Czech Republic, Hungary, Poland, Republic of Moldova, Romania, Slovakia, Ukraine.
- South-West Europe: Italy, Malta, Portugal, Spain.
- South-East Europe Albania, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Greece, Montenegro, Serbia, Slovenia, The former Yugoslav Republic of Macedonia, Turkey.

Some of the smaller UNECE member countries (Andorra, Holy See, Liechtenstein and Monaco) are not included in the EFSOS II analysis because they have very few forest resources and small markets.

1.3.3 Time horizon

The study analyses the period from 2010 to 2030, as this is the limit of robustness for analysis of markets.

1.3.4 Data

The analysis is ultimately based on official data supplied to UNECE/FAO and other organisations by national correspondents, through notably the Joint Forest Sector Questionnaire, the SoEF 2011 process and the Joint Wood Energy Enquiry. On this foundation, separate databases have been constructed over a long period for the different models, and enriched with the extra information needed for each model. Preliminary output of the models was submitted for checking by national correspondents, but some anomalies remain, and in a few cases, it has not been possible to completely reconcile the data in the different models. However the authors believe this does not invalidate the conclusions drawn.

The scenarios, with country data, are being made available on the internet for the use of analysts and policy makers who wish to create alternative scenarios or to examine trends in more detail.

1.4 Acknowledgements

EFSOS II is the result of a collaborative effort among numerous specialists from international organisations and other institutions. The UNECE/FAO wishes to thank those who worked on the development of the study.

The preparation was overseen and the main options agreed by a team led by Mart-Jan Schelhaas.

A smaller core group consisted of those who contributed data, analysis or methods: Ragnar Jonsson from the Southern Swedish Forest Research Centre, provided market projections in cooperation with Anders Baudin from Växjö University. Hans Verkerk from the European Forest Institute (EFI), elaborated EFISCEN forest resource projections with Mart-Jan Schelhaas while Alexander Moiseyev (EFI), developed EFI-GTM forest sector projections. Udo Mantau and Ulrike Saal from the University of Hamburg constructed the Wood Resource Balance for all EFSOS II countries based on the method developed in the EUwood project and on wood energy forecasts by Florian Steierer (FAO). Holger Weimar, Matthias Dieter and Hermann Englert from the Johann Heinrich von Thünen Institute provided an analysis of competitiveness in international markets. Douglas Clark, consultant, contributed to the innovation analysis. Mart-Jan Schelhaas brought together the results of the different models to create the overall balance used in EFSOS II. Gustaf Egnell (Swedish University of Agricultural Sciences), Ivonne Higuero (United Nations Environment Programme, UNEP), Jeff Prestemon (USDA Forest Service), Jesus San Miguel-Ayanz (European Commission Joint Research Centre at Ispra) and Peter Schwarzbauer (University of Natural Resources and Life Sciences, Vienna) also contributed to the work of the core group.

The study itself was drafted by Kit Prins, Mart Jan Schelhaas, Christoph Wildburger and Sabine Augustin. Christoph Wildburger contributed the analysis on biodiversity and Sabine Augustin contributed on adaptation to climate change in cooperation with Marcus Lindner (EFI). The rest of the study was drafted jointly by Kit Prins, who focused on wood energy, innovation and links to policy, and Mart-Jan Schelhaas, who focused on the reference scenario and climate change mitigation.

The Government of Switzerland provided financial support and the services of Sabine Augustin. The services of Christoph Wildburger were provided by UNEP. The Future Forest project in Sweden contributed the services of Ragnar Jonsson and Anders Baudin. Much of the work on the Wood Resource Balance and the energy forecasts was based on the results of EUwood, a project funded by the Intelligent Energy Europe programme (IEE).

The UNECE/FAO is grateful to the members of the UNECE/FAO Team of Specialists on Forest Sector Outlook and outlook correspondents for the review and contribution of the methods and the data in the context of three meetings held in Geneva in the period 2009-2011 (see Box 1), and to a number of experts who contributed to the development of EFSOS scenarios (see Box 2).

Box 1: UNECE/FAO Team of Specialists and correspondents on Forest Sector Outlook.

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Morten Thoroe, Confederation of European Forest Owners (CEPF)
Jukka Tissari, FAO
Jo Van Brusselen, EFI
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Jeremy Wall, DG Enterprise, European Commission
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The report was reviewed and edited by Jenny Heap, consultant. Franziska Hirsch and David Ellul from the UNECE/FAO Forestry and Timber Section, coordinated the development of the study in close cooperation with the Core Group of experts. Matt Fonseca, Alex McCusker and Karen Taylor (UNECE/FAO) provided support with data coordination and servicing of meetings. Douglas Clark organized a brainstorming session in January 2011 on innovation, which provided much of the substance for the innovation and competitiveness discussion. The entire study was reviewed and approved by Paola Deda. The report was designed and laid out by the Printing Section of United Nations Office at Geneva.

2 Main policy issues and challenges for the forest sector

2.1 Introduction

The intention of EFSOS II is to help policy makers and other actors to make well-informed choices, by providing them with objective analysis on which they can base these choices. Allowing policy makers to see the possible consequences of their choices, presented in a structured and objective way, should help them to make more informed, and presumably better, decisions.

However, policy makers face many challenges and it is not possible to address them all. After widespread consultation therefore, EFSOS II has focused on selected major challenges, which could all have significant consequences and could interact with each other. They are complex, international, and long term in nature. EFSOS II focuses on these major policy issues, and the analysis is designed to address these issues as a priority. The issues chosen are the following:

- Mitigating climate change;
- Supplying renewable energy;
- Adapting to climate change and protecting forests;
- Protecting and enhancing biodiversity;
- Supplying renewable and competitive forest products;
- Achieving and demonstrating sustainability;
- Developing appropriate policies and institutions.

This chapter provides an introduction to the policy issues as a context for the analyses in the rest of the study, and does not examine the issues themselves in any depth. After a brief description of the starting point for the analysis, which is the situation in 2010, the background to the chosen policy issues is briefly presented, together with the challenges that policy makers face in addressing these issues.

2.2 The situation in 2010

An analysis of the outlook can only be based on good knowledge of the past and present. Since 2003, regular reports of the state of Europe's forests have been presented to ministerial conferences, structured according to the pan-European criteria and indicators of sustainable forest management. The most recent is the SoEF 2011 report, based on data up to 2010, prepared for the FOREST EUROPE ministerial conference in Oslo in June 2011. SoEF 2011 presents a comprehensive, balanced quantitative and qualitative view of the situation based on official data. A few key data from SoEF 2011 are presented in Table 1, and the summary by country group is reproduced below. The 'areas of concern' are those identified by the SoEF 2011 assessment process.

2.2.1 North Europe

The forest sector in North Europe is mostly privately-owned, well organized, and focused on wood production, with a strong commitment to achieving environmental objectives.

In most of North Europe, the boreal forest is central to the landscape. There is intensive use of the resource and a sophisticated and well-resourced institutional structure. Forest-related questions have a high policy importance in the region.

Areas of concern which have been identified are: the large area at risk from eutrophication, the carbon/nitrogen ratio in forest soil, which is approaching the warning level in two countries; and, in some countries, the low percentage of forest protected for biodiversity.

2.2.2 Central-West Europe

Forest-related issues are not central to the economy or to society in Central-West Europe, although populations have tended to react strongly to threats to their forests.

The region contains many densely populated and highly prosperous urbanized countries, although there are significant rural and mountainous areas where most of the forest occurs. Forest institutions are stable and well-resourced, although they lack political weight relative to other parts of society, and are therefore less able to mobilize sufficient financial and human resources.

Areas of concern identified are: the high percentage of the land area at risk of eutrophication from nitrogen deposition; the carbon/nitrogen ratio near to warning level for soil imbalances in some countries; problems with landscape pattern and fragmentation; negative net entrepreneurial revenues in a few countries; a negligible share of wood in total energy supply in a few countries; and, the small share of the total workforce engaged in the forest sector.

2.2.3 Central-East Europe

The transition process, to a market-based economy, has been a challenge to forest institutions in Central-East Europe, but in many countries these institutions have retained their traditional foundations.

The countries in Central-East Europe were all centrally planned 25 years ago, but many have now been transformed and are increasingly prosperous. Five countries in this group are now members of the European Union (EU). Ecologically, the country group is heterogeneous, running from the Alps to the Volga basin.

Areas of concern identified are: the fact that the entire land area of the region is at risk of eutrophication from nitrogen deposition; the carbon/nitrogen ratio near to warning level for soil imbalance in one country; high defoliation level in one country; generally low per hectare (ha) values for marketed non-wood goods and services; the small share of the total workforce engaged in the forest sector; low levels of wood consumption; and, the low reported share of wood in total energy supply.

2.2.4 South-West Europe

There is some intensive management of forest in South-West Europe, but many forests suffer from fire, nitrogen deposition, changes in landscape pattern and rural depopulation.

In the region, most countries have a distinctively Mediterranean forest on much, but not all, of their territory. Despite the threats, some areas are managed intensively, sometimes with introduced species. There are serious information gaps.

Areas of concern identified are: the high percentage of land at risk of eutrophication due to nitrogen input; significant fire damage; high fragmentation of landscapes; and, negative trends for forest landscape pattern, in some countries.

2.2.5 South-East Europe

There are diverse forestry situations in South-East Europe, and many countries have weak information systems.

By European standards, most of the countries in the region have rather large rural populations and low per capita income. Some have new institutions which emerged after the conflicts in the former Yugoslavia. Fire is an issue throughout the region. In one country, the forest itself is under severe pressure from overgrazing and over-cutting (mostly for fuel) by the rural population. It appears that, in many areas, the forests are not intensively managed and not well protected for biodiversity – but information provision is very weak, so this cannot be verified. Because insufficient information is provided, and possibly also because the relevant forest sector information does not exist at the national level, it is not possible to say with any objectivity, whether or not forest management is sustainable.

Areas of concern identified are: the steeply falling forest cover and growing stock in one country; risk of eutrophication due to nitrogen deposition in almost the entire land area of the region; significant fire damage; fellings greater than net annual increment in one country; rather low per ha values for marketed non-wood goods; several countries with a high proportion of single species stands; low proportion of forest protected for conservation of biodiversity in many countries; and, low levels of wood consumption.

Table 1: Key facts on Europe's forests, 2010

	Unit	North	Central-West	Central-East	South-West	South-East	Europe
Area of forest	million ha	69.3	36.9	44.0	30.8	29.9	210.9
Forest as % of total land	%	52.1	26.4	26.8	34.8	23.1	32.2
Forest per capita	ha	2.18	0.15	0.29	0.27	0.25	0.31
Area of forest available for wood supply	million ha	54.5	34.4	33.9	24.8	21.3	168.9
Growing stock per ha	m^3/ha	117	227	217	81	140	155
Net annual increment per ha	m^3/ha	4.6	7.8	5.6	3.3	5.9	5.4
Carbon in living biomass	million tonne	3 115	3 410	3 988	1 082	2 038	13 632
Fellings	million m^3	181.1	172.4	114.2	29.3	16.9	513.2
Value of marketed roundwood	million EUR	4 979	7 941	2 596	703	1 524	17 743
Area of forest protected for biodiversity or landscape	million ha	NA	NA	NA	NA	NA	38.4
Share of forests in private ownership	%	71	62	12	72	16	50
Forest sector share of GDP	%	2.2	0.8	1.6	0.8	0.7	1.0
Forest sector work force	1000 FTE	346	925	879	582	406	3 138
Consumption of forest products per capita	m^3 RWE	3.0	1.5	0.8	1.0	0.7	1.2
Net trade (+ = net exports, - = net imports)	million m^3 RWE	+103	-49	+5	-36	-16	+8
Wood energy consumption per capita rural population	tonne	1.45	0.24	0.20	0.20	0.09	0.27

Source: SoEF 2011

2.3 Mitigating climate change

2.3.1 Background

Mitigating climate change is one of the largest and most complex challenges facing the world, with a unique complexity on the interface of biophysical processes, economic activity and considerations of geographic and intergenerational equity. The forest sector is at the origin of nearly a fifth of anthropogenic carbon emissions, mostly through deforestation, but also through wildfires, forest damage and wood harvest.

At the same time, the forest sector can make a significant contribution to mitigating climate change. The main climate change mitigation strategies focused on the forest sector are:

- **Sequestering carbon in forests**, by accumulating and maintaining carbon in the forest ecosystem (biomass and forest soil). Methods to achieve this include extending the resource; increasing its productivity; limiting harvests; reducing losses by improved protection against fire or insects; or changing silvicultural approach.
- **Sequestering carbon in harvested wood products**. Until these products (e.g. sawnwood or panels in houses and furniture, paper in books) decay or are destroyed the carbon embedded in them is not released into the atmosphere. Making and using more of these products, and maximising their in-service life span, will sequester more carbon.
- **Substituting for non-renewable raw materials**. Making products from wood from sustainably managed forests, to replace materials from non-renewable sources, should reduce carbon emissions, especially as wood processing often emits fewer greenhouse gases than its competitors (aluminium, concrete etc.).
- **Substituting for non-renewable energy**. To the extent that wood from sustainable sources replaces non-renewable energy sources, carbon emissions are reduced. Wood already accounts for half of the renewable energy in Europe and thus plays an important role in meeting energy needs. In general, a 'cascaded' use of wood may be desirable (i.e., firstly for wood-based products, secondly recovered and reused or recycled and finally used for energy).

The various mitigation strategies are, at the time of writing, treated quite differently in the Kyoto Protocol accounting processes, and there is no certainty about the future climate change regime. Rules exist for accounting for *carbon sequestration in forests*, but they apply in carefully defined circumstances, and there are ceilings imposed by the Marrakesh Accords (UNFCCC, 2001). At present, no accounting for *harvested wood products* is allowed, and carbon embedded in harvested wood products is assumed to return to the atmosphere when they are manufactured, not when they are actually destroyed. However, negotiations are well advanced to put in place a system to account for harvested wood products. There is also no 'credit' for using renewable sources in substitution, whether for non-renewable raw materials or energy. The benefit of such substitutions is on the other side of the accounting process, in that the emissions from non-renewable materials and energy will decline. Therefore the drop in carbon emissions is not directly accountable to the substituting material or energy source.

There are trade-offs between different mitigation strategies and other forest functions: between carbon sequestration and wood production; between intensive management (whether for rapid carbon sequestration or for wood production) and biodiversity or recreation; and so on. In addition, many of the trade-offs are not quantified. It is thus very difficult, if not impossible, to calculate objectively what is the optimum combination of silvicultural and policy measures to obtain maximum mitigation, with minimum negative consequences to the other dimensions of sustainable forest management.

Finally, these forest sector issues are rarely, if ever, included in the global climate models, which underpin decision making in the sector.

2.3.2 Challenges for policy makers

There are several specific challenges for the European forest sector, which must be resolved in a coordinated way with the other climate change related challenges. These are:

- defining the most effective and most sustainable combination of climate change mitigation strategies;
- reconciling the strategies that are desirable from the carbon point of view, with the other dimensions of sustainable forest management, notably biodiversity conservation; provision of ecosystem services; recreation; and, production of wood and other goods and services;
- reconciling strategies to sequester carbon in forests with strategies to achieve a more renewable energy future and balancing carbon storage maximisation with renewable energy promotion;
- implementing domestic policies without causing harm elsewhere. An example would be 'exporting carbon emissions' by sequestering carbon in domestic forests whilst relying on unsustainably produced materials and fuels from other regions.

2.4 Promoting renewable energy

2.4.1 Background

A major objective in energy policy all over Europe, and at the EU level, is to increase the share of renewable energies: targets have been agreed, and incentive systems set in place in nearly all European countries. The EU aims to have 20% of energy from renewable sources by 2020, although individual national targets vary widely. National renewable energy plans, specifying how these targets will be achieved, have been drawn up in all EU countries: similar plans exist for most non-EU countries or are being drawn up. Woody biomass accounts at present for about half of the total renewable energy supply. The forest sector is expected to play a major role in achieving these targets, although it is a reasonable assumption that wood energy supply will grow more slowly than newer renewable energies such as wind or solar, which are still at an early phase of their development.

Recent studies have shown that more wood is used for energy than previously estimated, and that a large part of this comes from non-forest sources: industry's co-products; landscape care wood; post-consumer recovered wood. There is also scope to use a larger proportion of woody biomass, including branches and tops, and even, under certain conditions, stumps.

There are two major areas of uncertainty. The first concerns the lack of information about the resource, taking into account the informal nature of many wood energy flows and the poor knowledge of the non-stemwood resource. The second concerns the possible consequence, for other parts of the sector, of the rapid and policy-driven reappearance of a major demand sector for wood.

2.4.2 Challenges for policy makers

Policy makers face four major challenges arising from the strongly rising demand for wood energy, driven by policy objectives for renewability and security of energy supply,

strengthened by recent developments for nuclear power, and high fossil fuel prices:

- mobilising enough wood on a sustainable basis to reach the targets for renewable energy, and to incorporate woody biomass fully into national renewable energy plans;
- finding the most effective climate change mitigation strategy, combining carbon sequestration in forests and products with substitution of wood-based materials for non-renewable materials and (fossil) energy;
- maintaining the sustainability of the other parts of the forest sector faced with the consequences of increased demand for wood energy: wood manufacturing industries fear for their raw material supply, which might be 'diverted' to energy uses, and will probably increase in price; the intensity of management needed to supply large volumes of wood for energy, for instance in 'energy plantations', could harm biodiversity[2] and other concerns could arise;
- ensuring that wood for energy is sustainably produced. This should apply to both local and imported wood, both of which should satisfy appropriate sustainability criteria.

2.5 Adapting to climate change and protecting forests

2.5.1 Background

The changing climate will affect the European forests: their management will have to adapt to the changing conditions. Whereas the degree and speed of change are unknown, the broad lines of likely change, and of how forest management should adapt, are becoming clearer (Lindner *et al.,* 2008). Rising temperatures; changing patterns of precipitation and extreme events; longer growing season; and drought, will all have consequences, some positive, but mostly negative. The speed of change is probably faster than the ability of ecosystems to evolve, making damage (fire, storms, infestations) rather likely in many parts of Europe.

Forest managers are being urged to modify their choice of species, rotations, thinning schedules, harvesting operations, drainage and other activities, to meet the expected changes in conditions, but also to increase the resilience of the ecosystems for which they are responsible. The concept of silviculture to manage risk is being developed and applied, at least by leading organisations, even in the absence of definitive scientific results, which need time to achieve.

However, much research is needed. There is not yet consensus on the best strategies, which are in any case highly site specific, and smaller owners need guidance and help. National forest programmes probably need to be revised to take specific account of the need to adapt to climate change, and to incorporate appropriate guidance for specific national circumstances.

Many of the adaptive measures being discussed will raise costs or reduce profitability, and may need financial support from governments, in the interests of protecting the forest's long term viability.

It is accepted that adaptation should start now, rather than when damage has already been observed, by which time it may be already too late to take-up the long term measures which may be necessary. This implies acting without full knowledge of the likely impacts of the measures taken – the precautionary approach.

2.5.2 Challenges for policy makers

Faced with a situation of fundamental change and great uncertainty, governments must provide guidance to forest managers, commissioning research and communicating its results. They must develop strategies, and, if necessary, help forest owners to implement the strategies, especially in particularly vulnerable areas, where there is a risk of forests losing part of their ability to provide ecosystem services and raw material.

2.6 Protecting and enhancing biodiversity

2.6.1 Background

Maintenance and conservation of biodiversity in forests has been part of sustainable forest management for many decades. Certainly, over the last two decades, forest management has changed to take account of biodiversity at the stand, local landscape and national levels. Forests are also, of course, included alongside other ecosystems in

[2] *For instance: conversion of natural forests to energy plantations (e.g. poplar forests in floodplains), and intensified management to produce biomass for energy (less deadwood, changes in nutrient cycles). Land use changes for energy plantations could have positive or negative impacts: the biodiversity of intensively managed agricultural land might improve; the biodiversity of natural grasslands might decrease.*

broader biodiversity policies. The area of forest protected for biodiversity conservation has increased by around 0.5 million/ha/yr over the last 10 years (SoEF 2011). However, a number of commercial forestry practices can detract from biodiversity conservation. For instance, it is widely acknowledged that the level of removal of deadwood in standard forestry practice is generally too high from a biodiversity standpoint. The target of the Convention on Biological Diversity (CBD), to significantly reduce the decline in biodiversity by 2010, has not been met. In addition, new and more differentiated, targets emerged from the Conference of the Parties to the CBD in Nagoya in October, 2010. The target for protected areas has been raised, from 'at least 10% of the world's terrestrial area' to 17% (comprising all ecosystems and not simply forests).

The challenges of conserving forest biodiversity in Europe are changing. Most large remote forest areas with high biodiversity values are already under some form of protection[3], and 'standard' silviculture and national forest programmes take biodiversity explicitly into account. However, the concepts of biodiversity conservation are developing into a more sophisticated large-scale approach, often centred on core areas and biodiversity corridors, and on increasing biodiversity in managed forest areas. There is also concern that not all ecosystems and forest types are equally well protected, and that some forest types are not adequately covered in the protection strategies. In addition, there has been considerable tension (and expense) surrounding some large scale protection programmes, whilst, at the same time, urban areas and transport infrastructure continue to expand, at the expense of biodiversity and other rural land uses.

All stakeholders are looking for win-win solutions, but these are increasingly hard to find, and the improvements for biodiversity sought by governments have increasingly clear economic and social costs. This tension is exacerbated by the rising demand for wood for energy, which implies more intensive forest management, leading to difficult trade-offs, for policy makers and for forest managers.

2.6.2 Challenges for policy makers

Governments are committed to improving their biodiversity protection, but are faced with stronger competition for suitable land, and with the difficulty of combining conservation and sustainable use not only at the national or landscape level, but also at the level of forest districts and even stands. The challenge is to develop and finance strategies and policies that protect biodiversity, but are still economically and socially sustainable. This is especially challenging at a time when economic and budgetary pressures are very strong and in the absence of strict EU-level or national targets. The way forward involves finding win-win solutions at the landscape level, which are effective in terms of biodiversity protection and, which attract the support of all stakeholders, including notably, for owners of biodiverse forests. This is not only a technical/economic question but also involves communication and participation, as well as innovative financing in some cases, notably through payment for ecosystem services (PES) schemes. A precondition, if the policies are to be widely accepted, is excellent scientific understanding and effective monitoring. Finally, a cross-sectoral approach is essential: biodiversity policies, forest policies, industry policies and land use policies must be consistent with each other.

2.7 Supplying renewable and competitive forest products to Europe and the world

2.7.1 Background

Europe produces and consumes very large volumes of forest products, and is a net exporter of forest products to the world. The forest sector[4] accounts for about 1% of European GDP, but considerably more in some countries, and employs some 3.1 million people. However, this situation may change as it depends on European forest products retaining their competitiveness, relative to other products, and relative to forest products from other parts of the world. The European forest products industry has been profoundly changed by globalisation, and it is certain that other materials and other regions will continue to compete strongly with European forest products on world markets.

Threats to the European forest industry can take the form of technical change, or competitors with lower costs. But the European forest industry also has many strengths and opportunities: closeness to markets, access to capital, excellent technology and infrastructure, capacity to innovate etc.

The time horizon of the EFSOS II analysis could see profound changes in the competitiveness of the European forest industries, positive or negative. These would affect the

[3] As they are often remote and not very productive economically, the loss of these forests to wood production was often easy to accept.

[4] The forest sector in this context includes forestry, wood industries (sawmilling, wood based panels, etc.), pulp and paper, but not further processed products such as furniture, joinery or books.

demand and prices of wood (and thereby the profitability of forest management), rural employment, economic growth, and, indirectly, the priorities of forest management, the economic viability of sustainable forest management and the possible need for government funds.

Improving and maintaining competitiveness depends on excellent and creative management, promoting innovation for products and manufacturing processes, as well as strict cost control and effective marketing. These are not the direct responsibility of governments but of the economic actors in the sector. However, many governments have policies to promote the competitiveness of their industries (not only forest industries, which should not expect preferential treatment in this respect), and they provide the essential infrastructure, which is not only physical, but also human (education and training), financial (venture capital) and institutional. Competitiveness could also change in relation to other regions due to factors outside the sphere of influence of the European forest sector policy maker. Such factors include economic growth or decline; exchange rates; trade measures (tariff and non-tariff); and, natural catastrophes. There is also scope for innovation in forest management, not only in silviculture, but also in supplying forest ecosystem services, and in being compensated for these.

2.7.2 Challenges for policy makers

Governments need to maintain and improve a positive supporting infrastructure for their forest industries, including physical infrastructure, good governance, education and training: research and development (R&D) plays a crucial role in fostering innovation and competitiveness. Governments also need to take the industry into account when drawing up forest policy, ensuring that wood supply matches the needs of industry in terms of volume and quality, while taking full account of all the dimensions of sustainable forest management. Given the long timescale of forestry and wood supply, and the complexities linked to globally competitive markets, there is a high degree of uncertainty involved in matching future wood supply with the needs of industry.

Furthermore, there is no guarantee that the steady progress in consumption of forest products observed over the last half century will continue. It is possible that wood demand from European industry could drop sharply, if a number of markets collapse (e.g. because of developments in IT or competition from other continents). Alternatively, wood demand could rise because of the many climate friendly characteristics of wood and its renewability compared to other materials.

2.8 Achieving and demonstrating sustainability

2.8.1 Background

The major challenge facing humanity as a whole is, in the long-term, to achieve true sustainability, in all dimensions – ecological, economic and social – without harming future generations or other ecosystems or regions. Each continent, each type of ecosystem and each economic sector must aim at achieving such sustainability, to contribute to the sustainability of the planet as whole: the European forest sector cannot be an exception. Many observers claim that the European forest sector is already sustainable, and a system of criteria and indicators has been in place, with regular regional monitoring studies, for nearly 15 years. However, it is only recently that data quality has improved enough to make possible the sound assessments of past trends (SoEF 2011), and the system of criteria and indicators is essentially backward looking, describing past trends, and not the future outlook. Also, the indicator system monitors a number of separate indicators, but does not analyse their interactions, although these are many and complex. In addition, the European public still has many misconceptions about its forest resource, despite the frequent publication of official information based on the indicators of sustainable forest management (Rametsteiner *et al.*, 2007).

2.8.2 Challenges for policy makers

For the forest sector, it is particularly difficult to identify sustainable pathways because of the long time horizon, and the possibility of interactions between different parts of the sector and the trends in other sectors. The challenge is to combine and weigh policies in such a way that they do not contradict each other, or generate perverse incentives, even in the distant future. Naturally, there will always remain a large amount of uncertainty.

Forest sector policy makers face the additional challenge of explaining to society the basic characteristics of the situation and outlook, which are still poorly understood by the general public. Most Europeans still believe that their forests are being over-cut and shrinking in area, as well as being severely damaged by air pollution. As long as this erroneous belief is widespread, it will be hard to persuade citizens to support policies for the long term sustainable development of the resource.

2.9 Developing appropriate policies and institutions

2.9.1 Background

Forest sector policies and institutions have been subject to the same pressures as those of other sectors, including deep socio-economic changes in many European countries, devolution, globalisation, cyclical movements, and pressures on public budgets. Sector-specific pressures have included the need to incorporate biodiversity and other aspects alongside wood production as major objectives, the growing influence of other sectors, and the need to communicate better with them at an institutional level. These pressures are all exacerbated by the widespread decline in the economic viability of many parts of the sector. Traditionally, a ministry or department funded from the central budget was responsible for policy formulation, implementation of legislation and management of publicly-owned forests. However, this model has had to adapt to changed circumstances. Over the past decades, forest laws and policies have been profoundly revised, stressing sustainable forest management, and the roles of public institutions have been more clearly delimited, into policy formulation, policy implementation and forest management, often at a sub-national level. In many countries, national forest programmes have been drawn up, and efforts made to coordinate them with similar programmes for other sectors (energy, biodiversity, rural development, climate change, restitution/privatisation of land). However, many issues still remain, which are complex, long term and international in nature and, which will require innovative policy making. Institutions too, whether ministries, managers of public forests, or those responsible for implementing forest regulations, may well need to be adapted. The multi-sector challenges, such as energy or climate change, may well encourage the development of new forms of inter-sectoral and inter-departmental communication and coordinated policy development. Finally the inevitable reductions to public budgets in the coming years will encourage more efficient work methods, but they may also cause the state to withdraw from certain activities or to seek innovative sources of funding.

2.9.2 Challenges for policy makers

In addressing the major policy issues outlined above, policy makers should consider whether the legal framework of the forest sector, and the structure and functioning of major institutions, is appropriate for the evolving situation. Two aspects which appear challenging are the ability of the forest sector to interact proactively and effectively with the policy formulation systems of other sectors, and the probable need to improve efficiency and effectiveness in handling public funds. Forestry must demonstrate that it gives the taxpayer good value for the funds made available – in fact better value for money, over the long term, than other sectors. If these two challenges – integrated policy formulation and using public funds wisely and well – are not met, the sector will find it hard to remain effective within the changing institutional conditions.

3 Scenario analysis: reference future and policy choices

3.1 Introduction

Forest managers, forest industry executives and consumers of wood products take decisions every day. The sum of these decisions forms the development of the forest sector as a whole. Each decision is based on a mixture of information, emotions, preferences and experiences. The policy maker hopes to influence the outcome of these decisions in a way that coincides with his or her objectives by modifying the framework within which these decisions are made. Possible instruments are legislation, tax incentives, subsidies, providing information and facilitating certain processes. However, in a free economy, the influence of the policy maker is generally limited. Many factors that influence the outcome of decisions, such as global market prices, cannot be determined by national policy makers. Moreover, it is very difficult in practice to evaluate the effect of specific policy measures, since all underlying drivers are continuously changing.

A scenario analysis can aid the policy maker in gaining insight into the consequences of certain policy choices. It enables the policy maker to change one factor at a time and to see how the object of study would react. These 'what-if' scenarios are not meant to give predictions of what will happen in future, but give insight into the behaviour of the system and how it could be influenced. The starting point of such an analysis is usually a *Reference scenario*, also called baseline or 'business-as-usual' scenario. Such a scenario provides a picture of a future without major changes from the past: current policies remain unchanged, and current trends continue. The policy maker can then create scenarios where changes are introduced. Such changes can include direct policy measures (like tax measures), or preferred effects of policies (like increased supply of wood energy). Such scenarios are referred to as policy scenarios. The *Reference scenario* provides a basis against which the policy scenarios can be compared. Differences in outcomes between the policy scenario and the *Reference scenario* can then be directly attributed to the changed assumptions introduced into the policy scenario. The number of scenarios one can create is infinite, but in this study only a few can be presented. Based on the policy issues presented in Chapter 2, four policy scenarios were developed: *Maximising biomass carbon; Promoting wood energy; Priority to biodiversity* and *Fostering innovation and competitiveness*. Each of these scenarios represents a uni-directional policy choice. The scenario results are subjected to a standard analysis (see Chapter 4) to identify trade-offs between important policy issues. The policy scenarios were selected to cover a very broad range of policy options and might therefore appear rather extreme. However the wide range of assumptions makes possible a clear identification of consequences and trade-offs of the selected policy choices. This should allow the reader to make an informed guess of the consequences of more intermediate scenarios, possibly combining more than one of the policy issues. The assumptions and outcomes of the reference and policy scenarios are described later on in this chapter.

3.2 Overview of projection methods

A common way to perform a scenario analysis is using computer models. A broad range of models exists for the forest sector, focussing on different parts of the sector and with varying level of detail. Such models may merely represent statistical relationships between observed variables, or may be based on a mathematical description of underlying processes. An example of the former is the relation between consumption of wood-based products and gross domestic product (GDP), while an example of the latter is a climate model, based on physical processes in the atmosphere. The advantage of models of the first category is that they are simple and accurate, but they yield very uncertain results when applied outside the range for which they were developed. Models of the second category can be very complex, but are more trustworthy in situations that are 'new' to the model. If no quantitative relationships can be established, simple reasoning can be used to estimate the direction, and perhaps the magnitude, of the change. This weaker approach is used when the consequences of unquantifiable major changes in the system must be addressed. An example is the *Fostering innovation and competitiveness scenario*.

For the scenario analysis in EFSOS II, a range of models was selected to cover the whole forest sector. Selection criteria used were robustness; transparency; ability to provide analysis at the country level within Europe; being based on validated data sets; and, the ability to address the stated policy challenges. The methods used and their linkages are briefly summarised in this section, and fully presented in the references quoted, including the EFSOS II Discussion Papers.

3.2.1 Econometric projections of production and consumption of forest products

Projections based on econometric analysis use observed relationships between economic development and activity in the forest sector to project future activity, based on assumptions regarding future economic growth. This method was used in an earlier outlook study, ETTS V, (Baudin and Brooks, 1995) and was also applied in the previous EFSOS (UN, 2005). It provides country-specific projections of consumption, production and trade of forest products. Products analysed are sawnwood, wood-based panels, paper and paperboard. At present, wood energy cannot be covered by econometric analysis due to the short historical time series available. Production and trade data were collected from UNECE/FAO while macroeconomic data came from FAOSTAT. Trade flows between countries were obtained from the UN COMTRADE database. Projections based on econometric analysis are only valid as far as the historically observed relationships can be expected to remain the same in the future. Hence, the method is not equipped for dealing with future trend breaks, such as the possible replacement of paper by communication methods which did not exist over most of the reference period. Making projections for longer time periods is questionable, as projections of some of the underlying variables used in the study, notably GDP, become increasingly unreliable over longer time periods, i.e., uncertainties start to dominate over pre-determined processes (Postma and Liebl, 2005). Furthermore, this projection method cannot deal internally with competition for limited resources, nor can it provide directions of future trade flows. It also requires an exogenous assumption about developments for prices and costs. EFSOS II used the price trends generated by the EFORWOOD project (Arets *et al.,* 2008).

3.2.2 Wood Resource Balance

The Wood Resource Balance (WRB) is a tool to map the supply and use of all woody biomass streams for a given spatial unit (country or region). The left-hand side of the balance contains all sources of woody biomass, of both primary and secondary origin. The right-hand side of the balance shows all uses of woody biomass. The WRB has four components: wood supply from forestry resources; supply of other woody biomass; material uses; and, energy uses. The WRB can be used to show the real woody biomass balance for a given year, or it can be used to show discrepancies between potential future supply and expected future demand. The WRB uses estimates generated outside the balance and is not able to indicate how a possible future discrepancy between potential supply and expected demand can be solved. More details on the WRB can be found in Mantau *et al.,* 2010.

3.2.3 European Forest Information Scenario model

The European Forest Information Scenario model (EFISCEN) is a large-scale forest resource assessment model. It applies to even-aged, managed forests. Results for uneven-aged forests, unmanaged forests and shelterwood systems are less reliable, but are included when needed to simulate the forest area available for wood supply (FAWS). EFISCEN projects the future state of the forest under assumptions of future wood demand and under a given management regime (rotation lengths, residue removals). The model is set up using aggregated forest inventory data, usually obtained from national forest inventory institutes. Age-dependent increment functions are derived from the same data, with 'increment' defined as a percentage of the growing stock. The soil model YASSO is built in (Liski *et al.,* 2005), to give estimates of soil carbon stocks and rate of carbon sequestration. YASSO assumes equilibrium conditions, based on the litter input to the soil in the first time-step of the model. Output variables include tree species distribution; felling/increment ratio; age class distribution; growing stock level; and, carbon sequestered in biomass and soil. Recently, indicators have been developed to reflect recreational value (Edwards *et al.,* 2011) and vulnerability of the forest structure to fire and wind (Schelhaas *et al.,* 2010). All three indicators are based on the distribution of forest area over age classes and tree species. Recreational values range from 1 to 10, indicating increased average recreational attractiveness per ha of forest. The vulnerability indicators range from 1 to 6, indicating increased average vulnerability per ha of forest to the disturbance agents: fire and wind. EFISCEN does not provide estimates of costs for harvested wood.

3.2.4 The Global Forest Sector Model

The Global Forest Sector Model (EFI-GTM) is a partial equilibrium model[5], focusing on forest products (six wood categories, 26 forest industry products and four recycled paper grades). It makes projections of global consumption, production and trade of forest products, in response to assumed changes in external factors such as: economic growth; energy prices; trade regulations; transport costs; exchange rates; availability of forest resources; and, consumer preferences. The model covers the whole world, with a special focus on Europe. The model calculates periodical investments in production capacity of forest industry for each region. In each period, the producers are assumed to maximize their profits, while consumers are assumed to maximize their surplus. Both producers and consumers are modelled as price takers, i.e. the model assumes competitive markets, and uniform characteristics within product groups (e.g. that each m^3 of sawnwood or tonne of paper is equivalent to every other m^3 or tonne, a necessary simplifying assumption). Wood energy is provisionally included as a separate product in EFI-GTM for EFSOS II purposes. It is not modelled in the same way as traditional products, and is only included for EFSOS countries, so that competition between traditional wood use and wood for energy is not yet optimally included. Because of the complexity of the model, it may be difficult to identify consequences of particular assumptions needed to initialise the model, and which processes cause differences between scenarios. More details on the model can be found in Kallio et al. (2006).

[5] *Partial equilibrium models equate supply and demand in one or more markets so that the markets clear at their equilibrium price levels. This makes prices endogenous. Partial equilibrium models do not include all production and consumption accounts in an economy, nor do they attempt to capture all of the economy's markets and prices. It is a useful and valid approach for sectoral analysis, in sectors, like the forest sector, which do not significantly influence general equilibrium.*

3.2.5 Competitiveness analysis

Competitveness can be measured by several indicators, export growth of a country being one of the most prominent. The constant market share (CMS) methodology is based on the countries exports. It analyses competitiveness in international markets, by comparing the exports of a specific country to the world exports, in different disaggregations. As a starting point, the CMS analysis assumes that the export share of a country compared to the world exports remains constant over time. The difference between the actual export growth of a country and the growth of a country under assumed constancy is attributed to a change in competitiveness. For the analysis in EFSOS II the formulation of Milana (1988) has been used. It differentiates the export growth of a country into four effects: the world growth effect; the commodity-composition effect; the market-distribution effect; and, a residual effect, which can be interpreted as the competitiveness effect.

The CMS analysis requires bilateral trade data in monetary values. The basic data for the ex-post analysis was taken from the UN Commodity Trade Statistics Database. The data for the scenario analysis, the so-called 'future ex-post', was derived from modelling results from EFI-GTM. Hence, scenario results of the CMS analysis are available for the *Reference scenario* and the *Promoting wood energy scenario*.

3.2.6 Linkage of models

Each of the methods listed above has its specific strengths and weaknesses. The general framework for linking the models is designed to take full advantage of the strengths of the components and to limit dependency on the weaker parts. The methodological core of the EFSOS II study is the WRB. In a first step, the future development of the four different sections of the WRB were projected separately, without taking into account possible interactions between them. Demand for material uses was derived from the econometric analysis, driven by the scenario assumptions on future GDP development. Demand for woody biomass for energy was calculated by taking existing trends and/or future policy targets into account (Steierer, 2010). The potential wood supply from the forest was derived from the EFISCEN model, using scenario-specific assumptions on availability of forest resources and management regimes. The potentials for wood supply from sources outside the forest were taken from the EUwood study (Mantau *et al.,* 2010). This first step gives a broad idea of whether potential available resources are sufficient to satisfy expected future demand. However, it does not indicate which resources are preferentially used, and how a possible discrepancy between expected demand and potential supply could be solved. Therefore, in the second step EFI-GTM was applied to see how possible imbalances would be 'solved' by the market. Based on the projected 'real' demand for stemwood and harvest residues, EFISCEN projected consequences for the development of forest resources and related indicators. Projected production and trade data from EFI-GTM were analysed using the competitiveness analysis to evaluate trends in competitiveness emerging from the scenarios. Not all scenarios employ the general framework fully. Assumptions in some scenarios affect only parts of the framework, while, in some other cases, not enough resources were available to cover all parts (Table 2).

The *Reference scenario* employs the full model framework, resulting in a closed balance between supply and demand, impacts on forest resources and competitiveness. The *Maximising biomass carbon scenario* uses EFISCEN to estimate the potential for increased carbon storage in forest biomass. It does not affect trade and competitiveness, since wood supply is not allowed to decrease as compared to the *Reference scenario*. In the *Priority to biodiversity scenario*, certain protection measures are applied in EFISCEN. The main outcome of this scenario is by how much the wood supply from the forest will decrease as a consequence of these measures. Impacts on trade and competitiveness are not analysed due to restricted resources. The *Promoting wood energy scenario* employs the full model framework, resulting in the identification of the sources of additional supply needed for wood energy, and also impacts on forest resources, and the competition between use of wood for products and energy and trade. The *Fostering innovation and competitiveness scenario* is only analysed in qualitative terms.

Table 2: Overview of methods applied in the different scenarios

	Reference	Maximising biomass carbon	Promoting wood energy	Priority to biodiversity	Fostering innovation and competitiveness
Potential supply from forest	EFISCEN	Unchanged	EFISCEN	Not modelled	Qualitative
Supply of other woody biomass	EUwood	Unchanged	EUwood	Unchanged	Qualitative
Demand for products	Econometric projections	Unchanged	Unchanged	Unchanged	Qualitative
Demand for wood energy	Trend projection	Unchanged	Policy targets	Unchanged	Qualitative
Balance	WRB	Unchanged	WRB	Not modelled	Qualitative
Impact on trade	EFI-GTM	Not modelled, no change assumed	EFI-GTM	Not modelled	Qualitative
Competitiveness analysis	CMS analysis	Not modelled, no change assumed	CMS analysis	Not modelled	Qualitative
Impact on forest resources	EFISCEN	EFISCEN	EFISCEN	EFISCEN	Qualitative

3.3 Reference scenario

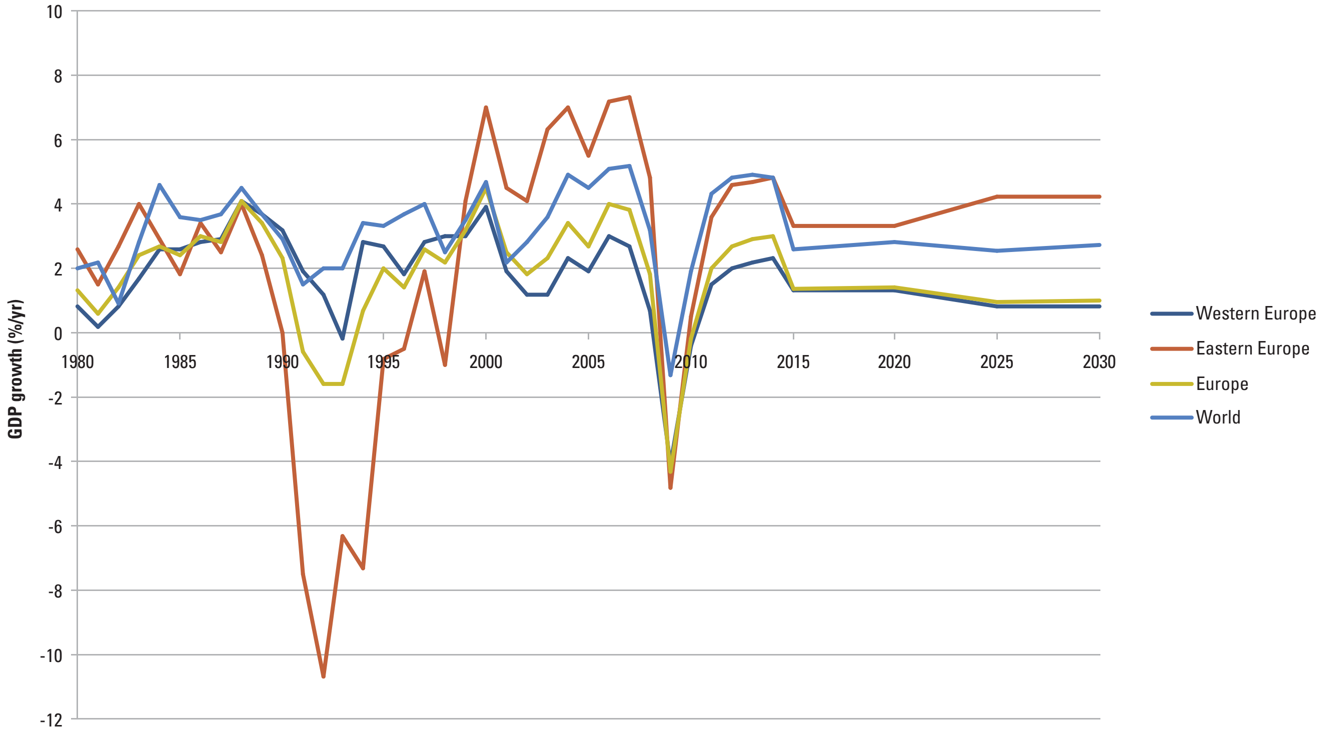
3.3.1 Description of the reference scenario

For its 4th assessment report, the IPCC has developed a series of four storylines (IPCC, 2000), each giving a consistent picture of the future development of key parameters such as population growth, economic development and energy prices, under contrasting assumptions of globalisation and environmental awareness. The B2 storyline was chosen to represent and quantify the *Reference scenario* in EFSOS II. The widespread use of the IPCC storylines enables direct comparison of the EFSOS II projections with other studies, most notably the North American Forest Sector Outlook Study (NAFSOS). The B2 storyline describes a world in which the emphasis is on local solutions to economic, social, and environmental sustainability. It is a world with continuously increasing global population, intermediate levels of economic development, and not so rapid and diverse technological change. Only the quantitative aspects of this storyline were used for the *Reference scenario*, as derived and documented in the EFORWOOD project (Arets *et al.*, 2008). A detailed picture of assumptions and outcomes of the *Reference scenario* is given below.

3.3.1.1 Developments external to the forest sector

The global population increases from 6.9 billion people in 2010 to 8.4 billion people in 2030. However, the population in Europe remains stable at about 500 million people. To take account of the economic recession, the International Monetary Fund figures for GDP growth were used for the period 2010-2014 (IMF, 2009), and the original B2 storyline projections for the period 2015-2030. GDP growth rates in Europe are modest, with a decline from about 1.4% per year in 2015 to 1% in 2030 (Figure 2).

Figure 2: GDP growth rates under the Reference scenario, 1980-2030



Source: IMF, 2009; IPCC, 2000.

3.3.1.2 Consumption of forest products and wood energy

Based on the increase in GDP, total consumption for wood products is projected by EFI-GTM to increase from 739 million m^3 roundwood equivalent (RWE) in 2010 to 853 million m^3 in 2030 (Figure 3). Over the last decades, wood fuel consumption has shown a growth rate of about 1.5% per year (Steierer, 2010). This historic growth rate was assumed to apply also for the period 2010-2030, for each country, leading to an increase in wood demand for energy use from 434 million m^3 RWE in 2010 to 585 million m^3 in 2030.

Figure 3: Development of consumption of wood products in the Reference scenario, 2010-2030.

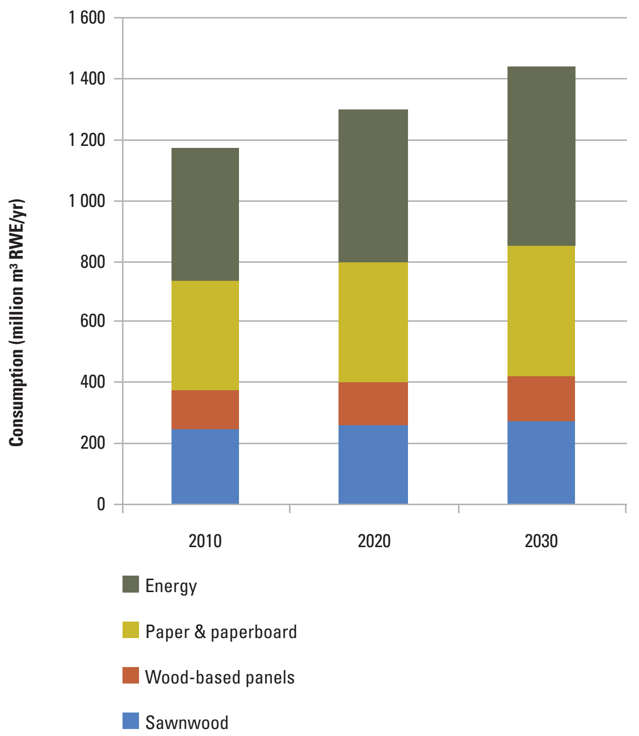
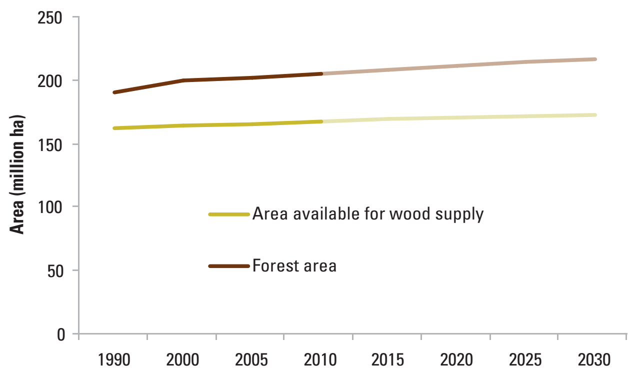


Figure 4: Development of forest area and forest area available for wood supply, 1990-2030.



Source: SoEF 2011; EFISCEN.

3.3.1.3 Development of forest resources

The total area of forest in 2010 for the EFSOS II region is 204.9 million ha, of which 166.7 million ha is classified as available for wood supply (SoEF 2011). The trend between 2005 and 2010 was extrapolated for both variables, yielding a total forest area of 216.9 million ha in 2030, of which 171.1 million ha available for wood supply (Figure 4). This means a forest expansion of 0.6 million ha/yr. Forest not available for wood supply (FNAWS) is expected to increase faster than total forest area. This may be caused by natural succession on abandoned areas and areas along the timberline, not being available for wood supply, or by increase in the forest area protected for biodiversity conservation. Nevertheless, forest area available for wood supply increases in all regions, except North Europe where it decreases slightly. Climate change effects on the increment were incorporated according to the methodology described by Schelhaas et al. (2010). By 2030, this would mean an increment gain of 11% as compared to no climate change. In the *Reference scenario*, no changes in tree species composition were assumed. Rotation lengths and share of thinning in the total harvest were taken from previous studies (Schelhaas *et al.*, 2006), but adapted based on country correspondents' comments.

In order to fulfil the increasing demand for wood products and energy, removals increase by 15% in 2030 as compared to 2010. The 685 million m^3 overbark (o.b.) of stemwood that are removed annually from the forest in 2030 are still well below the potential sustainable supply that is estimated by EFISCEN at around 750 million m^3 o.b. of stemwood per year. For the *Reference scenario* it is assumed that all countries would implement harvest residue extraction, based on the current practice and guidelines of the most advanced countries. Annual harvest residue extraction increases by 278% from 32.8 million m^3 RWE in 2010 to 91.4 million m^3 RWE. In 2010, harvest residues are equivalent to 2.5% of stemwood removals, but 6% by 2030, indicating a considerable increase in the intensity of harvesting methods over the twenty years. The total potential is estimated at 117 million m^3 RWE/yr. Countries that already practice stump extraction (Finland, Sweden and the United Kingdom) are assumed to continue to do so. The supply of extracted stumps increases from 3.6 in 2010 to 12.1 million m^3 RWE in 2030.

The forest resource under the *Reference scenario* can be characterised as slowly but steadily expanding (Table 3). The growing stock on the area available for wood supply continues to increase from 29.0 billion m^3 in 2010 (174 m^3 /ha) to 33.3 billion m^3 in 2030 (195 m^3 /ha). This is especially the case in North and Central Europe, while build-up in South-East Europe is modest. This might partly be related to data issues in this region. The ratio of fellings to net annual increment is increasing, with fellings increasing by 15% as compared to 2010, where the increment is increasing only by 8.6%. Fellings increase everywhere by the same order of magnitude, except in South-West Europe, where it increases only slightly. In most regions, the average increment per ha remains stable, but North Europe and South-East Europe show an increase.

The carbon stored in the biomass increases proportionally with the increase in growing stock. The total soil carbon stock in Europe increases slightly, but remains more or less stable when averaged per ha. However, North Europe and Central-East Europe show an increase of average soil carbon, while the other regions show a decrease. These results should be interpreted with care, since the estimation of initial soil carbon is difficult but crucial in soil carbon models.

Standing and lying deadwood show a slight tendency to decrease, presumably due to higher felling and residue extraction levels. However, these results are also influenced by uncertainties in model initialisation. Due to higher wood demand, the forest area with an age over 100 years is decreasing, while the forest in the youngest age class is increasing. Correspondingly, the average age of that part of the European forest which is managed on an even aged basis decreases from 54 to 50 years, in all regions except for Central-East Europe, where the average age shows little decrease.

Table 3: Key forest resource indicators for the Reference scenario.

		North		Central-West		Central-East		South-West		South-East		EFSOS Total	
	unit	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030
Area of forest	million ha	68.6	69.6	43.5	45.2	34.3	36.7	30.8	35.9	27.7	29.5	204.9	216.9
FAWS	million ha	53.1	52.4	34.1	35.0	32.0	32.8	24.8	27.0	22.7	23.9	166.7	171.1
FNAWS	million ha	15.5	17.2	9.4	10.2	2.3	3.8	6.0	8.9	5.0	5.6	38.1	45.8
Growing stock	million m^3	7 280.3	8 452.0	8 533.0	9 832.9	8 003.1	8 812.9	2 278.5	3 058.7	2 947.3	3 150.3	29 042.2	33 306.8
	m^3/ha	137.2	161.3	250.0	281.3	250.1	268.3	91.8	113.3	129.9	131.7	174.2	194.6
Increment	million m^3 /yr	268.7	310.9	293.9	304.5	219.9	221.7	78.1	86.3	53.2	68.9	913.8	992.2
	m^3/ha/ yr	5.1	5.9	8.6	8.7	6.9	6.7	3.1	3.2	2.3	2.9	5.5	5.8
Fellings	million m^3/yr	220.4	247.5	217.9	247.1	158.9	187.1	42.2	45.1	43.2	59.6	682.7	786.3
	m^3/ha /yr	4.2	4.7	6.4	7.1	5.0	5.7	1.7	1.7	1.9	2.5	4.1	4.6
Potential stemwood	million m^3/yr	226.4	232.6	225.4	222.7	190.0	179.8	51.9	50.4	65.0	60.8	758.6	746.3
removals	m^3/ha/yr	4.3	4.4	6.6	6.4	5.9	5.5	2.1	1.9	2.9	2.5	4.6	4.4
Stemwood removals	million m^3/yr	204.3	227.9	181.5	206.0	133.4	157.5	38.4	41.2	37.6	52.1	595.1	684.7
	m^3/ha /yr	3.8	4.3	5.3	5.9	4.2	4.8	1.5	1.5	1.7	2.2	3.6	4.0
Extracted residues	Tg dry matter/yr	4.5	11.3	5.0	13.7	3.4	9.5	1.1	3.4	0.9	3.2	14.8	41.1
	Mg dry matter/ha/yr	0.08	0.22	0.15	0.39	0.11	0.29	0.04	0.13	0.04	0.13	0.09	0.24
Extracted stumps	Tg dry matter/yr	1.6	5.3	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	1.6	5.5
	Mg dry matter/ha/yr	0.03	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03
Carbon in biomass	Tg C	2 873.2	3 355.6	3 234.6	3 695.4	3 033.1	3 340.3	1 066.1	1 434.8	1 300.9	1 387.9	11 507.9	13 214.0
	Mg C /ha	54.1	64.0	94.8	105.7	94.8	101.7	42.9	53.1	57.3	58.0	69.0	77.2
Carbon in soil	Tg C	4 791.2	4 932.7	3 432.1	3 488.3	3 398.9	3 472.4	1 284.8	1 342.9	1 984.8	2 001.3	14 891.8	15 237.7
	Mg C /ha	90.3	94.1	100.6	99.8	106.2	105.7	51.8	49.7	87.5	83.7	89.3	89.0
Standing deadwood	Tg dry matter	49.1	42.8	38.9	40.4	69.1	66.0	9.4	9.9	13.4	12.6	179.9	171.7
	Mg dry matter/ha	0.9	0.8	1.1	1.2	2.2	2.0	0.4	0.4	0.6	0.5	1.1	1.0
Lying deadwood	Tg dry matter	426.0	419.3	590.9	554.7	484.4	498.0	112.4	105.2	148.7	142.2	1 762.5	1 719.6
	Mg dry matter/ha	8.0	8.0	17.3	15.9	15.1	15.2	4.5	3.9	6.6	5.9	10.6	10.0
Total deadwood	Tg dry matter	475.2	462.2	629.9	595.2	553.5	564.0	121.8	115.2	162.1	154.8	1 942.4	1 891.3
	Mg dry matter/ha	9.0	8.8	18.5	17.0	17.3	17.2	4.9	4.3	7.1	6.5	11.7	11.1
Recreational value[1]		6.1	5.9	4.0	4.0	4.1	4.0	5.1	5.0	4.2	4.2	4.7	4.7
Wind vulnerability[2]		2.7	2.6	2.4	2.4	2.5	2.4	2.5	2.5	2.3	2.1	2.4	2.3
Fire vulnerability[2]		2.3	2.3	2.0	2.0	2.0	2.0	2.2	2.2	2.3	2.5	2.2	2.2
Average age	yr	54.3	47.5	55.9	53.1	55	54.5	46.7	38.9	59.8	56.1	54.3	49.8

[1] *Index 1-10 (10 = most valuable)*
[2] *Index 1-6 (6 = most vulnerable)*

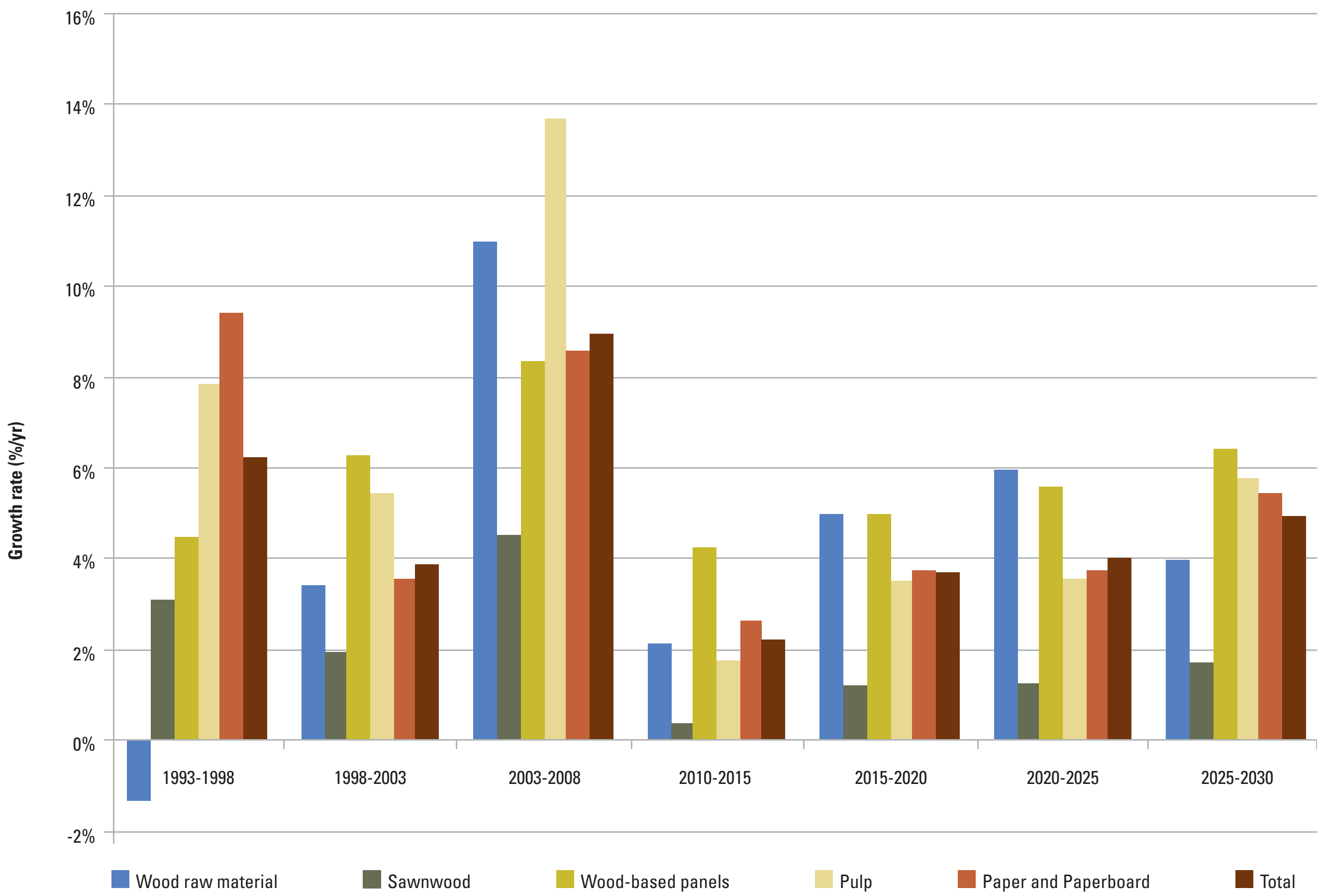
3.3.1.4 Supply from sources outside the forest

Sources of woody biomass outside the forest are: landscape care wood; post-consumer wood and industrial wood residues such as sawmill by-products; wood residues from other wood processing industries; and, black liquor. Estimates of their potential availability, with a 'medium' mobilisation are taken from the EUwood study (Mantau *et al.,* 2010) and adapted for the countries not addressed in the EUwood study. Availability of landscape care wood is estimated to increase from 63 million m^3 RWE in 2010 to 81 million m^3 in 2030. Post-consumer wood is estimated to increase from 46 million m^3 RWE in 2010 to 71 million m^3 in 2030. Industrial wood residues increase from 199 million m^3 RWE in 2010 to 229 million m^3 in 2030.

3.3.1.5 Trade of wood and forest products

In the period 1993-2008, global exports of forest products developed dynamically with an average annual growth rate of about 6.3%. For 2010-2030, a growth rate of only 3.7% is projected, due to the modest development of GDP (Figure 5). The average annual growth rate of the countries of the EFSOS-region in the period 1993-2008 was about 8.2%. The share of the EFSOS countries in world trade increased from 39% in 1993 to 50% in 2008. About 80% of this trade is within the EFSOS countries. In 2008, world exports were worth 254 billion USD. In the EFI-GTM projections, total export in 2010 amounts to only 150 billion USD. This difference is due to the reference price levels and aggregation of countries into specific regions in EFI-GTM. Due to these differences, the focus will be on the relative development rather than on changes of absolute values. All commodities show an increasing growth rate over time, except for wood raw material, which declines in the last time period as compared to the previous periods.

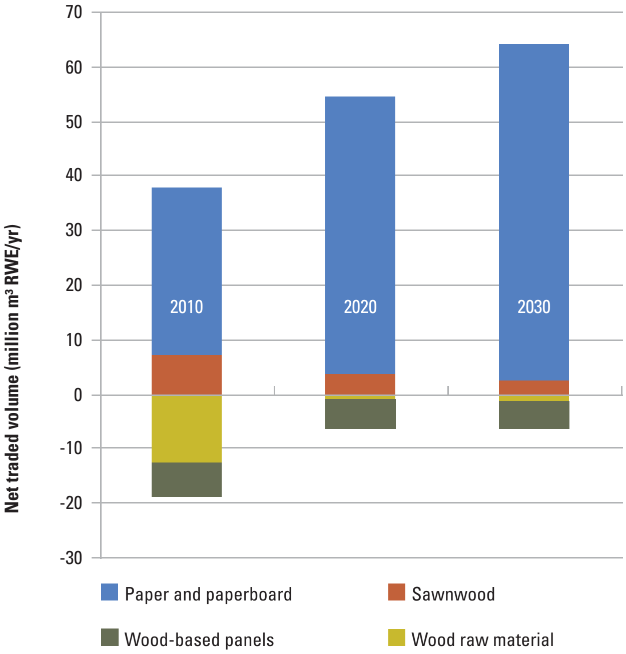
Figure 5: Growth rates of world export value per 5-year period per commodity group



Source: UN Comtrade; EFI-GTM.

The net trade of the EFSOS region with the rest of the world is increasing (Figure 6). Net imports of wood raw material are projected to decrease from 12.6 million m^3 in 2010 to 1.3 million m^3 in 2030. Net import of wood-based panels decrease slightly from 6.3 to 5 million m^3 RWE. Net exports of sawnwood are decreasing from 7 to 2.5 million m^3 RWE. Net exports of paper and paperboard are projected to double, reaching 61 million m^3 RWE in 2030. Overall, the EFSOS region is projected to increase its net exports from 19 million m^3 RWE in 2010 to 58 million m^3 RWE in 2030.

Figure 6: Net traded volumes per commodity group for the EFSOS region as a whole, 2010-2030.



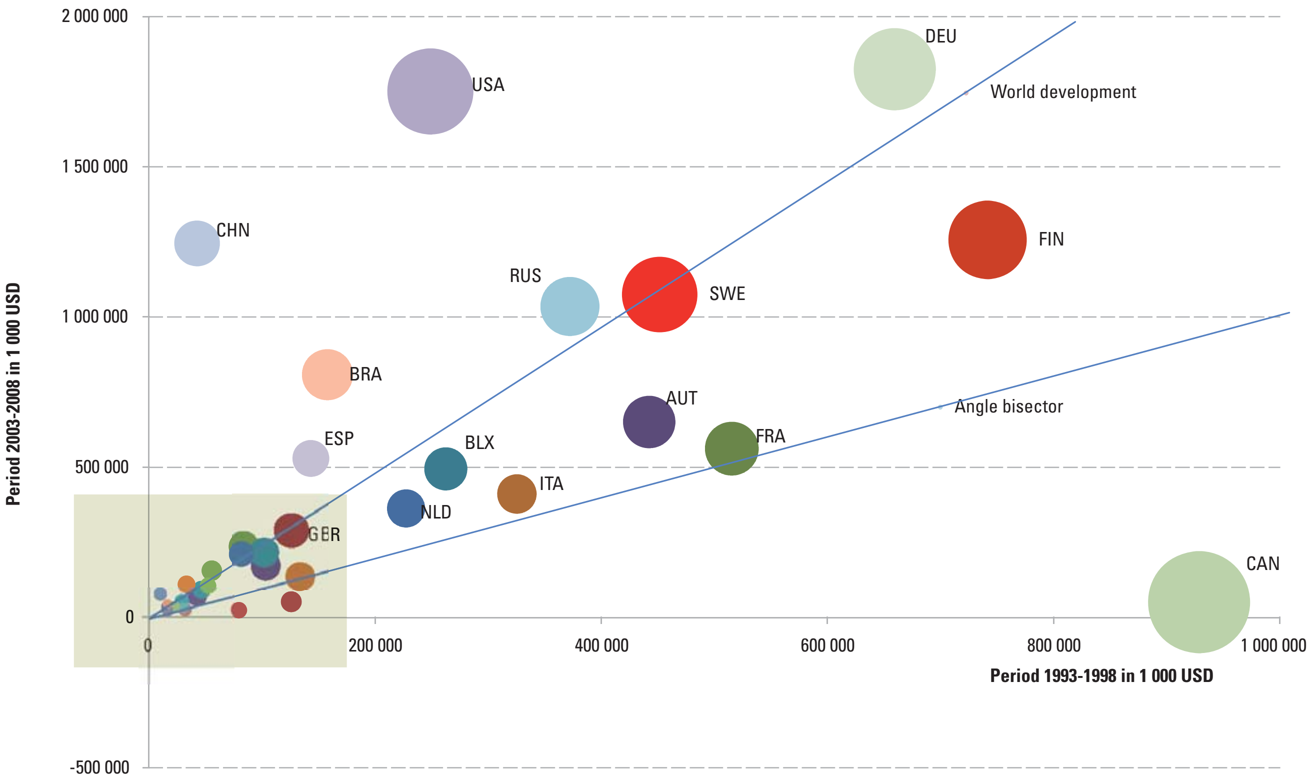
Source: EFI-GTM.

Note: Negative values denote imports, positive values denote exports.

3.3.1.6 Competitiveness analysis

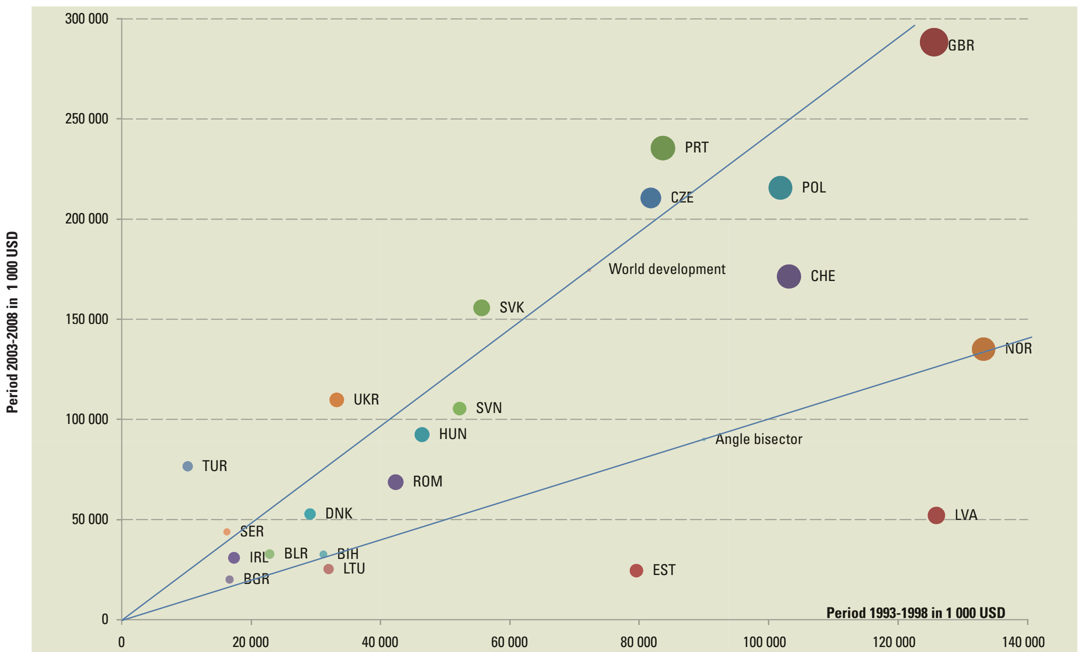
In addition to the EFSOS countries, the results of the competitiveness analysis will include other major wood producing, processing, and consuming economies; in particular Brazil, Canada, China, Russia, and the United States. To illustrate the dynamics of international trade Figure 7 and Figure 8 show the average annual growth in the period 1993-1998 compared to the average annual growth of exports in the period 2003-2008. The bubble size indicates the country's share of world exports in the period 2003-2008. Two baselines are inserted in the figure. The line 'world development' reveals which countries developed better than the world average, a comparison with the angle bisector illustrates which countries had a lower growth in 2003-2008 than in 1993-1998.

Figure 7: Development of annual growth of trade in 1993-1998 compared to 2003-2008, larger countries



Source: UN Comtrade
Note: See country list in annex 7.2

Figure 8: Development of annual growth of trade in 1993-1998 compared to 2003-2008, smaller countries



Source: UN Comtrade
Note: See country list in annex 7.2

As can be seen, having a large forest resource is no guarantee for having a dynamic export development. Canada in particular developed very slowly in the period 2003-2008. Countries from different continents (North America, Latin America, Europe, Asia) are among the countries which show an export growth above world average. However, most countries have a higher annual growth than in the period 1993-1998. Only Canada and the Baltic states show a slower development in 2003-2008 than in 1993-1998.

Figure 9: Average annual export growth and CMS-effects in the period 2003 to 2008, all products

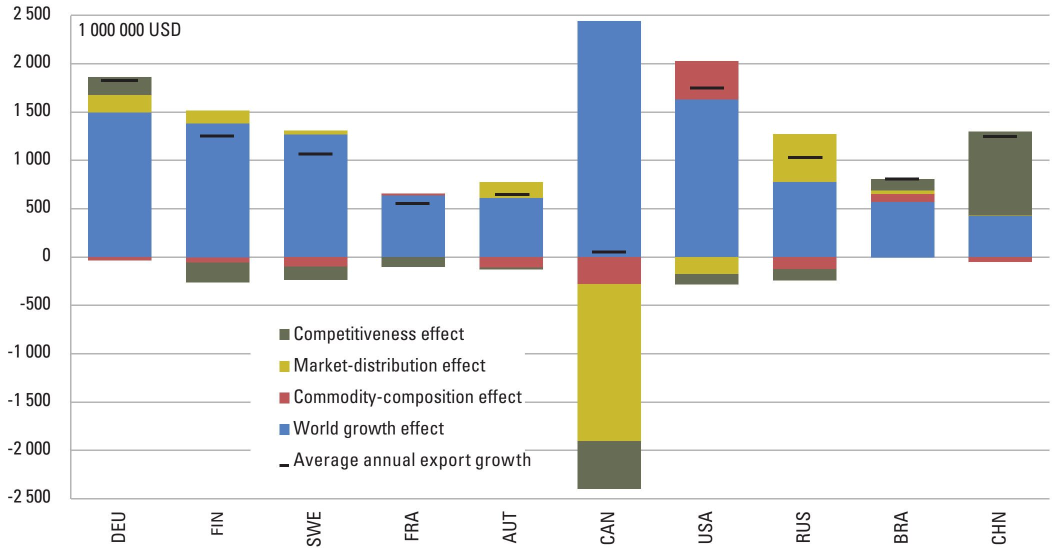
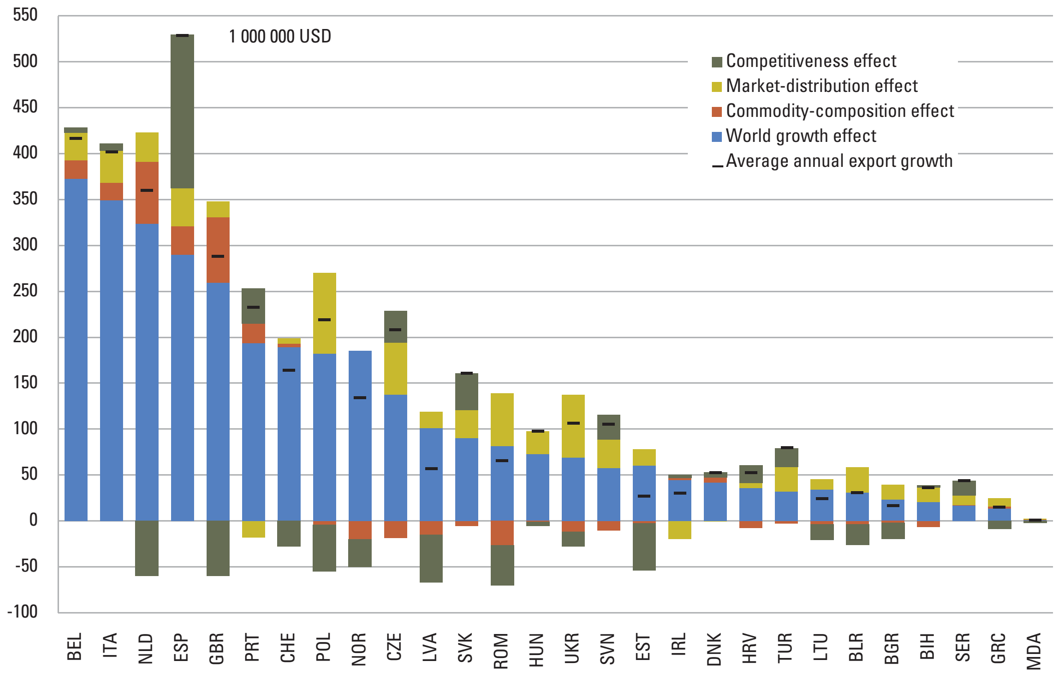


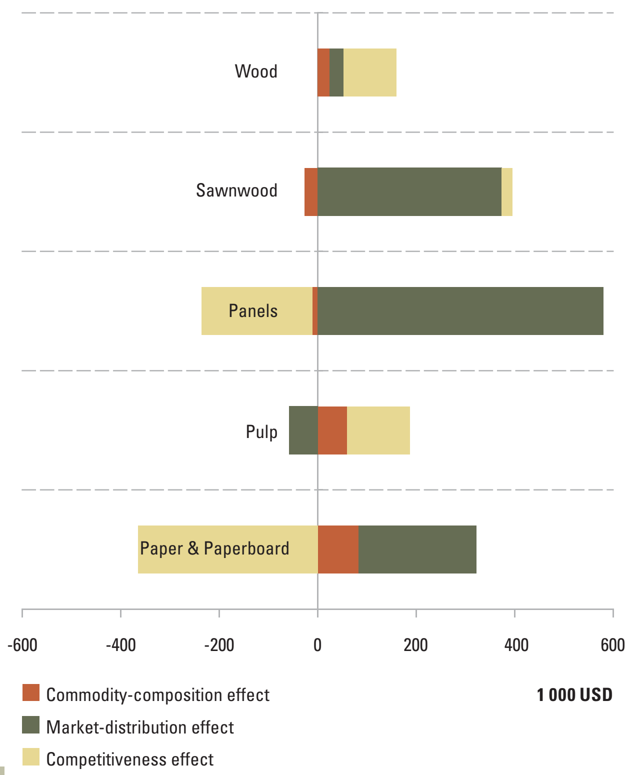
Figure 9a: CMS-Effects 2003-2008, smaller countries



Figures 9 and 9a show the average annual export growth subdivided into the four effects of the CMS analysis of the period from 2003-2008. The countries are ordered by share of world exports in the period from 2003-2008 and grouped into two figures, the larger values in 9 and the smaller values in 9a. The five countries outside the EFSOS region are arranged on the right hand side of Figure 9 and are also ordered by export share. In most countries world growth has the biggest effect on the export growth. There is no obvious structure on what the other competitiveness effects could be based on. However, the underlying factors and the coaction of the different effects will be discussed in detail in a subsequent EFSOS discussion paper. It is evident that the positive development of world trade in the period 2003-2008 causes a positive world growth effect for all countries. With regard to competitiveness one can identify winners and losers. Countries with the highest gains in competitiveness in the period 2003-2008 are, in descending order China, Germany, Spain and Brazil. Many of the other countries have lost competitiveness, among them also big forest product exporters like Canada, Finland, Sweden, Russia and the USA.

Figure 10 illustrates an aggregation of three CMS effects: commodity-composition; market-distribution; and, competitiveness of the countries of the EFSOS region, without the world growth effect. The country results of the three effects are tallied up by commodity group for the period 2003-2008.

Figure 10: Sum of effects of annual growth of the EFSOS countries by commodity groups, 2003-2008



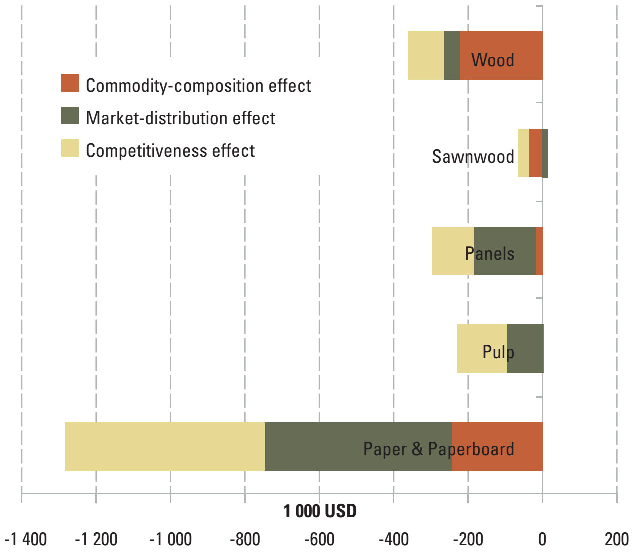
With regard to commodity composition the EFSOS countries do not show a consistent performance. The value of the effect in sum is rather low and varies from positive to negative values for the five commodity groups. It can be concluded that the EFSOS-region developed according to the world average with regard to their export basket of commodities.

A different development pattern can be deduced for the market-distribution in the period 2003-2008. Except for pulp the EFSOS countries show positive and high market-distribution effects, indicating that the EFSOS countries have particular access to fast growing regions and benefit from growing economies in these regions. Their performance in these markets is considerably higher than the world average. The economies with largest growth are in Asia (mainly China), followed by many EFSOS countries (Germany, France, Italy, Netherlands, Belgium).

The remaining residual effect, interpreted as the competitiveness effect, again shows a non-uniform pattern among the five commodity groups. Whilst enterprises which are exporting the wood, sawnwood and pulp commodities prove basically to be competitive, the producers of panels and paper and paperboard seem less competitive compared to producers in the rest of the world. Their negative competitiveness effect can be interpreted as a disadvantage in supply prices. It can be argued that those two industries need a high energy input for the production of their goods.

The CMS analysis was also applied to the outcomes of trade flows as projected by EFI-GTM in the *Reference scenario*. The world growth effect in the period 2010-2030 is expected to be positive. However, the other three effects are negative. This means EFSOS countries are expected to be below world average with regard to their presence in expanding regional markets, in particular, for growing commodity markets and with regard to their competitiveness. However, EFI-GTM is a purely economic model that might not include all factors that influence competitive effectiveness in real life. A deeper analysis of the factors underlying the differences in Figure 11 should be carried out before analysing the EFI-GTM results.

Figure 11: Sum of effects of annual growth of the EFSOS countries by commodity groups in the Reference scenario, 2029-2030



3.3.1.7 Development of prices

The price projections show steady increases throughout the forest sector, driven by increasing demand and emerging scarcities (Table 4). Sawlog and pulplog prices increase by 1.8% to 2.7% per year, while final product prices increase only by 0.6% to 1.3%. This difference indicates a lower profit margin for the forest industry, but higher prices for forest owners.

Table 4: Development of roundwood and product prices in the Reference scenario, 2010-2030

	Unit (2005 USD)	2010	2020	2030	Growth rate 2010-2030
sawlogs coniferous	USD/ m^3	65	76	93	1.8%
sawlogs non-coniferous	USD/ m^3	89	112	143	2.4%
pulpwood coniferous	USD/ m^3	50	64	86	2.7%
pulpwood non-coniferous	USD/ m^3	51	63	85	2.6%
sawnwood	USD/ m^3	174	177	198	0.6%
panels	USD/ m^3	216	233	279	1.3%
paper	USD/tonne	540	567	624	0.7%

Source: EFI-GTM.

3.3.1.8 Uncertainties and emerging tensions in the Reference scenario

The *Reference scenario* shows a gradually increasing demand for wood over the coming 20 years, driven by GDP growth. The demand for wood products is based on an established method, and apart from major trend breaks, it gives rather reliable results. Demand for wood energy is based on very little data and is much more uncertain. It shows much volatility in the past and could increase strongly, especially if the world energy price remains at the present high levels. Wood energy targets, as defined by the EU, will certainly play a major role, but those are captured by the *Promoting wood energy scenario*. The competitiveness in the period 1993-2008 showed large differences between countries. The projections of EFI-GTM show a general decrease in competitiveness, but it is unclear if this is a model artefact or a real development and should thus be treated with caution. EFI-GTM only includes cost and supply considerations, but other processes might play a role as well, such as trade preferences, quality needs and foreign investments. A more detailed analysis is needed of the pattern underlying the differences between countries, to better judge the outcomes of EFI-GTM.

On the resource side, the increased demand for wood is met by increasing harvest from the forest, increasing harvest residue extraction, and increase of sources outside the forest. The increases of landscape care wood and post-consumer wood are based on a range of assumptions about mobilisation, recovery rates, etc., and are thus not very certain. Availability of residues from the industry is coupled to increased industrial production and projections may be considered fairly reliable. Removals from the forest are still below the sustainable level, allowing a buffer for the uncertain supply from landscape care wood and post-consumer wood. Overall the supply of wood seems to be sufficient to meet the demand, without major changes in trade patterns and consumption rates. However, due to the increased demand for wood for energy, wood prices are likely to increase.

The forest resource continues its steady expansion, but the difference between fellings and increment is decreasing. The extraction of harvest residues is increasing threefold, based upon large-scale harvesting methods. Although not unrealistic, this implies a considerable effort in most of the EFSOS countries. Soil carbon and deadwood show developments that are either rather stable, or slightly decreasing. This is partly a consequence of increased removals of harvest residues and increased fellings, but the assumptions in the model also play a role. At the start of the simulation, soil carbon is assumed to be in balance with the situation in the first time step. This means that losses through decomposition of soil carbon are exactly balanced by inputs of fresh litter. Increased extraction of harvest residues will lead to lower input of fresh litter, leading to decreased quantities of soil carbon. The equilibrium assumption is necessary because measurements of soil carbon suffer from methodological differences between countries, are highly uncertain, and are not available for all countries. However, it is likely that in many countries the soils are still in a build-up phase, recovering from earlier over-exploitation or after recent afforestation. The same can be said for deadwood. The development of soil carbon and deadwood might thus be on the pessimistic side, but it can be interpreted as a signal that increasing extraction from the forest will have consequences for these two variables.

Table 5 gives an overview of the supply and demand balance as generated by different parts of the model framework. A minor discrepancy still exists between supply and demand. These originate due to inconsistencies between model assumptions and could be solved by iterating model runs.

Table 5: Balance between supply and demand in the Reference scenario

Components of wood supply									**Components of wood demand**
	source	2010	2020	2030	2010	2020	2030	source	
Stemwood removals	EFISCEN	595.1	649.5	684.7	237.7	244.8	252.9	EFI-GTM	Sawnwood
Harvest residues	EFISCEN	32.8	85.4	91.4	110.6	121.7	128.7	EFI-GTM	Panels
Stump extraction	EFISCEN	3.6	11.2	12.1	16.0	16.7	20.5	EFI-GTM	Plywood
Landscape care wood	EUwood	63.4	72.2	81.0	125.6	132.2	135.0	EFI-GTM	Chemical pulp
Post-consumer wood	EUwood	45.6	62.5	71.4	41.5	43.7	45.2	EFI-GTM	Mechanical pulp
Sawmill by-products	EFI-GTM	106.2	108.5	113.6	92.1	107.3	126.3	EUwood	Forest sector internal energy use
Black liquor	EFI-GTM	69.8	76.8	83.2	105.4	128.4	183.2	EUwood	Biomass power plants
Other industrial residues	EFI-GTM	34.4	37.7	40.6	23.5	43.4	49.5	EUwood	Households (pellets)
Net import	EFI-GTM	12.5	0.9	1.3	213.6	224.6	205.7	EUwood	Households (other wood energy)
					0.0	0.6	20.6	EUwood	Liquid biofuels
Total		**963.5**	**1 104.8**	**1 179.2**	**965.9**	**1 063.5**	**1 167.6**		**Total**

3.4 Policy scenarios

3.4.1 Maximising biomass carbon

3.4.1.1 Introduction

As outlined in Chapter 2, forests can play a role in climate change mitigation by sequestering carbon (in forest biomass, soil, and/or harvested wood products), or by substituting non-renewable materials and/or fuels. These strategies cannot be implemented at the same time for a single stand. The choice for a certain strategy is influenced by the state of the forest, trade-offs with other forest functions, and local possibilities with regard to the use of both products and wood energy. The *Maximising biomass carbon scenario* explored the amount of carbon which could be stored in the forest by changing silvicultural methods, without affecting the total harvest level. This scenario does not address carbon stocks in harvested wood products. Projections of soil carbon stocks were not included in the optimisation due to the associated uncertainties.

3.4.1.2 Scenario assumptions

Changes in the silvicultural methods were implemented in EFISCEN by changing rotation lengths and thinning shares. Rotation lengths were increased in 5-year steps to a maximum increase of 25 years. The maximum age of thinning was increased accordingly. The thinning shares were varied between 25 and 100% of the total required harvest, with 5% steps. All combinations of rotation lengths and thinning shares were tested in EFISCEN for each country, with the same demand as in the *Reference scenario*. The combination that gave the highest carbon stock in biomass, while still supplying the required demand, was selected as the final one. This scenario assumes there is an incentive for the forest owner to maximise the carbon in his forest, for example through a subsidy or carbon credits at a sufficient level to cover the extra costs of the modified management regime.

3.4.1.3 Scenario outcomes

The *Maximising biomass carbon scenario* assumes that the total removals from the forest will stay the same, and thus, that trade and industry will not be affected by this scenario. Table 6 shows the optimal combinations of increases in rotation length and thinning share by country. There is a clear correlation between both. High thinning shares can only be reached with long rotation lengths, while more age classes are available for thinning. At the same time, a high thinning share is needed to compensate for decreased final felling possibilities due to the smaller share of older stands. Consequently, countries characterised by rather high growing stocks and a relatively high share of older stands have the greatest possibility of extending rotation ages and increasing thinning shares. Countries with a rather young forest lose final harvesting possibilities very quickly with every 5-year increase in rotation length, which is not compensated for by the possibility of increased thinnings. Considerable extension of rotation lengths is thus not possible everywhere without losing harvest potential.

Table 6: Increases in rotation length and thinning share in the Maximising biomass carbon scenario.

Country group	Country	Rotation increase (years)	Thinning share (% of total harvest)	Stock change 2010-2030 (tonnes C/ha/yr)	
				Reference scenario	Maximising biomass carbon
Central-East	Belarus	25	0.65	0.69	1.16
	Czech Republic	20	0.55	0.28	0.69
	Hungary	5	0.4	-0.07	0.08
	Republic of Moldova	25	0.9	0.95	1.06
	Poland	5	0.4	0.13	0.32
	Romania	5	0.4	0.35	0.45
	Slovakia	0	0.35	0.14	0.16
	Ukraine	25	0.8	0.56	0.87
	Total			0.35	0.61
Central-West	Austria	25	0.55	0.32	1.32
	Belgium	5	0.35	0.09	0.24
	Switzerland	25	0.85	1.48	2.10
	Germany	10	0.45	0.71	0.89
	France	20	0.85	0.49	1.59
	United Kingdom	5	0.35	0.51	0.77
	Ireland	5	0.55	0.47	0.83
	Luxembourg	10	0.95	2.15	2.91
	Netherlands	5	0.55	1.18	1.26
	Total			0.55	1.23
South-East	Albania	25	0.95	0.26	0.31
	Bosnia and Herzegovina	NP	NP	-0.01	-0.01
	Bulgaria	10	0.6	0.16	0.32
	Cyprus	NP	NP	0.10	0.10
	Greece	NP	NP	-0.13	-0.13
	Croatia	5	0.35	-0.03	0.01
	Montenegro	NP	NP	0.85	0.85
	The former Yugoslav Republic of Macedonia	NP	NP	0.06	0.06
	Serbia	NP	NP	0.66	0.66
	Slovenia	25	0.7	0.41	0.77
	Turkey	25	0.4	-0.04	0.15
	Total			0.04	0.15
South-West	Spain	15	0.5	0.39	0.47
	Italy	25	0.9	0.50	0.61
	Portugal	0	0	0.76	0.65
	Total			0.51	0.59
North	Denmark	5	0.5	1.16	1.34
	Estonia	10	0.4	-0.06	0.27
	Finland	0	0.35	0.65	0.65
	Lithuania	0	0.35	-0.03	0.00
	Latvia	0	0.25	0.46	0.46
	Norway	25	0.55	0.35	0.67
	Sweden	10	0.45	0.46	0.66
	Total			0.50	0.63
EFSOS total				0.41	0.67

Note: NP= not possible due to data constraints

The average carbon sink in the forest in the period 2010-2030 is 0.67 tonnes C/ha/yr, an increase of 64% as compared to the *Reference scenario*. Central Europe in particular shows above-average potential for an increased carbon sink. This can be attributed to the favourable growing conditions in this region, and the presence of many countries with relatively high growing stocks and rather even age-class distributions.

The increase in carbon sink is caused by an increase in increment. Total increment in the EFSOS region in 2030 under the *Maximising biomass carbon scenario* is 1 137 million m^3/yr, an increase by 14.6% as compared to the *Reference scenario*. Part of the increment increase is due to the stimulating effect of thinning on the increment as formulated in EFISCEN. A second effect is that older stands still with a reasonable increment, are to a lesser extent replaced by young stands with initially lower increment than in the *Reference scenario*. The amount of harvest residues removed from the forest decreases by 15%, while residue extraction in thinnings does not yield as much as in final harvest. This has a minor positive effect on soil carbon. The intended consequence of the *Maximising biomass carbon scenario* is an increase in the growing stock. In 2030, the total growing stock volume is 7.8% higher than in the *Reference scenario* and amounts to 209.5 m^3/ha. Due to a higher share of older age classes, both recreational value and vulnerability to wind increase slightly as compared to the *Reference scenario*.

Table 7: Key forest resource indicators for the Maximising biomass carbon scenario

		North		Central-West		Central-East		South-West		South-East		EFSOS Total	
	unit	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030
Area of forest	million ha	68.6	69.6	43.5	45.2	34.3	36.7	30.8	35.9	27.7	29.5	204.9	216.9
FAWS	million ha	53.1	52.4	34.1	35.0	32.1	33.1	24.8	27.0	22.7	24.0	166.8	171.4
FNAWS	million ha	15.5	17.2	9.4	10.2	2.3	3.6	6.0	8.9	5.0	5.5	38.1	45.5
Growing stock	million m^3	7 309.9	8 816.0	8 660.6	11 189.2	8 089.8	9 456.9	2 290.6	3 149.9	2 963.4	3 295.3	29 314.3	35 907.4
	m^3/ha	137.7	168.2	253.7	320.0	252.2	285.9	92.3	116.6	130.5	137.6	175.7	209.5
Increment	million m^3/yr	271.9	332.5	304.8	381.4	227.0	255.0	79.6	91.0	54.3	77.1	937.7	1 136.9
	m^3/ha/yr	5.1	6.3	8.9	10.9	7.1	7.7	3.2	3.4	2.4	3.2	5.6	6.6
Fellings	million m^3/yr	220.4	247.3	218.0	248.4	159.0	186.0	42.2	45.0	43.1	59.9	682.7	786.7
	m^3/ha/yr	4.2	4.7	6.4	7.1	5.0	5.6	1.7	1.7	1.9	2.5	4.1	4.6
Potential stemwood removals	million m^3/yr	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	m^3/ha/yr	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Stemwood removals	million m^3/yr	204.3	227.7	181.5	207.2	133.4	156.5	38.5	41.2	37.6	52.4	595.2	685.0
	m^3/ha/yr	3.8	4.3	5.3	5.9	4.2	4.7	1.5	1.5	1.7	2.2	3.6	4.0
Extracted residues	Tg dry matter/yr	4.0	10.2	4.3	11.0	2.9	8.0	1.0	3.0	0.8	2.8	13.0	35.0
	Mg dry matter/ha/yr	0.08	0.19	0.12	0.31	0.09	0.24	0.04	0.11	0.03	0.12	0.08	0.20
Extracted stumps	Tg dry matter/yr	1.4	4.7	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	1.4	4.8
	Mg dry matter/ha/yr	0.03	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.03
Carbon in biomass	Tg C	2 885.1	3 495.7	3 277.6	4 174.5	3 061.3	3 536.3	1 071.0	1 477.7	1 307.7	1 445.6	11 602.6	14 129.8
	Mg C/ha	54.4	66.7	96.0	119.4	95.4	106.9	43.1	54.7	57.6	60.3	69.6	82.4
Carbon in soil	Tg C	4 793.5	4 957.8	3 439.9	3 535.7	3 402.0	3 474.5	1 284.9	1 344.5	1 985.8	2 006.7	14 906.1	15 319.2
	Mg C/ha	90.3	94.6	100.8	101.1	106.0	105.0	51.8	49.8	87.4	83.8	89.4	89.4
Standing deadwood	Tg dry matter	46.1	35.7	35.3	27.5	63.4	48.0	8.7	7.6	12.6	8.8	166.2	127.7
	Mg dry matter/ha	0.9	0.7	1.0	0.8	2.0	1.5	0.3	0.3	0.6	0.4	1.0	0.7
Lying deadwood	Tg dry matter	424.7	414.8	592.3	557.7	482.2	491.8	112.2	104.2	148.2	141.0	1 759.5	1 709.6
	Mg dry matter/ha	8.0	7.9	17.4	16.0	15.0	14.9	4.5	3.9	6.5	5.9	10.5	10.0
Total deadwood	Tg dry matter	470.8	450.5	627.6	585.2	545.6	539.8	120.9	111.8	160.8	149.9	1 925.7	1 837.2
	Mg dry matter/ha	8.9	8.6	18.4	16.7	17.0	16.3	4.9	4.1	7.1	6.3	11.5	10.7
Recreational value[1]		6.1	6.1	4.1	4.3	4.2	4.2	4.7	4.7	4.2	4.4	4.8	4.9
Wind vulnerability[2]		2.7	2.7	2.5	2.7	2.5	2.6	2.5	2.5	2.3	2.2	2.5	2.5
Fire vulnerability[2]		2.3	2.3	2.0	1.8	2.0	1.9	2.1	2.1	2.3	2.4	2.2	2.2
Average age	yr	54.3	50.3	55.9	63	55	59.3	46.7	43	59.8	61.1	54.3	55

[1] *Index 1-10 (10 = most valuable)*
[2] *Index 1-6 (6 = most vulnerable)*

3.4.1.4 Discussion

The *Maximising biomass carbon scenario* shows that it is possible to increase the carbon stored in the forest, without affecting the total supply from the forest. However, the switch from final fellings to thinnings has consequences for the quality and the dimensions of the wood delivered to the industry. This switch is therefore only feasible if the industry can deal with the altered quality and dimensions. Even more carbon could be stored in the forest if the harvest level were reduced. However, this would have considerable effects on the domestic industry. Moreover, this might lead to increased imports, leading to larger emissions from transport, and lower carbon sequestration outside the EFSOS region. Alternatively, the consumption of wood and wood products might decrease, and be substituted by more energy-intensive materials.

In the short term, it is possible to store more carbon in the forest. However, in the long term, at some point after 2030, the forest will become saturated. The forest will on average be rather old and have high growing stock volumes per ha, while the increment will decrease. Such a forest will be increasingly susceptible to disturbances, and such disturbances will have great consequences in terms of growing stock affected and carbon released. In the longer term, it is better to harvest the wood at some point, and use it to make products and/or to generate energy. The corresponding avoided emissions may be lower than the carbon stored in the wood, but they cannot be reversed in any way. Maintaining a high increment rate is important for mitigation purposes, as this is the only terrestrial process that actually removes carbon from the atmosphere. Any other actions should be targeted at keeping the carbon in the system as long as possible, or to use it as efficiently as possible to avoid emissions from fossil fuels.

At the moment, there are hardly any incentives in place for forest owners to increase the carbon stored in the forest. For this scenario to become a reality, such incentives should be created. The costs for the forest owners would generally be higher, because final fellings can be carried out more cost-effectively than thinnings. A price on carbon through carbon credits, for example, could help to cover these costs. However, it will be very difficult to measure and to verify these credits directly. How can an owner prove that he would have acted differently without these credits? Furthermore, such an assessment will probably be relatively costly, compared to the gains in carbon sequestration achieved. Innovative ways of providing the right incentives to forest owners will be needed to realise this scenario.

3.4.2 Priority to biodiversity

3.4.2.1 Introduction

The major challenges in protecting and enhancing biodiversity in forests in Europe as described in Chapter 2 are:

- improving biodiversity conservation, while facing a strong competition for suitable land at national, landscape, district and stand levels;
- developing and financing strategies and policies which protect biodiversity, but are still economically and socially sustainable;
- finding win-win solutions at landscape level, which are effective in terms of biodiversity conservation but attract the support of all stakeholders;
- ensuring consistency of biodiversity policies, forest policies, industry policies and land use policies through a cross-sectoral approach.

This scenario explores possible consequences for the forest sector of forest management, which gives priority to biodiversity conservation, and it tries to quantify the possible trade-offs between this policy goal and others, notably increasing carbon storage and furthering wood production and trade. The *Priority to biodiversity scenario* aims to provide the forest sector and political decision makers with a sound information basis that enables them to develop evidence-based strategies and policies. It should thus serve to meet the challenges in improving biodiversity conservation while being economically and socially sustainable under strong economic and budgetary pressures, and to facilitate win-win solutions in the trade-offs, which maximise benefits for society and attract the support of all interest groups.

3.4.2.2 Scenario assumptions

The *Priority to biodiversity scenario* assumes that political decision makers give priority to the protection of biological diversity and shape the political framework for the forest sector according to the goal to conserve and enhance biodiversity. In particular, when there are trade-offs between biodiversity and other functions, preference is given to biodiversity. In the scenario, as a necessary simplification for modelling purposes, the following measures are implemented:

- Designation of an additional 5% of the forest area for biodiversity conservation (no commercial harvest allowed), reducing FAWS by 5% in 2010, compared to the *Reference scenario*.

- Longer rotation periods: increased by 10 years for short-lived broadleaved species; increased by 20 years for coniferous species and long-lived broadleaved species.
- Intensified thinnings: the share of wood from thinnings increases by 10%.
- Conversion, after clear felling, of 50% of areas which are currently dominated by coniferous species to broadleaved dominated areas, and supporting tree species compositions closer to natural diversity.
- Strict biomass harvesting guidelines are applied and no residue extraction of any type takes place.

Due to restrictions in modelling, the assumptions do not address specific species or site selection or other detailed management procedures, which are of course also essential for biodiversity conservation.

3.4.2.3 Scenario outcomes

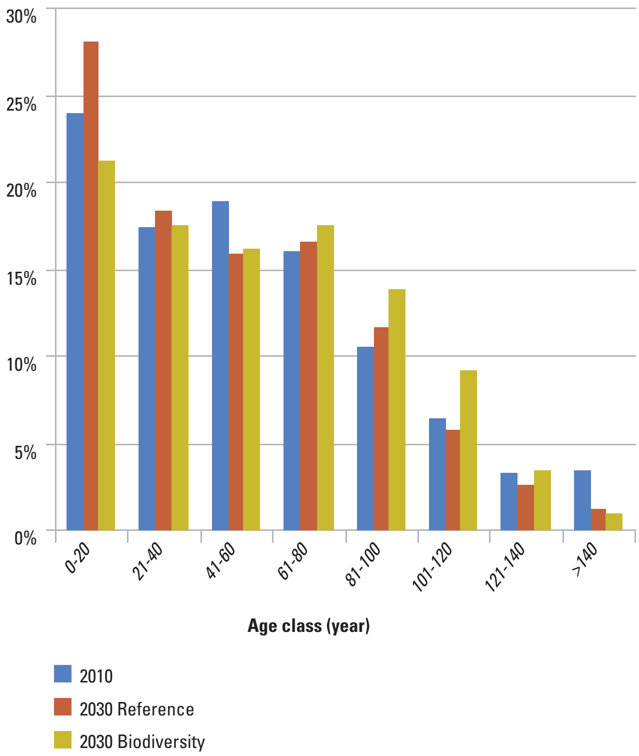
A number of factors delineating forest resources have been modelled, according to these assumptions, to give a reasonable picture of a *Priority to biodiversity scenario* in Europe. The outcomes of the model are described below and compared to the figures projected for the European region in the *Reference scenario*. All data refer only to FAWS, therefore the *Priority to biodiversity scenario* figures always relate to a reduced area, because not all of the forest area is available for wood production.

3.4.2.4 Forest area and age-class distribution

Forest area in the *Priority to biodiversity scenario* is developing in a similar way to that in the *Reference scenario*. The total forest area in Europe will increase by about 6% by 2030 as a consequence of pre-existing long term trends for forest expansion and afforestation programmes. FAWS show an increasing trend towards 2030 in both scenarios.

The age class distribution of forests in the *Priority to biodiversity scenario* differs from that in the *Reference scenario*. Whilst in the *Reference scenario* the youngest age class of less than 20 years gains most area (+4.0%), its percentage decreases most in the *Priority to biodiversity scenario* (-2.7%), due to intensified thinnings and thus less regeneration fellings. In contrast, the proportion in the age classes between 61 and 140 years is growing in the *Priority to biodiversity scenario* especially in the age classes 81-100 years and 101-120 years (3.4% and 2.8% respectively), as a result of extended rotation periods in the scenario. These age classes also show the most significant departure from the trends in the *Reference scenario*, where their share is lower due to the final fellings according to customary rotation periods. In the age class of over 140 years, the percentage is decreasing again in the *Priority to biodiversity scenario* as more harvesting takes place in the oldest age class (Figure 12).

Figure 12: Share of age classes in Reference scenario and Priority to biodiversity scenario, 2010-2030.

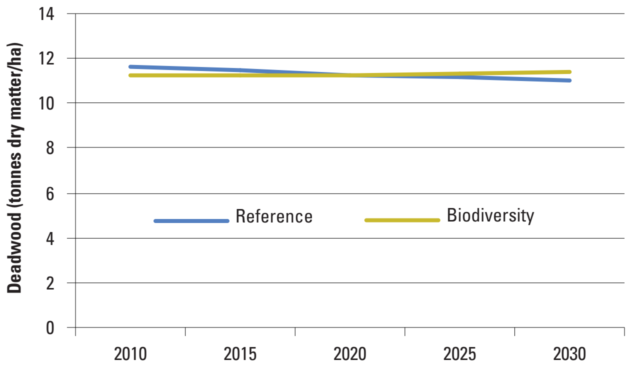


3.4.2.5 Deadwood and carbon

The average amount of standing deadwood per ha in FAWS is decreasing in both projected scenarios, but more significantly in the *Priority to biodiversity scenario*, due to a higher share of thinnings. By 2030, it will be 10% lower than in the *Reference scenario*. It has to be taken into account that these figures relate to FAWS only and it can be assumed that the proportion of standing deadwood will increase considerably in the additional area of forest, which is not available for wood supply. The amount of downed deadwood is growing constantly in the *Priority to biodiversity scenario*, while it is continuously declining in the *Reference scenario*. By 2030, the average per ha will be about 5% higher than in the *Reference scenario*. This significant increase is mainly caused by the absence of extraction of harvest residues, which allows branches and treetops to accumulate as deadwood.

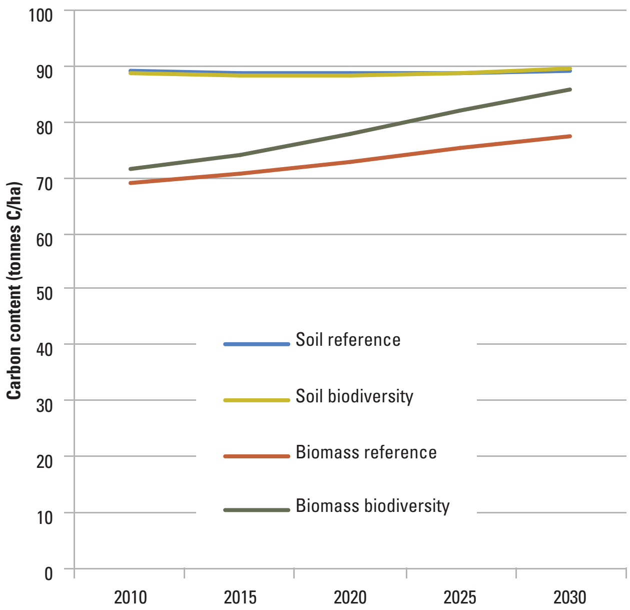
Overall, the amount of total deadwood (standing and downed) per ha in FAWS will slightly grow in the *Priority to biodiversity scenario*, while it is constantly decreasing in the *Reference scenario*. By 2030, it will equal 11.4 tonnes dry matter/ha, exceeding the *Reference scenario* figure by 2.7% (Figure 13). Based on the assumption that deadwood is, at least, not decreasing in the additional 5% of forest area that have been designated to biodiversity conservation, a significantly higher amount of deadwood than in all other scenarios will accumulate in European forests in the framework of the *Priority to biodiversity scenario*.

Figure 13: Development of average total deadwood per ha in FAWS in Reference scenario and Priority to biodiversity scenario, 2010-2030.



The total carbon stored per ha increases significantly more in the *Priority to biodiversity scenario*. In comparison to the *Reference scenario*, the average amount of carbon stored per ha of FAWS will be about 5% higher by 2030, reaching 175 tonnes/ha/yr, which is the highest figure of all scenarios. In particular, the amount of carbon stored in biomass is growing considerably in this scenario. By 2030, the average amount per ha will be 11% higher than in the *Reference scenario*, exceeding also the *Maximizing biomass carbon scenario*. Even in the reduced area in the *Priority to biodiversity scenario* the total carbon in biomass in FAWS will be around 7% higher. Soil carbon storage is increasing less than biomass carbon storage. Nevertheless, while the average storage per ha is slightly decreasing in the *Reference scenario*, due to residue extraction, minor growth between 2020 and 2030 is projected for the *Priority to biodiversity scenario*. Accordingly, by 2030, the average amount stored per ha is slightly higher than in the *Reference scenario*. Furthermore, it can be assumed that in the additional 5% of FAWS supply the biomass carbon is increasing considerably and the soil carbon slightly, depending on the conservation management. As a consequence, the total carbon storage in forests is by far higher in the *Priority to biodiversity scenario* than in the *Reference scenario* (Figure 14).

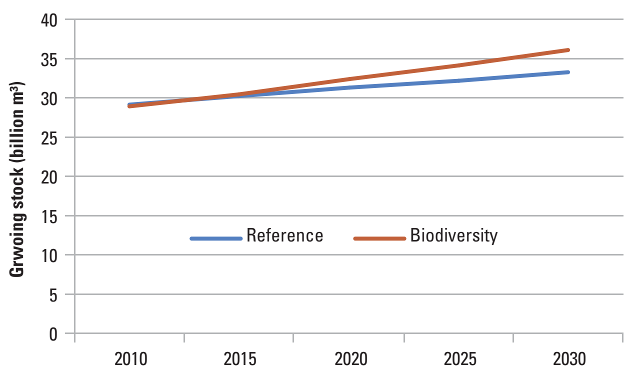
Figure 14: Development of average carbon storage in soil and biomass per ha in FAWS in Reference scenario and Priority to biodiversity scenario, 2010-2030.



3.4.2.6 Growing stock, increment and fellings

The growing stock shows considerably higher increase in the *Priority to biodiversity scenario*. The longer rotation periods result in an average growing stock of 218.8 m^3/ha by 2030, that is, more than 12% higher than in the *Reference scenario*. Even the total growing stock in FAWS of 36 091 million m^3 is more than 8% higher in the *Priority to biodiversity scenario* by 2030, despite the reduced area. Both the total and average growing stock are exceeding the figures for all other scenarios (Figure 15).

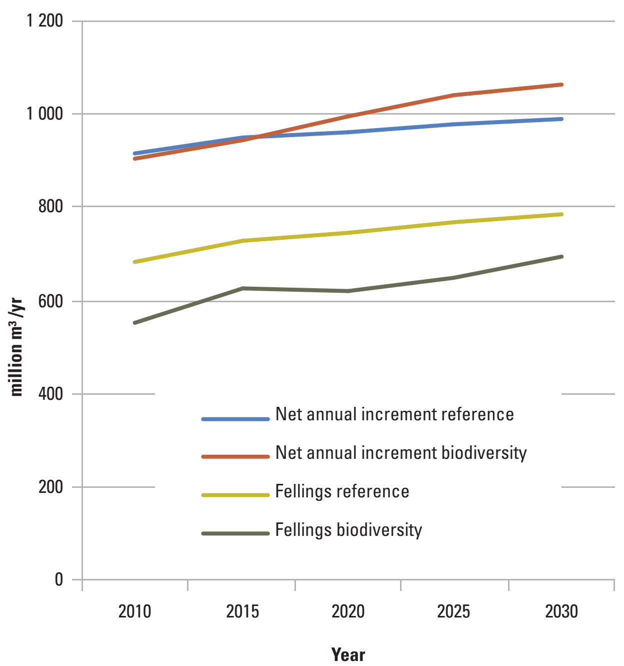
Figure 15: Development of total growing stock in FAWS in Reference scenario and Priority to biodiversity scenario, 2010-2030.



Due to longer rotation periods, more intense thinnings and less harvest, the increment in the *Priority to biodiversity scenario* is considerably higher than in the *Reference scenario*. By 2030, the average increment of 6.5 m^3 per ha is about 12% higher and the total increment in FAWS of 1 064.5 million m^3 is about 7% higher (on less area). That means that woody biomass is growing faster in the *Priority to biodiversity scenario* and accumulates at higher levels compared to the *Reference scenario*. If the total figures were related to the same area, the differences would show even more significantly.

Nevertheless, less area available for wood supply and longer rotations result in less fellings compared to the *Reference scenario*. Due to the limited availability of forests that are old enough to be harvested, by 2010, average fellings per ha are reduced by 15% in the *Priority to biodiversity scenario*, and total fellings in FAWS are 132 million m^3 or nearly 20% lower than in the *Reference scenario*. Over time more forests reach the harvesting threshold, and from 2020 on, the average fellings per ha are increasing significantly more in the *Priority to biodiversity scenario* than in the *Reference scenario*. Accordingly, the difference in total fellings in FAWS is reduced to 95.1 million m^3 (12%) by 2030 (Figure 16).

Figure 16: Development of total increment and total fellings in FAWS in Reference scenario and Priority to biodiversity scenario, 2010-2030.

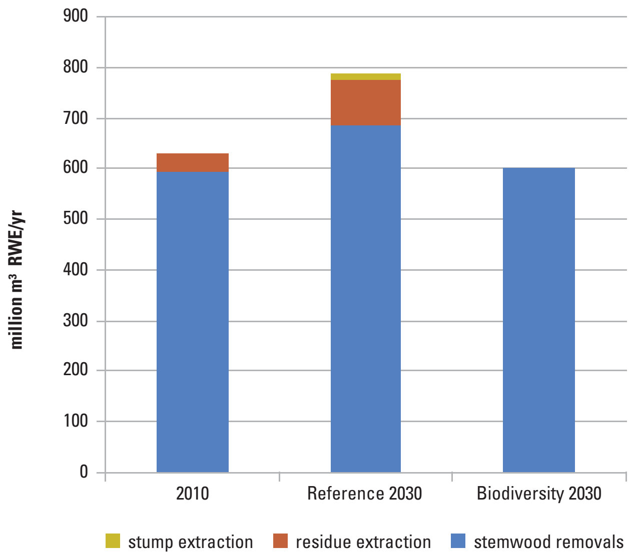


3.4.2.7 Removals and supply of woody biomass

The rate of stemwood removals is developing according to the fellings. In 2010, the total stemwood removals are 112.2 million m^3 or 19% lower than in the *Reference scenario*. However, the model shows a significantly higher increasing trend in the *Priority to biodiversity scenario* and the difference in stemwood removals is decreasing over time, especially between 2020 and 2030. By 2030, the difference between the *Priority to biodiversity scenario* and the *Reference scenario* is reduced to 84.3 million m^3 or 12%.

Residue extraction and stump extraction is completely abandoned in the *Priority to biodiversity scenario*. In contrast, 41.1 Tg dry matter residues and 5.5 Tg stumps are extracted in the *Reference scenario* by 2030. Overall, 600.4 million m^3 woody biomass are projected to be harvested in FAWS, while in the *Reference scenario* 788.2 million m^3 are extracted. Removals in forests designated for biodiversity conservation are not taken into account in this calculation (Figure 17).

Figure 17: Development of stemwood removals, residue extraction and stump extraction in FAWS in Reference scenario and Priority to biodiversity scenario, 2010-2030.



The estimate in the *Reference scenario* for the total supply of woody biomass by 2030 adds up to 1 179.2 million m^3. Reduced by 84.3 million m^3 less stemwood removals in the *Priority to biodiversity scenario* the supply would fail to meet the potential demand of 1 167.6 million m^3 by 72.7 million m^3. In addition, the absence of forest residues extraction has to be taken into account, and the projected total difference of 187.8 million m^3 woody biomass results in a shortage of 176.2 million m^3.

3.4.2.8 Discussion

As intended by underlying policies, those parameters that are strongly related to biodiversity conservation and of high importance for ecosystem services are developing predominantly positively in the *Priority to biodiversity scenario*. A shift from younger to older age classes in the age class distribution is projected, which will support biological and landscape diversity. A larger area of mature stands will allow forest ecosystems to develop more naturally. As a consequence more diverse stand structures will evolve, creating more habitats for a wider spectrum of species.

The positive trend in the development of the deadwood biodiversity indicator is not as high as would be expected in the *Priority to biodiversity scenario*, but more than in all other scenarios, where deadwood is decreasing steadily. The total amount of deadwood in FAWS in the *Priority to biodiversity scenario* exceeds the share of deadwood in the *Reference scenario* only slightly. Nevertheless, it has to be taken into account that a larger area of protected forests will accumulate more deadwood (see also Verkerk *et al.,* 2011) resulting in a significantly higher percentage of deadwood in the total forest area than in all other scenarios.

Based on the considerable increase in growing stock, the amount of carbon stored in forests shows a significantly positive trend and exceeds by far the projected figures for the *Reference scenario*. In addition, the extended area of protected forests further contributes to increased carbon storage. A win-win solution in the trade-off with maximising carbon policies would be achieved in this *Priority to biodiversity scenario*.

In addition, it is plausible that the provision of a range of other non-wood goods and services is also impacted positively in the framework of this scenario. For example, the shift of younger to older age classes and more protected areas are factors that add recreation value to forests. An index of recreational value in FAWS on a scale from 1 to 10 (based on Edwards *et al.,* 2011) has been used to assess the development in the different scenarios. While the index in the *Reference scenario* keeps at constant level, it increases in the *Priority to biodiversity scenario* and shows the highest value of all scenarios by 2030.

Also, other forest ecosystem services, such as water quantity and quality, soil preservation, and air quality are likely to benefit from the longer rotation periods, mixed stands, more diverse structures, less harvesting operations and larger areas of protected forests. The vulnerability of FAWS in different scenarios has also been assessed using an index scale of 1-6. Due to a larger area of older stands, the vulnerability to wind is slightly increasing in the *Priority to biodiversity scenario* and is higher than in the *Reference scenario*. However, in this context it has to be taken into account that the model always assumes even aged stands while it is likely that forest management that gives priority to biodiversity aims at uneven stands or small-scale even aged stands. These structures might reduce vulnerability to wind again. The fire vulnerability indicator for FAWS is slightly decreasing in the *Priority to biodiversity scenario*, while it keeps a constant level in the *Reference scenario*.

Woody biomass in forests is accumulating significantly faster in the *Priority to biodiversity scenario* than in the *Reference scenario*; growing stock and increment out-weigh the estimates for the *Reference scenario* by far. Nevertheless, the supply of woody biomass from forests is reduced by 187.8 million m^3 by 2030, that is 23.8% of the figure projected for woody biomass from forests (stemwood, residues and stumps) in the *Reference scenario*. The supply in the *Priority to biodiversity scenario* would fall short of meeting the projected demand in 2030 by 176.2 million m^3 (Table 8). The trend in stemwood removals would be increasing, but the absence of extraction of residues would create a constant gap.

Table 8: Key forest resource indicators for the Priority to biodiversity scenario													
		North		Central-West		Central-East		South-West		South-East		EFSOS Total	
	unit	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030
Area of forest	million ha	68.6	69.6	43.5	45.2	34.3	36.7	30.8	35.9	27.7	29.5	204.9	216.9
FAWS	million ha	50.7	50.9	32.5	33.3	30.9	32.1	23.7	25.9	21.6	22.8	159.4	164.9
FNAWS	million ha	17.9	18.7	11.0	11.9	3.4	4.6	7.1	10.1	6.1	6.7	45.5	52.0
Growing stock	million m^3	7 080.8	9 389.9	8 456.5	10 596.6	8 151.7	9 823.8	2 279.5	3 167.9	2 849.7	3 113.0	28 818.1	36 091.1
	m^3/ha	139.7	184.6	260.4	318.2	263.6	306.5	96.2	122.5	131.9	136.4	180.8	218.8
Increment	million m^3/yr	266.6	340.2	290.1	328.3	218.3	239.1	78.9	87.5	51.5	69.4	905.4	1 064.5
	m^3/ha/yr	5.3	6.7	8.9	9.9	7.1	7.5	3.3	3.4	2.4	3.0	5.7	6.5
Fellings	million m^3/yr	194.9	203.9	171.5	226.1	112.2	162.6	35.8	41.5	36.2	57.3	550.6	691.3
	m^3/ha/yr	3.8	4.0	5.3	6.8	3.6	5.1	1.5	1.6	1.7	2.5	3.5	4.2
Potential stemwood removals	million m^3/yr	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	m^3/ha/yr	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Stemwood removals	million m^3/yr	181.7	186.7	142.5	188.7	94.7	136.7	32.1	38.0	31.9	50.5	482.9	600.4
	m^3/ha/yr	3.6	3.7	4.4	5.7	3.1	4.3	1.4	1.5	1.5	2.2	3.0	3.6
Extracted residues	Tg dry matter/yr	3.9	0.0	3.8	0.0	2.1	0.0	0.9	0.0	0.7	0.0	11.4	0.0
	Mg dry matter/ha/yr	0.08	0.00	0.12	0.00	0.07	0.00	0.04	0.00	0.03	0.00	0.07	0.00
Extracted stumps	Tg dry matter/yr	1.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	0.0
	Mg dry matter/ha/yr	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Carbon in biomass	Tg C	2 795.0	3 711.9	3 193.3	3 917.9	3 071.4	3 637.4	1 064.6	1 484.3	1 256.5	1 364.0	11 380.7	14 115.5
	Mg C/ha	55.1	73.0	98.3	117.7	99.3	113.5	44.9	57.4	58.2	59.8	71.4	85.6
Carbon in soil	Tg C	4 552.2	4 808.2	3 249.7	3 370.5	3 214.1	3 331.8	1 231.5	1 315.8	1 890.0	1 919.0	14 137.4	14 745.4
	Mg C/ha	89.8	94.5	100.1	101.2	103.9	103.9	52.0	50.9	87.5	84.1	88.7	89.4
Standing deadwood	Tg dry matter	44.0	34.5	36.9	37.1	65.6	58.7	8.9	8.3	12.7	11.0	168.1	149.6
	Mg dry matter/ha	0.9	0.7	1.1	1.1	2.1	1.8	0.4	0.3	0.6	0.5	1.1	0.9
Lying deadwood	Tg dry matter	398.2	409.7	548.3	580.7	436.0	494.8	106.3	104.6	138.5	140.8	1 627.3	1 730.6
	Mg dry matter/ha	7.9	8.1	16.9	17.4	14.1	15.4	4.5	4.0	6.4	6.2	10.2	10.5
Total deadwood	Tg dry matter	442.2	444.2	585.2	617.8	501.6	553.5	115.3	113.0	151.1	151.8	1 795.4	1 880.2
	Mg dry matter/ha	8.7	8.7	18.0	18.6	16.2	17.3	4.9	4.4	7.0	6.6	11.3	11.4
Recreational value[1]		6.1	6.5	4.1	4.3	4.2	4.2	4.8	4.8	4.2	4.3	4.8	5.0
Wind vulnerability[2]		2.7	2.9	2.5	2.6	2.6	2.7	2.5	2.6	2.3	2.1	2.5	2.6
Fire vulnerability[2]		2.2	2.1	1.9	1.8	1.9	1.8	2.1	2.0	2.3	2.4	2.1	2.0
Average age	yr	54.3	55	55.9	59.6	55	62.1	46.7	44.3	59.8	58.8	54.3	56.3

[1] *Index 1-10 (10 = most valuable)*

[2] *Index 1-6 (6 = most vulnerable)*

3.4.3 Promoting wood energy

3.4.3.1 Introduction

Policy makers face major challenges arising from the strong rise in demand for wood energy, driven both by policy objectives and high fossil fuel prices. The *Promoting wood energy scenario* explores how the sector could contribute to meeting the renewable energy targets and what would be the consequences for other parts of the sector, of this policy priority. This scenario therefore takes as its starting point that the ambitious targets for consumption and production of renewable energy in 2020 are achieved, and that the trend continued to 2030. It then analyses how this objective might be achieved and how other parts of the sector would respond to this strong growth.

To construct this scenario, the targets for the share of renewables in total energy, agreed by all EU countries as well as most other countries in Europe, were added to the projected demand for products, which led to a very high aggregate demand for wood. To satisfy this demand, EFISCEN was used to estimate the highest possible sustainable supply of wood from Europe's forests, and estimates were made of the highest realistic potential supply of wood from outside the forest, including landscape care wood, post-consumer wood and industry residues. The consequences of this situation for product demand and for trade were estimated by EFI-GTM, which also supplied indications for price development.

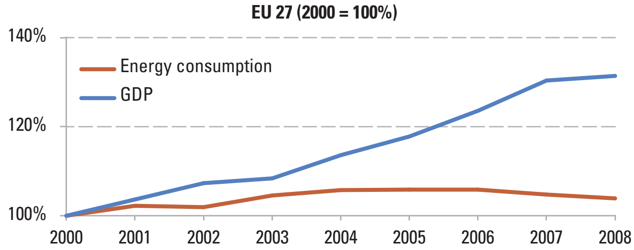
Europe in this scenario is characterised by strong demand for wood, emerging scarcities, and concern about sustainability of wood supply, inside and outside Europe. These tensions inside the forest sector should be put in the context of a world where energy scarcity is a major preoccupation, as the price of fossil energy rises, nuclear power encounters major opposition, and other renewable energies have difficulty expanding fast enough to satisfy demand.

3.4.3.2 Scenario assumptions

The assumptions underlying the scenario may be summarised as follows:

- Economic and population growth are the same as in the *Reference scenario*.
- Energy efficiency increases by 20% by 2020 for all European countries compared to the period around 2010, reducing overall energy demand for a given GDP level; this trend is already evident as total energy consumption has been stable since 2000, while GDP has risen (Figure 18).
- Other renewable sources of energy, which at present have a much smaller market share than wood, grow faster than wood, so that the share of wood in renewable energy supply falls, from about 50% to 40%
- As a result, in order to reach the targets for renewable energy by 2020, with a continuation of the trend to 2030, about 860 million m^3 of wood, of all types, should be used for energy in 2030, nearly double the figure of 435 million m^3 for 2010.
- To achieve the targets for wood energy, policy measures are put in place to mobilise woody biomass from Europe's forests and elsewhere, for instance by implementing the recommendations on sustainable wood mobilisation (MCPFE, DG AGRI, UNECE/FAO, 2010). Application of fertilizer is permitted to limit detrimental effects of logging residue and stump extraction on the soil.

Figure 18: EU27 Growth of GDP and energy consumption, 2000-2008.



Source: Steierer, 2010.

3.4.3.3 Scenario outcomes

3.4.3.3.1 Markets and consumption for forest products and wood energy

Following the methods and assumptions developed for the EUwood project (Steierer, 2010), the future use of wood for energy has been estimated (Table 9). The average rate of growth is very strong, about 3.5% per year for 20 years, but there are big differences between the markets for wood energy: household use of wood for energy is actually expected to drop and use of energy wood by the forest industry to grow only slowly. However household use of pellets will grow strongly, as will liquid biofuels (from a low base). Wood use by biomass-burning CHP plants is a residual in the calculation (i.e. what is needed to reach the targets after other markets have been considered): this is expected to grow very strongly.

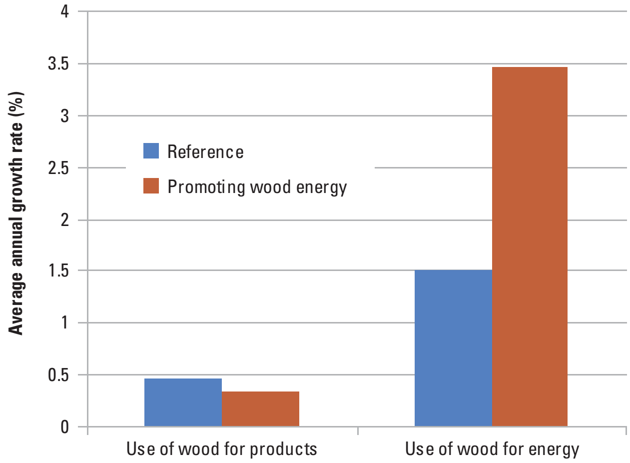
Table 9: Use of wood for energy in Promoting wood energy scenario, 2010-2030

	2010	2020	2030	Change 2010 to 2030	
	million m^3			million m^3	%/year
Forest industry process energy	92	107	126	34	1.59
Wood burning CHP	105	271	406	301	6.99
Households (pellets)	24	70	83	60	6.50
Households (other)	214	223	204	-10	-0.24
Liquid biofuels	0	1	40	40	NA
Total wood for energy	435	673	859	424	3.46

These are very high rates of growth, however, they coincide approximately with those forecast by EU countries in their National Renewable Energy Action Plans prepared in 2010/early 2011. These plans were prepared before the latest rise in oil prices and the nuclear accident at Fukushima, Japan. In spring 2011, Germany, Italy and Switzerland decided to phase out nuclear power, and Sweden had already taken this decision. These events and decisions may be expected to accelerate the speed of transition to renewable energies.

As competition leads to higher raw material prices, consumption of forest products is projected to grow until 2030, but slower than in the *Reference scenario* (Figure 19).

Figure 19: Average annual rates of growth in wood consumption, 2010-2030.



As a result, energy uses in the *Promoting wood energy scenario* would, by 2030 account for 60% of total wood use, compared to 50% in the *Reference scenario* and 45% in 2010. Total woody biomass use required in 2030, to satisfy the energy targets, would be more than 270 million m^3 higher than in the *Reference scenario*, and 424 million m^3 more than in 2010. This would be an increase of 98% in 20 years (Figure 20).

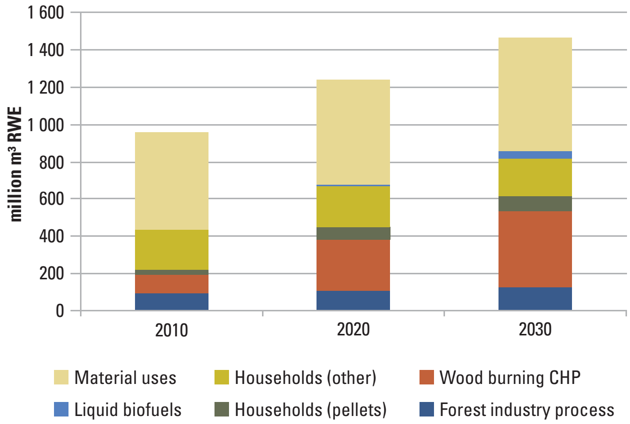
3.4.3.3.2 Forest resource and wood supply

To achieve these ambitious goals, every type of wood supply would have to be mobilised (Figure 21):

- Stemwood harvest would have to increase, advancing from 595 million m^3 o.b. to 700 million m^3 o.b., as each type of forest moves closer to – but not above – its theoretical potential, due to more intensive management. However, this does not imply any increase in harvest on FNAWS, or any wood harvesting in protected forests.
- There would have to be a strong increase in harvesting of forest residues (branches and tops, at present usually left in the forest), as well as an increase in stump harvesting. Supply of forest residues and stumps together would increase from 36 million m^3 in 2010 to over 270 million m^3 in 2030, a seven-fold increase. Within this total, extracted stumps would be multiplied nearly 30 times, going from 4 to 114 million m^3, mostly in North, Central-West and Central-East Europe.
- Supplies of wood from less conventional sources would also be at the higher end of their potential, with landscape care wood increasing from 63 to 108 million m^3. This represents an annual growth rate of 2.4%, and the contribution from post-consumer wood moving from 46 to 71 million m^3.
- Net imports of wood from other regions would also increase, according to EFI-GTM, from about 12 million m^3 wood equivalent to 33 million m^3.

This increase in the supply of wood, is within the physical limits of the European forest sector and technically feasible without reducing the growing stock, or removing protection from forests devoted to biodiversity conservation. However, to achieve this steep increase in wood supply would necessitate significant efforts by all actors: forest owners, consumers, intermediaries, and the governments who would have to provide the necessary framework conditions. An increase in wood price would be inevitable, as the price of fossil fuel would place a floor under the energy price[6]. The measures necessary for wood mobilisation have been outlined in MCPFE, DG AGRI, UNECE/FAO (2010). Changes would be necessary in many fields: land tenure (including wider use of forest owner associations and cooperatives for wood marketing); management; co-ordination and planning; infrastructures and logistics (e.g. roads and bridges, allowable truck sizes); markets and marketing; recovery channels for post-consumer wood; education and training; finance; legal and fiscal systems; silviculture. The consequences of such an intense mobilisation on other parts of the sector, notably on biodiversity, nutrient cycles and recreation, need to be explored. A first estimate of the overall sustainability of the five scenarios is presented in Chapter 4.

Figure 20: Consumption of wood in Promoting wood energy scenario, 2010-2030.



[6] *In this scenario, the general energy price would certainly increase.*

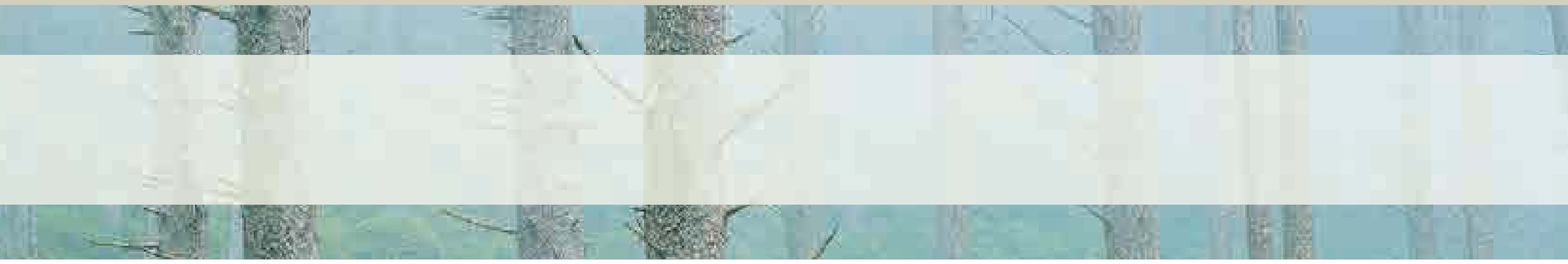


Figure 21: Components of wood supply in Promoting wood energy scenario, 2010-2030

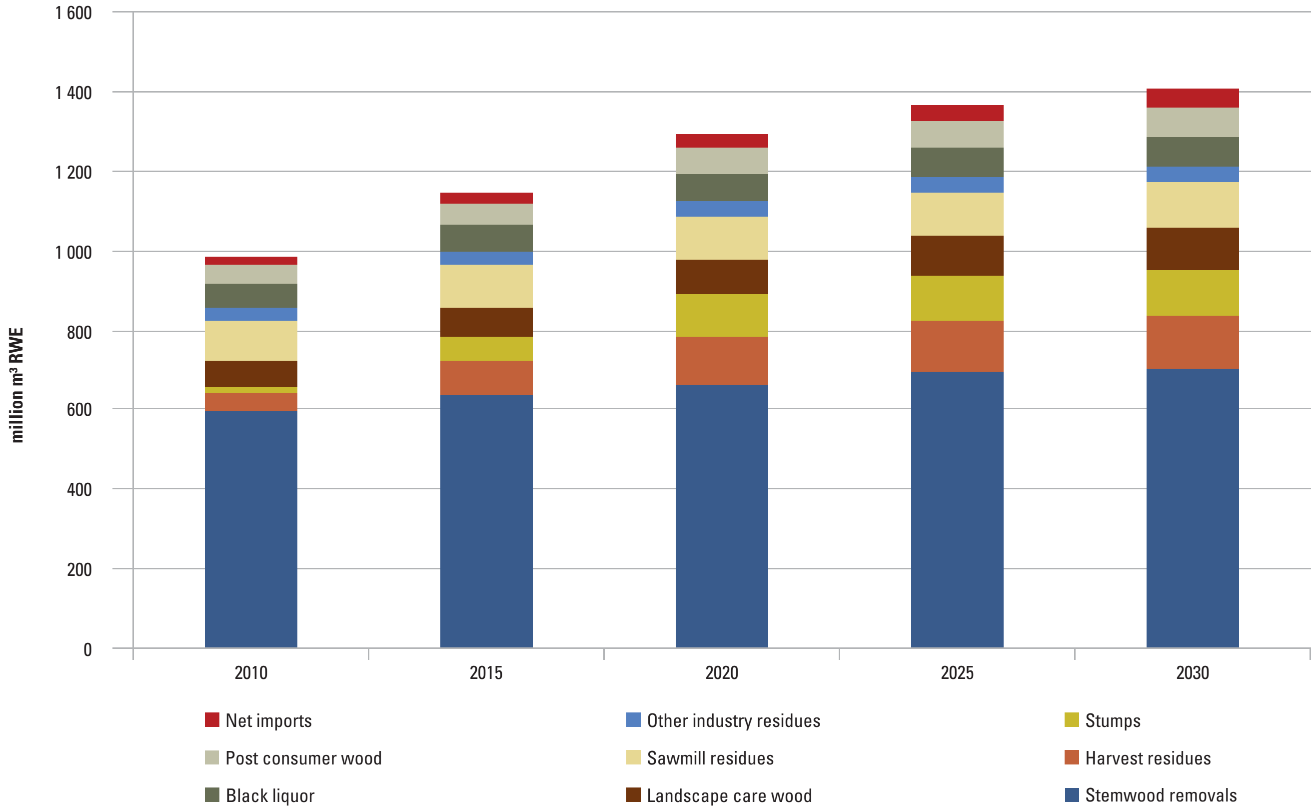
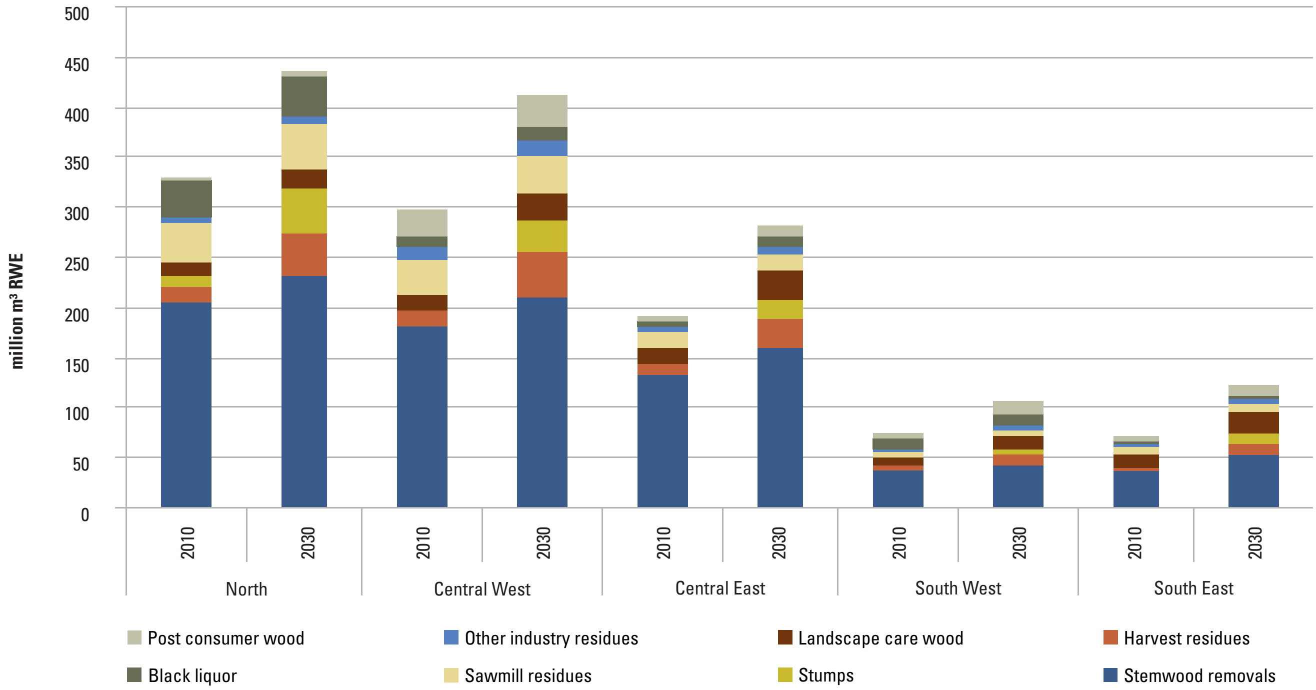
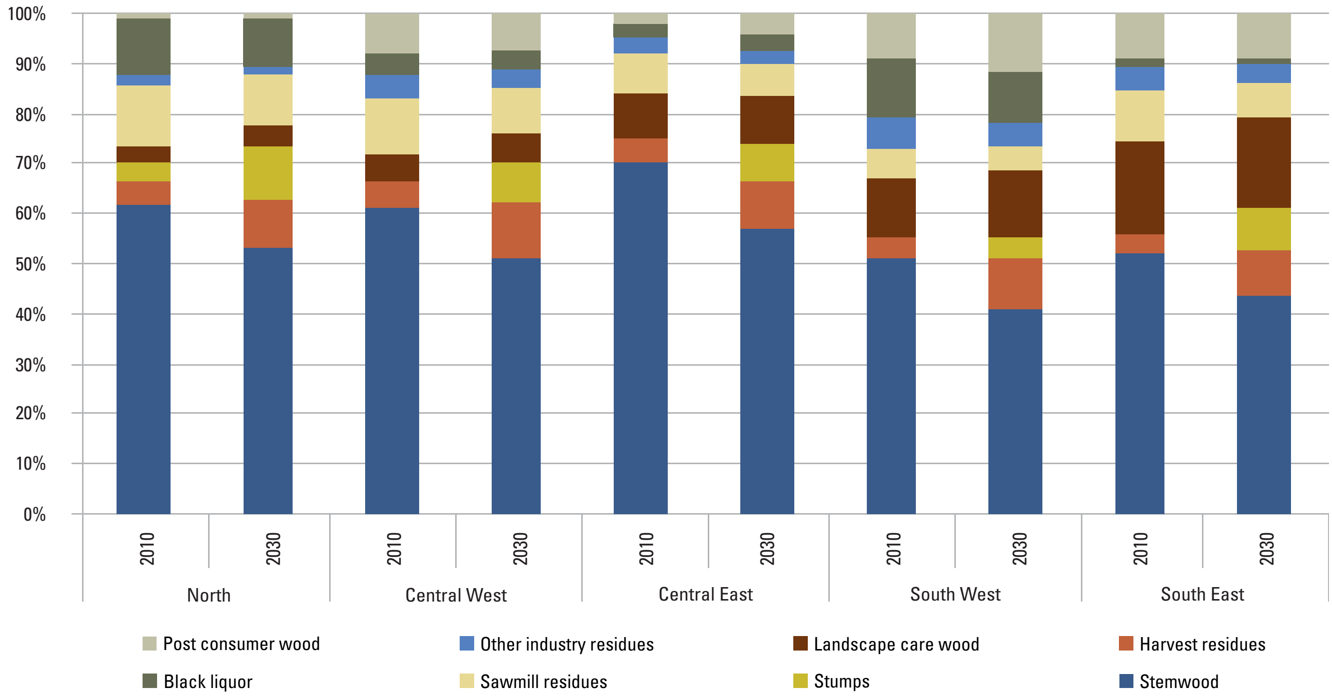


Figure 22: Components of wood supply (without trade), by country group in Promoting wood energy scenario, 2010-2030



All country groups show significant expansion of wood supply (Figure 22): North and Central-West Europe remain the largest suppliers, with the largest increase in wood supply by volume (115 and 105 million m³ respectively). However rates of growth in wood supply are highest in South-East and Central-East Europe where supply rose by 68% and 48% respectively between 2010 and 2030. The composition of wood supply also varies between country groups, as do the trends. Stemwood remains the largest component of supply in all groups, but its share is falling everywhere (Figure 23). As would be expected, black liquor is most important in regions with a strong chemical pulp industry, that is, North and Central-West Europe. Post-consumer wood is most important, in relative terms, in Central-West, South-West and South-East Europe. By far the fastest rate of growth is for forest residues (harvest residues and stumps) which, taken together, move from less than 5% of wood supply to 15-20% in all country groups. Other components of wood supply, stemwood and all the 'non-forest' components become relatively less important despite most of them showing growth.

Figure 23: Components of wood supply (without trade), as percentage of total in Promoting wood energy scenario, 2010-2030



No input is assumed at this stage from energy plantations on non-forest land, because of the impossibility of making a fact-based projection.

3.4.3.3.3 Trade in forest products

Under this scenario an extra 32 million m³ of wood would have to be imported from other regions, as compared to the *Reference scenario*. At the same time, forest products export is 14 million m³ RWE less than in the *Reference scenario*. There are several regions with the capacity to supply this extra volume, including fast growing plantations in tropical regions or the southern United States, or the extensive natural and semi-natural forests in Russia and Canada. However there are numerous causes of uncertainty, including whether these sources would be considered sustainable according to emerging EU rules (EU, 2009), and the strength of demand from other regions, notably China and other Asian countries, which would compete with possible European importers. In Europe, however, large biomass burning power plants are already being brought into production, which are almost entirely dependent on biomass imported from outside Europe. Their objective is to supply a higher percentage of renewable energy to the countries, in accordance with national policies for renewable energy. However, the overall energy and carbon balance of conventional electricity generation (i.e. without CHP), based on biomass imported from overseas, must be considered doubtful. Nevertheless, an intercontinental trade in biomass for energy has been observed since about 2009.

3.4.3.3.4 Supply and demand balance in the Promoting wood energy scenario

The 'gap' between supply and demand in this scenario is relatively small (2 million m^3), thanks chiefly to the very strong growth assumed for harvest residues and stump extraction. Although this material is technically available, such heavy extraction could well have negative consequences for the forest nutrient balance, leading to a long term impoverishment of forest stands. It is also possible that the disturbance of the soil due to stump extraction could lead to extra carbon emissions (not included in the EFISCEN estimate of changes in soil carbon). The strong increase in harvest residues and stump extraction assumed for the *Promoting wood energy scenario* seems to pose an unacceptable risk to the ecological balance of the forest. However, this is difficult to quantify with the current model framework

The *Promoting wood energy scenario* assumes a supply of harvest residues and stumps of nearly 170 million m^3 more than in the *Reference scenario*. If this amount cannot be mobilised, due to ecological, socio-economical or technical reasons, several alternative strategies are available:

- Even higher imports from other regions. However this seems unlikely because of competition from other importing regions. Moreover, negative aspects should be taken into account, like the possible negative carbon balance of the trade and the increased dependence of Europe on other regions for its energy supply. Nor does it appear truly sustainable to base Europe's supply of renewable energy on imports from other parts of the world.
- Establish intensive energy plantations on European agricultural or marginal land. Assuming a productivity of 10 to 30 m^3/ha/yr (Leek, 2010), between 6 and 17 million ha land would be needed to supply 170 million m^3 of wood. This is 3 to 9% of utilized agricultural land in the EU27. However, future changes in land use are almost impossible to forecast, given the uncertainty about land availability and price, driven by agricultural policy and conditions on world food and fuel markets. To establish millions of ha of intensively managed short rotation plantations would demand political will of a high order, and would only be socially acceptable if not seen as threatening to Europe's food supply.
- Under the conditions of strong demand for energy wood, leading to higher prices, it is possible that consumption of wood raw material could be below the already reduced level in the *Promoting wood energy scenario*. Industries processing wood might decide to change their focus from manufacture of products, with supplementary supply of wood based energy, to wood energy as the primary source of income, leading to a lower supply of forest products to the European market.
- On the energy side, other renewable energies, such as solar, wind or tidal, might develop even faster than expected, making it possible to reach the targets without such a large increase in wood energy. This would of course require massive investment in the development and deployment of these as yet immature technologies.

3.4.3.3.5 Prices

EFI-GTM generates price projections by country for the major products, for each scenario. These price projections show steady increases throughout the forest sector, driven by increasing demand and emerging scarcities already in the *Reference scenario*. In the *Promoting wood energy scenario*, prices in 2030 were usually slightly higher than for the *Reference scenario* (Table 10). Prices for roundwood increased by 2.3% to 3.4% per year, about 0.6% more than the *Reference scenario*. Product prices showed less influence, and increased only by about 0.2% per year. However the projections for the *Promoting wood energy scenario* are probably underestimates as the model reaches a global equilibrium only for industrial wood and its products: the large increase in demand for energy was added in volume terms only, and is not yet integrated into the global price forming process. This strong demand, driven by policy rather than internal model demand drivers, would certainly result in even higher prices throughout the model, notably for wood raw material.

Table 10: Development of roundwood and product prices in Promoting wood energy scenario, 2010-2030

	Unit (2005 USD)	2010	2020	2030	growth rate 2010-2030: Wood energy	growth rate 2010-2030: Reference
sawlogs coniferous	USD/m^3	65	73	103	2.3%	1.8%
sawlogs non-coniferous	USD/m^3	89	112	147	2.6%	2.4%
pulpwood coniferous	USD/m^3	50	61	97	3.4%	2.7%
pulpwood non-coniferous	USD/m^3	51	65	99	3.4%	2.6%
sawnwood	USD/m^3	174	175	203	0.8%	0.6%
panels	USD/m^3	216	234	290	1.5%	1.3%
paper	USD/tonnes	540	566	632	0.8%	0.7%

Source EFI-GTM

The consequences of these projected price developments for the sector as a whole would be higher income for forest owners and others who sell wood. This would encourage and facilitate the mobilisation measures described above, and would discourage waste (as wood is more valuable). It would also increase the profitability of forest management for wood production, and thereby, indirectly, the price of forest land.

3.4.3.4 Discussion

The scenario described above would take the European forest sector into a radically new situation, with fundamental changes in the framework conditions of the sector, notably an emerging scarcity of wood; intense public scrutiny; changed price relationships; and, new industrial actors, including some of the largest companies in the world. Energy supply would become the main objective of the European forest sector, leading inevitably to pressure on the other dimensions of sustainable forest management. These developments would test the resilience of the sector's legal and institutional framework, while bringing with it heavy investment, more profitability, improved technology and a changing power balance between different players in the sector.

In the *Promoting wood energy scenario*, there would be major differences between country groups (Table 11): regions with high forest cover would develop their wood energy capacity strongly, while those areas with few forests or concentrated populations would develop other forms of renewable energy, or import wood-based energy, in the form of pellets, biofuels or electricity, from other parts of Europe or possibly from overseas. Regions with large areas of suitable land would become the focus for developing short rotation coppice and other forms of intensive wood production. Suitable land could be land where growing conditions are good, or land which is of marginal value with few other potential uses, and therefore cheap, making the overall operation profitable.

It cannot be ruled out that the forest sector is simply unable to mobilise the large extra volumes of wood postulated by this scenario: the assumptions underlying the projections are for a fundamental change in attitude to forest management and wood supply, with a high input of political will. There is bound to be opposition from many stakeholders, including conservation organisations and forest industries, perhaps even other types of energy suppliers, not to mention the inertia of the many millions of forest owners whose primary management objective is not income or wood production and who are not dependent on their forests for their livelihood. If this opposition occurs, it will be even harder to mobilise the projected volumes. The targets would have to be revised downward and biomass supplies would have to be sought outside Europe, or from non-forest land. The wood-using industries would see significant constraints on their raw material supplies, or other renewables would have to grow even faster than already planned.

Many would claim that intensive mobilisation of wood for energy would threaten the general balance between the different dimensions of sustainable forest management, which prevails around 2010 (SoEF 2011), and should not therefore be taken as a policy objective. In pursuing this high mobilisation there are certainly risks, notably to biodiversity, nutrient cycles and perhaps to the resilience of forest ecosystems. However, the European forest sector must be seen in its context. If there is sustainable forest management in Europe, but European society as whole remains dependent on non-renewable sources of energy from other regions, can the forest sector be considered sustainable? It is far beyond the scope of EFSOS II to attempt an evidence-based answer to such a wide-ranging question. However, it is clear that the profound changes in the sector, which would be necessary to achieve the targets for renewable energy, should be the subject of an open and comprehensive dialogue between all those concerned, not only the existing stakeholders of the sector, but also those responsible for energy and biodiversity policy. Decisions should, in principle, only be made after a social consensus has been reached on the objectives and constraints in promoting wood energy. Given the rapid changes in energy markets and policy, as well as the increasingly alarming situation for climate change, this dialogue should be given high priority and carried out rapidly.

Table 11: Key forest resource indicators for the Promoting wood energy scenario

		North		Central-West		Central-East		South-West		South-East		EFSOS Total	
	unit	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030	2010	2030
Area of forest	million ha	68.6	69.6	43.5	45.2	34.3	36.7	30.8	35.9	27.7	29.5	204.9	216.9
FAWS	million ha	53.1	52.4	34.1	35.0	32.0	32.8	24.8	27.0	22.7	23.9	166.7	171.1
FNAWS	million ha	15.5	17.2	9.4	10.2	2.3	3.8	6.0	8.9	5.0	5.6	38.1	45.8
Growing stock	million m³	7 280.3	8 335.2	8 533.0	9 745.1	8 003.1	8 758.9	2 278.5	3 026.2	2 947.3	3 139.9	29 042.2	33 005.2
	m³/ha	137.2	159.1	250.0	278.7	250.1	266.7	91.8	112.1	129.9	131.3	174.2	192.9
Increment	million m³/yr	268.7	312.0	293.9	305.7	219.9	222.3	78.1	86.5	53.2	69.0	913.8	995.4
	m³/ha/yr	5.1	6.0	8.6	8.7	6.9	6.8	3.1	3.2	2.3	2.9	5.5	5.8
Fellings	million m³/yr	220.4	252.6	217.9	253.2	158.9	191.0	42.2	47.3	43.2	60.4	682.7	804.5
	m³/ha/yr	4.2	4.8	6.4	7.2	5.0	5.8	1.7	1.8	1.9	2.5	4.1	4.7
Potential stemwood removals	million m³/yr	226.4	241.1	225.4	229.9	190.0	181.3	51.9	53.1	65.0	61.6	758.6	766.9
	m³/ha/yr	4.3	4.6	6.6	6.6	5.9	5.5	2.1	2.0	2.9	2.6	4.6	4.5
Stemwood removals	million m³/yr	204.3	232.7	181.5	211.2	133.4	160.8	38.4	43.2	37.6	52.9	595.1	700.8
	m³/ha/yr	3.8	4.4	5.3	6.0	4.2	4.9	1.5	1.6	1.7	2.2	3.6	4.1
Extracted residues	Tg dry matter/yr	9.7	24.0	7.8	21.4	5.3	15.3	1.5	5.1	1.3	5.5	25.6	71.2
	Mg dry matter/ha/yr	0.18	0.46	0.23	0.61	0.17	0.46	0.06	0.19	0.06	0.23	0.15	0.42
Extracted stumps	Tg dry matter/yr	4.9	20.6	0.1	14.1	0.0	9.8	0.0	2.1	0.0	4.6	5.0	51.2
	Mg dry matter/ha/yr	0.09	0.39	0.00	0.40	0.00	0.30	0.00	0.08	0.00	0.19	0.03	0.30
Carbon in biomass	Tg C	2 873.2	3 310.4	3 234.6	3 663.9	3 033.1	3 321.6	1 066.1	1 419.9	1 300.9	1 383.9	11 507.9	13 099.8
	Mg C/ha	54.1	63.2	94.8	104.8	94.8	101.1	42.9	52.6	57.3	57.9	69.0	76.6
Carbon in soil	Tg C	4 773.6	4 831.9	3 426.0	3 429.6	3 394.8	3 426.9	1 284.1	1 332.5	1 970.0	1 972.8	14 848.6	14 993.6
	Mg C/ha	89.9	92.2	100.4	98.1	106.1	104.3	51.7	49.3	86.8	82.5	89.1	87.6
Standing deadwood	Tg dry matter	49.1	41.1	38.9	39.6	69.1	65.0	9.4	9.6	13.4	12.4	179.9	167.7
	Mg dry matter/ha	0.9	0.8	1.1	1.1	2.2	2.0	0.4	0.4	0.6	0.5	1.1	1.0
Lying deadwood	Tg dry matter	423.0	397.9	586.3	532.5	481.6	481.2	112.1	103.4	148.4	139.6	1 751.4	1 654.6
	Mg dry matter/ha	8.0	7.6	17.2	15.2	15.0	14.7	4.5	3.8	6.5	5.8	10.5	9.7
Total deadwood	Tg dry matter	472.1	439.0	625.2	572.1	550.7	546.2	121.5	113.0	161.8	152.1	1 931.3	1 822.3
	Mg dry matter/ha	8.9	8.4	18.3	16.4	17.2	16.6	4.9	4.2	7.1	6.4	11.6	10.6
Recreational value[1]		6.1	5.9	4.0	4.0	4.1	4.0	5.2	5.0	4.2	4.2	4.7	4.6
Wind vulnerability[2]		2.7	2.6	2.4	2.4	2.5	2.4	2.5	2.4	2.3	2.1	2.4	2.3
Fire vulnerability[2]		2.3	2.3	2.0	2.0	2.0	2.0	2.2	2.2	2.3	2.5	2.2	2.2
Average age	yr	54.3	47	55.9	52.7	55	54.2	46.7	38.2	59.8	56	54.3	49.3

[1] Index 1-10 (10 = most valuable)
[2] Index 1-6 (6 = most vulnerable)

3.4.4 Fostering innovation and competitiveness

3.4.4.1 Introduction

The major challenges facing policy makers and the private sector in fostering innovation and competitiveness were presented in Chapter 2. They are:

- maintaining and improving a positive supporting infrastructure for their forest industries, including physical infrastructure, research and development, good governance, education and training; and,
- involving wood using industries when drawing up forest sector policy, ensuring that wood supply matches industry's needs in volume, quality and price, while taking full account of all dimensions of sustainable forest management.

The *Fostering innovation and competitiveness scenario* explores the consequences for the sector of a successful strategy of innovation, leading to improved competitiveness. The projection methods used for the other scenarios are not appropriate here, as, by definition, the technical and cost relationships used to construct the projections cannot be assumed to remain unchanged in a more innovative future. The scenario is therefore based on qualitative reasoning only. There is a high degree of uncertainty in analysing the outlook for innovation, which, by definition, changes the fundamental ways in which the sector works.

3.4.4.2 Innovations which might influence the forest sector

There are essentially four[7] types of innovation:

- Product innovation, which involves a good or service that is new or significantly improved.
- Process innovation, which involves a new or significantly improved production method or system to deliver the products.
- Marketing innovation, which involves a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.
- Organisational innovation, which involves introducing a new organisational method in the firm's business practices, workplace organisation or external relations.

The process of implementing innovation is sometimes seen as incorporating three steps:

1. Best available technology (BAT): to obtain many permits to operate plants in the EU, it is compulsory to use the BAT approach.
2. Emerging technology: technologies that are likely to be ready and commercially available in 5 to 10 years, with significant development work already undertaken.
3. Breakthrough technology: technology that is still at the conceptual stage, with no prototype, no pilot, no demonstration model yet in place.

The main innovations which could have an impact on the forest sector, according to an informal brainstorming meeting in January 2011, are summarised below.

[7] *This list, which appears in many international studies, seems to be based on a list by Schumpeter published in 1911. Schumpeter however added a fifth: development of new raw materials (Poss, 2011). It could be said that EFSOS II, like its predecessors, is about developing new sources of raw material.*

3.4.4.2.1 Innovation in the sawnwood and panels sector

There has been considerable innovation in recent years to develop new types of combined product, with improved technical features, and lower raw material and processing costs. These are known as Engineered Wood Products, and have helped wood-based products become more competitive in many market sectors. There is clearly potential for more innovation here, not only at the level of particular products, but also as integrated systems, providing better technical performance with faster installation because of prefabrication, leading to considerably lower costs. Most prefabrication systems at present address new construction, but there is an opportunity to develop systems for the use of prefabricated forest products in renovation and reconstruction. This type of construction is growing faster than new residential construction and has traditionally been a strong consumer of forest products, which are often better adapted to renovation.

3.4.4.2.2 Innovation in the pulp and paper sector

Pulp and paper have been competing with highly innovative sectors for many years, especially in the field of communication, where television, internet, e-mail and e-books have all taken market share from paper products. However, although the growth of the competitors has been faster than that of paper, the latter has continued to grow over the long term[8], showing remarkable resilience, and innovative capacity, often in the process field.

The sector at present sees two main routes for innovation:

- Continue to produce the current range of goods, improved but not transformed, more efficiently than in the past.
- Develop new products for new uses.

Under the first route – organic improvement – the following show promise:

- Improved paper machines will better orient the wood fibres in the paper furnish better and cut down the energy needs.
- Altering the orientation of papermaking machinery: using vertical equipment, rather than long horizontal production lines, could achieve energy savings, as well as savings in term of the space or land requirements for such equipment.

[8] *An exception is newsprint, and some other graphic grades in North America, which seem to be on a long term downward trend.*

- Improved processes to sort and treat recycled fibre.
- Nanotechnology to improve both the quality and performance of the product and the efficiency of the papermaking process itself.
- More efficient drying which would reduce energy use, and therefore production costs, significantly.

The second route – radically new products - of necessity involves technical speculation, especially as those who develop totally new products do not usually advertise their ideas until the new products are ready for market. Some possible new products for new uses are listed below:

- Paper with capacity for conducting or storing electricity, such as paper batteries or wall paper which can store electricity, even a laptop based on recycled paper, incorporating the positive qualities of paper (flexibility, printability, light weight, recyclability and reduction of e-waste, possible links to micro-generators) into IT products.
- Packaging which indicates when the contents are past their 'use by' date, or when they are ready for consumption (heat sensitive).
- 'Intelligent paper', which interacts with the user by delivering additional and timely information (e.g. when a particular pharmaceutical has been used, temperature or past temperature of contents)

3.4.4.2.3 Bio-refineries and other non-traditional approaches

It has been known since at least the 1930s that the chemical industry could use wood as a feedstock for a wide range of chemical products[9]. However, with the exception of dissolving pulp, there has until now been no significant development of wood-based chemicals, notably because of the availability of cheap oil, which makes an excellent feedstock. World-wide the petrochemical industry processed about 90 million tonnes of oil based feedstock in 2008 (IEA). However, the changes in relative prices of renewable and non-renewable feedstocks, and technical progress, have re-kindled interest in so-called 'bio-refineries' to derive a wide range of commodity and specialty chemicals from wood, including its components such as lignin, or other biomass. It is not possible here to summarise the variety of possible 'pathways' in bio-refineries, nor list the possible outputs. For an overview, readers are referred to the appropriate parts of the Forest-Based Sector Technology Platform (FTP), notably the FTP Strategic Research Agenda, in particular research areas 1-7: Moving Europe with the aid of biofuels, 1-8 Pulp, energy and chemicals from wood bio-refinery, and 1-9: 'Green' specialty chemicals. (FTP, 2006)

There are already a very small number of bio-refineries in operation, most, but not all, as pilot projects. In most cases, they are replacing, from the wood supply point of view, existing pulp mills, so that the total demand for wood is not significantly increased by the new installations. If they live up to expectations, the profit margin will be considerably higher than for pulp, because higher prices can be demanded for speciality chemicals than for commodity grades of pulp. In at least one case (Domsjö in Sweden), the wood based bio-refinery is part of a 'cluster' of high tech industries (chemicals, energy, pharmaceuticals), which are not all part of the same company.

The potential for bio-refining to influence the shape of the forest sector is huge and is still uncertain. There is no single over-riding concept for the bio-refinery, the technical outcomes of the research are not yet available, and the profitability of the whole enterprise is heavily influenced by the price of alternative feedstocks, notably oil.

3.4.4.2.4 Innovation in forest management

Innovation is usually seen as part of the downstream end of the forest sector, but there could be innovation also in forest management. This might include:

- Developing and marketing new forest based services, linked to recreation, such as adventure playgrounds, visits focused on certain species or experiences.
- Developing and marketing forest ecosystem services, such as clean water or carbon sequestration.
- Improving marketing of wood, for instance through associations or cooperatives of forest owners, or through developing very local markets.
- Developing new markets for non-wood goods.

3.4.4.3 Description of Fostering innovation and competitiveness scenario

What changes would be expected from the *Reference scenario*, if the European forest sector successfully implements the *Fostering innovation and competitiveness scenario* and becomes more competitive than it would be in the *Reference scenario*? The assumptions and possible future developments under this scenario are outlined below.

[9] *See for instance The Coming Age of Wood by Egon Glesinger, first director of the UNECE/FAO Timber Division, published in 1949*

3.4.4.3.1 Basic assumptions

All parts of the forest sector in Europe become successful innovators and are able to implement their ideas.

Innovation which starts in Europe disseminates to other parts of the world, so Europe does not develop a permanent competitive advantage over other regions.

Innovation influences products, manufacturing processes, business models and communication.

Framework conditions for successful innovation are put in place and maintained, so that innovation becomes a permanent feature of the forest sector in Europe.

3.4.4.3.2 Consumption and markets

Wood based systems gain a large market share of renovation. Product durability is greatly increased, and waste in manufacturing and use is reduced even further. The image of wood based materials is transformed, in a world which is truly aware of the importance of sustainability. Companies engage in massive direct-to-public marketing campaigns.

European paper producers retreat from commodity graphic grades, but develop a wide range of 'smart' applications, in packaging, health care and elsewhere (some of which may not be 'paper' as we know it), which are much more differentiated and value added, and profitable, even if volume growth is small or even negative.

In an energy sector dominated by renewables, wood, as a flexible, local, renewable source has developed a wide range of fuel types which are convenient and good value for money, but coexists well with other renewables. There is a wood energy source for all uses, small/large, direct combustion/CHP/transport fuels, chips/pellets/4th generation biofuels etc. Wood burning systems have been developed for every situation which are as convenient as systems for oil/gas/electricity are now. Wood-based biofuels are used for transport and wood burning CHP plants are the standard source of heat and electricity in forest rich rural areas all over Europe.

There is strong demand for a wide range of specialty chemicals, which can be made from different feedstocks. Wood has an advantage over competing feedstocks because of its renewability and because the price of oil and gas has risen strongly.

3.4.4.3.3 Production and industry

The newly developed wood based building systems, although extremely practical, are bulky and expensive to transport, so production stays in Europe. There are so many and varied combinations of sawnwood and different wood based panels, that in practice, the distinctions between these products become meaningless.

The remaining commodity grades of paper are imported from areas where trees grow faster, along with some pulp (to be used with recovered paper from Europe). European paper manufacturing has become even more sophisticated technically and differentiated, so a given specialty paper product is only produced on one or two sites. Volume of production does not grow, or perhaps drops, but value added is much greater than in the *Reference scenario*. The manufacturing pattern is determined essentially by the business strategies of large companies, many of which are centred around non-forest products, such as energy, pharmaceuticals, food or cosmetics.

The large flow of wood energy from other continents which emerged around 2010 disappeared when the environmental and economic costs of this transport become obvious, and most energy wood used in Europe originates there. A sophisticated energy infrastructure has been put in place (dominated by former pulp companies) to handle wood supply (from forests, landscape care, industry, consumers, etc.), processing and distribution of the energy products. There is no waste of wood at all.

Bio-refineries of different size and technical profile produce a wide range of 'new' products, with no single dominant market or customer. Wood components (cellulose, lignin etc.) are the basis, sometimes in combination with oil based or other materials, for products, whose success does not depend on the cheapness of the raw material but on the technical and marketing (customer oriented) qualities of the final product. The wood raw material is not the major cost factor, but it is important that it is available in the right quality and quantity.

3.4.4.3.4 Prices

There is stiff competition in the building materials markets, preventing increase in profit margins for any material. The price premium for the new combined systems, and thus for sawnwood and panels, is limited.

The relative prices of commodity paper grades fall, but specialities, if successful, are able to charge a large price premium.

'New' products, such as specialty chemicals, are profitable, as a product will not be developed if there is not a profitable market for it. Margins are much higher than those of the traditional forest sector (but costs, especially capital costs, are very high, and many new products fail, so there is more risk for investors)

The strong demand for energy wood has already put a floor under the market price for wood, as the minimum price of wood is determined by its energy content. All sectors using wood as a raw material have to pay a premium over the energy price which is expected to rise steadily in the long term.

3.4.4.3.5 Innovative forest management

Under the conditions of this scenario, marked essentially by higher prices for wood and forest products, and an increasing scarcity of land in Europe (due to rising demand for energy, food and biodiversity, as well as still expanding urban settlements), the price of land could rise steeply. As there is now potential for high income from forest land, the inactive forest owner becomes a thing of the past as does low value rural land. Forest owners, public or private, compete and specialise to provide wood, biodiversity, ecosystem services or recreational opportunities (or combinations of these[10]). All of these demands are turned into economic demand, notably by much improved PES systems. Potential income from rural land (the distinction between agricultural and forest land becomes blurred) rises strongly as the need for sustainability makes it unacceptable and unaffordable for Europe to export its 'footprint' to other parts of the world.

There are many types of forest recreation which have the potential to provide higher income per ha than wood production, if developed in an innovative way: sport; riding (horses, bikes, motorbikes); hunting; culture (concerts); eco-tourism; silence/darkness[11]; adventure; paintball etc. This applies to public and private owners, and represents a real entrepreneurial opportunity. The only condition is that owners have the legal right to charge an entrance fee or for the service provided. Under the *Fostering innovation and competitiveness scenario*, these opportunities would be taken.

Whether or not forest managers change their practice to maximise their income from carbon sequestration depends on the emerging climate change regime and the resulting price for carbon. If the new climate change regime proposes sufficient rewards for carbon sequestration in forests, owners will adapt their silviculture. The *Maximising biomass carbon scenario* explores how this might be achieved, if maximising carbon in forests was the over-riding policy goal. Under the *Fostering innovation and competitiveness scenario*, forest owners would choose between management objectives, mostly as a function of the economic attractiveness of the various options.

PES could increase forest owners' income and influence their management choices. For this to happen, considerable system innovation will be necessary, setting up viable payment structures and developing new 'rules of the game'. This is an area where policy makers will have to take the lead if there is to be significant change. For instance, system innovation is needed to find real 'markets' where a provider and a purchaser of an ecosystem service can be identified, as the basis for a financial transaction. Innovation will also be needed on the legal side and to set a fair price.

3.4.4.4 Framework conditions for innovation

Many conditions must be satisfied to encourage successful innovation, and these are the subject of much research. Some of the main features of an innovation friendly environment (adapted from Coyle and Childs, 2008) are:

- A good science and knowledge base, with capable research institutes, and good networks.
- Excellent physical infrastructure (transport, communication, internet, housing etc.).
- An educated and skilled workforce.
- Sound intellectual property rules and institutions.
- Entrepreneurship.
- Flexibility of organisation and regulation.
- Access to capital, whether venture capital, loaned or internally generated.
- Open markets.
- Appropriate product standards (i.e. performance based, not prescriptive).
- Access to marketing and communication.
- Culture which welcomes and rewards innovation.

[10] *For instance, mountain areas would supply a very profitable mix of protective services, biodiversity and concentrated recreation facilities. In more remote, less visually attractive areas, the focus would be on wood for energy and raw material, with local focus on recreation and biodiversity. Peri-urban forest would be (as now) exclusively devoted to the provision of recreation, but the range of types of experience offered would be wider, more intensive in land use, and more profitable (unlike now, when walking in open access forest is the dominant form of recreation). Biodiversity supply would be coordinated at a continental scale, not only protecting special areas, but considering fragmentation and corridors for migration of fauna, including pollinators and large predators.*

[11] *The UK Forestry Commission already organises forest nights to observe stars away from the light pollution of cities.*

None of these is sufficient by itself to promote innovation: all must be addressed. With a few exceptions, the culture of the forest sector has stressed prudence and sustainability over innovation and risk taking, so the development of a truly innovative culture in the forest sector will require fundamental changes in attitude from many of the actors in the sector. This new innovative spirit must not of course damage the long standing concern for sustainability which characterises the European forest sector at present.

Policy makers play an essential role in creating an environment which promotes innovation. The Organisation for Economic Co-operation and Development (OECD) has identified a number of 'Policy principles for innovation' (OECD, 2010). The main measures recommended by OECD are in the realms of empowerment (skills, flexibility, employment policy, facilitating organisational change, consumer participation, entrepreneurial culture), framework conditions conducive to innovation, mobilisation of private funding, open markets, public investment in reseach, providing an excellent knowledge infrastructure, networks and markets, improved delivery of public services, better scientific and technological cooperation, a flexible and predictable policy regime, encouraging entrepreneurship at all levels and putting innovation policy at the centre of government.

These principles are not specific to the forest sector, but policy makers in the sector should consider which of these measures can be applied at the level of the sector, and advocate 'innovation-friendly' policies for the society as a whole. Examples of specific forest sector measures are: vocational training in forest related areas; dedicated research institutes, with adequate resources; sector-specific organisations with flexible and appropriate structures; access to finance for new forest sector firms; rapid diffusion of best practice inside the sector; open markets for wood and forest products; investment in public forest related research; excellent knowledge infrastructure for the sector; and, innovative state forest organisations.

Recently the FTP circulated a draft vision for the sector in 2030, which outlines the main strategic directions which might be followed (FTP, 2010).

3.4.4.5 Possible consequences of the scenario for the forest sector

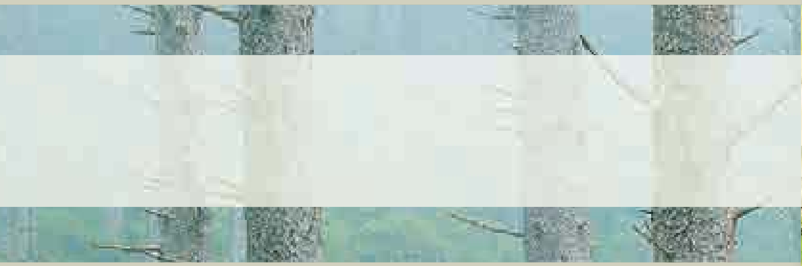
Table 12, which is based on the reasoning of earlier sections, without any quantitative analysis, shows the possible direction and magnitude of changes in the main parameters in the *Reference scenario*, with very brief explanations.

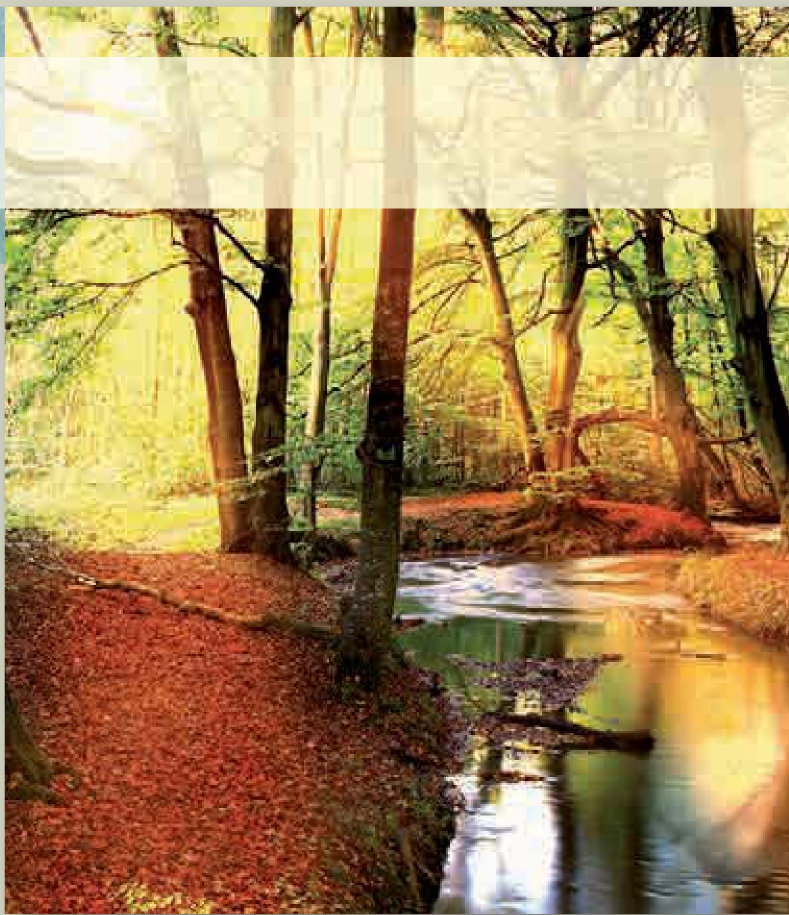
Table 12: Possible differences between the Fostering innovation and competitiveness scenario and the Reference scenario, 2030.

	Sawnwood	Panels	Paper	Energy wood	"New products"
Consumption in Europe	+/0 (wood based systems gain market share, commodity grades lose)	+/0 (wood based systems gain market share commodity grades lose)	0 (more value added grades, fewer commodity grades)	++ (innovative fuels and processes, as well as marketing)	+++ (main focus of innovation, strong customer orientation)
Production in Europe	+/0 (new systems require production close to markets)	+/0 (new systems require production close to markets)	0/- (Most innovative grades and processes based in Europe, others shift to areas with better growth conditions)	++ (Scale and transport costs mean the new wood based fuels will not be traded over long distances)	+++ (production and end uses will develop together, so the new products will be both produced and consumed in Europe)
Prices	+ (constrained by competition with other materials)	+ (constrained by competition with other materials)	-/+ (High prices for innovative products in their specialised niches, others under severe pressure)	++ (will follow general energy trends)	++ (As the new products will dominate their market niche, prices will rise)

In the *Fostering innovation and competitiveness scenario*, the sector would be more dynamic, more fast moving and more profitable, but what would be the consequences for the supply/ demand balance for wood? It is possible to speculate along the following lines:

On the one hand, in this scenario, production of traditional products in Europe would be at the same level as the *Reference scenario* or slightly higher, while new products and biofuels would be significantly higher. However, innovation would be expected to lead to more efficient use of raw





material and less wood consumption for a given purpose. Total demand for wood in volume terms might not be much higher than in the *Reference scenario*, although prices could be higher. Furthermore, if economic conditions are properly aligned, notably by the widespread implementation of PES, high innovation in the wood using industries need not lead to an exclusive focus on wood supply by forest owners. For instance if good income is available for supplying recreation, carbon sequestration or ecosystem services, wood supply need not become the over-riding function of many forests. However if PES is not implemented, the *Fostering innovation and competitiveness scenario* would lead to an even stronger focus on wood supply, because of the higher wood prices on offer. Also, the new uses, notably bio-refineries, might have specific requirements regarding size, species etc. that differ from those of the present wood buyers, leading in the long term to changed management, and in the short term to changing structures in the wood market. However, as the different bio-refineries would not have the same product profile, this would not mean uniform forests all over Europe.

The overall supply/demand balance for wood might be tighter than in the *Reference scenario*, but not to the same extent as in the *Promoting wood energy scenario*. In the *Fostering innovation and competitiveness scenario*, demand is driven by innovation and is therefore sensitive to cost. In this scenario, a rise in wood price due to tightening supply would certainly slow, or even halt, the innovation processes which drive the scenario. This is not the case for the *Promoting wood energy scenario*, which is driven by policy objectives.

4

Assessing the sustainability of the outlook for the European forest sector

4.1 Introduction

Chapter 3 has presented a Reference scenario and four policy scenarios, describing possible outlooks according to different assumptions. These have shown in particular, the consequences of certain strategic policy choices. But are these projected outcomes truly sustainable? This chapter attempts to answer that question, using the framework of the FOREST EUROPE criteria and indicators of sustainable forest management.

SoEF 2011 has developed an approach to assessing the sustainability of forest management, based on 'key parameters' for each of the quantitative and qualitative indicators, assessing performance for each key parameter and combining these assessments at the country-group and criterion level, to obtain an overall assessment. This approach is still experimental, and certainly needs further development and discussion. However, initial results are positive. Ideally, it would be desirable also to apply the approach used for the present SoEF 2011 to the various alternative futures, and thereby to assess the sustainability of each scenario. This is not possible because, in the present situation, the scenarios are not detailed enough to provide the information for all 50 key parameters, nor are the methods of deriving key parameters from scenario variables reliable in all cases. Nevertheless, it is of great importance to investigate the sustainability of the proposed alternative futures, from all angles, not only those used to construct the scenario.

For this chapter therefore a limited choice of key parameters has been selected, coinciding to the extent possible with those used for SoEF 2011. Using the best available methodology, estimated trends for these parameters are made for the various alternative futures. The aim is to say something about five of the six quantitative criteria[12], listed below. All parameters are based on numerical outcomes of parts of the model system applied by EFSOS II. However, some parameters used are still experimental and may be considered less reliable than others. The essential feature has been to address all major dimensions of sustainability, not only for wood supply.

4.2 Methodology for assessing sustainability of scenarios

FOREST EUROPE distinguishes 6 criteria of sustainable forest management: C1: Forest resource and global carbon stocks; C2: Health and vitality; C3: Productive functions; C4: Biodiversity in forest ecosystems; C5: Protective functions; and, C6: Socio-economic functions. Each of these criteria contains a set of indicators, which allows an assessment of that criterion. In SoEF 2011, a methodology was developed to assess these indicators as objectively as possible, with the final

[12] No key parameters have been developed for C5: Protective functions, as data on which to base such an assessment are rather weak (the SoEF 2011 assessment was based on availability of information rather than outcomes), and there is no reason to believe that the protective functions of European forests would be significantly changed under any of the scenarios.

purpose of combining these assessments in an overall sustainability assessment. A key parameter was selected for each indicator. Each parameter was assigned a score from 1 to 5[13], depending on the respective thresholds defined. The assignment was done on a country basis, but the results were presented only at the country group level. For the sustainability assessment in EFSOS II, those parameters were selected that could be quantified from the model system. Some new parameters were also included in the analysis. In the end, 16 parameters were included in the sustainability assessment, covering 5 of the 6 criteria. Table 13 presents the final parameter set used in EFSOS II, as well as the thresholds applied and the exact data source used within the model system. When parameters were exactly the same as in SoEF 2011, the thresholds were retained. Thresholds for other parameters were defined based on the range of values occurring, and so that a score of 3 would coincide with stable conditions. A major difference with SoEF 2011 is that most of the parameters were evaluated on their development (2010-2030), rather than on their state in a particular year. Assessment of country group scores was done in EFSOS II on the average values of the parameters for the group, rather than on weighted averages by total land area, as was the case in SoEF 2011. Scores by criterion were obtained by simply averaging the scores per parameter within that criterion. This means that all indicators get an equal weight in the final score for each criterion. As in SoEF 2011, there is no final overall sustainability assessment, as users may prefer to attach different weightings to different criteria.

[13] *SoEF 2011 uses a tree symbol in the table to represent the score 1 to 5, where 5 trees indicates the highest threshold.*

Table 13: Key parameters used to assess sustainability of scenarios

Relates to FOREST EUROPE indicator	Key parameter	Unit	Thresholds					Data sources
			1	2	3	4	5	
1.1	annual change in forest cover	%	< -0.2%	-0.2% - 0.0%	0.0 - 0.1%	0.1 - 0.2%	> 0.2%	forest area (EFISCEN), total land area (SoEF 2011)
1.2	annual change in growing stock/ha	m³ha	< -1.0	-1.0 - 0.0	0.0 - 1.0	1.0 - 3.0	> 3.0	EFISCEN
1.4	annual change in living carbon stock/ha	tonnes C/ha	< -1.0	-1.0 - 0.0	0.0 - 1.0	1.0 - 3.0	> 3.0	EFISCEN
1.4	annual change in soil carbon stock/ha	tonnes C/ha	< -1.0	-1.0 - 0.0	0.0 - 1.0	1.0 - 3.0	> 3.0	EFISCEN
2.4	fire vulnerability/ha in 2030	index/ha	> 4.0	2.5 - 4.0	2 -2.5	1.5 - 2.0	< 1.5	EFISCEN
2.4	wind vulnerability/ha in 2030	index/ha	> 4.0	2.5 - 4.0	2 -2.5	1.5 - 2.0	< 1.5	EFISCEN
3.1	ratio fellings/NAI, 2025-2030	%	> 100%	95% -100	n.a.	<95%	n.a.	EFISCEN
3.2	annual change in ratio of value of marketed roundwood/growing stock	EUR/1000 m³	< -20	-20 - 0	0 - 20	20 - 40	> 40	value of roundwood (EFI-GTM), growing stock (EFISCEN)
4.5	annual change in quantity of deadwood/ha	t dry matter/ha	< -0.2	-0.2 - 0.0	0.0 - 0.1	0.1 - 0.2	> 0.2	EFISCEN
4.9	FNAWS in 2030 as percentage of total forest area	%	< 5%	5% - 10%	10% - 20%	20% - 40%	> 40%	EFISCEN
	change in share of forest stands >100 years of age	%	< -0.2%	-0.2% - 0.0%	0.0 - 0.1%	0.1 - 0.2%	> 0.2%	EFISCEN
6.2	annual change in share of GDP taken by forest sector	%	< -0.1%	-0.1% - 0%	0% - 0.1%	0.1% - 0.2%	> 0.2%	total added value in forest sector (EFI-GTM), GDP (scenario assumption)
6.7	consumption of wood products (RWE) per capita in 2030	m³/capita	< 0.45	0.45 - 0.8	0.8 - 1.6	1.6 - 2.9	> 2.9	consumption of wood products (EFI-GTM), population (scenario assumption)
6.8	net import as percentage of apparent consumption in 2030	%	> 65%	20% - 65%	-20% - 20%	-70% - -20%	< -70%	EFI-GTM
6.9	wood energy use (RWE) per capita in 2030	m³/capita	< 0.45	0.45 - 0.8	0.8 - 1.6	1.6 - 2.9	> 2.9	consumption of wood used for energy (EFI-GTM), population (scenario assumption)
6.10	recreational value/ha in 2030	index/ha	< 3.5	3.5 - 4.0	4.0 - 4.5	4.5 - 5.0	> 5.0	EFISCEN

4.3 Analysis of the sustainability of the scenarios

4.3.1 C1: Forest resource and global carbon stocks

This criterion covers four parameters, all derived from simulations using the EFISCEN model.

Forest cover has been expanding gradually in the whole EFSOS region and is expected to continue to do so in all scenarios. In South-West Europe, expansion is considerably faster than in the rest of Europe.

The growing stock per ha is increasing under all scenarios and in all regions, but at different rates. North, South-West and South-East Europe show no differences between the scenarios, with South-East Europe showing lower growth rates. This might partly be caused by weak input data for this region. The *Priority to biodiversity* and *Maximising biomass carbon scenarios* show faster increases in growing stock than the *Reference scenario* and the *Promoting wood energy scenario* in Central Europe. For the whole EFSOS region, growing stock per ha grew more slowly in the *Promoting wood energy scenario* than in the other scenarios.

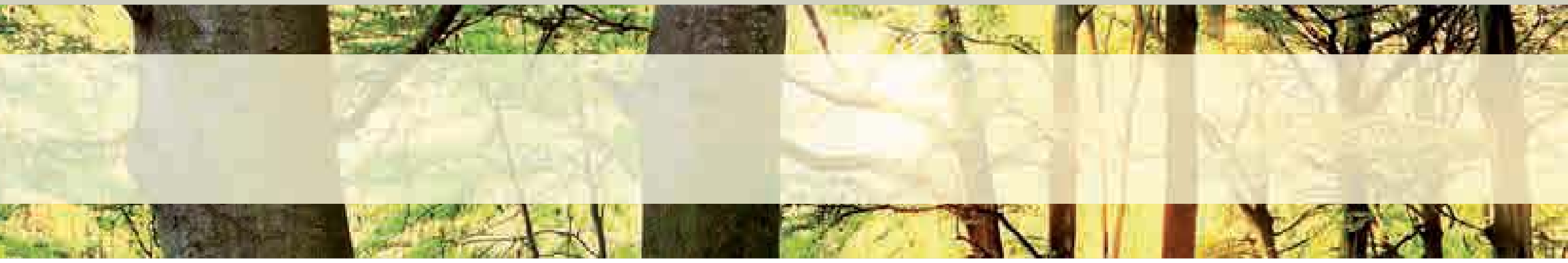
Carbon stored in biomass is very much correlated with the growing stock, but due to relatively higher thresholds, most regions and scenarios score 3. Only Central-West Europe scores better in the *Priority to biodiversity scenario* and the *Maximising biomass carbon scenario*.

Soil carbon stocks are slightly decreasing in all scenarios and in all regions. An exception is North Europe for all scenarios, and Central-West Europe for the *Priority to biodiversity scenario* and *Maximising biomass carbon scenario*. Trends in soil carbon development may well be influenced by the assumptions made in the EFISCEN model, on how much soil carbon is already present, and thus differences between scenarios should be seen as more reliable than the absolute trends.

Averaged over all parameters, North, South-West and South-East Europe show no differences between the scenarios with regard to Criterion 1: Forest resources and carbon stocks (Table 14). In Central Europe, especially in Central-West Europe, the *Priority to biodiversity* and *Maximising biomass carbon scenarios* score better than the *Reference scenario* and the *Promoting wood energy scenario*. Over the whole EFSOS region, the *Promoting wood energy scenario* scores a bit lower than the other three scenarios, reflecting the strain put on the resource by the very high level of extraction in that scenario.

Table 14: Scores for C1: Forest resource and global carbon stocks

		reference	carbon	biodiversity	wood energy
Annual change in forest cover	North	3	3	3	3
	Central-West	3	3	3	3
	Central-East	3	3	3	3
	South-West	5	5	5	5
	South-East	3	3	3	3
	EFSOS total	**3**	**3**	**3**	**3**
Annual change in growing stock/ha	North	4	4	4	4
	Central-West	4	5	5	4
	Central-East	3	4	4	3
	South-West	4	4	4	4
	South-East	3	3	3	3
	EFSOS total	**4**	**4**	**4**	**3**
Annual change in living carbon stock/ha	North	3	3	3	3
	Central-West	3	4	4	3
	Central-East	3	3	3	3
	South-West	3	3	3	3
	South-East	3	3	3	3
	EFSOS total	**3**	**3**	**3**	**3**
Annual change in soil carbon stock/ha	North	3	3	3	3
	Central-West	2	3	3	2
	Central-East	2	2	2	2
	South-West	2	2	2	2
	South-East	2	2	2	2
	EFSOS total	**3**	**3**	**3**	**2**
C1: Forest resources and carbon	North	3.3	3.3	3.3	3.3
	Central-West	3.0	3.8	3.8	3.0
	Central-East	2.8	3.0	3.0	2.8
	South-West	3.5	3.5	3.5	3.5
	South-East	2.8	2.8	2.8	2.8
	EFSOS total	**3.3**	**3.3**	**3.3**	**2.8**



4.3.2 C2: Health and vitality

The SoEF 2011 parameters in criterion C2: Health and vitality, are not directly covered by the EFSOS model framework, since they relate to the impact of disturbance agents. However, EFISCEN generates two indicators that express the vulnerability of the stand structure to fire and wind (Schelhaas *et al.,* 2010). Both indicators are based on the area covered by different tree species and age-classes. For wind, the index of vulnerability is lowest for young trees and broadleaved trees, and highest for old coniferous stands. For fire, the index is highest in young, coniferous stands, and is lowest in old, broadleaved stands. It must be noted that these indicators are still rather experimental, and only give an indication of the vulnerability at a national scale. In particular, the fire indicator lacks information on the spatial arrangement of stands, and on fuel build-up within the stands. Furthermore, it must be stressed that direct effects of climate change are not incorporated in these indicators, they purely give an indication of the vulnerability of the forest which has developed along the lines projected by EFISCEN, assuming today's climate.

The fire vulnerability index is highest in South-West Europe, and lowest in Central-West and Central-East Europe with their rather high share of older forests. There is no difference between the scenarios, except for a slight improvement in South-West Europe in the *Priority to biodiversity scenario*. The scores for wind vulnerability show the opposite pattern to that for fire vulnerability. A higher proportion of old stands leads to increased wind vulnerability and thus to lower scores. In particular, the *Priority to biodiversity* scenario and the *Maximising biomass carbon scenario* have higher proportions of old stands, leading to lower scores for wind vulnerability in Central-West and Central-East Europe. Overall, only the *Priority to biodiversity scenario* shows increased wind vulnerability, and thus also a lower score for the criterion as a whole (Table 15).

The total scores are obtained simply by averaging the two underlying parameters. However, the importance of the disturbance agents is clearly different in the different regions in Europe. Central-West Europe and North Europe are more likely to be affected by wind, while in South-West and South-East Europe fire is more prevalent. The final assessment of the scores for these regions should take these aspects into account.

Table 15: Scores for C2: Health and vitality

		reference	carbon	biodiversity	wood energy
Fire vulnerability/ha in 2030	North	3	3	3	3
	Central-West	4	4	4	4
	Central-East	4	4	4	4
	South-West	2	2	3	2
	South-East	3	3	3	3
	EFSOS total	**3**	**3**	**3**	**3**
Wind vulnerability/ha in 2030	North	2	2	2	2
	Central-West	3	2	2	3
	Central-East	3	2	2	3
	South-West	4	4	4	4
	South-East	3	3	3	3
	EFSOS total	**3**	**3**	**2**	**3**
C2: Health and vitality	North	2.5	2.5	2.5	2.5
	Central-West	3.5	3.0	3.0	3.5
	Central-East	3.5	3.0	3.0	3.5
	South-West	3.0	3.0	3.5	3.0
	South-East	3.0	3.0	3.0	3.0
	EFSOS total	**3.0**	**3.0**	**2.5**	**3.0**

4.3.3 C3: Productive functions

The ratio between fellings and increment is the first parameter in C3 Productive functions, and is derived from the EFISCEN simulations. Although a few individual countries show a ratio of fellings over net annual increment of more than 100%, all regions show a level below 95% for all scenarios.

The second parameter concerns the ratio between the value of marketed roundwood and the growing stock, and is not available for all scenarios: the value of marketed roundwood is derived from the EFI-GTM simulations, while the growing stock is taken from EFISCEN. As EFI-GTM was only applied to the *Reference scenario* and the *Promoting wood energy scenario* the value of marketed roundwood was not available for the

Priority to biodiversity scenario and the *Maximising biomass carbon scenario*. However, total felling volume was the same in the *Maximising biomass carbon scenario* as in the *Reference scenario*, so the value of marketed roundwood was taken from the *Reference scenario*. On the other hand, the felling level in the *Priority to biodiversity scenario* was reduced considerably, so assessment of the value of marketed roundwood was not possible without EFI-GTM, and this indicator is not available for the *Priority to biodiversity scenario*. Under the *Reference scenario*, the whole EFSOS region shows an increase in prices and marketed roundwood volume, leading to a score of 4. North and Central-East Europe have higher than average increases in this ratio. Marketed roundwood value is the same under the *Maximising biomass carbon scenario*, but the increase of growing stock is higher, leading to lower scores than the *Reference scenario*. The *Promoting wood energy scenario* couples increased value of marketed roundwood, due to higher prices and higher fellings, with slightly lower growing stock volumes. Scores therefore increase in most of the regions.

Overall for the C3 Productive functions, the *Maximising biomass carbon scenario* scores slightly lower than the *Reference scenario* and the *Promoting wood energy scenario*. North and South-West Europe in particular show relatively high improvements in the productive functions in all scenarios (Table 16).

Table 16: Scores for C3: Productive functions

		reference	carbon	biodiversity	wood energy
Ratio fellings/NAI, 2025-2030	North	4	4	4	4
	Central-West	4	4	4	4
	Central-East	4	4	4	4
	South-West	4	4	4	4
	South-East	4	4	4	4
	EFSOS total	**4**	**4**	**4**	**4**
Annual change in ratio of marketed roundwood/growing stock	North	4	4	NA	5
	Central-West	3	3	NA	4
	Central-East	4	4	NA	4
	South-West	3	3	NA	3
	South-East	3	3	NA	4
	EFSOS total	**4**	**3**	**NA**	**4**
C3: Productive functions	North	4.0	4.0	NA	4.5
	Central-West	3.5	3.5	NA	4.0
	Central-East	4.0	4.0	NA	4.0
	South-West	3.5	3.5	NA	3.5
	South-East	3.5	3.5	NA	4.0
	EFSOS total	**4.0**	**3.5**	**NA**	**4.0**

4.3.4 C4: Biodiversity in forest ecosystems

Indicators for C4 Biodiversity in forest ecosystems are exclusively derived from EFISCEN simulations. Deadwood quantities are slightly decreasing in all regions and scenarios, except for the *Priority to biodiversity scenario* in the case of Central-West Europe. The decline of deadwood is likely to be influenced by the structure of the model. However, the formation of deadwood is likely to become less with increasing felling activities and extraction of residues.

The development of FNAWS is the same in the *Reference scenario*, *Promoting wood energy scenario* and the *Maximising biomass carbon scenario*. Only in the *Priority to biodiversity scenario* did this area increase. In Central-West and South-East Europe, this increase is sufficient to bring the region into a higher assessment group. Overall, this does not lead to a different score for the whole EFSOS region for this indicator, mainly because of the relatively large classes for this parameter. Central-West Europe clearly has less area in the FNAWS category than the other regions.

The share of old forest is decreasing in all scenarios, except for the *Priority to biodiversity scenario*. The major decreases are in North Europe and South-West Europe, even in the *Priority to biodiversity scenario*. In the other regions, both the *Maximising biomass carbon scenario* and the *Priority to biodiversity scenario* have a positive effect. Overall, the *Priority to biodiversity scenario* scores slightly higher than the other scenarios for C 4 (Table 17).

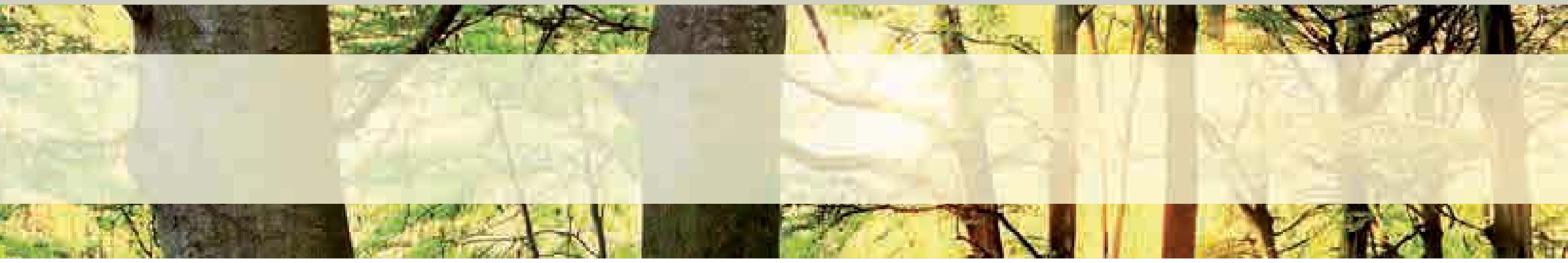


Table 17: Scores for C4: Biodiversity in forest ecosystems

		reference	carbon	biodiversity	wood energy
Annual change in quantity of deadwood/ha	North	2	2	2	2
	Central-West	2	2	3	2
	Central-East	2	2	2	2
	South-West	2	2	2	2
	South-East	2	2	2	2
	EFSOS total	**2**	**2**	**2**	**2**
FNAWS in 2030 as percentage of total forest area	North	4	4	4	4
	Central-West	2	2	3	2
	Central-East	4	4	4	4
	South-West	4	4	4	4
	South-East	3	3	4	3
	EFSOS total	**4**	**4**	**4**	**4**
Change in share of forest >100 years of age	North	1	1	2	1
	Central-West	2	4	3	2
	Central-East	3	4	5	3
	South-West	1	1	1	1
	South-East	3	4	3	3
	EFSOS total	**2**	**2**	**3**	**2**
C4: Biodiversity in forest ecosystems	North	2.3	2.3	2.7	2.3
	Central-West	2.0	2.7	3.0	2.0
	Central-East	3.0	3.3	3.7	3.0
	South-West	2.3	2.3	2.3	2.3
	South-East	2.7	3.0	3.0	2.7
	EFSOS total	**2.7**	**2.7**	**3.0**	**2.7**

4.3.5 C6: Socio-economic functions

All parameters in C6 Socio-economic functions are derived from EFI-GTM output data, except for the attractiveness for recreation index, which is derived from EFISCEN outputs. For the *Maximising biomass carbon scenario*, EFI-GTM data from the *Reference scenario* is used, while for the *Priority to biodiversity scenario* indicator scores could not be established due to lack of data from EFI-GTM.

The share of GDP taken by the forest sector increases slightly in all regions, for all scenarios, except in Central-East Europe where it decreases slightly.

Consumption of wood products increases at a similar pace in the *Reference scenario* and the *Promoting wood energy scenario*. It increases for all regions, whilst population remains more or less stable. Therefore, there is a slight positive trend in all regions and all scenarios, with the same score everywhere, except for South-East Europe, where population grows faster than consumption of forest products.

For the trade parameter, North Europe and, to a lesser extent Central-East Europe, remain net exporters under all scenarios, whereas South-West Europe is a net importer. For most country groups, there is no difference between scenarios for this parameter. Only in Central-East Europe is the net trade position less favourable in the *Promoting wood energy scenario* than in the *Reference scenario*.

Wood energy use per capita remains much higher in North Europe than in the other country groups. As would be expected, this indicator is higher in the *Promoting wood energy scenario* than in the *Reference scenario*, with Central-East and South-West Europe moving over the threshold between a score of 2 and 3.

The recreation indicator as developed by Edwards et al. (2011), uses the area of different tree species, and age classes, to give a score of average forest attractiveness for recreation purposes. Recreation scores per age class were derived from expert panels for four different regions in Europe. In general, older stands are evaluated as being

more attractive than younger stands. The *Reference scenario* and the *Promoting wood energy scenario* tend to reduce the share of old forest, leading to lower recreation scores for these scenarios. For the region as a whole, the *Priority to biodiversity scenario* shows an increase in attractiveness, especially in South-West Europe.

Averaged over all indicators and for the whole EFSOS region, there are no differences for socio-economic factors between the *Promoting wood energy scenario*, and the *Maximising biomass carbon scenario*. It was not possible to give an assessment of the *Priority to biodiversity scenario*. North Europe in particular shows high scores for this criterion (Table 18).

Table 18: Scores for C6: Socio-economic functions

		reference	carbon	biodiversity	wood energy
Annual change in share GDP taken by forest sector	North	3	3	NA	3
	Central-West	3	3	NA	3
	Central-East	2	2	NA	2
	South-West	3	3	NA	3
	South-East	3	3	NA	3
	EFSOS total	**3**	**3**	**NA**	**3**
Consumption of wood products (RWE) per capita in 2030	North	4	4	NA	4
	Central-West	3	3	NA	3
	Central-East	3	3	NA	3
	South-West	3	3	NA	3
	South-East	2	2	NA	2
	EFSOS total	**3**	**3**	**NA**	**3**
Net import as percentage of apparent consumption in 2030	North	5	5	NA	5
	Central-West	3	3	NA	3
	Central-East	4	4	NA	3
	South-West	2	2	NA	2
	South-East	3	3	NA	3
	EFSOS total	**3**	**3**	**NA**	**3**
Wood energy use (RWE) per capita in 2030	North	5	5	NA	5
	Central-West	2	2	NA	3
	Central-East	2	2	NA	3
	South-West	2	2	NA	3
	South-East	2	2	NA	2
	EFSOS total	**3**	**3**	**NA**	**3**
Annual change in recreational value/ha	North	5	5	5	5
	Central-West	3	3	3	3
	Central-East	3	3	3	3
	South-West	2	3	3	2
	South-East	3	3	3	3
	EFSOS total	**4**	**4**	**5**	**4**
C6: Socio-economic funtions	North	4.4	4.4	NA	4.4
	Central-West	2.8	2.8	NA	3.0
	Central-East	2.8	2.8	NA	2.8
	South-West	2.4	2.6	NA	2.6
	South-East	2.6	2.6	NA	2.6
	EFSOS total	**3.2**	**3.2**	**NA**	**3.2**

4.4 Discussion

The overall scores by each criterion are presented by region in Table 19. This discussion focuses on the differences between scenarios and on areas of concern where the parameters show what could be a negative trend.

In North Europe, the productive functions develop positively, especially in the *Promoting wood energy scenario*, but the criteria on health and vitality, and on biodiversity require attention. There is a considerable proportion of mature forests, with stands in the range of 60-100 years old, which increase the wind vulnerability. At the same time, stands over 100 years of age are felled and regenerated at a faster pace, leading to lower biodiversity values. Also maintaining adequate levels of deadwood requires attention.

In Central-West Europe, biodiversity and socio-economic functions are an issue in the *Reference scenario*. Forests are used intensively in this region, and consequently the share of FNAWS is the lowest in the EFSOS region. The lower score in socio-economic functioning is caused by moderate scores for all parameters, but especially in wood energy use. In this country group, the *Maximising biomass carbon* and the *Priority to biodiversity scenarios* show improvements for the forest resource, as growing stock and carbon are accumulated, and for biodiversity, but have a weakened health and vitality score. The *Promoting wood energy scenario* shows a strengthening of the productive functions in this region compared to the *Reference scenario*.

In Central-East Europe in the *Reference scenario*, reductions in soil carbon per ha are causing somewhat low scores for the forest resources and carbon criterion. Wood energy use is relatively low, and the share of the forest sector in total GDP is decreasing in all scenarios. Productive functions and health and vitality improve. In the *Priority to biodiversity scenario* and the *Maximissing biomass carbon scenario*, biodiversity improves, without a significant decline for the other criteria. The *Promoting wood energy scenario* increases productive functions, and, to a lesser degree, socio-economic functions, without having negative consequences for the other criteria.

South-West Europe has relatively little old forest. In combination with concerns on deadwood, this lack of old forest gives rise to low scores on biodiversity. Socio-economic concerns are the low use of wood energy, and the fact that the region is a net importer of wood and wood products. Also the recreational value of the forest is relatively low. For this region, there are surprisingly few differences between the policy scenarios.

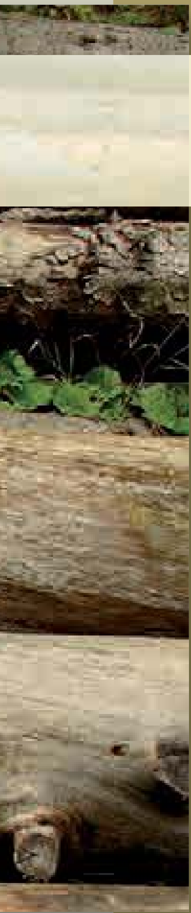
South-East Europe shows scores below 3 in three of the five criteria. These low scores are partly influenced by the low quality of the forest resource data in this region[14]. Concerns arise on soil carbon and deadwood quantities in the region, but these are influenced by both data quality and modelling issues. The lower score on the socio-economic criterion is due to low levels of consumption of wood products and wood energy use. The productive functions are higher in the *Promoting wood energy scenario*, but otherwise little difference between the scenarios is apparent.

For the region as a whole, the biodiversity indicator merits special attention. Increased harvest pressure influences the amount of deadwood and reduces the share of old stands. The *Maximising biomass carbon scenario* lowers the productive function, but the parameters are otherwise unchanged. The *Priority to biodiversity scenario* improves biodiversity, as intended, apparently at a cost to forest health and vitality, as the average age of the forest increases. In terms of ecosystems, the forest is healthier and more vital if it has the full, natural age variation: thus in terms of timber production, the forest in the *Priority to biodiversity scenario* is not as healthy and vital, but in ecosystem terms it has more health and vitality. Under this scenario it is likely that the productive and socio-economic functions, which could not be quantified, would also be lower than in the *Reference scenario*. At the European level, the *Promoting wood energy scenario* shows a reduction in forest resources and carbon, compared to the *Reference scenario*, due to the heavy pressure of increased wood extraction. Under this scenario, no change appears at the level of the European aggregate for the productive functions, although three of the five country groups show an increase due to higher harvests and higher wood prices.

[14] *No information on age-classes was available for 6 out of the 11 countries*

Table 19: Overall sustainability assessment

		reference	carbon	biodiversity	wood energy
North	C1 Forest resources and carbon	3.3	3.3	3.3	3.3
	C2 Health and vitality	2.5	2.5	2.5	2.5
	C3 Productive functions	4.0	4.0	NA	4.5
	C4 Biodiversity in forest ecosystems	2.3	2.3	2.7	2.3
	C6 Socio-economic functions	4.4	4.4	NA	4.4
Central-West	C1 Forest resources and carbon	3.0	3.8	3.8	3.0
	C2 Health and vitality	3.5	3.0	3.0	3.5
	C3 Productive functions	3.5	3.5	NA	4.0
	C4 Biodiversity in forest ecosystems	2.0	2.7	3.0	2.0
	C6 Socio-economic functions	2.8	2.8	NA	3.0
Central-East	C1 Forest resources and carbon	2.8	3.0	3.0	2.8
	C2 Health and vitality	3.5	3.0	3.0	3.5
	C3 Productive functions	4.0	4.0	NA	4.0
	C4 Biodiversity in forest ecosystems	3.0	3.3	3.7	3.0
	C6 Socio-economic functions	2.8	2.8	NA	2.8
South-West	C1 Forest resources and carbon	3.5	3.5	3.5	3.5
	C2 Health and vitality	3.0	3.0	3.5	3.0
	C3 Productive functions	3.5	3.5	NA	3.5
	C4 Biodiversity in forest ecosystems	2.3	2.3	2.3	2.3
	C6 Socio-economic functions	2.4	2.6	NA	2.6
South-East	C1 Forest resources and carbon	2.8	2.8	2.8	2.8
	C2 Health and vitality	3.0	3.0	3.0	3.0
	C3 Productive functions	3.5	3.5	NA	4.0
	C4 Biodiversity in forest ecosystems	2.7	3.0	3.0	2.7
	C6 Socio-economic functions	2.6	2.6	NA	2.6
Total EFSOS	C1 Forest resources and carbon	3.3	3.3	3.3	2.8
	C2 Health and vitality	3.0	3.0	2.5	3.0
	C3 Productive functions	4.0	3.5	NA	4.0
	C4 Biodiversity in forest ecosystems	2.7	2.7	3.0	2.7
	C6 Socio-economic functions	3.2	3.2	NA	3.2



5

Main policy issues and challenges, in the light of the scenario analysis

5.1 Introduction

Chapter 2 identified the main policy issues and challenges for the European forest sector. Chapter 3 presented a *Reference scenario* and four policy scenarios exploring the long term consequences of certain policy choices. Chapter 4 analysed in a systematic way whether or not the scenarios are sustainable, and where problems might arise. This chapter uses the analysis carried out through the scenarios to explore the policy challenges. In particular, it aims to point out the main trade-offs facing the policy makers of today, by comparing the analysis of the scenarios.

5.2 Overview of the scenarios

Table 20 presents the *Reference scenario* and the four policy scenarios in comparable, quantified terms, including the main parameters as regards wood supply and demand, as well as some of the parameters to be influenced by the policy choices, notably carbon stock in forest biomass. The scenarios are summarised below, for Europe as a whole.

Table 20: Overview of EFSOS scenarios

				Reference scenario		Maximising carbon		Priority to biodiversity		Promoting wood energy		Fostering innovation and competitiveness
				2010	2030	2030		2030		2030		2030
		Unit	source			absolute	difference	absolute	difference	absolute	difference	difference
Wood balance												
Wood supply	Stemwood removals	Mm^3 o.b.	EFISCEN	595.1	684.7	685.0	0.3	600.4	-84.3	700.8	16.1	+
	Harvest residues	Mm^3	EFISCEN	32.8	91.4	77.8	-13.6	0	-91.4	158.2	66.9	0
	Stump extraction	Mm^3	EFISCEN	3.6	12.1	10.7	-1.4	0	-12.1	113.7	101.5	0
	Landscape care wood	Mm^3	EUwood	63.4	81.0	81.0	0.0	81.0	0.0	108.0	27.0	
	Post-consumer wood	Mm^3	EUwood	45.6	71.4	71.4	0.0	71.4	0.0	71.4	0.0	-
	Industrial residues	Mm^3	EFI-GTM	210.4	237.4	237.4	0.0	237.4	0.0	236.3	-1.0	
	Trade	Mm^3	EFI-GTM	12.5	1.3	1.3	0.0	1.3	0.0	32.9	31.6	-
	Total	**Mm^3**		**963.5**	**1 179.2**	**1 164.5**	**-14.7**	**991.5**	**-187.8**	**1 421.3**	**242.1**	
Wood demand	Products	Mm^3	EFI-GTM	531.4	582.3	582.3	0.0	582.3	0.0	560.4	-21.9	+
	Energy	Mm^3	EFI-GTM	434.6	585.3	585.3	0.0	585.3	0.0	858.7	273.4	+
	Total	**Mm^3**		**965.9**	**1 167.6**	**1 167.6**	**0.0**	**1 167.6**	**0.0**	**1 419.1**	**251.4**	
Gap	Supply-Demand	Mm^3		-2.5	11.6	-3.1	-14.7	-176.2	-187.8	2.2	-9.4	
Product balance												
Production	Sawnwood	Mm^3 RWE	EFI-GTM	255.5	274.0	274.0	0.0	NA	NA	270.2	-3.8	
	Wood-based panels	Mm^3 RWE	EFI-GTM	122.8	145.7	145.7	0.0	NA	NA	140.0	-5.7	
	Paper and paperboard	Mm^3 RWE	EFI-GTM	392.1	492.1	492.1	0.0	NA	NA	482.9	-9.2	
	Total	**Mm^3 RWE**	**EFI-GTM**	**770.4**	**911.9**	**911.9**	**0.0**	**NA**	**NA**	**893.2**	**-18.7**	
Consumption	Sawnwood	Mm^3 RWE	EFI-GTM	248.4	271.5	271.5	0.0	NA	NA	269.9	-1.6	
	Wood-based panels	Mm^3 RWE	EFI-GTM	129.0	150.7	150.7	0.0	NA	NA	149.0	-1.7	
	Paper and paperboard	Mm^3 RWE	EFI-GTM	361.6	430.7	430.7	0.0	NA	NA	429.6	-1.1	
	Total	**Mm^3 RWE**	**EFI-GTM**	**739.0**	**852.9**	**852.9**	**0.0**	**NA**	**NA**	**848.5**	**-4.4**	
Net trade	Sawnwood	Mm^3 RWE	EFI-GTM	7.1	2.5	2.5	0.0	NA	NA	0.4	-2.2	
	Wood-based panels	Mm^3 RWE	EFI-GTM	-6.3	-5.0	-5.0	0.0	NA	NA	-9.0	-4.0	
	Paper and paperboard	Mm^3 RWE	EFI-GTM	30.6	61.5	61.5	0.0	NA	NA	53.3	-8.1	
	Total	**Mm^3 RWE**	**EFI-GTM**	**31.4**	**59.0**	**59.0**	**0.0**	**NA**	**NA**	**44.7**	**-14.3**	
Trade balance												
	Wood	Mm^3	EFI-GTM	-12.5	-1.3	-1.3	0	-1.3	0	-32.9	-31.6	
	Products	Mm^3 RWE	EFI-GTM	31.4	59.0	59.0	0	NA	NA	44.7	-14.3	
	Total trade	**Mm^3**	**EFI-GTM**	**18.9**	**57.7**	**57.7**	**0.0**	**NA**	**NA**	**11.8**	**-45.9**	
Main impacts												
	Carbon in biomass	tonne C/ha	EFISCEN	69.0	77.2	82.4	5.2	85.6	8.4	76.6	-0.7	
	FNAWS	Mha	EFISCEN	38.1	45.8	45.5	-0.3	52.0	6.2	45.8	0.0	

Note: the apparent discrepancy between total wood demand for products in the wood balance section and the wood raw material equivalent of production of products (531.4 million m^3 and 770.4 million m^3 RWE respectively) is due to the fact that the latter includes the equivalent of recovered paper, while the former only counts the wood used to manufacture sawnwood, panels and pulp. In product balance and trade balance figures, negative values denote net imports while positive values denote net exports.

5.2.1 Reference scenario

In 2030 demand for wood is about 20% higher than in 2010, with slower growth from the forest products industry and faster growth for energy. In the *Reference scenario*, without any strong policy input, wood energy demand is expected to grow by 1.5% per year. With a broadly unchanged policy environment, both supply and demand of wood grow at just under 1% per year, and are in balance in 2030. The largest component of forest based supply, stemwood removals, would grow the slowest, with much faster rates of growth for harvest residues and stump extraction, both at rates of over 5% per year. Other types of wood supply, notably post-consumer wood, also grow, at rates of up to 2.6% per year. As a consequence, practically no wood is wasted, as all is recovered for recycling or is used as a source of energy.

Production and consumption of products grow at less than 1% per year, but net exports of products increase by 30 million m^3 RWE, in a world characterised by strongly rising trade in forest products. There is little change in net imports of wood, and therefore no major change in Europe's dependence on other regions.

In this scenario, most of the other indicators of sustainability are moving in a positive direction. In particular, forest cover, forest available for wood supply and net annual increment all increase: fellings stay well below net annual increment. However the indicator of recreational value moves in a negative direction, and the amount of deadwood per ha decreases.

The major area of concern in the *Reference scenario* is the feasibility and possible negative consequences of the much increased level of supply of forest residues.

However, it is not sufficient to ask whether a particular scenario is sustainable, using only indicators referring to the European forest sector. In a world of major global challenges, notably as regards energy, climate change and biodiversity, it must be asked whether the European forest is making the best possible contribution to sustainable development of the planet. Policy makers in other sectors, notably climate change, energy and biodiversity are making certain demands on the forest sector. The policy scenarios explore how the forest sector could respond to these demands and with what consequences inside the sector.

5.2.2 Maximising biomass carbon

This scenario explored how much more carbon could be sequestered by European forests, without reducing the annual harvest of stemwood for products and energy, and without expanding the area of forest. The scenario found that by lengthening rotations and increasing the share of thinning in harvest, average biomass carbon per ha would be 5 tonnes/ha (6.7%) higher than in the *Reference scenario*, and 13 tonnes/ha (19.4%) higher than in 2010. The average carbon sink in forests over the period 2010-2030 is 0.67 tonnes C/ha/yr, or 64% more than in the *Reference scenario*. This is due essentially to higher increment. Soil carbon would also increase.

The other parts of the scenario (wood supply from outside the forest, wood use for products and energy) were not calculated separately as they would be nearly identical to the *Reference scenario*.

For biodiversity, the area of protected forest would be the same as in the *Reference scenario*, but levels of deadwood would be higher, because fewer harvest residues are extracted.

The *Maximising biomass carbon scenario* demonstrates that it is possible to accumulate more carbon in European forests than in the *Reference scenario*, by changing silvicultural practice, with minor consequences for wood supply (15 million m^3 of harvest residues and stumps less). However the silviculture necessary to maximise biomass carbon varies according to national circumstances, and considerable extension efforts would be necessary to influence the behaviour of forest owners.

5.2.3 Promoting wood energy

In the *Promoting wood energy scenario*, absolute priority is attached to meeting the official targets for renewable energy. Use of wood for energy in 2030 would be nearly 860 million m^3, 60% of total wood consumption. This would require total wood supply to reach over 1.4 billion m^3 in 2030, 250 million m^3 (22%) more than in the *Reference scenario*.

To achieve this would require an unprecedented mobilisation of all types of wood. Stemwood removals would be 16 million m^3 higher than in the *Reference scenario*, and landscape care wood would be 27 million m^3 more. The largest increase would be for harvest residues and stumps. In 2030, harvest residue extraction would be five times more than in 2010, and 67 million m^3 more than in the *Reference scenario*. Stump extraction, at 114 million m^3, would be 30 times more than in 2010 and 100 million m^3 more than in the *Reference scenario*. In addition, 30 million m^3 of wood would need to be imported from other regions. If it proved impossible, for whatever reason, to mobilise these volumes of harvest residues and stumps, meeting the targets would necessitate mobilising equivalent volumes from higher imports, fast growing plantations on non-forest land, or faster expansion of non-wood renewable energies (which are already assumed to grow faster than wood).

In this scenario, production and consumption of forest products would be lower than in the *Reference scenario*, and wood prices higher. There would be no change in protected forest area, compared to the *Reference scenario*, and only slightly less biomass carbon per ha.

However the mobilisation of such high volumes would have significant environmental, financial and institutional costs. To achieve the highly intensive silviculture and harvesting necessary for the scenario would require strong political will to modify many framework conditions for wood supply, including land tenure and forest owner cooperatives, wood markets, norms and standards, as well as physical infrastructure. The very high levels of extraction of residues and stumps would negatively affect nutrient flows and soil carbon. Forests would also be less attractive for recreation.

5.2.4 Priority to biodiversity

This scenario assumes a significant increase in area of forest protected for biodiversity conservation (6.2 million ha more than in the *Reference scenario*) and several measures intended to promote biodiversity in forests available for wood supply: no extraction at all of harvest residues or stumps, longer rotations and more mixed stands. Demand for wood (for products and energy) is assumed to remain unchanged from the *Reference scenario*, as are the non-forest components of wood supply.

As a consequence, more carbon is sequestered in the forest than for the *Reference scenario*. However total wood supply is nearly 190 million m^3 (16%) less than in the *Reference scenario*, and only 28 million m^3 higher than in 2010. This leads to a supply projection which is 176 million m^3 less than projected demand.

The complex consequences of this significant 'gap', and how it would be absorbed, could not be explored in a quantitative way. However solutions could include some of the following: lower wood consumption for products; less supply of wood energy; higher imports of wood or of products[15]; or expansion of forests onto former agricultural land (if establishing high intensity wood producing forests was considered acceptable in a society which gave the highest priority to biodiversity).

5.2.5 Fostering innovation and competitiveness

This scenario assumes that the forest sector would become considerably more innovative than at present, under the influence of framework conditions transformed by policy measures and the attitudes of actors in the sector. As a result of innovation in products, processes and communication, new markets for goods and services would be created, and price relationships would change. Examples of possible developments include: 'intelligent paper'; improved wood based construction systems; bio-refineries producing a wide range of specialty chemicals and biofuels; widespread forest PES; and, innovative (and more profitable) types of forest-based recreation. Most of these would lead to higher sophistication, specialisation and value added in the whole forest sector, generating more income to be shared between the actors in the sector.

In this scenario, trends and relationships between parameters would be, by definition, qualitatively different from those of the past, so no quantified projections based on past relationships were made. It is therefore not possible to make detailed comparisons between the *Fostering innovation and competitiveness scenario* and the *Reference scenario*. However some speculative estimates are possible.

The expansion of higher value added production would increase income, but not necessarily lead to a higher volume of wood demand, because of increased efficiency in wood use, and because commodity grades (if they are still necessary) are imported from regions with better growing conditions. Thus the supply/demand balance might be tighter than in the *Reference scenario*, but probably not as tense as in the *Promoting wood energy scenario*.

There is no reason to believe that less carbon would be sequestered than in the *Reference scenario*, or that biodiversity would be less well protected. Wood supply would not rise as steeply as in the *Promoting wood energy scenario*, perhaps because of innovation for other renewable energies.

In general, the world described in the *Fostering innovation and competitiveness scenario* is rather positive for the sector. Indeed, all of the scenarios would benefit from increased innovation and competitiveness within a nurturing policy environment[16]. The main question is not whether innovation and competitiveness are desirable, but how to transform the attitudes of a sector which in the past, with few exceptions, has tended to be prudent and slow moving. Political will and significant resources are necessary to make the sector more innovative, but not sufficient: experience shows that creating an environment conducive to innovation is a complex and long term undertaking, which must address culture, finance, education, infrastructure and the legal environment, among other aspects. Nor can policy makers, working alone, effect this transformation: all actors, inside the sector, as well as outside (financiers, suppliers, consultants etc.) must work together.

[15] *Or reduced net exports of products.*

[16] *In that sense, this scenario does not represent an alternative to the other policy scenarios, but a possible supplement to any of them.*

5.3 Mitigating climate change

There are two main ways in which the European forest sector can contribute to mitigating climate change: sequestering carbon, either in forests (including forest soils) or in harvested wood products; and, substituting for non-renewable materials and energy. The challenge for policy analysis is to find the optimum mix of these broad strategies. Which will provide the greatest benefit in terms of carbon flows, sequestration or avoided emissions? How significant are those benefits, compared with other carbon flows? To what extent are the strategies complementary or mutually exclusive? What are the associated risks? How does the time frame influence the decision? The EFSOS II scenarios make it possible to provide preliminary quantitative answers to these strategic questions, even if some of them are incomplete.

Before examining carbon sequestration, it is important to restate the obvious: the largest terrestrial carbon stock in Europe is the forest, and the first priority must remain to prevent any reduction of this stock. However, all the EFSOS II scenarios indicate that Europe's forest area will continue to grow, felling will remain below increment and total soil carbon will increase compared to 2010. The only major threats to the carbon stock in European forests would be forest damage caused by climate change (fires, pests, diseases) or losses in soil carbon due to a warmer climate. Within the EFSOS II framework, these risks are not assessed. Disturbance impacts and climate-induced change in soil carbon flows are not included in the EFISCEN set-up for EFSOS II.

5.3.1 Carbon sequestration and avoided emissions in the EFSOS II scenarios

Using some of the data generated by the EFSOS II scenarios, it is possible to make quantitative estimates of carbon sequestration and avoided emissions predicted under the assumptions of the various scenarios. Carbon sequestration in forests is directly calculated by the EFISCEN model, as described earlier.

It is possible to quantify stocks and flows of carbon in harvested wood products by estimating the average lifetime of each product type. On the basis of consumption data, it is then possible to estimate how much carbon enters the stock in harvested wood products. However, this sequestration is balanced by emissions of carbon at the end of the useful life of the products, so the size of carbon stock in harvested wood products will only change if consumption and use patterns change, for instance by higher consumption of harvested wood products, or longer lifetimes of the products. Carbon stocks and flows in harvested wood products were estimated here by assuming an average life span of 30 years for consumed sawnwood and 15 years for panels, particle board and fibreboard. The stock in 2010 was assumed to be in balance with the consumption in 2010.

To calculate the contribution from substitution of non-renewable products and energy, it is necessary to answer two basic questions:

- Which product/energy source is being substituted, by what, for what purpose?
- What is the carbon balance of the product pathways, from raw material extraction to final disposal? (It should be born in mind that in many cases, notably construction, the most carbon emissions are connected with the use of the product, rather than the carbon actually embedded in the product).

The rapidly expanding science of Life Cycle Assessment (LCA) provides detailed answers to these complex questions, and is able to compare solutions to specific choices (e.g. wood windows compared to aluminium windows), but not able to make reliable general estimates at the aggregate level. Indeed, the basic concept of 'substitution' is unclear at the aggregate level: if, say 100 million m^3 RWE of forest products is consumed, what type of alternative consumption, if any, do they 'substitute'[17] for? For these reasons EFSOS II does not attempt to quantify the substitution effect of consumption of forest products, even though, in many cases, it may well be the case that the use of forest products emits less carbon over the whole life cycle than alternative materials. Whatever the size of the substitution effect, it is unlikely that there would be significant differences between carbon substitution levels in the policy scenarios.

For wood energy however, it is possible to estimate, very roughly, the mitigation effect of the use of wood energy in Europe. The use of one m^3 of wood would avoid the emission of about 0.16 tonnes CO_2 equivalent from fossil fuels (Schelhaas *et al.*, 2007). This assumes that all wood energy is used for heating in small-scale pellet systems, and substitutes for heating by oil and natural gas. The real avoided emissions depend strongly on the efficiency of the system used to generate wood energy (open fireplaces versus large efficient

[17] *For instance, does a modern timber frame house 'substitute' for a traditional concrete/brick construction, a highly energy efficient new system or a traditional chalet? All of these might provide an equivalent service, but with very different impacts on the environment and carbon emissions. The only objective fact is the construction of a modern timber-frame house, and rejected options cannot be quantified.*

CHP plants) and the systems they will replace. This estimate ignores emissions of other greenhouse gasses from wood combustion, and does not take into account any adverse effects on air pollution.

5.3.2 Comparison of scenarios in relation to climate change mitigation

The resulting calculations undertaken for those scenarios which are fully quantified (see Table 21), provide an indication of the best combination of forest management strategies from the point of view of carbon mitigation. The main conclusions from the calculations are:

- The two main carbon stocks, biomass and forest soil, are of the same order of magnitude, but in the *Reference scenario* carbon sequestration in biomass is 5 times greater than carbon sequestration in soil.
- The net change of the carbon stock in harvested wood products is about 18 Tg C/yr, much less than the change in forest biomass, and roughly equivalent to that for forest soil.
- Carbon sequestration in the forest (biomass and soil), when the silvicultural strategies of the *Maximising biomass carbon scenario* are applied, is 50% higher than in the *Reference scenario*. In the *Promoting wood energy scenario*, carbon sequestration in forests in 2030 is 20% less than in the *Reference scenario*, because of the high extraction of biomass in stems, branches and stumps.
- If the *Maximising biomass carbon scenario* strategy is applied, the carbon stock in Europe's forests in 2030 is 11.5% more than in 2010 and 3.5% more than in the *Reference scenario* for 2030.
- Under the *Promoting wood energy scenario* about twice as much carbon is substituted in energy uses in 2030 than in 2010, and nearly 50% more than in the *Reference scenario* in 2030.
- In aggregate, taking together carbon sequestration and avoided emissions, the *Maximising biomass carbon scenario* strategy is more effective than either of the others, as it combines special measures to maximise carbon sequestration in biomass with an unchanged supply of renewably produced wood. The strategy focused entirely on substitution effects (Promoting wood energy) achieves its objective of high avoided emissions, but at the cost of a smaller carbon accumulation in the forest.
- It was not possible to quantify fully the *Priority to biodiversity scenario*, but it would not make a bigger contribution to mitigation than the *Maximising biomass carbon scenario*. Carbon in forest biomass is slightly more than in the *Maximising biomass carbon scenario*, but as removals of stemwood and harvest residues are much lower, the substitution effect would also be lower.

In summary therefore, for carbon mitigation, in the medium term, the best results would be with a strategy which combined measures for increased sequestration of carbon in forest biomass (longer rotations, higher share of fellings in thinning) with maintaining a steady flow of wood for products and energy. In the long term however, the sequestration capacity limit of the forest will be reached, and the only potential for further mitigation will be regular harvesting, to store the carbon in harvested wood products or to avoid emissions from non-renewable materials and energy sources.

Table 21: Carbon stocks and flows in the EFSOS scenarios, total Europe

		Unit	Reference		Maximising biomass carbon	Promoting wood energy
			2010	2030	2030	2030
Carbon stocks	Forest biomass	Tg C	11 508	13 214	14 130	13 100
	Forest soil	Tg C	14 892	15 238	15 319	14 994
Carbon flows	Change in forest biomass	Tg C/yr		85.3	131.1	79.6
	Change in forest soil	Tg C/yr		17.3	21.4	5.1
	Net change in HWP	Tg C/yr		18.2	18.2	17.6
Substitution effects	For non-renewable products	Tg C/yr	NA	NA	NA	NA
	For energy	Tg C/yr	61.6	83.0	83.0	121.7
Totals	Stock (forest only)	Tg C	26 400	28 452	29 449	28 093
	Flow (sequestration + substitution)	Tg C/yr		203.7	253.6	224.0

5.4 Supplying renewable energy from wood

The *Promoting wood energy scenario* has shown that it may be technically possible for wood from existing European forests and the downstream wood flows, to supply 40% of the renewable energy targets, provided that two conditions are satisfied: that energy efficiency improves significantly compared to 2010 and that renewable energies other than wood expand considerably faster than wood energy. It appears that it would be technically possible to supply 1.4 billion m^3/yr of wood in 2030, by intensive silviculture and harvesting, and by steeply increasing the extraction of harvest residues and stumps (together 272 million m^3 in 2030, compared to 36 million m^3 in 2010, a six fold increase), as well as developing all non-forest wood sources in Europe to their reasonable potential. The forest products industry would also have 20 million m^3 less raw material than in the *Reference scenario*.

However, to achieve this technical potential would have severe costs, notably an impoverishment of forest sites as nutrients are removed with the residues and stumps, a reduction in biodiversity in forests available for wood supply (estimated by a decline in deadwood per ha) and a reduction in the attractiveness of forests for recreation.

To put such a strain on European forests, risking their long term future, could only be justified if no alternatives existed. However there are alternative paths which could be followed, which, taken together, could relieve the pressure on the European forest resource:

- Further increase energy efficiency, thereby reducing total energy consumption.
- Develop renewable energies other than wood even faster than originally assumed for the scenario.
- Establish large scale new sources of wood in Europe, notably short rotation coppice on agricultural land.
- Import wood for energy, or wood based fuels, from other continents.

Each alternative has its own advantages and disadvantages, which are briefly discussed below.

5.4.1 Increasing energy efficiency

Since 2000, Europe's energy consumption has hardly increased despite slow but steady economic growth (see Figure 18). This has been due to many factors, including improving efficiency of energy use, but also to a drop in the relative importance of energy intensive industries, many of which have moved offshore, notably to Asia. Relatively few energy intensive manufacturing industries are now located in Europe, so this trend must be nearing its natural limit. Nevertheless, there is still much potential to improve overall energy efficiency, in particular by improving uptake of best available technology, notably in sectors, such as construction, which have a very long turnover period. National energy strategies already plan considerably improved energy efficiency, but with sufficient investment and strong official support, even higher levels could be achieved.

5.4.2 Renewable energies other than wood

Renewable energies are in a phase of strong expansion, mostly from very low levels (the exceptions are wood and hydro, both of which are already well established). Technologies such as solar heating, photovoltaic electricity, concentrated solar power, large scale and/or offshore wind, tidal/wave energy or geothermal are far from maturity, and are encountering technical problems and social resistance as they develop. Attitudes and infrastructures must adapt to the changed circumstances, in a process which may take many years[18]. The potential of these as yet immature technologies is enormous, (and very difficult to quantify): it will take time, capital and political will to achieve. Wood should, and will, contribute to filling the gap between the 'all fossil' recent past and the 'all-renewable' long term future.

5.4.3 Short rotation coppice

Intensive cultivation of trees or grasses can produce 4-12 tonnes dry matter/ha/yr of energy crops in European conditions (Leek, 2010). Thus a shortfall in wood supply from the existing forest could be counter-balanced by establishing such plantations on non-forest land (which means in practice, agricultural land). To replace the 270 million m^3 of wood from harvest residues or stumps in the *Promoting wood energy scenario*, about 16 million ha would be needed (assuming medium productivity coppice producing 20 m3/ha/yr). This represents about 9% of the utilized agricultural area of the EU27.

A major new European source of wood would significantly reduce the pressure on the forest and help to build the share of renewables in energy supply. However this pathway also has its problems. For instance:

[18] *One example is the rising resistance to large wind turbines, even in remote mountainous areas.*

- Is sufficient suitable land available? What will be the consequences of rising global food demand, because of population and changing diets, and of developments in farming techniques? Will the move towards organic farming reverse the trend to more intensive land use in agriculture?
- What would be the consequences for food supply and rural development if significant areas of land were devoted to producing biomass? This refers to the discussion about so called 'Indirect land use change' in the climate change debate.
- Would such energy plantations, if composed of trees rather than grasses, be treated as forests or as agricultural crops, notably with regard to multiple functions, including biodiversity conservation? The FOREST EUROPE guidelines on afforestation (MCPFE/PEBLDS, 2009) lay down that new forest should adhere to the same principles of sustainable forest management, but already, intensively managed biomass production on agricultural land has been exempted from forest law, for instance about change of land use, obligation to conserve biodiversity etc.

At present, despite intense research and modelling efforts, there is no scientific consensus on the complex issue of land availability for biomass supply (Kretschmer, 2011 and Leek, 2010). For EFSOS II, therefore, this is treated as an alternative for discussion at the policy level.

5.4.4 Imports of wood energy

Another possibility is to import wood energy from outside Europe, in the form of chips, pellets, or biofuels. There are over 210 million ha of planted forests in the world, excluding the EFSOS region (FAO, 2010), of which about three quarters are for wood production, as well as large areas of degraded forest and marginal land suitable for afforestation, with good climatic conditions, making possible very high growth rates. There are already significant imports of wood for energy by Europe. In 2009, the EU27 imported about 1.8 million tonnes of wood pellets, mostly from the US, Canada and the Russian Federation (UNECE/FAO, 2010), and several large power stations have been built or are under construction, with plans to use imported biomass. There are also supplies of wood from natural disasters such as windblow or disease, e.g. the Mountain pine beetle catastrophe in western Canada. However, there are several severe obstacles to the expansion of wood energy imports to Europe:

- Wood demand, whether for energy or raw material, is rising fast in other regions, which will compete with Europe for available supplies.
- Sustainability criteria for biofuels are in place for the EU27 and may well be extended to other forms of biomass. This will help implement the EU's requirements that biofuels must deliver substantial reductions in greenhouse gas emissions and should not come from forests, wetlands and protection areas (EU, 2009), and will prevent the development of certain projects which are unsustainable
- The same issues of competition between food and fuel for land and of indirect land use change also apply to imports from other regions.

In short, although at present there is no shortage of energy wood on world markets, the level of future reliable long term supplies is rather uncertain. It also appears paradoxical to achieve targets designed to improve energy security and self-sufficiency by increasing dependence on imports from overseas. One possibility would be to develop a stable level of imports from Russia, which has a very large forest resource, relatively close to several EFSOS countries. However, the official long term Russian forest strategy is to increase exports of value added goods, not of low value commodities like wood energy.

5.4.5 Clean and efficient wood energy use

There is enormous variability in the efficiency of use of wood energy, ranging from open fireplaces with very low efficiency or electricity generation without heat recovery, to modern district heating or CHP installations with high combustion efficiency and low energy losses at all stages. It is therefore of great importance that wood for energy should be used only in an efficient and appropriate way. In practice, this usually means district heating or CHP in efficient modern installations. Often the most energy efficient installations are at a rather larger scale than today's typical wood burning installations (e.g. for individual houses), which implies that investment in wood burning installations is necessary.

It may be that the changing general energy consumption patterns require electricity in uses where it is irreplaceable (e.g. computers, television, lighting, all of which are growing fast). However electricity generation is associated with unavoidable efficiency losses[19]. As far as possible, electricity

[19] CHP is much more energy efficient, but is only possible where there is a plausible nearby use for the heat generated.

should be generated from sources suited to it (wind, hydro, tide, all of which essentially only produce electricity), rather than from wood, which is well suited to heat production.

Furthermore, wood resources are much less concentrated than those of many other energy sources, especially fossil fuels and nuclear. The use pattern should reflect the distribution of the resource. Wood is bulky and contains much water, so transporting it long distances, for instance to generate electricity, only makes ecological and economic sense in a few cases. Normally, wood energy use should be directed in the first place to heat production and CHP in areas which have sizable forest resources, or to making pellets, whose greater energy intensity makes it possible to transport them long distances.

Increasing concern is expressed about pollution by particulate matter, especially fine particles (< 2.5 µm), produced by combustion of diesel fuel and wood (EPA, 2007). The World Health Organisation (WHO) has recommended air quality guidelines for exposure to particulate matter (WHO, 2006). Many of these pollution problems are in developing countries (indoor wood burning), but there is now no doubt that fine particle emission from wood burning can be dangerous to human health, even in European conditions. Clearly an expansion of wood energy cannot be allowed to lead to increased pollution by microparticles. The consequence of this is that wood should only be burnt in efficient installations, equipped with the necessary filters. Several countries (e.g. Germany, Switzerland) have in place regulations to prevent the use of polluting wood burning equipment.

5.4.6 Discussion

There are two interacting policy imperatives:

- Europe's forest must be sustainably managed; and
- Europe's energy supply pattern must move away from the present unsustainable mix based on non-renewable resources, often imported from other regions.

The level of wood supply (for products and energy) in the *Reference scenario* seems sustainable from the forest point of view, but makes an insufficient contribution to the development of renewable energies. On the other hand, the level of wood supply assumed in the *Promoting wood energy scenario* supplies just enough wood to meet the renewable energy targets (with some quite optimistic assumptions), but poses unacceptable risks to the forest resource, through very high extraction of harvest residues and stumps. What are the consequences of this dilemma for policy makers?

A strategy should be drawn up, at the national level, which integrates the needs of the energy sector with those of the forest sector, and is produced after detailed dialogue between forest sector and energy sector policy makers. The main lines of such a strategy could be:

- Continue to promote energy efficiency, preferably at a faster rate than the existing targets.
- Continue to develop non-wood renewable energies, with the sustainability constraints applicable to each type.
- Implement the guidelines for wood mobilisation (MCPFE, DG AGRI, UNECE/FAO, 2010) so that each forest provides as much wood as possible consistent with sustainable forest management.
- Develop non-forest wood supplies to their maximum extent, notably landscape care wood and post-consumer wood.
- Integrate the supply of wood energy with the supply of products to ensure optimum use ('cascade principle').
- Develop fast growing biomass plantations on agricultural land where this is possible.
- Ensure that wood, like other energy sources, is used as efficiently and cleanly as possible: installations with low efficiency or which generate electricity without use of the waste heat should be avoided, and wood energy should be consumed near its source.
- If necessary import energy wood (or fuels derived from wood such as pellets or biofuels, which are considerably more energy intensive) from sustainable sources outside Europe.

There should be periodic monitoring of progress and continued communication and cooperation between policy makers for energy and for the forest sector, thus avoiding unnecessary conflicts, unrealistic objectives and sub-optimal solutions. This consultation could be based on quantified analysis of the outlook, combining forest analysis, like EFSOS II, with equivalent analysis for renewable energy, including land availability for biomass plantations.

5.5 Adapting to climate change and protecting forests

5.5.1 Introduction

Forest ecosystems have a natural ability to adapt to changing environmental conditions, but such adaptation processes are not fast enough to keep up with the rapid changes in climate. The projections on the extent and the regional variations of climate change differ largely and this uncertainty will remain. No new stable state is expected in the foreseeable future; moreover, larger fluctuations in weather conditions and more extremes will also affect the forests.

The predicted higher frequency of severe events including devastating storms, droughts and heat waves will increase the susceptibility of forests to secondary damage such as from insect and fungal infestations, and will enhance the probability of forest fires. The increased temperatures will favour some tree species and weaken others, and change the species competition dynamics in European forests. These effects will be more pronounced in regions, where the dominant species are today already outside their optimum ecological range. This is for instance the case for Norway spruce (*Picea abies spec.*) in relatively dry lowlands of Central Europe, where even now they suffer increasingly from summer drought.

Another severe threat for forests in some regions are invasive alien species. A recent example of the appearance and establishment of new species in forests is the palm (*Trachycarpus fortunei*) in Ticino, Switzerland (Walther *et al.,* 2007). Invasive species already present, like the Camphor tree (*Cinnamomum camphora*), the Tree-of-heaven (*Ailanthus altissima*) or the Robinia (*Robinia pseudoacacia*) could have a higher potential to spread and out-compete the established species. This may affect the regeneration of forests and impair forest growth due to competition for nutrients, water and light.

Additionally, there are often combined effects of climate change and air pollution, which may significantly differ from the sum of separate effects due to various synergistic or antagonistic interactions (Bytnerowicz *et al.,* 2007).

The signatory states of the United Nations Framework Convention on Climate Change (UNFCCC) have committed to drawing-up and implementing national programmes, which will enable an appropriate adaptation to climate change (UNFCCC, 1992). In recent years, action plans and national strategies for adaptation have been developed, which also include the first recommendations for the adaptation of forests. The countries mostly base their adaptation strategies on the principle of sustainable forest management, with an emphasis on climate risk reduction and maximizing carbon sequestration to mitigate climate effects (SoEF 2011).

5.5.2 Objectives of forest adaptation to climate change

Some changes in climate may be too fast for autonomous adaptation of forest ecosystems and extreme events could act as 'tipping points' threatening forests and the services and functions they provide (Lenton *et al.,* 2008). The overall objective of adapting forests to climate change is to moderate harmful effects or exploit beneficial opportunities, in response to actual or expected climatic stimuli or their effects. Adaptation targets to reduce both sensitivity to climate change impacts and to increase adaptive capacity of forest ecosystems will help to maintain forest resilience to climate change[20]. Forests will continue to fulfil important ecosystem functions like the sustainable production of timber and non-timber forest products; soil protection; the provision of drinking water; the regulation of water and nutrient cycles; but, also the preservation of forests for recreational purposes.

A convenient side effect of adaptation measures is often the mitigation of climate change effects by enhancing carbon sequestration in stands and soils. Other aims and targets differ depending on regional threats and priorities.

Table 22 gives an overview of the expected changes, potential impacts and main threats of climate change for forests. Obviously, any adaptation should take into account the various regional constraints.

[20] *Resilience is the ability of an ecosystem to come back to a site specific stable state after perturbation or disturbances (fire, storm, insects, drought, etc.). A resilient ecosystem is able to maintain its 'identity', i.e. the site specific composition and structure. However, climate change will lead to changed site conditions, so that here the meaning is that the 'future site specific state' will be different from the state which is site specific now.*

Table 22: Overview of expected changes, potential impacts and main threats for forests, by bio-geographical region.

Boreal	
Expected change in climate	• Temperature increase between +3.5 to +5°C by end of the century
	• Precipitation up to +40%. Winters are projected to become wetter
Potential impacts on forests	• Increased forest growth rates, higher yields
	• Frequency of snow and wind damage may increase
	• Northward expansion of closed forests and the associated shift of tree line will affect species distribution and biodiversity
	• Biotic pests are expected to have increased damage potential
	• Shortened frost periods will affect harvesting and transport
Temperate Oceanic	
Expected change in climate	• Temperature increase between +2.5 to +3.5°C, slightly less in UK and Ireland
	• Summer dryer and hotter; Precipitation in winters higher; more extreme events
Potential impacts on forests	• Tree growth increased in some regions, decreased in others
	• Risk and frequency of wind damage is expected to increase
	• Extreme events: storms, droughts, flooding, heat waves
	• Shifting of natural species distribution may negatively impact esp. rare species
	• Biotic pests and diseases are expected to have increased impact
Temperate Continental	
Expected change in climate	• Temp. increase +3 to +4°C, slightly more in continental regions of Central Europe
	• Precipitation is expected to increase (ca. 10%), mainly in winter; summer precipitation may decrease in many regions
Potential impacts on forests	• Tree growth may increase in some regions, decrease in others
	• Risk and frequency of wind damage is expected to increase
	• Drought risks and extreme events (storm, flooding, fires)
	• Biotic pests are expected to have increased damage potential
Mediterranean	
Expected change in climate	• Temperature increase between +3 to +4°C, larger in summer
	• Precipitation is expected to decrease, mainly in summer
Potential impacts on forests	• Tree growth is expected to decline, extreme drought limitations for some species
	• Increased fire risk
Mountainous regions	
Expected change in climate	• Similar to surrounding regions, in Alps more pronounced temperature increase in summer
Potential impacts on forests	• In higher altitudes tree growth is expected to increase; in lower altitudes it depends on water availability
	• Biotic damages are expanding into higher elevations
	• Melting permafrost increase risks of landslides and flooding
	• Main threat: the maintenance of the protective functions of forests due to storms, insect outbreaks and fire

Source: Lindner et al. 2008

5.5.3 Adaptation options for forests

Forests in Europe are very diverse. They are subject to different management practices and also projected impacts of climate change vary a lot regionally (Lindner *et al.,* 2010). Whereas in North Europe and in higher mountain altitudes climate change is going to increase forest productivity at least in the short-mid-term, impacts are likely to be more negative in other regions. Consequently, it is important to pursue regional approaches to adaptation.

Depending on the main forest management objective, the focus of adaptation strategies may be more or less on timber production, other ecosystem services or reduction of disturbance risk. Forest management needs to support the adaptation process either by increasing the natural adaptive capacity (e.g. by enhancing genetic and species diversity) or with targeted planned adaptation measures (e.g. introducing an adapted management system or other species). A huge variety of adaptation options have been identified (e.g. Lindner *et al.,* 2008) and some of these are briefly described below.

Many adaptation measures can be combined, while others are mutually exclusive at the stand scale. It is important to note, however, that at the scale of management units or landscapes even conflicting strategies can be simultaneously applied in different places, thereby increasing overall diversity of forest conditions. Combining different adaptation options is one possibility to deal with the uncertainties of climate change.

Additionally, many forests in Europe are planted with trees, which are outside their optimum natural ecological range (for example, Norway spruce in lowland areas), in non-natural even-aged monocultures (as in the Pine forests in Central-East Europe) or in unfavourable mixtures. Often the used provenance of the trees used for afforestation is unknown. Beside the need to establish climate resilient forests, in many regions there is a need to convert the existing forests. Regarding the future higher fluctuation of water and therefore nutrient availability, a site specific mixture of different tree species is recommended. Stands should be developed, which are climate-adaptive with a high degree of self-regulation, which adapt to a changing climate by changing abundance of tree species (Jenssen, 2009). Models for this can be seen today in the composition of forests in the transition zones of different climatic regions.

In the following sections, the main options for forest adaptation measures are described briefly. In the next section, results of the EFISCEN scenarios will be discussed against the background of possible adaptation measures.

5.5.3.1 Forest regeneration

Forest regeneration offers a direct and immediate opportunity to select tree species or provenances that have a high potential under changing climate conditions. Regeneration is the stage in which it is easiest to manipulate and establish the diversity of species and the genetic composition of the stand. Successful establishment and early growth of stands requires a high effort in selecting the right provenances, preparing the site, weed control and possibly measures against damage from animal browsing.

Forest regeneration can be natural or artificial, by planting. The chosen method depends on the overall philosophy of forest management (e.g. 'close to nature' forestry) and the suitability of prevailing species for the expected future climate conditions. If there is no natural regeneration of the favoured tree species in the existing forest, or if it is of an unsuitable provenance, artificial regeneration needs to be used. In Europe a lot of provenance tests have been established in the past and these can be very useful in identifying suitable ecotypes or provenances for future climate conditions. However, results of new provenance tests aiming explicitly at the identification of drought and heat resistant provenances are not to be expected in the near future.

5.5.3.2 Tending and thinning of stands

The tending of stands means any treatment carried out to enhance growth of preferred species, quality and vigour, and to regulate the composition of a forest after establishment or regeneration and before final harvest. Most of the adaptation measures focus on modifications of tending and thinning practices, with regard to frequency and intensity. The aims of the measure depend on regional needs. In dry areas like the Mediterranean region, the reduction of the water demand is of high priority. In other regions it is important to create richer stand structures with fewer but vigorous trees, able to withstand storm events. In the Boreal region intensified thinning is recommended, since increases in growth in response to the changing climate may affect the stand stability of monocultures and stands with higher densities are more susceptible to biotic disturbances. In Alpine regions the main reason for increased tending and thinning is to promote a diversity of structure and composition to increase stability, which is important for fostering the protective function of these forests.

5.5.3.3 Harvesting

Tree harvesting removes trees from the forest either selectively or from complete forest patches. Harvest practices can be used to reduce the possible effects of extreme events, by selective harvesting of tall trees in wind exposed areas, by avoiding large felling areas and open stand edges, and by shortening rotations in vulnerable stands.

In stands with a neglected forest management, such as the dense coppice in the Mediterranean regions, more frequent harvesting will diminish the danger of forest fire and insect outbreaks.

5.5.3.4 Pest and disease management and forest fire prevention

In all climatic regions forests are likely to become more vulnerable to damage by insects and pests, which are likely to benefit from reduced tree vitality associated with droughts and higher volumes of damaged timber following wind disturbances. Measures against insects, pests and disease are crucial elements of adaptation strategies in many countries (SoEF 2011), especially in the Mediterranean region. Even though man is often the actual trigger for forest fires, the more pronounced dry and hot periods in summer are aggravating the severity of forest fires.

In many regions the main problems (storm, insects, fire) are interlinked, in that increased amounts of dry wood after storm events enhance the danger of forest fires and insect outbreaks.

5.5.4 EFISCEN scenario results and adaptation

The EFISCEN scenarios aim at identifying the possible development of forests under various assumptions in the period 2010 to 2030. However, forests should be sustainable for life spans of 120-150 years, and in the following evaluation of possible adaptation measures this is mentioned where necessary.

The productivity of a site is determined by the amount and availability of the primary growth factors: water, nutrients, light and temperature. These factors determine the 'carrying capacity' of a site, which cannot be manipulated too much in the long term by traditional forest management measures. Only with high investments for fertilizing, drainage or other melioration of sites it is possible to enhance the productivity.

In the scenarios short rotation plantations outside existing forest are not addressed. The use of fertilizer was included to compensate for nutrient losses due to harvest residue and stump extraction in the *Promoting wood energy scenario*. Limited forest growth due to water shortage is not included.

5.5.4.1 Reference scenario

In the *Reference scenario* the tree increment increased by 11% due to climate change, leading to higher growing stocks and fellings, but also to a considerably higher amount of extracted residues and stumps. The existing forestry guidelines are implemented, but no species composition change was allowed and rotation length was unchanged. The deadwood was as high as in the *Priority to biodiversity scenario*.

The increased extraction of forest residues and stumps in 2030 of 184% compared to 2010 is crucial, since nutrients and carbon are removed from the sites, leading to lower site productivity in the long term. The extraction of carbon from the forest with the residues and stumps lower the water storage capacity of the soils, which is essential to withstand long drought periods.

In this scenario, the ability of forests to adapt is more or less low, depending on the actual tree species and provenance composition, and it will be reduced further by the depletion of carbon and nutrients from soils. Another factor is the current guidelines, which will be left unchanged. This means for many regions, that climate change aspects will not be considered.

Adaptation measures should focus on the reduction of risks due to storms (preferential fellings in exposed areas), insects (removal of deadwood), and drought (reduce water demand by more frequent thinning).

5.5.4.2 Maximizing carbon sequestration

Maximising carbon sequestration can be achieved by partly increasing the rotation period. Combined with more intensive thinning this implies that more diverse forest structure is developing with increasing importance for natural forest regeneration (as in close to nature forest management in Central Europe). Natural forest regeneration over a long management cycle favours high genetic diversity in the following stand generations, which supports the natural adaptive capacity. On the other hand, long rotation periods can be problematic in situations where the existing species or provenance is not suitable for the future climate conditions. In the extreme case of maximising carbon storage in an unmanaged stand, only natural adaptation processes can take place. Given the rapid changes in climate expected in most European regions this implies increasing the risk of maladaptation in the future climate conditions.

The rotation periods in this scenario are long, and the management input may be relatively high in the early development of a stand.

5.5.4.3 Promoting wood energy

The rotation periods are short, compared to the other scenarios, facilitating more frequent adjustment of species and provenance composition. If artificial regeneration is used it is crucial to secure high genetic diversity in the plant material. With tending and thinning, the yield in the highly productive youth phase of a stand will be used. The use of energy wood from thinning is therefore in line with climate change adaptation measures to reduce water demand and lower the risk for fire and insect calamities. Early and regular thinning also improves stand stability against wind damage.

Removing harvest residues improves accessibility of stands for site preparation, if artificial regeneration is used. Removal of harvest residues helps to reduce fire and insect disturbance risks. On the other hand, the loss of soil carbon may lead to ecologically unwanted effects, e.g. higher risk of erosion, loss of water holding capacity of soils, problems with natural regeneration. The application of fertilizers to compensate for nutrient losses cannot substitute the beneficial effects of harvest residues in forests (water and nutrient storage capacity, soil biology).

The biodiversity under this scenario is lowest, due to a lesser amount of deadwood, and a more narrow age distribution of the trees. On the other hand, keeping stands more open supports also light-demanding species which are easier to maintain in mixed forests.

In the long term, the high mobilisation of wood energy may lead to a depletion of many forests, with the above mentioned increased ecological risks. To facilitate the harvest and to have a certain calculability of the yield, it is to be expected that stands with a relatively low diversity will be promoted, leading to a further reduced biodiversity. This will enhance the vulnerability (insects, drought periods). The transition to plantations will be 'smooth'.

Adaptation measure should focus on high resistance against weather extremes combined with effective tools for early warning of insects, fire, etc.

5.5.4.4 Priority to biodiversity

The *Priority to biodiversity scenario* requires, in many European regions, a high initial input to convert the existing forests to close to nature conditions. In the scenario a conversion of 50% of coniferous dominated forests to broadleaved and mixed forests upon clearfelling is assumed.

Beside this, the *Priority to biodiversity scenario* builds more on natural adaptation processes than the other scenarios. The increased share of protected forests, with only biodiversity management, will develop into valuable habitats for biodiversity. Due to reduced management interventions, species composition might not adapt quickly enough in some regions to the changing climate. Artificial regeneration of suitable provenances might be needed to complement natural regeneration and to adjust the genetic composition fast enough. There is a risk that mature dense stands could be more strongly affected by storm damages and consequent insect outbreaks. The wind vulnerability is the highest compared with the other scenarios.

The carbon sequestration is nearly the same as in the *Maximising biomass carbon scenario*. The annual fellings are lowest with 691 million m^3, but in 2030 they are still in the same range as in the *Reference scenario* today (2010). For an economic valuation on the long term, the reduced costs for management actions should be considered in addition to the reduced ecological risks. Under this scenario the need for planned adaptation is probably lowest in most European regions.

5.5.4.5 Fostering innovation and competitiveness

This scenario aims at a more efficient use of wood for new products and an optimized use of forests for recreation, sport and well-being. The challenge for the forest sector is the supply of various wood assortments and the environmentally friendly provision of recreation infrastructure. This might, in the long run, only be assured by the division of forest area for wood production purposes and those predominantly for recreation. The short-to mid-term economic benefits drive forestry decisions of the owners, due to the high possible yield.

Climate change adaptation under this scenario is similar to the *Maximising biomass carbon scenario* due to the fact that high amounts of wood are needed for new products. On the other hand, negative impacts can be avoided by payments to the forest owners for the desired ecosystem services, and by governance measures such as the implementation of strict guidelines for minimal standards of good silvicultural practice.

5.5.5 Research needs

To move forward, the research outlined below is needed.

1. Implementing adaptation strategies: there is insufficient experience of how and especially when to adapt management practices. Current species may experience increasing amounts of damage in the future, but new provenances or species may not yet be fully suitable for the current climate. Trade-offs between business-as-usual, reactive, or fully forward-looking adaptive decision making are not yet well understood.
2. Forest monitoring: forest monitoring is crucial as an early warning for changes in health and vitality of forests, for pest and disease outbreaks as well as forest fires. Such data constitute the basis for forest planning, and for practical research (Bernier and Schöne, 2009). It helps to quantify and map the risks linked with climate change. There is also a need to monitor the success (or non-success) of adaptation measures. Decisions have to be made on incomplete information and 'learning by doing' according to an adaptive forest management will be a common practice in the future. Documenting the experience will help to optimize the measures.

3. Ecological / physiological range of forest trees: knowledge about the ecological range of forest trees and stands is insufficient. Many relationships are known mainly on an empirical basis, but knowledge of quantified cause-effect relations is scarce. The response of trees to combined stresses (e.g. ozone, nitrogen, drought) is largely unknown (Bytnerowicz *et al.,* 2007). More understanding is also needed on tolerance of extreme events, and physiological limits of specific trees species.

5.5.6 Needs in further development of climate change governance in forestry

There are a number of specific measures which are needed in order to enhance the effectiveness of forest governance processes. These are outlined below.

1. Decision-support systems: the implementation of decision-support systems may help to transfer the results from empirical observations, monitoring and scientific results to the forest practitioners. In the future such decision-support systems may help to integrate the information from different disciplines.
2. Adapting policies and institutions, including capacity building: in order to react more flexibly, it is necessary to create adequate structures within the relevant institutions (Lindner *et al.,* 2008). In the future it will be increasingly necessary to transfer new experiences and knowledge into policy guidelines and to develop programmes to train forest practitioners on adaptive forest management. The harmonization of national forest plans and adaptation strategies with those on climate, energy and biodiversity will become a priority task. Such tasks are new for the forest sector and will require skilled personnel and appropriate structures.

5.6 Protecting and enhancing biodiversity

5.6.1 Policy framework and targets

Society's expectations of both forest management and the conservation of biological diversity are evolving. In the last decade the conservation of forest biodiversity has increasingly been addressed in global agreements as well as in European and national policies. Driven by societal demands European governments have taken up the issue, and stakeholder groups have been continuously pushing for further action at international, regional and national levels (see McDermott *et al.,* 2010, Wildburger, 2009a).

Correspondingly, the CBD as the most comprehensive global biodiversity policy instrument not only adopted a work programme on forest biodiversity, but also set the targets to include 10% of all forest types in protected areas by 2010 as well as to have at least 10% of each of the world's forest types effectively conserved (see Wildburger 2009b). At the same time FOREST EUROPE, as a pan-European platform for forest policy development, committed itself to contribute to the implementation of the CBD and translated the global decisions to the regional level in several declarations and resolutions, striving for their coordinated implementation at European level. Furthermore, the EU, being a signatory to the CBD, implemented the respective commitments in its regulatory framework (European Commission, 2011).

As a result of these developments biodiversity conservation now gets more attention in forest management. SoEF 2011 concludes that the conservation of biodiversity is increasingly promoted within sustainable forest management practices. Most notably, the area of forests protected and managed for the conservation of biological diversity has increased considerably in the last ten years and covers about 10% of the European forest area. Another 9% is designated for landscape protection. At global level, 13% of terrestrial areas are protected to date (CBD 2011b), and according to the most recent Forest Resource Assessment (FAO, 2010) 12% of the world's forests are designated for biodiversity conservation (but not all of them are in protected areas).

Yet, the Millennium Development Goal[21] to significantly reduce the current rate of biodiversity loss by 2010, has not been met. In response, in its Strategic Plan the CBD has set global headline targets for 2020, including designating 17% of terrestrial areas for conservation, and has adopted the updated Global Strategy for Plant Conservation, which sets a target to conserve at least 15% of each of the world's ecological regions and vegetation types (CBD 2011a). Correspondingly, the EU has confirmed its goal to halt biodiversity decline and the degradation of ecosystem services in Europe by 2020 (European Commission 2011). In the context of these political efforts the challenge is to achieve a win-win outcome that satisfies needs for wood raw material while meeting the conservation targets and halting the decline of biological diversity.

[21] *MDG Target 7b: 'Reduce biodiversity loss, achieving, by 2010, a significant reduction in the rate of loss'*

5.6.2 Trade-offs between biodiversity conservation and other policy goals

Several factors essential for meeting biodiversity conservation targets are furthered in the projected *Priority to biodiversity scenario*, but are rather difficult to advance in other policy scenarios. An increase in protected forest areas designated for biodiversity conservation is only projected in the *Priority to biodiversity scenario* and might also be compatible with the goal to maximise carbon storage, but will hardly be achieved in any scenario focusing on a fast and significant growth in wood supply. Even if there is high mobilisation of wood, it would be impossible to meet the extremely high demand assumed in the *Promoting wood energy scenario* with a reduced area of forest available for wood supply, as assumed for the *Priority to biodiversity scenario*. The segregated approach (i.e. biodiversity conservation on a large area of protected forest, intensified wood production on remaining forest available for wood supply) would not seem capable of supplying enough wood to meet the renewable energy targets.

Deadwood, an important biodiversity indicator, is increasing only in the *Priority to biodiversity scenario* in the long run, but decreasing in all other projected policy scenarios. Accumulating larger amounts of deadwood is always contradictory to considerably raising the levels of woody biomass removals from forests. Residue extraction, in particular, is a key factor in this context, as residues are an important deadwood component, but also a source for wood supply that has been exploited very modestly up to now and, which is projected to be used more intensively.

The quality of deadwood and its distribution over age classes, both of which are important for its suitability as habitat, have not been assessed. In this respect it should be kept in mind that intensified thinnings might reduce deadwood in some age classes. Furthermore, it should be considered that it might even be useful to extract residues of spruce stands outside their natural range, if they are of limited benefit for creating deadwood qualities supporting increased biodiversity. Instead, they could contribute to enhanced wood supply, especially in cases where the conversion of conifer to broadleaved stands is the goal.

A shift in age class distribution from younger to older age classes, enhancing structural diversity and providing a wider range of habitats, is only projected for the *Priority to biodiversity scenario* and, to a lesser extent, for the *Maximising biomass carbon scenario*. All other policy scenarios are expected to reduce the percentage of older age classes, thereby diminishing the richness of stand structures. This dynamic is usually correlated with the development of tree species composition, which is potentially more diverse in a broader range of structures. The *Promoting wood energy scenario* is projected to have the least supportive age class distribution in terms of biodiversity conservation.

Some other policy goals are achievable in compliance with biodiversity conservation strategies. The average amount of total carbon per ha will be highest in the *Priority to biodiversity scenario* creating a win-win situation with the *Maximising biomass carbon scenario*, as its main goal would be met. To assess the sustainability of the carbon balance in the long run carbon sequestration beyond 2030 and the substitution issues would also need to be taken into account.

The provision of other ecosystem services such as recreation, water and soil protection, and air quality will be developing very positively in a *Priority to biodiversity scenario*. Creating additional forest related incomes might require innovative approaches to non-wood forest goods and services. It can be assumed that (eco) tourism is generally positively correlated with the developments in a *Priority to biodiversity scenario*. The support of market based recreational services and the establishment of PES schemes are examples of relevant political approaches in this context.

While increment and growing stock figures are highest in the *Priority to biodiversity scenario*, the wood supply is projected to fall short of meeting the 2030 potential demand in the *Reference scenario*, by 176.2 million m^3. This reduction in the supply would need to be balanced. A possible source could be wood from the enlarged areas managed for biodiversity protection. The SoEF 2011 data shows that more than 62% of the forest area designated for biodiversity conservation is actively managed on a regular basis, and no active intervention is taking place in merely 12% of the protected forest (MCPFE class 1.1). Schelhaas *et al.*, 2011 conclude in their paper on the impact on sustainability of European forests of different levels of nature conservation designation, that while "an increase in nature designation level gave a comparable decrease in maximum sustainable harvest…, close to nature management in part of the designated areas could mitigate about 60% of this reduced harvest potential". Based on the assumption that 60% of protected forests are managed actively and the harvest rate is 60% of the harvest in FAWS, around 58 million m^3 stemwood could be supplied out of forest areas not designated for wood production.

A higher share of 'landscape care wood' might also partly contribute to balance shortages in a *Priority to biodiversity scenario*. The EUwood study (Mantau *et al.,* 2010) for example estimates that this source could be expanded significantly. Their medium estimate, as taken in the *Reference scenario*, is 81 million m^3 for 2030. The *Promoting wood energy scenario* assumes a higher mobilisation rate, with an estimated availability in 2030 of 108 million m^3, providing an additional 27 million m^3 of woody biomass. Mobilising these two sources might have the potential to reduce the gap by 85 million m^3 to 91.2 million m^3.

In addition, a larger area of short rotation plantations on agricultural land could make a major contribution to the wood supply in Europe. However, as Prins et al. (2009) point out, major uncertainties surround this potential, concerning competition with other agricultural production and food supply as well as land prices and social preferences. In addition, the impacts on biodiversity and especially landscapes might be severe and might contradict biodiversity policy targets. FOREST EUROPE's Pan-European Guidelines for Afforestation and Reforestation, already take account of these issues, and give guidance for site selection for afforestation. For example, afforestation of areas of high ecological value, particularly the conversion of natural and semi-natural non-forest ecosystems and areas of high soil carbon stock should be avoided (MCPFE 2008). Based on appropriate site and species selection, coppice could be a traditional silvicultural system suitable for increasing biodiversity and wood supply at the same time.

In this context it has to be taken into account that in the socio-economic framework of a *Priority to biodiversity scenario*, consumers are presumably more environmentally aware. If strict policies for biodiversity conservation are accepted nationally, most likely a rather high level of environmental awareness of the respective society will be the precondition. Therefore, it is likely to find acceptance for higher prices for the 'environmentally friendly' resource wood, but on the other hand consumers will be more concerned where the wood is coming from, if it is from sustainably managed resources and if the CO_2 balance is neutral. More imports from outside the European region might raise some concerns, too.

The *Priority to biodiversity scenario* does not consider particular species, site selection and detailed management procedures, due to restrictions in modelling. However, in forest management aimed at biodiversity conservation, landscape and site-specific approaches are needed, and respective strategies and measures have to take care of that. These approaches would also allow more flexibility for adjustment of trade-offs between policies. In addition, it has to be considered that a long term perspective beyond 2030 is crucial for forest biodiversity conservation and needs to be taken into account in all decisions.

5.6.3 Conclusions

The *Priority to biodiversity scenario* shows as the expected outcome that biodiversity conservation goals are furthered. A win-win solution is possible with the goal to maximise carbon storage in European forests as well as with ecosystem services such as recreation, water and soil protection, and air quality. A win-win solution for forest related incomes would depend on further political efforts to implement PES schemes and on the development of market-based recreational services.

Achieving a win-win solution with a 'regular' increase in wood supply seems to be difficult and would require further investigations and creative solutions on how to close the gap between potential supply and expected demand. However, a modest rise in wood supply is definitely possible in the projected *Priority to biodiversity scenario*.

A clear win-lose situation exists in the trade off with the goal to promote wood energy and meet respective policy targets, as there would not be enough woody biomass available to meet the projected strongly increased demand. The gap created by the absence of residue and stump extractions, as well as less fellings, could not be balanced by alternative sources.

5.7 Supplying innovative and competitive forest products and services to Europe and the world

"Innovation is a central driver of economic growth, development, and better jobs. It is the key that enables firms to successfully compete in the global marketplace, and the process by which solutions are found to social and economic challenges, from climate change to the fight against deadly diseases. It is the source of improvements to the quality of our everyday life." Francis Gurry, Director General of the World Intellectual Property Organization, in his introduction to the Global Innovation Index 2011 (INSEAD, 2011).

EFSOS is primarily intended for policy makers and their advisers, but it is important to remember that the outlook for the sector is not only the result of external events and of policy choices, but of the ideas and actions of everyone in the sector. Each actor, from the lowest to the highest, may or may not be innovative, generating new ideas and implementing them in his/her own area of action.

There are many types of innovation, notably for products, processes, marketing and organisation. Chapter 3 presents some innovations and their possible consequences for the sector, including improved housing systems from composite wood products, bio-refineries, intelligent paper and development of PES. Many of these are already well advanced and on the brink of implementation, but in the medium term, say to 2030, it is not possible to say with any certainty which innovations will succeed and which will fail. What is important is that innovation, by individuals, companies or governments, can influence the long term development of the sector in powerful but unexpected ways. Successful innovation can much improve the outlook for the sector, in any of the scenarios. The conceptual analysis presented in Chapter 3 focused on the potential to move from a commodity approach to a more specialised, sophisticated and value added approach in all parts of the forest sector, with the result that the forest sector in Europe became more varied, technologically advanced and prosperous. However, other pathways could be imagined.

Innovation might improve the outlook in any of the policy scenarios, for instance, by finding new ways to use wood energy more efficiently, thus reducing the stress on the forest, or by developing silvicultural systems which supplied more biodiversity without reducing wood supply, or by maximising the long term productivity of European forest sites by silvicultural measures, without external inputs.

On the other hand, if there is no innovation in the European forest sector, or if other regions or sectors innovate more successfully, the consequences would be negative, including shrinking markets, falling exports/rising imports, lower incomes, wood shortages and less attractive and bio diverse forests.

However, innovation cannot be ordered by a law or regulation, or even by large sums of public money, but must be nurtured with care, in a process which is as yet imperfectly understood. In today's knowledge-based economy governments and companies are seeking to understand the 'secret' of successful innovation which accounts for the intense academic activity whose main conclusions were summarised in Chapter 3. The knowledge base, physical infrastructure, workforce, intellectual property rules, entrepreneurship, flexibility, access to capital, open markets, appropriate standards, access to marketing and communication all play a role. Perhaps most important, and most difficult to replicate, is a culture which welcomes and rewards innovation.

Furthermore, it is not possible, or even desirable, to develop an innovative culture and framework conditions which are focused only on the forest sector. EFSOS certainly has no tools to monitor or compare innovation in different national forest sectors. Innovative ideas move from one sector to the other, and feed on each other, so it is the whole society which should become more innovative, not just a single sector. However, some countries within Europe are among the most innovative in the world. The Global Innovation Index 2011 shows six of the top ten countries for innovation in the world are from Europe (world rank 2011 in brackets): Switzerland (1), Sweden (2), Finland (5), Denmark (6), the Netherlands (9) and the UK (10) (INSEAD, 2011). Some of these countries have important forest sectors.

What conclusions can be drawn from this brief discussion of the importance of innovation?

The outcomes in terms of production, consumption and trade, could be quite different (better) from those in the *Reference scenario* if innovation became well established in the European forest, or worse if competing regions or sectors innovated more effectively than the European forest sector.

Further development of a true culture of innovation should therefore be an objective for the sector and governments. Each actor, government, enterprise, sector association, should consider what it could do to encourage innovation and be open to innovative ideas.

Governments should consider whether there are any obstacles to innovation in their country, such as excessive bureaucracy, weak education systems, poor infrastructure (roads, harbours, internet connections), difficulties to raise capital for innovative ideas, rigid standards. If this is the case, corrective action would very probably be a worthwhile investment.

Finally, innovation is mainly seen as a preoccupation for the forest products industry (manufacture and trade of forest products). However, forest management also needs innovative approaches, for instance in developing new forms of recreation or new ways of financing biodiversity conservation or the provision of other ecosystem services. Some European forest owners have proved they are capable of very innovative approaches. The state forest organisations have consistently been at the forefront in this field. There is a need to persuade all forest owners that they can innovate, in their silviculture, their management of recreation and biodiversity, and their communication and that such innovation can bring them long term benefits.

5.8 Achieving and demonstrating sustainability

Chapter 4 presented a method to assess the sustainability of those EFSOS scenarios which were quantified. The method is based on the experimental assessment method developed for SoEF 2011. It is based on 16 key parameters, covering 5 of the 6 criteria for sustainable forest management. The values for the key parameters are derived from the scenarios and give an overview within the constraints set by data availability and quality of the sustainability of each scenario. Results were calculated at the country level, but presented at the country group level, for each parameter, and then aggregated to the criterion level and for Europe as a whole.

At the level of Europe, most of the parameters for most of the scenarios scored 3 (out of 5), or more, which may be considered broadly acceptable. The main areas identified as being of concern are biodiversity in all scenarios except for the *Priority to biodiversity scenario*, and the carbon flows in the *Promoting wood energy scenario*.

The challenge identified in Chapter 2 is to achieve and demonstrate sustainability. EFSOS II as a whole is intended to support policy makers in their search to achieve sustainability. Demonstrating sustainability implies accurate monitoring of trends, leading to objective assessments, and communication of the results and outlook to society as a whole, as well as to related sectors, notably climate, biodiversity and energy.

The two methods developed in 2011, for SoEF 2011 and for EFSOS II, show that there has been significant progress on monitoring and assessment of sustainable forest management in Europe. This has been made possible first of all by an improvement in the basic data, which is now much more comparable and comprehensive than in the past[22]. Nevertheless, both assessment methods need further development and more testing before they can be considered a completely reliable basis for policy making. In particular, the approach pioneered in EFSOS II should be expanded by the inclusion of more parameters, with more consideration of the form of the parameters[23], and thresholds. Possible new parameters to be included in the sustainability outlook analysis would be: consequences of climate change; effects of soil disturbance on carbon flows; condition of forest soils; nutrient balances; forest damage due to external agents (e.g. insects, game or pollution); supply and value of non-wood goods and services; species loss; landscape fragmentation; employment; and, entrepreneurial revenue. This development process should, like SoEF, call on specialists in the relevant areas, and be linked to the development of models to be used for the outlook studies.

Given this likely progress in assessment methods, the next stage is to use them to evaluate policy choices. In this way, forest sector decision making can be objectively linked to perceptions of external developments, and policy priorities, as well as taking account of a wide range of consequences for sustainability.

The availability of these instruments for policy analysis will also strengthen the sector's ability to communicate with other policy making processes and with the general public. For this communication to be effective, the analysis must be based on reliable and comprehensive data, and be presented in a rigorous and simple way. For other sectors, notably climate and energy, the outputs of the forest sector analysis must be made available in the appropriate units –tonnes of carbon and tonnes of oil equivalent – and in such a way as to be linked to policy analysis in the other sector. When there is consensus on how to monitor changes in biodiversity – which is not the case at present – the forest sector must be in a position to supply information on forest biodiversity in a way which can be understood by the biodiversity community.

Until recently, communication and dialogue between the forest sector and other sectors has been imperfect and many misunderstandings persist on all sides. The approaches developed for SoEF 2011 and EFSOS II have the potential to improve this situation.

5.9 Developing appropriate policy responses and institutions

EFSOS II has focused on quantifying the consequences of policy choices, and exploring the sustainability of the various options, and on trade-offs between the strategic alternatives. However, institutions play a crucial role in policy formulation and, above all, in policy implementation. This section briefly reviews the present state of European forest sector policies and institutions and how the major challenges are being addressed at present.

[22] *The improvement in data quality and, even more important, coverage (as measured by number of indicators), is visible by comparing successive versions of The State of Europe's Forests. The version presented in 2003 in Vienna, had many missing data and no attempt at assessment, that of 2007 (Warsaw) contained the rather simple 'traffic lights' approach to assessment (change rates of a subset of quantitative indicators), and in 2011 (Oslo), each indicator, quantitative and qualitative, was assessed.*

[23] *For instance whether to use percentage change or the state of the parameter in 2030.*

It also asks whether the existing institutions and policies are adequate to address the challenges identified by EFSOS II.

The main source of information on forest sector policies and institutions is Part II of SoEF 2011, which reports on the qualitative indicators of sustainable forest management and provides considerable detail, based on a recent comprehensive official enquiry. Relevant parts of SoEF 2011 are summarised in the present section.

5.9.1 State of forest sector policies and institutions in 2010

According to SoEF 2011:

- All 37 reporting countries have a national forest programme or a similar process in place, with 27 of the countries reporting that these were formal NFPs or processes guided explicitly by NFP principles. A 'National forest programme', 'forest policy' or 'forest strategy' document existed in 33 countries and were on average around five years of age. European countries have significantly strengthened their mechanisms for participatory policy development over the past decade.
- Almost two thirds of the reporting countries stated that significant changes had been made in their institutional frameworks since 2007. This mainly took the form of merging bodies with forest competencies which had been separate before or integrating them into other existing bodies. The second most frequent change was measures to establish forest services and/or private forest owner associations, particularly in South-East Europe.
- Nearly 80% of the countries had changed their legal/regulatory framework since 2007, with most changes affecting silvicultural practice, enshrining institutional reorganisation and reorganising financing arrangements. EU Regulations and Directives on forest have heavily influenced a range of national regulations in EU member states, and possibly also in candidate countries.
- Total government spending on forest related activities was about EUR 18.4 of public spending per ha of forest and other wooded land. Financial support for sustainable forest management across the region has been fairly stable, with any increases occurring mainly in those Eastern European countries which have become EU members since 2007.
- Improvements in information provision were reported by 24 out of 35 countries, which ranged across data collection systems, easier access to data and providing targeted information to different groups. Communication strategies, public participation and consultation were improved. It was clear that communication was gaining in importance and political relevance across the region, especially in Eastern Europe.

5.9.2 Policies and instruments on climate change mitigation and adaptation

Newly developed and adopted national instruments were influenced by recent international climate change debates, agreements and targets. Many countries reported a stronger focus than in 2007 on carbon sequestration by forest and wood products, and adaptation of forests to climate change impacts. In addition, several countries mentioned the importance of increasing the use of wood as raw material and a source of renewable energy, and reducing national GHG emissions. EU countries consistently reported policy objectives in line with the principal objectives of the EU Climate and Energy Package 2008[24]. Nearly half the responding countries aimed to increase or maintain carbon stocks in forests, mainly through afforestation.

Many countries drew attention to the need to develop measures and programmes for the adaptation of forests to changing climatic conditions and the increased frequency of extreme weather events such as heat waves, droughts, storms, fires and floods.

In almost all countries, the legal basis for forests and their relevance for the carbon balance was a set of laws and regulations relating to climate change, renewable energy and energy efficiency, as well as strategies and programmes for climate change and forests.

Countries have established specialised entities responsible for implementing regulations and programmes on climate change, renewable energy and energy efficiency. Financial mechanisms included transfer payments, mainly for afforestation and regeneration, renewable energy and energy efficiency measures. Only three countries reported the increasing use and improvement of information instruments, such as forest monitoring to get better information on carbon sink and source effects.

[24] *To achieve, by 2020, a 20% reduction in GHG emissions, 20% of energy consumption and production from renewable sources and 20% reduction in primary energy use.*

It is clear from the above that countries are putting in place policies and instruments on the role of forests in climate change mitigation and on adaptation of forests to climate change, and that these are integrated with traditional forest sector policy instruments, such as NFPs and transfer payments for afforestation. Are these policies and instruments sufficient for the complex challenges identified by EFSOS II? The scenario analysis showed the importance of finding the right balance between carbon sequestration and storage, and substitution of non-renewable products and energies. The *Maximising biomass carbon scenario* found that the optimum mitigation effect results from combining certain silvicultural measures with a steady supply of wood raw material: it is not clear, from preliminary observations, that the instruments in place are sufficiently precise and detailed to achieve this delicate balance. In most countries forest monitoring for carbon flows is not rapid enough to observe carbon flows in the short term, and so to correct negative trends.

Likewise, although the challenge of adaptation to climate change was recognised in the SoEF 2011 reporting, there is little evidence of the site specific strategies and guidelines which appear necessary. At present, informational instruments would seem to be the most necessary in a situation marked by risk and uncertainty about the future, although economic incentives, perhaps even regulations, may become necessary as the situation develops.

5.9.3 Policies and instruments for wood energy

Instruments and policies relevant to wood energy were reported under several headings: production and use of wood, land use and forest area, as well as carbon balance (mentioned above).

Several countries reported that a main current objective was to undertake measures to enhance the productivity of forests and the efficiency of their utilisation. One third of countries reported the aim to increase both the harvests and the rate of utilisation of the annual increment, whereas 16 countries defined the target for harvests to remain the same. A clearly visible trend in the SoEF 2011 report compared to 2007 is the increased use of wood to meet renewable energy targets. Almost two thirds of the reporting countries aimed to increase their use of wood for energy.

Increasing the area of forest was a main policy objective for 45% of reporting countries. About 30% of countries reported clear targets with defined thresholds and targets. These objectives have been incorporated into the *Reference scenario*. There was growing interest in short rotation forestry; nine countries proposed to increase short rotation forestry in the next few years, mainly for energy purposes. In general, no specific policy objectives or quantified targets for short rotation forestry were reported, as it was considered part of agriculture or energy policy, not forest policy. Most regulation and laws on land use focused on protecting existing forest cover.

The main legal basis or policy document for the production and use of wood was the forest law but, in addition, several countries referred to specific regulations dealing with bioenergy, climate change and public procurement.

The majority of countries reported no change in institutional structures for wood production and use. As in 2007, most countries referred to forest management and/or regional development plans as the main instruments to secure sustainable use of wood. However, several more countries than in 2007 reported measures to promote the use of wood by creating demand through public procurement (or green public procurement), certification schemes, building standards and regulations.

Most countries demonstrated that they were aware of the issues connected with wood energy and the need to expand wood supply to meet renewable energy targets. However, most of the regulations in place are intended to prevent unsustainable management by limiting harvests, rather than to meet renewable energy targets by mobilising large volumes of wood on a sustainable basis. There is little evidence in the responses to SoEF 2011 of the realisation that an exceptional mobilisation effort is needed, inside and outside the forest, to mobilise enough wood to meet the agreed targets for renewable energy. The mobilisation guidance (MCPFE, DG AGRI, UNECE/FAO, 2010) and similar documents, which have been prepared and discussed at the expert level, have not yet been translated into official policy nor have sufficiently powerful policy instruments been put in place to mobilise enough wood (if that is possible or desirable), or to develop alternative strategies.

5.9.4 Policies and instruments for biodiversity conservation

A significant number of countries reported new and more ambitious forest biodiversity targets, compared to 2007. Several countries have developed new objectives and related instruments or have developed existing policies. Protected forest areas have been increased or will be increased. Several countries reported their efforts to include biodiversity conservation in sustainable forest management practice, by, for example, aiming for greater natural species composition and diversity in their forests, or by integrating islands of old/dead wood in managed forest. Some countries reported specific programmes to improve ecological connectivity between protected areas.

In most cases, objectives were rather general (e.g. to stop the loss of biodiversity) or instrument oriented (e.g. to increase protected areas). A significant number of countries emphasized a general goal to increase the protected forest area with about one third setting quantified goals for this objective.

In most countries, the institutional framework remained stable, compared to 2007, although there have been some amendments to the legal framework. Biodiversity conservation was mostly addressed by regulatory instruments, but voluntary financing schemes had grown in importance. Financial incentives related mainly to establishing protected areas in EU countries, especially for Natura 2000 sites. Regional differences could be seen in the approach chosen: mostly regulatory instruments in Eastern and Southern Europe, whereas voluntary and financial instruments tended to dominate in the Nordic countries. EU biodiversity, agriculture and rural development policies have led however, to a convergence of approaches.

Biodiversity policy and instruments are now well established, with strong momentum, and stable institutions. SoEF 2011 did not enquire as to how biodiversity objectives are reconciled with those for wood supply, renewable energy or climate change, and how the trade-offs apparent from the EFSOS II scenarios should be resolved. The main challenge appears to be the harmonisation of policy objectives and instruments for biodiversity with those for energy and climate change.

5.9.5 Policies and instruments for innovation and competitiveness

When reporting on production and use of wood for SoEF 2011, 'innovation' was frequently mentioned by countries, without further specific information. The European Commission prepared a communication to the Council and the European Parliament on innovative and sustainable forest-based industries in the EU, as a contribution to the EU's Growth and Jobs Strategy (European Commission, 2008). This presents an integrated approach to enhancing the EU forest-based industries sustainable competitiveness, and recommends actions in the fields of: access to raw materials; climate change policies and environmental legislation; innovation and R&D; trade and cooperation with third countries; communication; and, information.

The EU Forest Action Plan Objective 1 is to improving long term competitiveness, with Key Actions 1 and 2 on the effects of globalisation and on encouraging research and technological development respectively. Under the latter the FTP has been set up, and has developed a Strategic Research Agenda. FTP is coordinating major research programmes, funded by the EU, member states and the private sector (FTP, 2006).

There is general agreement on the vital importance of innovation and competitiveness for the long term vitality of the sector, but, with the exception of the FTP, action is not sectoral, but broader, focusing on multi-sector aspects such as education, infrastructure, enterprise law, or costs and exchange rates, and, for that reason, not reported in forest-centred studies.

Most discussion of innovation in the forest sector refers to the downstream part of the sector: production and consumption of forest products. The potential for innovation in forest management is often overlooked. Innovation by forest managers could develop and market a wide range of recreation and ecosystem services, which could radically change the balance between wood and the other goods and services provided by the forest.

5.9.6 Discussion

The brief summary of the responses received by SoEF 2011 shows that forest sector policies, institutions and instruments in Europe are in general stable, recent and effective. Increasingly the forest sector enjoys public support through the participatory nature of NFP processes, which integrate the positions of the many concerned actors, and provide a basis for dialogue with other sectors on the major challenges of the day. Objectives have been formulated for the policy challenges addressed by EFSOS II: climate change mitigation and adaptation, renewable energy, biodiversity, innovation and competitiveness.

However the challenges posed by climate change, energy and biodiversity issues are exceptionally complex and long term, and require quite profound changes if they are to be satisfactorily resolved. They will, of course, benefit some actors in the sector while harming others. It will require a very high level of sophisticated policy making, sharply focused policy instruments and strong political will to mobilise enough wood for energy, to implement the right balance between carbon sequestration and substitution and to conserve biodiversity without sacrificing wood supply. The policy environment will be increasingly difficult, as government budgets are cut and international commitments and negotiations increasingly influence domestic policies. Will today's policies and institutions rise to the challenge? To do so will require much improved monitoring systems, the ability to reach consensus, inside and outside the sector, on complex issues, as well as the creation and implementation of sharply targeted policy instruments, which make the best possible use of limited government funds. High level political will is also necessary, to ensure that forest management is not only sustainable, but makes the best possible contribution to the sustainable development of society as a whole.

6 Conclusions and recommendations

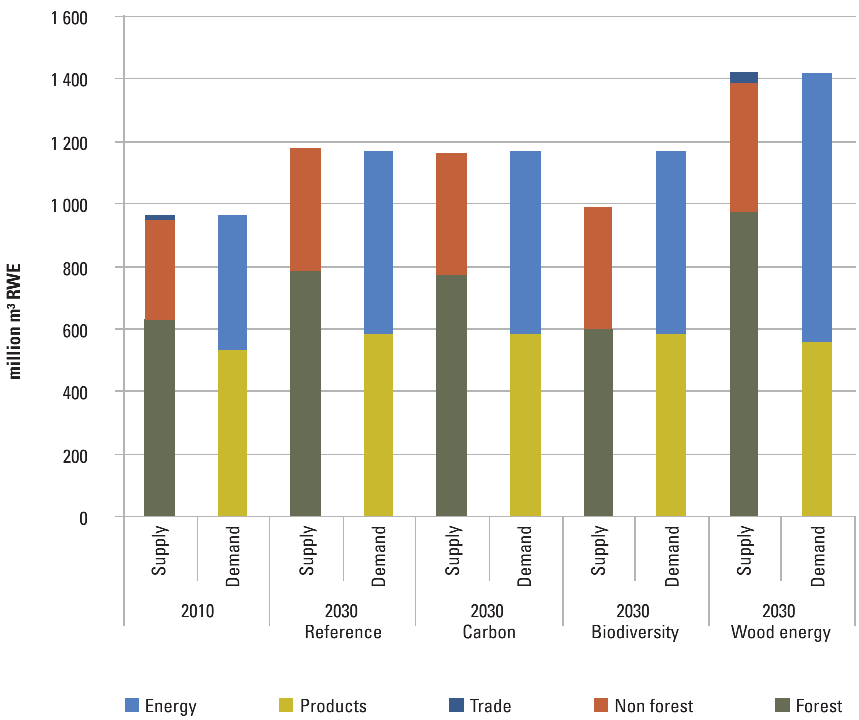
6.1 Conclusions

If no major policies or strategies are changed in the forest sector and trends outside it follow the lines described by the IPCC (B2 scenario), consumption of forest products and wood energy will grow steadily and wood supply will expand to meet this demand. All components of supply will have to expand, especially harvest residues (*Reference scenario*).

To maximise the forest sector's contribution to climate change mitigation, the best strategy is to combine forest management focused on carbon accumulation in the forest, longer rotations and a greater share of thinnings (*Maximising biomass carbon scenario*), with a steady flow of wood for products and energy. In the long term however, the sequestration capacity limit of the forest will be reached, and the only potential for further mitigation will be regular harvesting, to store the carbon in harvested wood products or to avoid emissions from non-renewable materials and energy sources.

If wood is to play its part in reaching the targets for renewable energy, with rather favourable assumptions about energy efficiency and increases for other renewable energies, and without expanding forest area, wood supply would have to be mobilised strongly, increasing by nearly 50% in twenty years (*Promoting wood energy scenario*). However the mobilisation of such high volumes would have significant environmental, financial and institutional costs. To achieve this level of highly intensive silviculture and harvesting, strong political will would be necessary to modify many framework conditions for wood supply. The very high levels of extraction of residues and stumps would negatively affect nutrient flows, soil carbon and thus water holding capacity and biodiversity. Forests would also be less attractive for recreation.

Figure 24: Supply/demand balance in the quantified scenarios, 2010-2030.



To increase European wood supply from outside the existing forest sector, it would be necessary to establish short rotation coppice on agricultural land. To supply an extra 100 million m^3, about 5 million ha would be needed, assuming medium productivity. Thus, to supply the equivalent of harvest residues and stumps in the *Promoting wood energy scenario* would require about 9% of the utilised agricultural area of the EU27. This could significantly reduce the pressure on the existing European forest and help to build the share of renewables in energy supply, but at the cost of trade-offs with other land uses and, depending on site selection processes, landscape and biodiversity.

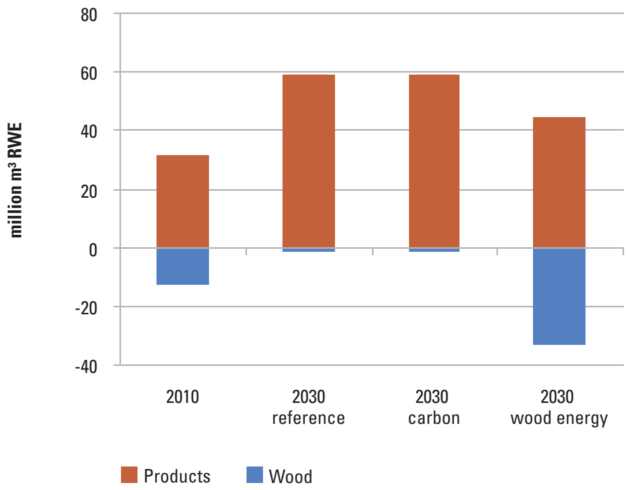
Demand for energy wood is directly determined by the efficiency with which it is used. The most efficient ways in general are for heat production or in CHP installations. The distribution of the resource also influences the efficiency of the wood energy pathway, as transporting large volumes of bulky, moist wood is inefficient. Use-efficiency is improved if transport distances are kept short, or if wood energy is transported in a concentrated form, such as pellets or biofuels. Efficient wood burning installations equipped with the necessary filters prevent the emission of fine particles which are harmful to human health.

If biodiversity were given priority, for instance by setting aside more land for biodiversity conservation and changing forest management to favour biodiversity, the supply of wood from the European forest would be 12% less than in the *Reference scenario*, necessitating reduced consumption of products and energy, and/or increased imports from other regions and/or intensified use of other sources like landscape care wood and wood originating from conservation management and short rotation coppice (*Priority to biodiversity scenario*).

A more innovative approach in all parts of the sector could create, defend or expand markets, create new opportunities, reduce costs and increase profitability (*Fostering innovation and competitiveness scenario*). There are particular opportunities, in the product field, for improved housing systems from composite wood products, bio-refineries, and ‘intelligent paper’. Forest management also needs innovative approaches, for instance in developing new forms of recreation, new ways of financing biodiversity conservation or the provision of other ecosystem services. Developing a culture of innovation is a complex challenge, going far beyond the boundaries of the forest sector.

Europe is, and will remain in all scenarios, a net exporter of wood and forest products[25]: significant net exports of products outweigh relatively minor net imports of wood. The positive balance (net exports, aggregate of wood and products, in m^3 RWE) is about 20 million m^3 in 2010, and would triple, to 60 million m^3, in most scenarios. Even in the *Promoting wood energy scenario*, where net imports of wood rise to over 30 million m^3, there are still net exports of the whole sector of more than 10 million m^3 (Figure 25).

Figure 25: Europe, net trade, 2010-2030.



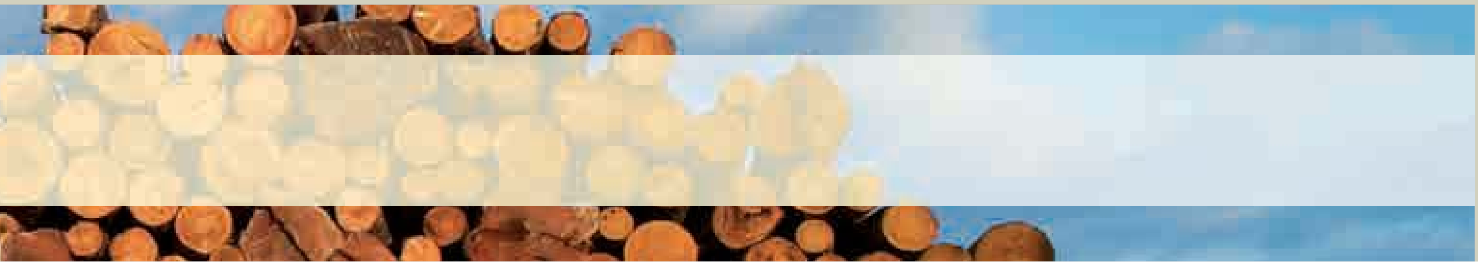
Note: Negative values denote net imports, positive values denote net exports.

Supplies of landscape care wood (e.g. from urban and highway trees, hedges, orchards and other wooded land) and post-consumer wood have the potential to increase by about 50%, reducing waste disposal problems for society as a whole.

Projections, notably by EFI-GTM, show a steady rise in prices of forest products and wood over the whole period, driven by expanding global demand and increasing scarcity in several regions.

A method developed for EFSOS II, which builds on the sustainability assessment of SoEF 2011, has been used to review the sustainability of the *Reference scenario* and all three quantified policy scenarios. The results are presented in Chapter 4, with an overview in Table 19. Most parameters, in this experimental method, are relatively satisfactory. The main concern is for biodiversity, as increased harvest pressure in all scenarios, except for the *Priority to biodiversity scenario*,

[25] *The data do not take into account trade in processed wood products such as furniture, joinery (windows and doors, building components), toys, or books. This trade has been expanding and Europe may be a net importer of these products, especially as China has been increasing its exports in these sectors.*



lowers the amount of deadwood and reduces the share of old stands. The *Promoting wood energy scenario* shows a decline in sustainability with regards to forest resources and carbon, due to the heavy pressure of increased wood extraction to meet the renewable energy targets.

The European forest will have to adapt to changing climate conditions, whose effects will vary widely by geographic area and forest type. Forest management needs to support the adaptation process either by increasing the natural adaptive capacity (e.g. by enhancing genetic and species diversity) or with targeted planned adaptation measures (e.g. introducing an adapted management system or other species). A huge variety of adaptation options have been identified. Many adaptation measures can be combined, while others are mutually exclusive at the stand scale. At the scale of management units or landscapes even conflicting strategies can be simultaneously applied in different places, thereby increasing overall diversity of forest conditions. To manage this adaptation process, more scientific and forest monitoring information is needed. For decisions now, the further development of existing regional forest management guidelines is important, as well as the implementation of decision-support systems. Moreover, management strategies need to be adaptive to changing circumstances. This means that for example disturbance events are used as an opportunity to adapt species composition and to adjust harvest schedules.

Forest sector policies, institutions and instruments in Europe are in general stable, recent and effective. Increasingly the forest sector enjoys public support through the participatory nature of NFP processes, which integrate the positions of the many concerned actors, and provide a basis for dialogue with other sectors on the major challenges of the day. Objectives have been formulated by many countries and the EU, for the policy challenges addressed by EFSOS II: climate change mitigation and adaptation; renewable energy; biodiversity; innovation and competitiveness. However the challenges posed by climate change, energy and biodiversity issues are exceptionally complex and long term, and require quite profound changes if they are to be satisfactorily resolved. It will require a very high level of sophisticated cross-sectoral policy making, sharply focused policy instruments and strong political will to mobilise enough wood for energy, to implement the right balance between carbon sequestration and substitution and to conserve biodiversity without sacrificing wood supply. Will today's policies and institutions rise to the challenge? To do so will require much improved monitoring systems, the ability to reach consensus, inside and outside the sector, on complex issues, as well as the creation and implementation of sharply targeted policy instruments, which make the best possible use of limited government funds. High level political will is also necessary, to ensure that forest management is not only sustainable, but makes the best possible contribution to the sustainable development of society as a whole.

6.2 Recommendations

6.2.1 For policy makers

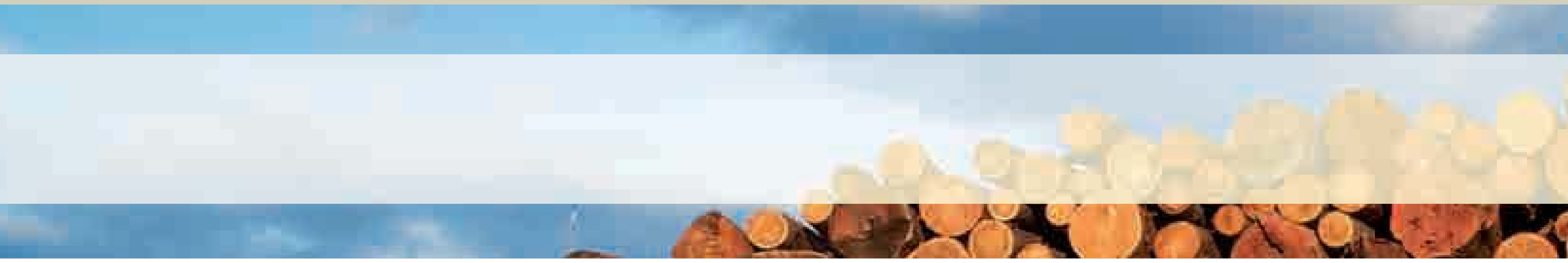
Climate mitigation: policy measures should be put in place to encourage the optimum combination of carbon sequestration and storage with substitution, as well as systems to monitor, rapidly, trends for this, to enable adjustment of the incentive system in the light of results attained. Carbon credits and carbon taxes (for non-renewable materials and fuels) could play a role. Certification and monitoring systems, adapted to European conditions (many, small forest holdings), would be necessary to ensure equitable payments. Cascade use of wood should be encouraged.

Carbon stock in forests: prevent any reduction to the carbon stock in forests, for instance due to fire, pests and insects or pollution. Measures can be proactive (e.g. reducing pollution, fuel reduction in forests subject to fire, silviculture for more resilient forest ecosystems), or reactive (e.g. fire suppression).

Adaptation to climate change: guidelines, by region and forest type, based on the best available scientific knowledge, should be developed to support practitioners in their decisions, and to build resilience in European forests. The guidance should be supported by extension services, addressed to all forest owners. Monitoring is also crucial to keep pests and diseases under control and to identify drought related dieback quickly. Monitoring and understanding the impact of climate change is an essential part of adaptive management.

Wood energy: a strategy should be drawn up, at the national level, which integrates the needs of the energy sector with those of the forest sector, and is produced after a scientifically based dialogue between forest sector and energy sector policy makers. The main lines of such a strategy could be as suggested in Chapter 5, section 5.4.6.

Wood supply: guidance, based on best available scientific knowledge, should be prepared on what levels of extraction of harvest residues and stumps are sustainable, in what forest types.



Short rotation coppice: develop national strategies for rural land use, integrating concerns related to sustainable supply of food, raw material and energy, as well as the other functions of forests, and all aspects of rural development.

Wood energy use: ensure that wood, like other energy sources, is used as efficiently and cleanly as possible: installations with low efficiency or which generate electricity without use of the waste heat should be avoided, and wood energy should, to the extent possible, be consumed near its source

Wood mobilisation: implement the existing wood mobilisation guidance (MCPFE, DG AGRI, UNECE/FAO, 2010), monitoring success/lack of success, and modifying the guidance in the light of experience.

Post-consumer wood: remove constraints to the mobilisation of post-consumer wood, including market structures and transparency, physical infrastructure, waste disposal regulations and classification systems.

Biodiversity: identify win-win areas and forest management techniques where biodiversity, wood supply and carbon sequestration can be combined, and then implement measurers to promote these practices.

Innovation: governments should work to develop good conditions for innovation, perhaps by applying the Policy principles for innovation developed by OECD and summarised in section 3.4.4. Policy makers in the sector should consider which of these measures can be applied at the level of the sector, and advocate 'innovation-friendly' policies for the society as a whole. Examples of specific forest sector measures are: vocational training in forest related areas, dedicated research institutes, with adequate resources, sector specific organisations with flexible and appropriate structures, access to finance for new forest sector firms, rapid diffusion of best practice inside the sector, open markets for wood and forest products, investment in public forest-related research, excellent knowledge infrastructure for the sector, and innovative state forest organisations.

Forest ecosystem services: provide positive framework conditions for PES. Move from the pilot phase to implementation of schemes which have proved their effectiveness and are applicable to local circumstances. State forest organisations can play a leading role in this respect, coordinating the actions of suppliers of forest ecosystem services, monitoring delivery of services etc.

Policies and institutions: countries should review whether their forest sector policies and institutions are equipped to address the challenges of climate change, renewable energy and conserving biodiversity, and whether intersectoral coordination in these areas is functioning properly. If necessary, modifications should be made. The policy instruments should be precisely targeted and linked to stated policy objectives.

Assessment of sustainability: countries should develop objective methods of assessing the present and future sustainability of forest management, preferably linked to the regional systems under development.

Outlook studies: develop national/regional outlook studies, possibly based on EFSOS II, and use them as the basis for policy discussions.

6.2.2 For international organisations

Adaptation of forest management to climate change: encourage the sharing of knowledge and experience between countries on strategies to increase resilience of forests to climate change, promote the preparation of guidance for regions/forest types.

Wood energy: use existing forums to discuss strategic options for increasing contribution of wood to renewable energy, identifying constraints, and developing precisely targeted policy instruments.

Biodiversity: forest sector organisations should communicate the EFSOS II analysis to regional and global organizations focused on biodiversity, and encourage the exchange of analysis and information between the two sectors.

Innovation in forest management: there is a need to share innovative ideas and approaches in forest management. An informal structure, centred on periodic forums and exchanges, could be initiated by an existing international organisation.

Competitiveness: review factors underlying results of the competitiveness analysis in EFSOS II, bringing together analysts and the private sector to identify what lessons can be learnt from this analysis, and whether there are implications for policy.

Knowledge base: international organisations should continue to work together to maintain and improve the knowledge infrastructure needed to carry out reliable analysis of the European forest sector and of the outlook for the sector. The completion of EFSOS II would be an opportunity to review the situation in this respect, comparing analysts' needs, which are expanding as the models become more sophisticated, with data availability. Data suppliers, notably national correspondents, should be involved in this review.

Assessing sustainable forest management in Europe, now and in the future: the experimental approaches developed for SoEF 2011 and EFSOS II should be the subject of widespread consultation and review. Approaches, methods and data need to be defined and regularly implemented. The approaches for the present and the outlook will not be the same, but should be as closely coordinated as possible.

Outlook studies: review EFSOS II, with a view to improving methods and impact in future outlook studies. Communicate analysis to other regions and the global level, to improve consistency between the outlooks.

6.2.3 For research

Soil carbon: carbon in soils is an important component of nutrient and water holding capacity and therefore productivity of forest sites. Investigate carbon flows in forest soil, and the consequences of disturbance (e.g. from afforestation, harvesting and stump extraction) on forest soil carbon.

Strategies for adaptation to climate change: There is insufficient knowledge and experience at present on which management practices will help adaptation in specific circumstances and regions: which species or structures are more resilient, which new provenances or species would be more resilient than those in place now? When and how should changes in silviculture be implemented? Should changes be proactive, before damage is serious, or reactive, after disturbance events? Information on these matters has to be generated, and reviewed, and then used as the basis for guidance for practitioners.

Forest monitoring for adaptation to climate change: this is crucial as an early warning for changes in the health and vitality of forests, for pest and disease outbreaks as well as forest fires. Monitoring should cover not only the condition of the forest, but also the changing climate, to establish cause-effect relationships as a basis for adaptation strategies. There is also a need to monitor the success, or lack of it, of adaptation measures, so that practice can react flexibly and quickly to changing knowledge.

Ecological / physiological range of forest trees: knowledge about the ecological range of forest trees and stands is insufficient. Many relationships are known mainly on an empirical basis, but knowledge of quantified cause-effect relations is scarce. The response of trees to combined stresses (e.g. ozone, nitrogen, drought) is largely unknown (Bytnerowicz *et al.,* 2007). More understanding is also needed on tolerance of extreme events, and physiological limits of specific trees species.

Sustainability of wood supply: measure in detail the relations between net and gross annual increment, fellings and removals, including consideration of natural and harvesting losses, measurement methods and wood supply from outside the forest, to provide an accurate basis for calculating sustainable levels of wood supply.

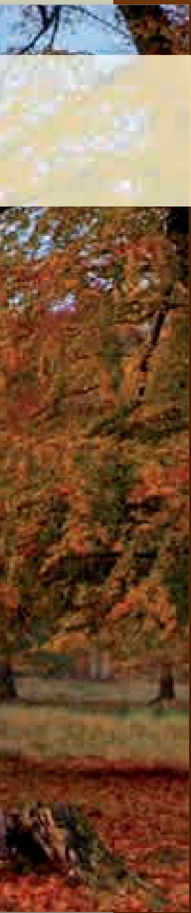
Drivers of wood supply: for each country and forest type, review and, to the extent possible, quantify, those factors which drive and constrain wood supply, to support decisions on wood mobilisation policy and wood supply forecasting. Factors to be considered include, price elasticity of supply, cost structures (silviculture, harvesting, transport), management priorities and behaviour of forest owners, other sources of income (forest-related or not) etc.

Short rotation coppice and rural land use: establish how much land is realistically available for short rotation coppice, and where it is available, taking account of competing land uses and policy priorities. The research should be carried out jointly by institutions with expertise in agriculture, land use and forestry.

Non-forest wood supply: quantify potential and constraints for supply of wood from outside the forest, notably landscape care wood and post-consumer wood.

Wood for energy: develop intermediate scenarios for demand and supply of energy wood, between those of the *Reference scenario* and the *Promoting wood energy scenario*, specifying, for each scenario, demand drivers (price, policy, etc.) and supply constraints, and taking account of national and local circumstances.

Models: maintain and develop the models used for the analysis in EFSOS II and improve the connections between them. Review underlying data with official national correspondents. Encourage the development of national forest sector models or national use of European or global models.



7 Annex

7.1 Acronyms and Abbreviations

AEBIOM	European Biomass Association
BAT	Best Available Technology
C	carbon
CBD	Convention on Biological Diversity
CEI-Bois	European Confederation of Woodworking Industries
CHP	Combined Heat and Power
CMS	Constant Market Share
CO_2	carbon dioxide
DG AGRI	Directorate-General Agriculture and Rural Development, European Commission
EFI	European Forest Institute
EFI-GTM	The Global Forest Sector Model EFI-GTM
EFISCEN	The European Forest Information Scenario Model
EFSOS II	European Forest Sector Outlook Study
EPA	United States Environmental Protection Agency
EU	European Union
EU IEE	EU Intelligent Energy Europe
EU27	EU 27 countries
EUR	euro
FAO	Food and Agriculture Organization of the United Nations
FAWS	Forest available for wood supply
FNAWS	Forest not available for wood supply
FOWECA	Forest Sector Outlook Study for Western and Central Asia
FTP	Forest-Based Sector Technology Platform
ha	hectare
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
m^3	cubic meter
MCPFE	FOREST EUROPE (formerly Ministerial Conference on the Protection of Forests in Europe)
Mg	megagrammes
µm	micrometre
NA	not available
NAFSOS	North American Forest Sector Outlook Study
NAI	net annual increment
NFP	National Forest Programme
NP	not possible
o.b.	overbark
%	per cent
OECD	Organisation for Economic Co-operation and Development
PEBLDS	Pan-European Biological and Landscape Diversity Strategy
PES	payment for ecosystem services
R&D	Research and development
RWE	roundwood equivalent
Tg	teragrammes
SoEF	State of Europe's Forests
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change
USD	US dollar
USDA	United States Department of Agriculture
WHO	World Health Organization
WRB	Wood Resource Balance
yr	year

7.2 List of 3-letter country codes

EFSOS countries	
ALB	Albania
AUT	Austria
BGR	Bulgaria
BIH	Bosnia and Herzegovina
BLR	Belarus
BLX	Belgium - Luxembourg
CHE	Switzerland
CYP	Cyprus
CZE	Czech Republic
DEU	Germany
DNK	Denmark
ESP	Spain
EST	Estonia
FIN	Finland
FRA	France
GBR	United Kingdom
GRC	Greece
HRV	Croatia
HUN	Hungary
IRL	Ireland
ISL	Iceland
ISR	Israel
ITA	Italy
LTU	Lithuania
LVA	Latvia
MDA	Moldova, Republic of
MKD	Macedonia, the former Yugoslav Republic of
MLT	Malta
MNE	Montenegro
NLD	Netherlands
NOR	Norway
POL	Poland
PRT	Portugal
ROM	Romania
SER	Serbia
SVK	Slovakia
SVN	Slovenia
SWE	Sweden
UKR	Ukraine

Others	
BRA	Brazil
CAN	Canada
CHN	China
RUS	Russian Federation
USA	United States

7.3 Discussion Papers

A series of Discussion Papers accompanies EFSOS II. These papers provide more detail on the methods and findings of the study. These will be available in electronic format at: http://live.unece.org/forests/outlook/welcome.html

Jonsson, R. (in press) Econometric Modelling and Projections of Wood Products Demand, Supply and Trade in Europe - A contribution to EFSOS II. Geneva Timber and Forest Discussion paper, ECE/TIM/DP/59. Geneva: UNECE.

Mantau, U. (in press) The Method of the Wood Resource Balance - A contribution to EFSOS II. Geneva Timber and Forest Discussion paper, ECE/TIM/DP/60. Geneva: UNECE.

Moiseyev, A., Solberg, B. and Kallio, A.M.I. (in press) Analysing the impacts on the European forest sector of increased use of wood for energy - A contribution to EFSOS II. Geneva Timber and Forest Discussion paper, ECE/TIM/DP/63. Geneva: UNECE.

Verkerk, H., Schelhaas, M.J. (in press) European forest resource development - A contribution to EFSOS II. Geneva Timber and Forest Discussion paper, ECE/TIM/DP/61. Geneva: UNECE.

Weimar, H., Englert, H., Moiseyev, A. and Dieter, M. (in press) Competitiveness of the European Forest Sector - A contribution to EFSOS II. Geneva Timber and Forest Discussion paper, ECE/TIM/DP/62. Geneva: UNECE.

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The European Forest Sector Outlook Study II (EFSOS II) is the latest in a series of studies, which started in 1952, to provide a regular outlook report for the European forest sector. All these studies have aimed to map out possible or likely future developments, on the basis of past trends, as a contribution to evidence-based policy formulation and decision making.

A reference scenario and four policy scenarios have been prepared for the European forest sector between 2010 and 2030, covering the forest resource and forest products. The scenarios are based on the results of several different modelling approaches, and in particular of econometric projections of production and consumption of forest products, the Wood Resource Balance, the European Forest Information Scenario model (EFISCEN), the European Forest Institute - Global Forest Sector Model (EFI-GTM), and competitiveness analysis.

The four policy scenarios (Maximising biomass carbon, Priority to biodiversity, Promoting wood energy, Fostering innovation and competitiveness) help policy makers gain insights into the consequences of certain policy choices. These choices are assessed according to their sustainability and recommendations are proposed based on the trade-offs facing policy makers. Decision makers are encouraged to reflect upon these analyses and to consider them when taking possible future policy actions.

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