# SHAPE YOUR SUSTAINABILITY TOOLS

## - and let your tools shape you

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# 1. ORAL PRESENTATIONS

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# Concepts and Challenges of Sustainability Assessment

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The question of how this society should deal with its natural environment is not new. Biblical directives call for man to "subdue the earth." Resource management questions go back to the practices of early herders and agriculturists. Primitive attempts at water management systems are often cited as ultimately contributing to the development of human cooperative institutions and bureaucracies. In America, an important part of our resource history is found in the intellectual disputes between Gifford Pinchot and John Muir more than a hundred years ago. Pinchot espoused the "wise use" doctrine of conservation – resources should be used wisely for the betterment of humankind. Elements of this message carried over to the ethos of the Great Depression. Woodie Guthrie, the folksinger, wrote songs lauding the growth of great water development projects with lyrics like "while the water is flowing to the sea, why not let it do a little work for me." By contrast, in an earlier era Muir had embraced notions closer to that of pristine preservation. Resource development that compromised the pristine nature of the resource or resource system was to be strongly frowned upon.

Although "wise use" conservationism was on the ascendancy in the late 19th and well past the middle of the 20th century, it was never to dominate public thought completely. Nature preserves, wildlife areas and the wilderness have always been a part of the American landscape and the American psyche. Indeed, it was a preservationist concern for naturalness, uniqueness and habitat the establishment Yellowstone as the world's first national park in 1870. Today, the old concepts of "wise use" conservation and simple preservation both appear to have been subsumed by the broader and more dynamic concept of sustainability, i.e., sustainability in the context of systems that inevitability change through time. This paper will explore the concept and its evolution and applications.

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# The European Forest-Based Sector in the 21st Century

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In February 2005, the launch of the Vision 2030 document in Brussels marked the official start of the European Forest-Based Sector Technology Platform - FTP. The Vision described four years ago in the document has already become a reality in a rapidly changing world:

*The European forest-based sector plays a key role in a sustainable society. It comprises a competitive, knowledge-based industry that fosters the extended use of renewable resources. It strives to ensure its societal contribution in the context of a bio-based, customer-driven and globally competitive European economy.*

The present financial and economic crises request actions to strengthen a sustainable development of the European Union's economy. Parts of the European forest-based sector are under transformation enhancing the concepts of biorefineries. Other parts implement advanced technologies and business concepts to maintain their position on the market. But, new economic challengers from outside Europe enforce the competition on the global and local markets. The needs for value added products and services are obvious and compulsory. Innovative ways in cross-disciplinary and trans-disciplinary research will be one pathway to achieve breakthrough results. Furthermore an even closer collaboration between economy actors and research providers is a crucial factor to secure the best exploitation of research results and their implementation in industries and the service sectors.

The European Union has set the goal to become a sustainable, knowledge-based economy. This can only be achieved on the basis of highly qualifying education systems, excellent research and sciences. Important research projects and related activities are running within various 'Research Areas' described in FTP's Strategic Research Agenda at present to achieve the objectives set in the Vision 2030 document.

The joint actions between the economy drivers and sciences are the key forces for shaping the European forest-based sector for a sustainable and fruitful future and secure its contributions to the European society

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# SIAT: A Tool to Explore the Sustainability of Policy Options

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The sustainability impact assessment tool (SIAT) enables a quick scan of the potential impacts of EU policies at regional level. SIAT integrates the main findings of the EU FP6 integrated project SENSOR. The tool calculates the impacts of policy options on land use sustainability through sustainability indicators and land use functions. Land use functions are based on a multi-functionality approach summarising the most relevant environmental, economic and social aspects of a region, taking regional sustainability limits into account. By comparing the impacts of different policy options, and allowing for a region-specific limit sensitivity analysis, the system supports exploration of the room-to-manoeuvre within the sustainability choice space.

In order to understand the implications of policy impacts, it is important to understand the modelling assumptions and methodological concepts. The SIAT system provides this information by: (1) offering context sensitive fact sheets and (2) a drill-down facility to analyse the impact calculation process in depth. Drill down shows how, and under which assumptions, the region-specific indicator calculations have been carried out.

The SIAT system is available as an interactive web application, based on an enterprise application architecture in which the light-weight front end is implemented as a rich internet application (RIA). Data rich model calculations are performed on the server using the data and model integration framework OpenMI. OpenMI standardises model connections and data descriptions between models. The SIAT system decouples functional software from specific models and data, making it flexible for adaptation to other applications in terms of:

I. impact drivers, such as policy scenarios (incl. reference scenarios) and external drivers (e.g., technological innovations, climate change and population growth);
II. target years;
III. regionalisations (spatial extent and resolution);
IV. indicators.

Described in this paper are the end user needs, and the main characteristics of the system in response to those needs. Finally, possible improvements and adaptations of the system for other applications are discussed.

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# Sustainability Indicator Development – Science or Political Negotiation?

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Since the publication of the Brundtland Report in 1987 the concept of 'sustainability' has been adopted as a key political principle by most governments. The development of indicators for sustainability assessments has gained popularity ever since, and across the globe indicator development processes for all kinds of sectors have started. In Europe there are currently at least four integrated projects financed within the framework of the EU research programme dedicated to the design of tools for sustainability assessments. Indicator development lies at the heart of their research designs. All four focus on land use-related questions of sustainability, but each handles the indicator development process differently as no common approach is available. This challenge facing the development of sustainability indicators is not primarily or exclusively technical. Indicators may be viewed as solely technical devices that depict real world factors, as well as politically developed factors. The aim of the study is to compare the underlying concepts of the indicator development processes, indicator selection, methods, and criteria of selection. We argue that the development of sustainability indicators is a process of both scientific 'knowledge production' and of political 'norm creation,' and that both components need to be properly acknowledged in the design of a process to develop sustainability indicators in general, and in science-driven sustainability indicator development processes in particular. Our hypothesis is that indicator developers are often not aware of and/or negate the political 'norm creation activity' they perform. This hypothesis implies that purely science-based sustainability indicator development processes are unlikely to succeed as they (mainly) negate the norm creating activity. However, politically-driven indicator development processes can easily 'hide' behind the knowledge production activity, downplaying the norm creating activity. In both cases, normative issues may be hidden and the indicator set may quickly become biased towards one or other dimension or specific issue of sustainability, which may lie in the interest of the political actors. The findings, however, suggest that science-led processes of sustainability indicator development are not necessarily biased in favour accuracy, with the associated risk that they are irrelevant in practical political terms. Accordingly, government-led processes of sustainability indicator development are not necessarily more policy relevant. In fact, results generally show that aligning sustainable development indicators to explicit policies, such as sustainable development strategies, enhances the political relevance (and use) of such indicator sets.

**Bernhard Wolfslehner** holds a PhD in engineering sciences and is working as a researcher at BOKU University, Vienna. His main fields of expertise are sustainable forest management, indicator design and application, and multi-criteria analysis (MCA). In EFORWOOD, he is engaged in the development of an MCA-software prototype for the evaluation of forest-wood chains.

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# Concepts for a Common Implementation of Cost-Benefit Analysis and Multi-Criteria Analysis in Sustainability Impact Assessment

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Sustainability impact assessment (SIA) is an integrated assessment approach endorsed by the EU Commission as a means to support the European Sustainable Development Strategy. Beyond the generation and preparation of data for forecasting purposes, there is a great need for evaluation tools in order to better assist decision-making by providing holistic, cumulative comparisons of the options available. Cost-benefit analysis (CBA) and multi-criteria analysis (MCA) are commonly applied tools in this context. As CBA is founded on neoclassical economics and MCA on decision theory, these methods differ in their theoretical backgrounds and their practical application. There are ongoing debates over whether both methods are compatible in their application, or whether they represent discordant approaches in SIA. In particular, there are arguments over how to incorporate interests and preferences, and over how to treat time, the valuation approaches and the procedural aspects within the decision-making process.

Opportunities and practical challenges related to the application of CBA and MCA were identified as part of the 'EFORWOOD' project, an integrated project of the European Commission's 6th Framework Programme focusing on SIA of forest-wood chains (FWCs) at different European scales.

The results of the study demonstrated that both methods must be adapted in order to handle the specific SIA objectives, and for application in scenario-based indicator systems. The type of information that is crucial for both methods was recapitulated, and practical recommendations were made in relation to data collection and management from the perspective of the evaluation tools.

Finally, there was an analysis of how the comparative advantages of both methods can be integrated and utilised in order to enrich the analyses and decision-making of the SIA evaluation systems.

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# Agri-Environmental Footprint Index (AFI), Time Series and Participants vs. Non-Participants in Agri-Environment Schemes

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The lack of agreed methods to assess the environmental consequences of changing agricultural practices and of consensus on how to monitor and evaluate the environmental, agricultural and socio-economic effects of agri-environmental schemes (AES) in EU Member States calls for better evaluation methods. The 'Agri-environmental Footprint' project proposed a new evaluation method to solve these problems, namely the agri-environmental footprint index (AFI) (Purvis et al. 2009). The AFI has been tested in seven EU Member States by means of case studies.

Due to the high national priority afforded the issue of groundwater, the Danish case study tested agricultural practices at two locations designated as groundwater protection zones. Twenty five farms were selected for the calculation of the index. Farm data was collected from the IACS databases and through interviews with farmers. The index was calculated for 1998 and 2008 in order to track a development over time and to examine the effect of the signing of AES agreements.

The Danish case study demonstrated that the index may be used to track changes in environmental standards and that the signing of AES agreements had an effect on the value of the index. The index should be used with caution, however. The index method requires awareness of the scope of the local AES in terms of both broad and smaller scale environmental issues, and deep and shallow schemes. Retrospective use of stakeholder preferences is subject to error, because preferences may change with time. Use of the index over time may also cause the geographical unit the index covers to change.

When choosing indicators it is very important to consider the robustness of each indicator; to assess whether changes will occur over time; whether it is linked to management practices or external factors; and whether data are available and up to date. Indicators dependent upon AES participation and indicator-estimates based on uptake data should be used with great caution.

**David Edwards** is a social scientist with a background in ecology and forestry. After working in Africa and Asia, he joined Forest Research (the research agency of the UK Forestry Commission) in 2004, where he manages social research projects in support of sustainable forest management in UK and Europe.

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# A Delphi Approach to Assess the Impacts of Forest Management on the Recreational Value of European Forests

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This paper describes a framework to assess the impacts of changes in forest management on the recreational value of forests, based upon a typology of forest stand types with common silvicultural characteristics across Europe. The paper summarises the results of four Delphi panels which were used to obtain recreational scores on a ten-point scale for 60 forest stand types in each of four case study areas. The case studies were chosen to represent contrasting European regions: the Atlantic Region; the Nordic Region, Central Europe, and the Mediterranean Region. Where possible, the panels consisted of experts in forest preference research. Their scoring decisions were supported by a summary of findings from a literature review of public preferences for silvicultural attributes of European forests previously undertaken by the authors. Experts were asked to explain the rationale behind their decisions, which provided additional qualitative insights to help interpret the results. Variations between experts' scores were analysed to explore the relative contribution of forest stand type, stand age, and tree species type to the overall recreational value of forests in each region. The results of the Delphi survey were then combined with outputs from the European forest resource projection model, EFISCEN, to assess the impacts of contrasting levels of implementation of the Natura 2000 policy on the recreational value of forests. The discussion considers the opportunities and risks associated with use of this approach in a European context to guide policy decisions and planning.

**Maarit Kallio** works at the Finnish Forest Research Institute, where her research focus is on economic analyses and modelling of the forest sector. Her current projects include 'Climate change – forests in terrestrial adaptation and mitigation in Europe' and 'Impacts of forest conservation on the Finnish forest sector.' She holds a DSc from the Helsinki School of Economics.

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# Natura 2000 and the Sustainability of the European Forest Sector

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Our study addresses the impacts of Natura 2000 on the European forest sector and the forest sector's sustainability. Under Natura 2000, some forests are either partially or entirely set aside from timber production, which decreases the market supply of timber and thereby has an adverse impact on the forest industry. The overall impacts are considered in relation to issues such as forest owner incomes; forest industry turnover and profits; employment; energy consumption in the forest industries; paper recycling rates; carbon sequestration; self-sufficiency of Europe in relation to fibre and forest products; and the value of the net exports of the sector.

We report the results for Europe, divided into four sub-regions with respect to two baseline development scenarios for 2005–2020, which seek to parameterise the IPCC storylines A1 and B2 to the global forest sector. The baseline growing stocks, the restrictions placed on forest management and timber supply by Natura 2000, and the carbon sequestered in the forests are quantified using the EFI-SCEN forestry simulation model. The global forest sector model EFI-GTM is used to project the development of the market-driven sustainability indicators.

**Sara Gonzáles García** is a Chemical Engineer. She is joined the department of Chemical Engineering at the University of Santiago de Compostela, where she has carried out her PhD studies in the analysis of the environmental performance of wood and non-wood based industries such as pulp and fibreboard mills. This study is involved in two Integrated European Projects (BIORENEW and AQUATERRE) in the area of Industrial Biotechnology and Clean Technologies.

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# Comparison of Spanish and Swedish Pulp Industries from an Environmental Perspective

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Two case studies of pulpwood production and supply to pulp mills located in Spain and Sweden were analysed and compared using LCA. The forest sector has considerable weight in the national economies of both countries, and both make a remarkable contribution to European pulp production. Plantations of Eucalyptus and Norway spruce were assessed for Spain and Sweden, respectively. All forest operations, from site preparation to the hauling of wood from the forest to the pulp mill gate, were taken into account. The results, expressed according to environmental impact categories, showed large differences between both forest management systems. Logging operations were identified as the hot spot in the Spanish case study and secondary hauling in the Swedish. Higher energy use in Spanish silviculture and logging operations can be linked to the more intensive nature of the management activities in Eucalyptus stands. Regulations regarding the payload of freight lorries also affected the Spanish system considerably. The Swedish system had lower energy requirements, and significantly lower contributions to the environmental impact categories.

The main conclusions drawn from both studies were:

I) The results can help Spanish and Swedish industries improve their environmental performance;
II) Spanish forest operations involve higher energy consumption due mainly to the use of inefficient machinery;
III) The leakage of nutrients from fertilisers is a significant environmental aspect in Spain;
IV) The introduction of biofuels is an option for reducing carbon dioxide emissions;
V) Identification of the best delivery routes and transport modes can mitigate the high contribution of secondary hauling to the environmental profile in Sweden.

Several improvement alternatives are proposed, such as the use of more efficient machines in the Spanish system and the introduction of wood transport by train in Sweden. Alternative scenarios of pulpwood supply were proposed in order to identify a more environmentally friendly wood transport strategy. Scenarios in which electric trains are introduced for wood transport reduce the environmental impact considerably due to advantageous traits of the Swedish railway network as the Swedish electric profile relies greatly on renewable sources. The reduction of wood imports would also appear to be an interesting alternative allowing for a reduction in energy requirements and negative environmental effects. The results demonstrate the impact of the geographical origin of the wood processed in a pulp mill.

**Sven-Olof Lundqvist** manages the research cluster 'Optimised fibres for pulp and paper production' with industrial partners from Europe and South America and the 'Wood and Fibre Measurement Centre' of Innventia (formerly STFI). The projects undertaken focus on wood, fibres, pulp, paper, forestry, genetics, climate change, etc., and relate to species from many countries.

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# Forest Resource Databases with Properties of Wood and Potential Products for Improved Raw Material Allocation and Sustainability

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The appropriate allocation of raw materials with suitable properties to mills, and for specific processes and products, is crucial for the sustainability of the forest-wood chains. All aspects of sustainability are influenced: environment, economy and society. The allocation of unsuitable material to a process will normally lead to losses in yield and value, less efficient processing, with greater use of material, energy, etc. Unsuitable materials may have to be redirected to other processes or mills, resulting in more transportation. Quality, product functionality and customer satisfaction may be compromised.

This report describes the concept 'regional resource databases' for the mapping of the properties of forest resources, providing a basis for optimal allocation. Developed previously at STFI-Packforsk, and emphasising the properties of fibres and their use for the production of pulp and paper, it has now been expanded and adapted for wider applicability in order to match the needs of the EFORWOOD project, dealing with all major wood-based production chains in an integrated way.

In a 'regional resource database' data about stands and trees are complemented by estimates of the properties and volumes of trees and parts of trees related to potential products. Inventory data or harvester data are used as input data to sets of integrated models. The size, shape and properties of wood, knots and fibres of the stems are simulated successively. The simulated stems are then divided into the parts of interest: logs, parts of logs to be chipped or sawn, etc. The properties of each part are calculated and all of the data are compiled in a database, offering a virtual representation of the available resource and its potential products, which can be used in many applications. The size of the database, the properties included and the level of detail in the description of the trees and parts of trees are adapted to the application.

In the report, the general concept of 'regional resource databases' is briefly presented and illustrated using the example of a national resource database for all Sweden. Then the EFORWOOD version is described, along with the mapping of the forest resources in Västerbotten, studied in one of the EFORWOOD case studies. Also indicated in the report is the way in which it may be used, together with knowledge of the raw material demands of products and processes, to improve the allocation of wood to different industries, ensuring the provision of more uniform and suitable raw materials for specific products, providing the basis for a study with ToSIA about the effects of allocation on sustainability.

**Diana Vötter** holds a PhD in forestry and wood science, and is specialised in forest technology and process modelling. She has worked in Germany, Sweden and Finland, and now holds a position as senior researcher at the European Forest Institute (EFI), Finland.

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# Systems Analysis and Sustainability Impact Assessment – A Dynamic and Flexible Method

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The present situation of the European FWC and its corresponding processes was determined. This was achieved by means of the modelling and calculation of the individual process steps and capacities using professional modelling software, namely ARIS Architect.

The individual processes, from tree harvesting and wood transport to the provision of the pre-processed materials fed into industrial processes, were described, also incorporating parameter and resource-related (machine and personnel) data, decision points and variants, such as sensitivity analyses.

Within these models, it is possible to link individual activities with economic, environmental and social indicators. These indicators represent a selected and balanced set of IPCC and MCPFE indicators. Values for these individual indicators are either calculated within the model itself, or by means of existing partial models for allocation, wood quality, transport and harvesting.

Consequently, all processes and activities are linked to numeric values for each indicator, which assess the process's sustainability. These can be summed up per chain alternative, allowing for comparison of the sustainability of different alternatives on the basis of hard figures for all three levels of sustainability.

**Risto Päivinen** has been working as Director of the European Forest Institute (EFI) since 2000. He graduated as a Dr.Sc. from the University of Joensuu, Finland, in 1987. Between 1987-89 he worked in the United Nations Environment Programme in Geneva, Switzerland as Forestry Project Officer. He has been Professor of Forest Inventory in the University of Joensuu since 1998 and served as the Deputy Director of EFI between 1993-2000.

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# An Approach to a Sustainability Impact Analysis of the Complete Forest-based Sector

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Due to the efforts towards sustainable use of natural resources, and EU policies requiring actions towards sustainable development, there is a demand for means to address these new challenges. In the EFORWOOD project, methodologies and tools are developed and tested to assess sustainability impacts of alternative production chains of the forest sector. The concept includes describing the forest sector as a set of processes by which forest resources are used to (i) produce biomass which is routed through different value-adding production chains and converted to products, and (ii) provide other ecosystem services. Each production process included in a production chain will be characterised by a set of indicators covering environmental, economic and social aspects of sustainable development. The volume of wood material flowing through the processes is a basis for adding up the overall sustainability impact of changes in production chains. An analysis of trade-offs between economic, environmental and social characteristics is carried out to assess holistically the impact of changes between alternative production chains.

The method developed provides a tool for quantitative analysis for the environmental, economic, and social impacts of changes in the production of forest-based sector.

**Marcus Lindner**, Head of the Programme for Forest Ecology and Management at the European Forest Institute, has more than 15 years research experience in the areas of climate change impacts and the development of response strategies in forest management, forest sector sustainability assessment and environmentally constrained bio-energy potentials from European forests.

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# A Tool for Sustainability Impact Assessment (ToSIA) of Forest-Wood Chains Linked with a Database of Sustainability Indicators Collected within the EFORWOOD Project

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Within the EFORWOOD project new approaches to assess the sustainability impacts of forest-wood chains (FWC) using indicators of environmental, social and economic sustainability were developed. Two main products hold and integrate the extensive information collected in the project, namely the sustain-ability impact assessment tool ToSIA and the EFORWOOD Database Client. In the paper both ToSIA and the Database Client, which are used in different EFORWOOD applications, will be presented. The main functionalities of both software products will be introduced.

ToSIA analyses forest-wood chains as chains of production processes (e.g., harvesting – transport – industrial processing), which are linked with products (e.g., a timber frame house). Firstly the topology of the FWC is designed and the data is input into the Database Client. The data is then generated from the database and transferred to ToSIA. Sustainability is determined by analysing environmental, economic and social sustainability indicators for all of the production processes along the FWC. The ToSIA software enables dynamic interaction with users/stakeholders in the defining of specific FWCs and criteria of sustainability, reads sustainability information, and calculates results with regard to sustainability, thereby allowing for the comparison of the selected chains.

In the presentation the methods behind the tools will be introduced and the ways in which they can be utilised in different applications after the successful completion of the EFORWOOD project will be discussed.

**Tommi Suominen** has a MSc degree in Computer Science from the University of Helsinki. He has previously been doing software development at Nokia Networks and TietoEnator, and since 2006 at the European Forest Institute. He is responsible for developing the Tool for Sustainability Impact Analysis (ToSIA) within the EFORWOOD project.

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# ToSIA – A Tool for Sustainability Impact Assessment of Forest-Wood Chains

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Within the forest sector, the sustainability concept has evolved from a narrow focus on sustainable wood production to a much broader evaluation of environmental, social and economic sustainability for whole value chains. A new software tool – ToSIA –has been developed to assess the sustainability impacts of changes in forest-wood chains (FWCs). Under this approach, FWCs are analysed as chains of production processes (e.g., harvesting – transport – industrial processing) that are linked with products (e.g., a timber frame house). Sustainability is determined by analysing environmental, economic and social sustainability indicators for all of the production processes along the FWC. The tool calculates sustainability values by multiplying relative indicator values (i.e., indicator value expressed per unit of material flow) by the material flow entering a process. The calculated sustainability values are then aggregated either for the segments of the FWC or for the complete chain.

ToSIA was developed in the Java programming language, and takes advantage of the OpenMI standard and programming interface in implementing its calculation routines. The entire ToSIA distribution package includes a separate database and a database interface for chain design and data entry, and also tools for performing cost-benefit analyses (CBA) and multi-criteria analyses (MCA) to interpret the results produced in ToSIA. The CBA is implemented in ToSIA in Java, and the MCA in a separate tool programmed in C++, which is linked to ToSIA via data files.

The aim of the presentation is to give an outline of the implementation of the tool, especially with regard to the impact of the choices made in the design of the tool on the range of problems that can be assessed using it. The presentation will highlight the flexibility of the tool with regard to using different indicator sets, chain topologies and its capacity to adapt to different decision making problems or topics. The presentation will also show the expected benefits of this tool for industry as it can be used to demonstrate sustainability impacts relating to their actions; for decision makers by providing ex-ante information on the sustainability impacts of policies; and for scientists seeking to conduct detailed scenario analyses of the impacts of a range of changes impacting upon the FWCs.

**Gunnar Niblaeus**, representing Tieto Corporation, is the dissemination & exploitation manager of Indisputable Key. With degrees in physics and business administration, he has held different positions in the forest industry for more than 30 years, starting as a researcher in operations research and lately as manager and business consultant.

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# Indisputable Key – Industrial Breakthrough of New Methods and Technologies in the Wood Industry

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Large volumes of wood are going to waste. Knowledge of log characteristics and their impact on the quality and final end-use of wood products can help in the selection of the most suitable log for a specific product while still in the forest. This can significantly reduce the waste associated with harvesting and transporting logs with unsuitable characteristics.

New methods and technology for traceability are needed. It must be possible to mark individual logs and boards, and to trace these through the forest-wood supply chain.

This is the background to the Indisputable Key project. The objective is to develop the necessary methods and advanced ICT solutions to improve the use of wood and optimise forest production. With a budget of € 12.7 M, partly financed by the EU (FP6), and 28 partners, Indisputable Key started in October 2006 and will end in March 2010.

The project covers different areas such as data exchange, models and indicators of economic and environmental performance, RFID technology and other technologies for marking and reading, and software modules for integration. The industrial implementation is supported by exploitation planning, industrial demonstrations and training.

Major achievements of the project include new RFID transponders; ink-based marking and reading; an infrastructure for data exchange based upon existing standards such as papiNet, Stanford and EPC-global; software for tracing objects and for monitoring economic and environmental key performance indicators; models for predicting wood properties and models for the simulation of supply chain scenarios.

The expected benefits include better yield; reduced emissions; better tools for the tracing of timber origin and the prevention of illegal logging and better tools for product and process development.

The functionality and benefits will be demonstrated at locations in France and Sweden. The main demonstration is in Sweden and will involve Sveaskog, Setra Group (Malå sawmill) and Norsjö Trä (component manufacturing).

**Beatrix Szirmay** is currently working as an analyst with the Market Research and Business Strategy Department of AIDIMA, the Furniture, Wood and Packaging Technology Institute of Spain. She graduated in economic sciences and international relations at the Corvinus Universtity, Budapest, Hungary.

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# Analysis of Consumers, Wood-based Products and Substitutes in the Context of the Forest-Wood Chain Sustainability Concept, including the Identification of Hot Spots

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The aim of the EFORWOOD project was to provide methods and tools that, for the first time, integrate sustainability impact assessment of the whole European forest-wood chain (FWC), by quantifying the performance of FWCs, using indicators for all three pillars of sustainability; environmental, economic and social. The main activity within Module 5 of Eforwood was to assess the perceptions of consumers, indicating potentials for the upgrading of forest-based products in terms of general functionality and sustainability. Consumers and customers are essential as social, economic and environmental actors. Future sustainability requires the consideration of citizens' opinions, which really drive the evolution of the markets.

There were different studies carried out to investigate the perceptions of consumers in relation to different FWC products, from the supply and also the demand side, using qualitative methods, based on the opinions of experts, professional buyers and adult end-users. These products included those from the solid wood sector (furniture), the energy/bioenergy sector (pellets), the fibre-based packaging sector (juice packaging) and the fibre-based printed material industry (books).

The objectives were to identify the attitudes and perceptions of consumers in relation to wood-based products and their substitutes from the point of view of the forest-wood chain sustainability concept, including the identification of 'hot spots.' This information is needed to support the assimilation of sustainable forest-based products and to ascertain the key points of acceptance or rejection of sustainable policies or market actions.

The results of the research into consumer perceptions are qualitative, and the identified hot spots indicate strengths and weaknesses in the consumption of wood-based products with regard to sustainability. The hot spots are the key aspects influencing consumer behaviour during the purchasing process, and are of different levels of importance. Hot spots indicate areas of action and, in some cases, the need for further studies where knowledge gaps exist in relation to consumption.

The hot spots identified affect the consumption of products of the forest-based industries. There are strong links between the three pillars of sustainability and consumer behaviour.

**Franka Brüchert** studied biology, focussing on botany and geography. After completing a PhD on tree biomechanics she gradually moved into forestry and wood science. The main scope of her research is on the effects of silvicultural management on wood quality, and quality assessment of roundwood and sawn timber with respect to end-user requirements. In addition to the Eforwood project, she most recently concentrated on the non-destructive characterisation of internal roundwood properties using computer tomography.

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# Baden-Württemberg's Forest and Timber Industries – Sustainability Impact Assessment for the Present and the Future

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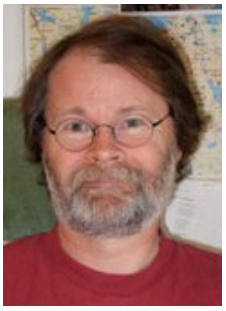
Located in the south west of Germany, the federal state Baden-Württemberg is renowned for its innovativeness and economic strength. Its industrial base is characterised on the one hand by highly advanced technology industries of international importance, such as automobile and chemical industries, but is at the same time also influenced strongly by the locally important agriculture and forestry sectors. Forestry and wood-based industry contribute about 7 % to Baden-Württemberg's GDP (compared to 2 % on a national level). Altogether 39 % of the area is covered by forests, with mixtures of broadleaf and conifer species, large variations in forest type and a wide age range of the stands. The challenge associated with this highly diversified forest production base is the resultant varied wood-based industry, with a heterogeneous structure in terms of mill size and degree of specialisation in production, and with a multitude of linkages between the different industries.

The wood-based industry in Baden-Württemberg is also characterised by the contrast between privately owned small and medium sized companies producing for the local and regional market on one hand and large conglomerates operating internationally on the other. The large contribution of the forestry and wood-based industries to the economic strength of Baden-Württemberg, and the diversity of the forestry and wood-based industry, makes Baden-Württemberg a typical example of a region in the central European area. This case study is regionally defined, and aims to describe the network of forest-wood chains in Baden-Württemberg in all phases, from forest production through primary conversion and manufacturing to consumption by the end-user, recycling and incineration.

This paper will present the results of sustainable impact assessment using the 'ToSIA' analysis tool developed in the EU-funded 'EFORWOOD' project. Datasets of social, ecological and economic indicators are presented based on different assumptions of general economic developments worldwide and altered regional developments, such as increased bio-energy production. Data will be analysed with respect to the regional effects over time and compared to the sustainability of the sector in 2005.



**Erik Valinger** works as professor of silviculture at the Department of Forest Ecology and Management at SLU, Umeå. His research areas are the effects on single tree growth of thinning, fertilisation, soil preparation, and the effects of wind and snow damage to trees and stands.

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# Scandinavian Case Study – A Technology-driven Utilisation of the Forests

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The Scandinavian case study within EFORWOOD dealt with the whole forest-wood chain (FWC), from the production and harvesting of the trees to the end-user of the forest product originating from the wood produced in Västerbotten county, Sweden. The status of the forested area of 3179491 ha in the base line year 2005 was described, and the area divided into five different management regimes; i.e., close to nature forestry (pine and spruce), combined objective forestry (birch and mixed), and intensive even-aged forestry (mixed).

The initial proportion of the regimes was 18, 2, 1, 70 and 9 %, respectively. The transport of the trees harvested annually from the forests to the industries was described, and the further processing of the cut volumes defined and presented up to the end of the wood chain. The products were divided into three groups (wood products, paper products and bio-energy). During 2005, the amount of wood cut in the forests of Västerbotten was 7819000 $m^3$ob. That year, approximately 30 % of the volume cut came from thinnings. The flow of material through the wood chain to the market outside the county was described. Timber logs were handled by model sawmills of two sizes (150000 and 50000 m3/yr), and all pulpwood went to one integrated fine paper mill (85000 tonnes/yr) and one kraftliner mill (290000 tonnes/yr). Pellet production for energy (80000 tonnes/yr) across the whole chain was also described. After establishment of the base line of the Scandinavian chain, a scenario based on a development in technology within the sawing industry was evaluated.

The advances included the scanning of the internal properties of stems and logs for the optimisation of sawing operations; measuring systems for the characterisation and grading of sawn timber and supporting secondary conversion; and information systems and intelligent material flow controls. The impact of the scenario on the FWC was increased quality of the products produced, including defined properties; the creation of a new group of value added products; lower residues; less chip for the milling industry and pellet production; and less demand on the increased wood supply for the reference years 2015 and 2025. The effect on political, economic, social, technological and environmental indicators was also evaluated.

**María Gafo Gómez-Zamalloa** graduated as a forest engineer from the Polytechnic University of Madrid, and also completed studies in Wageningen Agricultural University in the Netherlands and in Debrecen Agricultural University in Hungary. She has a diploma in European studies from the Diplomatic School of Madrid. She started working for the European Commission in 2001, dealing with environmental policy in relation to energy and transport. Since 2004 she has been part of the Forest-based Industries Unit of DG Enterprise and Industry. Before joining the Commission she was a consultant with Arthur Andersen.

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# The Policy Framework of SIA

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Policy is not an authoritative choice of values; it is a representation of a particular way of seeing and understanding the world. The first step in policy design is understanding what the problem is, before setting off to solve it. Herein lies the contribution of science to policy. Sustaining the forest sector depends upon the development of collaborative partnerships between scientists and policy makers.

EU competitiveness is linked to sustainability. This link is even stronger for the forest-based industries: the sector uses a renewable and recyclable raw material that should be managed in a sustainable way.

In 2008 the Commission adopted the APIS FBI (Action Plan on Innovative and Sustainable Forest-based Industries in the EU). In this plan the Commission proposes major policy guidelines that ensure a coherent approach to strengthening the competitive position of the forest-based industries in Europe, while integrating the climate change objectives into industrial strategy. The challenges facing the forest-based industries relate to innovation, increased global competition, access to third-country markets, climate change and high energy and transport costs. Moreover, the access and availability of both virgin and recovered raw material at competitive prices, and the strategic role played by these industries in limiting climate change impacts, are issues that need to be addressed specifically. Furthermore, and in particular in the woodworking and printing sectors, the SME dimension is especially relevant. The Commission is currently working together with Member States and relevant stakeholders in the implementation of the actions.

An impact assessment taking into account the economic, social and environmental implications should be carried out for all policy decisions. Some practical examples proving the importance of having tools to assess the impact of policy developments on the forest sector are the effects of the economic downturn along all of the links in the forest chain and the effects of climate change and energy policy decisions on forestry and forest-based industries. The economic slowdown is impacting on business prospects but it has also affected the beginning of the forest chain, with a decrease in the demand for wood as a raw material. The 2020 targets of the energy and climate change package have had an impact on the demand for forest biomass and on the way the forests are managed.

The APIS FBI aims to strengthen the efforts made by the forest-based industry to be sustainable and competitive. The EFORWOOD project can provide an important contribution to the knowledge base needed to achieve competitiveness and to meet the sustainability challenge.

**Christopher Prins**. Educated in classics and modern languages at Oxford, he joined the United Nations Economic Commission for Europe in 1972, in the ECE/FAO Timber Division, as a research assistant. He rapidly became interested by the challenges of the forest and wood sector in Europe and North America, and made significant contributions to the work on outlook studies and forest resource assessment, as well as contributing to the design and implementation of the MCPFE criteria and indicators of sustainable forest management and reports on the state of Europe's forests for the ministerial conferences in Lisbon, Vienna and Warsaw. He is now an independent consultant.

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# Criteria and Indicators to Assess the Sustainability of the Forestry-Wood Chain

Christopher Prins

Criteria and indicators serve as support to decision making and analysis by selecting and organising the most relevant information, on a consensus basis. In that way the risk of sterile discussions about data and their significance can be minimised. Ideally, the indicators should be politically meaningful, scientifically sound and practical for measurement and reporting. Although each indicator usually "belongs" to a specific area of specialisation and expertise, the set as a whole must be accessible to all, balanced and comprehensive. Given the complex issues of sustainability of the forest wood chain, criteria and indicators rarely produce unambiguous answers as to whether a particular system is sustainable or not.

The presentation will review European experience of criteria and indicators of sustainable forest management, focusing on the MCPFE set, and analyse progress, problems and challenges, including data weaknesses and gaps, policy impact and analysis of the significance of the information collected for the ministerial conferences. It will ask how to find synergies between the EFORWOOD results and the criteria and indicators, as well as synergies between EFORWOOD and other ongoing work, notably the State of Europe's Forests report and the Forest Sector Outlook Study.

**Irina Prokofieva** holds a PhD in economic analysis from the Autonomous University of Barcelona, Spain. Her research experience lies in the fields of general economic theory, environmental economics, cost-benefit analysis, contract theory, and law and economics. Currently, she is leading the work package on sustainability impact assessment within the Eforwood project.

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# An Application of Cost-Benefit Analysis for the Sustainability Impact Assessment of Forest-Wood Chains: An Example Employing the Baden-Württemberg FWC

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Cost-benefit analysis (CBA), originally developed for the appraisal of investment projects, has grown in importance in the field of policy appraisal and evaluation in recent decades. As concerns in relation to sustainable development and the sustainability impact of economic activities grow among policy-makers, the discussion centres on which tools can be applied to assess these impacts. In this article, the applicability of cost-benefit analysis to the sustainability impact assessment of forest-wood chains is discussed, and the methodological framework for the assessment is laid down based on the main principles of the CBA. Explicit attention is paid to the role of sustainability indicators in the evaluation context, and the incorporation of relevant externalities in the analysis. The sound implementation of the cost-benefit analysis hinges on the availability of a significant amount of accurate and detailed quantitative and qualitative data, which in practice is difficult or very costly to obtain, especially when dealing with the assessment of large scale projects or policies.

The practical implications for the cost-benefit analysis of limited data availability are discussed in the paper, and a methodological framework capable of circumventing some of these limitations is constructed.

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# Optimizing Resource Efficiency and Carbon Intensity in the Wood Processing Sector in Austria

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Economies are currently based largely on fossil and mineral resources, which end up as waste or fossil $CO_2$ emitted into the atmosphere. Achieving the ideal of a sustainable economy requires a shift to a solar-based economy. The use of renewable resources for the generation of products and energy services is one of today's main challenges. An efficient use of biomass is a major pillar of a sustainable resource management; the maximum should be derived from a material on its way from being a resource to, finally, $CO_2$ in the atmosphere.

The pulp and paper industry ('paper industry') and the wood processing industry are two major pillars in the use of biomass in a public economy. This is also the case in Austria.

Two process chains for products of biogenic origin are currently being investigated:

- Austrian wood processing industry,
- Austrian pulp and paper mills.

Object-oriented process models describing the entire production system, including the life cycle of its products, have been created. Each of the models consists of the individual processes of the production chain, but also includes the usage phase and the end of life options (recycling or waste disposal). The in- and outputs of the processes were combined as flow balances of materials and energy. The carbon flow balance of the total life cycles of the product lines considered was derived from the carbon content of the respective flows. The flows are grouped according to fossil and renewable carbon, in order to distinguish the transfer of fossil carbon into the atmosphere from the renewable carbon cycle. Various scenarios can be investigated with the model, by changing the characteristics of the single processes, the process line structure and the framework conditions.

The effects of improvements in the efficiency of the use of the resources and on the carbon flow balances are presented and discussed. Parameters, presented in the form of comprehensive key data for the evaluation of the overall performance, are suggested. Problematic issues such as the long-term storage of carbon in products, the export and import of products and intermediates, etc., are addressed and discussed.

Acknowledgement: The current project is supported by the Austrian Research Promotion Programme "Fabrik der Zukunkft/Factory of Tomorrow", BMVIT, FFG.

**Barry Gardiner** is the Forest Research Programme group leader for 'Physical Properties of Stands, Trees and Timber' with overall responsibility for research into forest wind risk, timber properties, and remote sensing. His current focus is linking models that predict timber properties to growth models and sawn timber performance models.

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# Allocation Effects on Sustainability within a Solid Wood Chain: A Case Study in South Scotland

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The Scottish sawmilling industry is a large and productive sector. In 2005, there were 72 sawmills in Scotland, which consumed almost half of the softwood delivered to UK mills, approximately 2, 351, 000 green tonnes (Forestry Statistics, 2007). However, Scottish forests face increasing challenges due to a broad number of factors ranging from complex demands from various wood processing industries to shifts in consumer patterns. Consequently, there is a growing need for intelligent allocation throughout the harvesting and transport processes to maximise efficiency and timber product potential and to minimise waste and transport distances.

This case study is focussed on Craik forest in the Scottish Borders district. Craik forest is approximately 5000 ha and is predominately spruce. It produces significant amounts of high value timber, and is located within 300 km of 11 sawmills. The purpose of the case study is to examine the current management plans including the timber products created from Craik's forest stands, and then to make modifications to the allocation system. The modifications include altering how the timber is cut, which sawmill material is sent to and increasing the harvesting of residues for biomass. A product allocation model has been developed and is utilised when comparing different log breakout scenarios. Within these scenarios, log product proportions are adjusted based on stem straightness and other measures of timber quality.

The impacts of these changes will be measured using four key indicators: gross value added (GVA), transport distance, greenhouse gas emissions, and employment. The aggregated results of these indicators will then be compared using multi-criteria analysis. Sustainability issues and areas for concern will be identified and discussed.

**Ljusk Ola Eriksson** has been professor of forest management planning at SLU since 1965. His main focus relates to long range forest planning; i.e., the use of the forest resource considering a time horizon of a hundred years or more, and focuses on methods for the analysis of multiple uses and criteria.

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# Climate Implications of Increased Wood Use in the Construction Sector – Towards an Integrated Modelling Framework

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Forestry faces a number of challenges that will have profound implications for how forest management should be conducted. Some are linked to global developments such as climate change, increased demand for biofuels and changing demand patterns stemming from emerging economies like China and India. Thus, a number of decisive issues faced by forest managers cannot be analysed accurately unless viewed from global perspective. This means that a number of models must be linked, from the global trade models down to models in which forest management actions can be quantified. This presentation illustrates how models at different levels can be amalgamated, and highlights the problems associated with such an endeavour.

The modelling system was applied to an analysis of the potential effects of an increased use of wood for construction purposes in Europe. This is not an unlikely scenario considering that carbon could be sequestered in wooden buildings. Step one was to use the EFI-GTM partial equilibrium model to translate the increased European demand for timber into a long-range projection of timber prices and harvest volumes for the supplying countries. This projection was subsequently used in a long-range regional forestry model for Sweden to project harvests nationally. The prices of the EFI-GTM projection were finally applied to a Finnish stand level model. An increase in the number of timber frame buildings would reduce net carbon emissions in the construction sector. In order to quantify the total net effect, the volumes of the regional forest model had to be constrained to those of the EFI-GTM model. Guiding the forest management of the regional model using only prices resulted in inconsistent volumes. The long-term steady state analyses at stand level indicated small differences in carbon stocks due to the price increases predicted by the scenarios. The forest management implications predicted by the regional and stand level models were generally of the same nature.

Linking the wood construction scenarios with the EFI-GTM, however demanding, works without major problems. The most problematic part of the system appears to be the linkage between the EFI-GTM and the regional forest model.

**Ana Cláudia Dias** is a researcher at the University of Aveiro, Portugal. She has a degree in environmental engineering and a PhD in environmental applied sciences from the University of Aveiro. Her research focuses on greenhouse gas balances in the forest sector, as well as on life-cycle thinking tools.

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# Modelling Carbon Accumulation in Wood Products

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Wood products play an important role in the carbon cycle of the forest sector. Carbon accumulates in forest ecosystems through the absorption of atmospheric carbon dioxide and its assimilation into biomass. Part of this carbon is transferred to wood products, which may remain in use for decades to centuries, storing considerable amounts of carbon. Furthermore, the total lifetime of wood products may be extended if they are disposed of in landfills, where they are only partially decomposed, forming a permanent carbon sink.

The aim of this study is to develop a model to estimate carbon accumulation in wood products in Portugal, using country-specific data, whilst also citing associated uncertainty levels. Carbon accumulation was calculated separately for semi-finished wood products in use and in landfills. Semi-finished products consist of sawnwood, wood-based panels, other industrial wood, paper and paperboard.

According to the method adopted in this study, carbon accumulation in wood products in a specific year is equal to the difference between carbon input and carbon output from that pool, in the same year. Carbon input was estimated from historical data of production, import and export of wood products, whereas carbon output was calculated based on the lifetimes of wood products and assuming a first order decay. The uncertainty of the results was estimated using Monte Carlo simulation.

The model provided results for three alternative approaches that differ in the way carbon stocks or emissions are allocated to countries that consume and produce wood products: the stock-change approach, the production approach and the atmospheric-flow approach. The stock-change approach considers the net change in carbon stocks of wood products within national boundaries, whereas the production approach accounts for the net change in carbon stocks of wood products produced from domestically-grown wood. Rather than estimating carbon stocks, the atmospheric-flow approach estimates the flow of carbon between the forest sector and the atmosphere within national boundaries.

The results indicate that wood products in Portugal have been accumulating carbon at rates ranging from 110-1350 kt C/year for the period 1990 to 2005. For some years, this accumulation exceeds carbon sequestration estimated for the Portuguese forest in the National Greenhouse Gas Emission Inventories. The results of the uncertainty analysis suggest that the uncertainty level varied between 20 % and 90 %. The atmospheric-flow approach generated the highest carbon accumulation in wood products as Portugal is a net exporter of wood products.

**Margareta Wihersaari** is an Associate Professor at the University of Jyväskylä, Finland and a senior research scientist at VTT. She holds a PhD in Energy Engineering and Environmental Protection from the Helsinki University of Technology (2005). Her area of expertise has for more than 20 years been environmental aspects of bioenergy production systems.

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# Scenario Analysis of Fuel-Pellet Production – The Influence of Torrefaction on Material Flows and Energy Balances

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The market for forest chip, forest residue and forest industry by-products is becoming more and more interesting due to challenging EU bioenergy strategies. The rapidly growing fuel-pellet industry, which today still relies mainly on high quality raw materials such as sawdust, is one of the sectors looking for a larger market share of raw biomass materials.

In 2005, pellet production in Europe was still at a rather low level; 2-3 million t of pellets were produced in about 200 pellet plants, meaning that 1-2 % of the harvested wood ended up as pellets. Similar quantities of raw material suitable for use in pellet factories (mainly dry and wet sawdust) could be found from among the by-products of the sawmill industry.

Pellet production capacity has grown rapidly in some parts of Europe. For example, in Germany it has grown from about 0.25 million t in 2005 to almost 3 million t at the end of 2008. Other countries such as Denmark and the Netherlands have been expanding pellet production capacity despite a very limited national forest biomass resource. New raw material approaches have already been introduced in these countries. Assuming a general annual growth in pellet production of 10 % (far less than the present growth rate), some 10-12 % of the harvested wood would end up in pellets by 2025 (Eforwood scenarios). Such developments would strongly affect the price of wood chips and the production of pulp and paper. Therefore, other biomaterial flows must be developed and introduced.

Studies carried out within the 'Eforwood' project focusing mainly on biomass flows, the potential for pellet production and on the energy balances of the process solutions studied are presented. A new biofuel upgrading technology, torrefaction, is described and analysed. The process allows a large range of low-grade raw materials to be used in the production of high quality fuel-pellets, the energy density and handling properties of which are significantly enhanced compared to conventional wood pellets. Torrefaction is expected to enter the commercial phase soon but has not yet been modelled within Eforwood. This technology will affect raw material availability, material flows and energy balances in both the transportation and production of fuel-pellets.

**Susana Barreiro** is a PhD student at the Lisbon Technical University, focusing on the theme: 'Simulating the effect of different management alternatives and climate change on wood production and carbon sequestration in eucalyptus stands in Portugal.' This research is supported by a grant from the Portuguese Foundation for Science and Technology and by the Eforwood project.

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# SIMPLOT: The Regional Simulator for Eucalyptus Forests in Portugal

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The use of simulators for scenario analysis can be a powerful tool to explore policy options and to illustrate the consequences of different management alternatives on the evolution of forest resources. SIMPLOT is a regional forest simulator developed for eucalyptus stands. It was conceived under the 'EFORWOOD' project to simulate the development of all eucalyptus stands in a region, providing as output several forest characteristics and sustainability indicators at a social, economic and environmental level. The simulator combines forest inventory data with growth models, taking into account the effect of different drivers:

I. wood demand, the main driver of the simulator, which has implications for the annual harvested volume;
II. occurrence of hazards, taking into account the burnt area per forest type and the percentage area suffering mortality brought about by several agents (e.g.: Phoracantha semipunctata, drought, frost, etc.);
III. land use changes (LUC) to and from other uses (representing the afforested and the deforested area per year);
IV. percentage change between different forest management alternatives (FMAs) and/or options.

The influence of the drivers is expressed through the scenario described in the input scenario file. The implementation of the drivers takes into account two main points: the total amount of each driver and the probability of occurrence of the event for each stand. The driver's total amount for each year can be given as an area, a volume or a proportion of an existing area, whereas the probability of occurrence of the event is estimated according to a probability function and implemented with Monte-Carlo simulation. In case the event actually occurs, the simulator takes a specific action depending on the event. As eucalyptus is an exotic tree species in Portugal, only three of the five FMAs have been considered: combined objective forestry, intensive even-aged forestry and wood-biomass production (short rotation forestry).

**Vasileios Drosos** teaches in the Postgraduate Studies Programme of the Department of Forestry and Management of the Environment and Natural Resources. He teaches a course entitled 'Sustainable management of the environment and natural resources. He has over 60 publications/contributions in Greek and foreign magazines and conferences.

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# Zoning as an Instrument for Sustainable Development and Exploitation of Mountainous Areas

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The abandonment and depopulation of mountainous areas are an effect of urbanisation and the dominance of tertiary sector activities in Greece.

The objective of this study is to specify strategic directions for an integrated development of mountainous areas through zoning policies and specialised production activities, according to a proper typology that differentiates regional problems, needs and perspectives.

Policy measures for the integrated development of mountainous areas are proposed, the aims of which are to maximise the potential of agriculture, stockbreeding and forestry in these areas. This can be achieved with the proper technology, but in harmony with the sensitive and invaluable natural and cultural environment of Greece.

The study sets some strategic directions for the integrated development of mountainous areas through spatial planning; the attraction of investment, suited to the natural and cultural environment; the financial promotion of the public infrastructure, strengthening the polycentric structure within the country and achieving better connectivity between the regions through an interregional road network; the promotion of cultural heritage and the protected natural environment; and the establishment of management bodies for mountainous areas.

The sustainable development of the mountainous areas of Greece targets regional and social cohesion in the framework of the following strategic targets:

- Integrated development of mountainous areas, and the concentration of private and public investments in these areas, targeting environmental protection and the economic revitalisation of forestry, agriculture, tourism, cultural heritage and the existing network of villages, as well as a total environmental upgrading.
- Adjustment of the economy of mountainous areas in line with European and international trends, multiplying the distribution of public economic resources and taking the proper restructuring measures for the improvement of the competitiveness of enterprises and the implementation of new technologies, management measures and economic incentives.
- Improving the transportation system in mountainous areas and access to the basic infrastructure system, as well as new information technology systems to address isolation problems.
- Protection and upgrading of the natural ecosystems, forest aesthetics, and the natural and cultural resources of mountainous areas.

**Mart-Jan Schelhaas** holds PhD from the University of Joensuu, Finland. He has worked for ten years in forest scenario modelling at the European level with the EFISCEN model, both at Alterra and the European Forest Institute. He studies effects of climate change, changes in management and changes in wood demand on forest structure and carbon sequestration.

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# Impact of Different Levels of Nature Conservation Designation on European Forest Resources

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Currently, about 7 % of the EU forest area is allocated to biodiversity conservation (MCPFE class 1; MCPFE 2007). According to the Natura 2000 Agenda, 15 % of the territory of the EU should be designated as conservation area by 2025. It is to be expected, therefore, that the forest conservation area will increase considerably in the near future. Although a certain level of harvesting will probably be allowed in these areas, a negative effect on the total wood production is likely. Over the same period, wood consumption is expected to increase further, especially given the increased emphasis on woody biomass for energy generation.

The possible consequences include an increase in imports and more intensive forestry on the remaining areas. The impact of different nature conservation implementation levels on the state of the forest resource in Europe was explored using the forest scenario model EFISCEN. Developments in variables such as growing stock, increment, species distribution, age class distribution, wood production and carbon sequestration were considered against two background futures (A1 and B2 from the SRES scenarios) and four different nature conservation implementation levels.

**Eric Arets** is a tropical forest ecologist at Alterra, Wageningen UR. Originally his main field of expertise was in the modeling of tree population dynamics in tropical forests in order to assess sustainable management options. Over the past couple of years he has mainly been involved in a number of studies on the effects of land use, land use change and climate change on biodiversity.

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# The EU Wood Chain in a Globalised World – The Impact of Trade and Policy Factors on the Sustainability of Wood Chains between the EU and Developing Countries

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In this globalised world the EU and its forestry sector are not isolated. Through trade and policies they depend on and influence forestry sectors in other regions. The growing world population and increasing wealth will lead to an ever-increasing demand for wood worldwide. As a result of this increasing demand, in combination with greater competition for land for the production of other commodities such as soy and palm oil, the pressure on forests will continue to grow, especially in tropical regions.

With the aim of promoting the sustainability of wood sourced from tropical regions, the EU launched an action plan to restrict the amount of illegal timber entering the EU. A number of Member States are also putting in place stricter timber procurement policies, with a focus on certification. In the same period, the demand for wood in developing giants such as China and India has been and continues to increase. This is likely to have a considerable effect on trade between the EU and developing countries.

Using the IMAGE-GLOBIO integrated assessment models in combination with the EFI-GTM trade model, we evaluated the sustainability of wood chains between the EU and developing countries. A number of scenarios were assessed and the impacts on trade balances, forest management and biodiversity evaluated. As future demographic, economic and social developments are very uncertain, the scenarios were built on two contrasting reference futures. They included changes in the supply of and demand for wood based on an evaluation of current and projected trends in the forest sector in the EU and in the major wood producing tropical regions. This included an analysis of the major trade and policy factors in the EU and tropical regions that are likely to affect each other.

**Astrid Kaemena**. Studied veterinary medicine and completed a Ph.D. in Hanover, Germany. Subsequently trained in public administration and spent nearly 12 years working in German administration. In 1999 she started working for the European Commission, and since 2002 has been dealing with nature and biodiversity, first in environmental policy and since 2007 in the area of research policy, in the Management of Natural Resources Unit.

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# Closing Remarks

Astrid Kaemena

EFORWOOD – Sustainability Impact Assessment of the Forest-Wood Chain – is a research project funded under the 6th Framework Programme of the European Community for research and technological development (FP6).

**Why do we need European research?**
European research is an essential element in the functioning of industrialised countries such as EU Member States. The competitiveness of companies and the employment they can provide depend to a great extent on research. Research is also essential as a support for policy; for example, in relation to consumer protection policies and the protection of the environment. In short: the individual and collective wellbeing of citizens depends on the quality and relevance of research.

**What are the objectives of FP6?**
The general objective of FP6 is to contribute to the creation of the European Research Area (ERA) by improving the integration and co-ordination of research in Europe.
One of the goals of research undertaken under the sub-priority 'Global change and ecosystems' (of the FP6 special programme 'Focusing and integrating European research') is to strengthen the necessary scientific base, including socio-economic assessments and tools and management practices, for the future orientation of the European Sustainable Development Strategy.

**To what extent is EFORWOOD contributing to these objectives?**
EFORWOOD is one of 5 integrated projects funded within the 6th Framework Programme under the area 'Strategies for sustain-able land management' of the sub-priority 'Global change and eco-systems.' As an integrated project with 38 partners from 21 countries, EFORWOOD is certainly contributing to improving the integration and co-ordination of research in Europe.
The aim of the 4-year project is to provide methods and tools that will, for the first time, integrate sustainability impact assessment of the whole European forest-wood chain, using indicators for all three pillars of sustainability: environmental, economic and societal. The project provides methods to assess the sustainability impacts of modifications to forest-wood chains as influenced by policy changes, market drivers and technological innovations. This can certainly be deemed an important contribution to the implementation of the Sustainable Development Strategy.

**Will EFORWOOD results continue to be useful in future?**
The main objective of research for the environment under FP7 is to promote the sustainable management of both the man-made and the natural environment and its resources. Specific attention will be given to informing decision-makers in their design of environmental policy, as well as business leaders and ordinary citizens about the challenges and opportunities they face. EFORWOOD results may provide an excellent foundation/starting point for such future research.

# 2. POSTERS

## Contents

**Veerle Buytaert** is a bioscience engineer in land and forest management with a master's thesis on the sustainability of agricultural systems and landscapes in southern Brazil. Having spent time as an educational worker providing information on sustainable agriculture and the environment in Bolivia, in 2007 she began a Ph.D. on the sustainability of bio-energy systems at VITO, Belgium

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# Towards Integrated Sustainability Assessment for Energetic Use of Biomass: A State of the Art Evaluation of Assessment Tools

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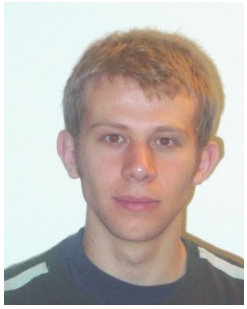
Worldwide, biomass is expected to play an increasingly significant role in the 'greening' of heat, electricity production and transport. European policies such as the Renewable Energy Directive, Strategy on Biofuels and the Biomass Action Plan push the implementation of energy derived from biomass in developing and industrialised countries in order to meet the greenhouse gas reduction targets of the Kyoto Protocol and post-Kyoto agreements. These targets are a source of increasing concern amongst policy makers due to questions over the sustainability of large-scale bio-energy crop production. Potential negative impacts include land use change and biodiversity loss, agricultural land use pressure, rising agricultural commodity prices and threats to food security. These risks have to be weighed against potential benefits such as improved greenhouse gas balance, employment and income generation, rural development, conversion of conventional industries and increased security of energy supply. Therefore, the environmental, economic and social impacts of bio-energy development must be assessed carefully before deciding whether and how this industry should be developed, and what technologies, policies and investment strategies should be pursued. This concern has led certain governments and institutions to start developing sustainability tools and standards to evaluate the environmental, economic and social performance of biomass energy production. However, the high variability in biomass sources, conversion technologies and backgrounds (ecological, social and institutional) complicate such assessments. Some controversial issues and questions arise when trying to tackle sustainability assessment.

This study analyses and compares the applicability and performance of a number of basic sustainability assessment tools for bioenergy systems: sustainability criteria and indicators (C&I), life cycle analysis (LCA), environmental impact assessment (EIA), cost benefit analysis (CBA), exergy analysis, Markal and system perturbation analysis (SPA). In the analysis, we considered both biomass sources (input related evaluation) and conversion technologies (output related evaluation). The results highlight strengths and weaknesses of the studied tools and help to optimise the choice and use of a certain tool with respect to a particular sustainability question. The shortcomings of the existing tools for the execution of an integrated sustainability assessment are identified and suggestions for their integration in a more comprehensive tool are made.



**Wouter H. Maes** has masters' degrees (M.Sc.) in bio-engineering in forest ecology and management (2004) and environmental studies and management (2006). He is currently a Ph. D. student at K.U.Leuven, Belgium.

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# EDUBO: A Standard of Quantitative Indicators for the Monitoring and Evaluation of the Ecological Aspects of Sustainable Forest Management at the Stand Level

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The standard was designed as an operational but science-based tool for the evaluation of forest management in the Flemish region of Belgium, and aims to address the effects of forest management on forest composition, structure and function. Based on a literature study, 157 potential indicators were listed, 40 of which were subsequently selected by an expert panel, based on 10 operational selection criteria. All indicators were quantitative variables measurable in the field. No indicators derived from management plans or management intentions were allowed. The resulting standard was made according to the guidelines of the hierarchical framework for standards of principles, criteria and indicators of sustainable forest management, proposed by Lammerts van Bueren & Blom (1997). The standard was tested in the field by applying it in 115 forest stands, well spread over the three main site types of the region, and including different ownership categories, stand ages and management systems. The time and cost of measuring each indicator was recorded. The past and present management was also described in detail for each of the evaluated stands, using existing management plans and interviews with the responsible forest managers. Applying this management database it was possible to test which of the 40 quantitative indicators were sensitive to management. Based on this analysis, a final indicator set comprising 36 indicators was left. Furthermore, the management database was used to apply the ecology-related criteria of the official Flemish standard for sustainable forest management (inspired by Helsinki and FSC criteria). This allowed for comparison of the outcome of the new quantitative standard with a more conventional sustainability assessment. The new standard exhibited greater sensitivity to management and demonstrated better discriminating power.

**Gunilla Clancy** has a M.Sc. in chemistry from the University of Göteborg, 1994, and is currently a Ph.D. student at the Department of Chemical Environmental Science at Chalmers University of Technology. Among other positions she has worked as an environmental specialist at IKEA of Sweden and participated in the work of the Centre for Environmental Assessment of Product and Material Systems (CPM).

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# Comparing the Sustainability of using a Non-Renewable Oil Based Material in an Absorbent Hygiene Product with that of using a Renewable Wood Based Material

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The WooDi project – the Wood based Diaper, is research collaboration between industry and university. The goal of the project is to make a new diaper that is more sustainable than today's product, by replacing non-renewable North Sea oil based materials in the diaper with a renewable material based on wood from the Nordic countries. This calls for a way to compare the sustainability associated with using the different raw materials. Comparisons of the implications of using crude oil and biomass resources have so far mainly been made for fuels used in transportation. The available literature assessing the use of fossil fuels versus bio-fuels focuses primarily on greenhouse gas emissions, often referred to as the carbon footprint [1]. It does not include, e.g., effects on ecosystem quality, employment, economy, etc. The increased use of bio-fuels for transportation is discussed in relation to food and feed grain prices, as well as negative environmental impacts arising from deforestation and land conversion, as food and fuel compete for scarce land resources [2, 3]. Some life cycle impact assessment (LCIA) weighting methods include resource use, but are generally based on only one or a few parameters. One example is the monetary values used by the environmental priority strategies (EPS) method [4], which involves a weighting for renewable and non-renewable resources based on the cost of producing an equivalent from renewable resources. For forestry there are several voluntary sustainable forest management (SFM) systems, e.g., Forest Stewardship Council (FSC) certification and the Programme for the Endorsement of Forest Certification (PEFC) scheme. Requirements within such systems include a broader set of aspects than greenhouse gas emissions or available LCIA weighting methods. The SFM laboratory [5] suggests eight different sustainability criteria such as the maintenance of ecosystem health and vitality; cultural, social and spiritual needs and values and maintenance of the forests' contribution to global carbon cycles. No comparable sustainable management criteria have been found for fossil oil extraction and use, other than an initiative with recommendations on how to include biodiversity into strategies for oil and gas development [6].

Consequently, there exists no readily available method for comparing the sustainability of using North Sea oil and Nordic wood as raw materials. The methods mentioned above can be a starting point but need to be developed further. The method development work carried out in the WooDi project should also be useful for other sustainability assessments comparing forest and fossil resources.

**Pekka Lauri** is a researcher in the Finnish Forest Research Institute. He has a Ph.D. in economics. His experience in forest economics is based on use of the EUFASOM model (European forest and agricultural sector optimisation model), which he has been developing together with some other members of the team over the last 9 months.

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# The Battle for Forest-Based Biomass – the Impact of Climate Policy on the European Forest Industry

Pekka Lauri[1], A. Maarit I. Kallio[1], Uwe A. Schneider[2] and Gregor Fiedler[3]

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Climate policy is expected to place restrictions upon the use of fossil fuels in the future, which is likely to lead to an increase in energy prices and in the demand for forest-based biomass for energy production. This will have far-reaching consequences for the European forest industry. First, the energy and raw material costs of the industry will increase, bringing about a reduction in the competitiveness of the forest industry compared to those industries that are less raw material- and energy-intensive. Second, there will be some substitution of energy-intensive products by less energy-intensive products. Third, there will be some substitution of forest-based biomass by other raw materials. In this study we use a forest sector sub-model of the European forest and agricultural sector optimisation model (EUFASOM) to evaluate the impact of climate policy on the European forest industry. In particular, we examine how the alternative fossil fuel prices affect production quantities, market prices, raw material proportions and the industry structure in the coming decades.

*This research is part of the CC-TAME Project, which is funded by the European Commission under the 7th Framework Programme, under the theme 'Environment including Climate Change'.

**Ruediger Hildebrandt** graduated from the University of Goettingen with a Diplom in forestry. Later he specialised in geographic information systems. His subsequent work for the University of Hamburg focused on forest growth modelling. He currently works for the Johann Heinrich von Thünen Institut in Hamburg, where he is engaged in modelling single tree growth.

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# Future National Roundwood Potentials in Germany According to Different Forest Management Objectives

Potentials and dynamics of carbon sequestration in forests and timber (CSWH)

Rüdiger Hildebrandt[1]

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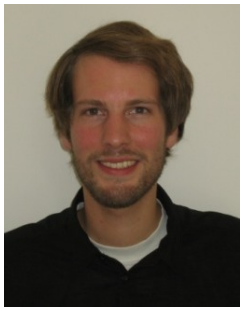
There is considerable uncertainty in relation to the potential value-based contribution of the forest and timber sector to the mitigation of the concentration of carbon dioxide in the atmosphere. In order to provide a quantitative approach to the prediction of future C emissions and removal by the forest and timber sector under different climate change and market economy situations, a complex simulation suite has been developed. Data from Germany were used to model the future roundwood potentials under a variety of management regimes targeting different objectives. The simulation suite combines data from the German forest inventory (BWI$^2$), from a statistical climate model (WETTREG) that implements the SRES scenarios B1 and A1B and estimates regional climatic changes based on data from meteorological stations throughout Germany. The point-related BWI$^2$ and the area-related WETTREG data were merged by means of geostatistical analyses. Basic soil data and digital terrain data were linked to the BWI locations. The combined database was used to identify roughly 2 500 sites with similar growing conditions and forest structures for the reference year 2000. These sites were utilised as model stands, representing almost the entire array of forest cover in Germany, and served as input data for growth simulations. The growth simulations were carried out using the individual tree growth model SILVA 2.3. Based on the model stands and climate predictions, site-specific developments of the parameters driving growth were modelled for a simulation period ranging from 2005 to 2100. The amount of harvested wood was simulated for different forest management objectives and climate change scenarios.

The following figures show the influence of three management objectives on roundwood availability in Germany within the next one hundred years. The management objectives implemented were (1) maximising profit, (2) maximising growth, and (3) harvesting trees upon reaching a specific dbh-threshold. Maximising profits leads to a fluctuating supply with both broadleaf and coniferous roundwood. The use of coniferous roundwood peaks around the years 2030 and 2060, and falls to a very low level in the last 40 years of the simulation period. However, the supply of broadleaf roundwood increases in this last phase. Maximising the net yield of forest results in a more or less continuous supply of broadleaf roundwood, while the availability of coniferous timber is increases over time, especially towards the end of the simulation period.

Harvesting trees only once they have reached a defined DBH provides the most constant supply of coniferous and broadleaf roundwood, both of which slowly increase over time and are not sensitive to developments in timber prices.



**Thomas Vogelpohl** studied political science and specialised in environmental policy. Within the Eforwood project he worked on sustainability indicators for the forest-wood chain (FWC) and the analysis of FWC-related policies at BOKU University in Vienna, Austria. He is now affiliated with the Institute for Ecological Economy Research in Berlin, Germany.

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# Incorporating the Institutional Dimension into Sustainability Impact Assessment for an Advanced Sustainability Analysis of the Forest-Wood Chain

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Scholars from various scientific backgrounds advance the view that the institutional sphere should be considered the fourth dimension of sustainability, emphasising that the institutional setting is of critical importance to achieving the goal of sustainable development. This fourth dimension is an integral part of sustainability and it represents an important challenge to the full integration of economic, social and environmental sustainability objectives within the necessary institutional structures. This also holds true for the forestry sector. The aim of this paper is to describe and discuss how the institutional dimension of sustainability can be incorporated into sustainability impact assessment (SIA) efforts using the Eforwood project as an example. In this context, a set of sustainable development indicators (SDIs) capable of providing a basis for the SIA tool and able to capture the impacts of the forest-wood chain (FWC) on sustainability has been defined. Following the common definition, the SDI are aligned with the 'triple bottom line' approach to sustainability, addressing the latter's economic, social and environmental dimensions, but leaving out the institutional. To make up for this, a policy database was developed within the context of Eforwood, the purpose of which is to connect the SDI set used in the project to its institutional and political background. This database covers all FWC-related policies of key relevance to its sustainability performance. Every policy included in the database is directly related to the SDIs and categorised according to the type of policy, the governing institution and the mode of governance. This connection provides direct and detailed insights into the governance structures prevailing in the European forest-based sector and thus into the institutional dimension of FWC sustainability in general. Results show that the specific issues concerning FWC sustainability are governed and regulated rather inconsistently, with many political institutions involved, various types of policies in force and different modes of governance applied. This suggests that a more coherent policy approach would be conducive to sustainable FWC governance. In summary, the connection between sustainability indicators and a comprehensive database of sector-related policies created within the Eforwood project, and presented in this paper, marks an innovative approach to overcoming the often observed lack of consideration given to the institutional sphere of sustainability. Moreover, the possibilities to build on this approach and to enhance the integration of the institutional dimension of sustainability into SIAs are also discussed in the paper.

**Alexander Moiseyev** is a senior researcher of forest products markets at the European Forest Institute. His main area of expertise is forest sector analysis and global forest sector modelling. Prior to joining EFI he worked at the Russian Institute of Continuous Education in Forestry (1990-95) and the Moscow State University (1983-89).

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# Impact of the Global Economy and Future Scenarios for the Forest Sector on the EU Wood Chain

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The future of the EU forest sector is dependent not only on EU policies, but also largely on the future global socio-economic context. Two IPCC SRES scenarios A1 and B2 are used as contrasting reference scenarios, each representing a different path of evolution of the forestry sector in developing countries and the CIS region. The A1 scenario is one likely future scenario, and has dominated over the past couple of decades, as the world economy and the forest sector have become increasingly globalised. The A1 scenario is defined as the continuation of relatively high economic growth and a correspondingly high growth in the consumption of wood-based products. Environmental issues are attributed relatively high significance in the EU and other developed countries, but in other less developed countries the environment and sustainability are of less concern. This disregard leads to the continuation of unsustainable forestry and the degradation of forests in the developing world. The B2 scenario foresees future development, whereby the environment is afforded a high level of importance in all world regions, and under which concerns are addressed through local, regional approaches. Under this scenario regionalisation counters the globalisation trend and economic growth is slower. These contrasting global contexts expose the EU forest sector to different conditions, which have a substantial impact on forestry and the development of the forest industry.

The global forest sector model EFI-GTM was used to analyse the above scenarios for the EU and the global forest sector. The EU is expected to continue increasing imports of raw wood from Russia and other countries under A1, which will help to sustain the growth of the pulp and paper industry while ensuring that there is less pressure on EU forests. However, a declining supply of wood from outside of the EU and decreasing imports of wood into the EU under the B2 scenario will lead to slower growth of the EU forest industry and result in more pressure on European forests.

**Christine Fürst** is a graduate of the Ludwig-Maximilian University of Munich, with a Diploma in forestry. Since 2000 she has been a scientific coordinator and member of staff of the Institute of Soil Sciences and Site Ecology at the TU Dresden, focusing on forest and environmental management. The emphasis of her work at present is on environmental assessment and the development of cellular-automaton based management support approaches at the landscape level.

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# Pimp your landscape – a cellular automaton-based tool to evaluate the impact of planning measures on sustainable landscape development

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Pimp your landscape was developed to support communicative processes in environmental planning. The tool uses Corine Landcover 2000 maps and georeferenced information relating to climatic parameters, geology and topography. The object-oriented software has been developed as a cellular automaton, which is able to integrate complex interactions between different land-use forms at a regional level with a maximum resolution of 100x100 $m^2$. Each 100x100 $m^2$ cell has as attributes 'land-use form', 'geological substrate', 'climatic parameters' and 'topographic parameters'. The attribute 'land-use form' is evaluated on the basis of the impact of each land-use form on a number of sustainability indices, which can be chosen and adapted for the regional context. The evaluation is based on indicators / indicator sets, which are adapted to regional conditions, derived regional knowledge and experience. The adaptation is supported by the multiple-client approach of the system, where experts can introduce, test and exchange their propositions, which are finally assigned as specific regional value sets.

Several rule systems can be activated and adapted by the user. A rule system describing the impact of the additional cell attributes (climate, geology, topography) on the evaluation result forms the basis. Based on this is a rule system, which describes the interaction between the cells (direct and over gradients), and the impact of time on the value of a land-use form. Finally, the user can introduce restrictions in regional planning, which are derived from national / regional regulations or EU directives such as Natura 2000 and the Water Framework Directive. The rules can also be adapted as part of a communicative process.

Pimp your landscape can be run in several modes, according to different user profiles. In the 'game mode', users can test the effects of regional planning measures by assigning new land-use forms to the cells, through the introduction of infrastructural elements with different impact categories such as roads, or different categories of water bodies. They use a predefined value set. In the expert mode, it is possible to introduce planning restrictions and thresholds (min / max) for the sustainability indices. In the scientific mode, the full variety of adaptations to the rule sets and the possibility to define new rules is opened up. The tool was tested by more than 1000 users involved in environmental education and training, and in the screening of the effects of planning measures. The current version has been adapted to test different climate change mitigation strategies in Saxony. Application examples and an evaluation of the results will be presented.

**Ariane Messner** is a student of the International Joint Master's Programme 'Natural Resources Management and Ecological Engineering' at the University of Natural Resources and Applied Life Sciences (BOKU), Vienna, with a study focus on international business and sustainability. The programme included semesters at Lincoln University, Christchurch, New Zealand and EPFL, Lausanne, Switzerland. The research presented is her Master's thesis.

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# Sustainability Assessment of Wood Products: A Comparison of the Methods Ecological Footprint, MIPS and the Sustainability Impact Assessment Approach of Eforwood

Ariane Messner[1], Bernhard Wolfslehner[1], Eva Burger[2], Friedrich Hinterberger[2], Manfred J. Lexer[1]

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Environmentally friendly and sustainable production has recently attracted increasing attention. A variety of approaches have been proposed to objectively evaluate and measure the sustainability of industrial production processes and supply chains. The European Commission is also taking steps to enhance sustainable production and consumption with an 'action plan on sustainable production and consumption and sustainable industrial policy', released in July 2008. Even though several methods for the life-cycle-wide assessment of a product's sustainability performance were developed, no common European standard for sustainability assessment exists, yet. The objective of this study is to compare three contrasting sustainability assessment methods, (i) ecological footprint, (ii) MIPS (material input per service unit), and (iii) the integrated sustainability impact assessment approach of Eforwood by highlighting strengths and weaknesses, and identifying opportunities for improvement. First, the three assessment methods are described including their underlying concepts and background, as well as their data requirements. Next, the methods are applied to a case study example where the manufacturing processes of two specific wood products are analysed (solid wood plank versus particleboard). For this case study a generic production chain is analysed, involving an age-class conifer forest land use type, regional transport, sawmilling, and particleboard mill. The store of a regional retailer is defined as the system boundary. The three methods are compared with regard to (1) the relative ranking of the two wood products in terms of their sustainability impact, and (2) by a set of performance measures such as practicability, required know-how, time, and data requirements. Advantages and disadvantages of the different methods are discussed, as are possible domains for their application.

**Bernhard Wolfslehner** holds a Ph.D. in engineering sciences and is working as researcher at BOKU University, Vienna. His main fields of expertise are sustainable forest management, indicator design and application, and multi-criteria analysis (MCA). In Eforwood, he is engaged in the development of an MCA software prototype for the evaluation of forest-wood chains.

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# Implementing a Participatory Multi-Criteria Evaluation Tool for Sustainability Impact Assessment of Forest-Wood Chains

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Sustainability impact assessment (SIA) is a prospective, integrated assessment approach for potential impacts of policy actions. It is expected to integrate economic, environmental and social issues, and to support policy-making under strong involvement of concerned stakeholders. In response to this demand, the use of evaluation methods is a core element of SIA. Going beyond classical economic tools such as cost-benefit analysis, multi-criteria analysis (MCA) is reported to be a particularly suitable approach when participatory elements such as stakeholder interaction are required in evaluation procedures. MCA methods are used to evaluate policy options or management strategies and to support indicator-based assessments by including value information, i.e. weights and preferences, in the decision-making process.

Within the Eforwood project, a set of sustainability indicators is employed to assess a wide range of sustainability aspects of production, consumption and recycling processes occurring along forest-wood chains (FWCs). MCA is intended to facilitate a multi-indicator evaluation in this framework in order to foster transparent decision-making processes and support group-decision environments for SIA. Based on methodological analysis and the stated demands of experts and stakeholders, the PROMETHEE method was selected for further development in Eforwood, due to its flexibility and broad applicability. PROMETHEE was adapted to a semi-hierarchical indicator-subindicator structure and, for the purposes of transforming dominance relations among alternative FWCs, to sustainability impact ratings.

Special emphasis is placed on the modes of interaction with decision-makers and stakeholders, both for single users and in a group mode. Therefore, the software tool ToSIA-MCA is introduced, supporting the evaluation of alternative FWCs by (a) selecting indicators, (b) weighting indicators, (c) making judgments on indicator values, (d) aggregating individual indicators in a holistic impact profile, and (e) providing uncertainty and sensitivity analysis for input data and indicator weights.

The manner in which participatory MCA-features in stakeholder interaction are implemented is demonstrated in a client-server architecture that is designed for both physical group sessions and web-based online meetings. In this way, ToSIA-MCA is fostering guided and iterative group evaluations of FWCs, catalysing negotiations on SIA-related topics and supporting an informed, well-documented decision-making process.

**Taru Palosuo**, D.Sc. (Agr.&For.), is a principal research scientist at MTT Agrifood Research Finland. She is currently working with the integrated assessment modelling of agrifood systems with a particular focus on soil carbon and crop modelling in the context of climate change mitigation and adaptation. She has also been working with the assessment of the carbon budgets of forests and their uncertainties.

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# A Modelling Framework for the Assessment of the Impacts of Alternative Policy and Management Options on the Sustainability of Finnish Agrifood Systems

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Agrifood systems need to adapt to cope with the risks and opportunities related to global changes in climate, markets and policies. The impacts of these changes on food production, the environment and farmer livelihoods, as well as those of changes to technology and management practices, are not clearly understood. There is a need for improved assessment methods and tools that consider multiple factor and scale interactions. In recent years, European consortia have worked to create flexible and widely applicable frameworks for the integrated assessment and modelling of agrifood systems. This work has been valuable in developing common concepts, methods and more flexible frameworks. However, their generic character reduces their competitiveness when it comes to detailed regional applications. In Finland, there are several individual modelling tools available for the analysis of the environmental and socio-economic impacts of agricultural activities from field to national scales. Recently, a new project focussing on integrated assessment modelling of agrifood systems (IAM-Tools) has been launched at MTT Agrifood Research Finland to gather, evaluate, refine and develop these component models and to link them in an IAM framework for Finnish conditions. The framework was developed for ex-ante assessment of alternative policy and management options in relation to climate change adaptation and mitigation, biodiversity and reducing nutrient emissions from agriculture. A set of alternative scenarios of the main global and national driving factors have been down-scaled to construct regional scenarios of the major factors likely to influence agro-ecosystems. The framework is being built by revising existing and designing new models, interlinking the models or their results at the farm and regional level, and integrating the information in a GIS environment. The component models applied are, for example, a dynamic regional sector model of Finnish agriculture (DERMFIA), a static agent model of agriculture (SAMA), a dynamic crop growth simulation model (WOFOST), models describing the nutrient dynamics in agricultural systems (INCA-N, ICECREAM and COUP) and a hydrological rainfall-runoff model (WSFS-P). This framework represents a novel approach to the integration of data and output from several existing models. The aim is to apply the tool in relation to questions of high importance for Finnish agriculture, especially policy interventions targeting more sustainable agriculture-environment interactions, for example, in terms of water quality, greenhouse gas emissions and adaptation to climate change.

**Christian Gamborg** is a senior scientist at the Centre for Forestry, Landscape and Planning and at the Danish Centre for Bioethics and Risk Assessment, both part of the Faculty of Life Sciences, University of Copenhagen. Since 1998, his key areas of research have been applied ethics and stakeholder analysis in relation to forestry, agriculture and modern biotechnology.

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# Successful Interaction with Stakeholders: Using Roadshows as a 'Sustainable' Approach

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Interaction with stakeholders in larger EU projects is notoriously difficult. Questions concerning the representativeness (i.e., who should be involved), issues (i.e., interaction about what) and purpose (i.e., why involve, and for the benefit of whom) need to be addressed and, subsequently, suitable methods must be applied. This paper presents the main approach used to interact with stakeholders in the Eforwood project, the so-called roadshows, and describes the main outcomes and results of this interaction. The conclusion drawn from the roadshows is that this form of stakeholder interaction would appear to be a more 'sustainable' approach than many bigger, multi-stakeholder workshops, as are often employed in similar projects.

Throughout the Eforwood project, various methods of interaction have been used, including workshops, interviews and written consultations. However, to enable more in-depth feedback from stakeholders and a more consistent creation of awareness about the project among key stakeholders, a 'roadshow' approach was developed. A roadshow is defined here as a smaller, dedicated and targeted two-way discussion meeting with key persons from Eforwood and representatives of a certain end-user or other stakeholder group; i.e., the target group for the meeting, usually at their premises. The target groups for the roadshow comprised representatives of the EU Commission, large industries, other FBS industry and associations, other decision/policy makers, and significant non-industrial NGOs. The aim of the roadshows was twofold: a) to increase awareness and understanding of the project impacts, and b) to get direct input/feedback on project developments (general and specific). Approx. 25 stakeholder organisations in Europe and the USA were visited at their premises.

In general, the stakeholders visited were interested in and positive about the Eforwood project, but they also expressed their difficulties obtaining an overview of the project as a whole, grasping the consequences of the application of TOSIA and conceptualising the boundaries to the use of the tool. The main topical areas of discussion at the meetings were: ToSIA as a tool, indicators, MCA and scenarios. The main outcomes of the stakeholder interaction, especially the roadshows, were: a) communicating the project to key stakeholders, b) exploring concerns and views related to Eforwood and c) getting feedback on key project elements, in particular ToSIA, indicators, MCA and scenarios. The 'results' – i.e., the issues and concerns that arose more or less consistently at the meetings – of the roadshow have been used internally as input and feedback in the project modules and externally in the form of FAQs etc. on project web portal.

**Isabel Van den Wyngaert** is a system ecologist with focus on carbon and nutrient cycling. After some years of empirical (measurement) work she moved to incorporating these processes into process-based (forest) models. She has developed and used a simple empirical model for the Dutch LULUCF forest carbon calculations since 2004.

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# EFISCEN-Space: high resolution modelling of forest resources at a pan-European scale

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The EFISCEN model has been successfully used for forest resource analyses at the pan-European scale for a range of applications. However, these scenario projections are most reliable for managed even-aged, monospecific forests, as were traditionally dominant in large parts of Europe. With European forestry shifting away from a timber production system towards more nature-oriented management and alternatively towards short rotation biomass plantations, there is a need to adopt a more flexible approach. As the goals of forest management are becoming more diversified, and the calculation of scenario projections has moved towards extensive sustainability impact assessments integrated over a whole sector, the robust but simple approach of EFISCEN no longer fulfils the current requirements.

EFISCEN-Space is a new high resolution (1 km x 1 km) forest simulator, an improved tool to analyse the development of forest resources on a regional to European scale under different management scenarios, societal demands and environmental circumstances. The model is based on a large set of national forest inventory plot level data integrated in a GIS framework, including earlier pan-European forest maps and related information. Algorithms have been developed to translate the original geo-referenced plot data into maps with the data needed to initialise a dynamic forest development model. Without the complexity of a physiological model, the latter has been developed to deal with anticipated trends in forest management. Indicator values calculated from the output provide information about non-timber services for different forest types, allowing for the evaluation of the ecosystem functions provided by forests in the simulated region. The first results will be presented.

**Diana Vötter** holds a PhD in forestry and wood science, and is specialised in forest technology and process modelling. She has worked in Germany, Sweden and Finland, and now holds a position as senior researcher at the European Forest Institute (EFI), Finland.

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# Sustainability Impact Assessment of Alternative Small- and Large-Scale Bio-Energy Chains

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Changing forest management practices towards more intensive biomass utilisation for energy purposes will affect the sustainability of resource management. In northern Europe wood has always played an important role in terms of energy supply. New policy targets of increased shares of renewable energy create challenges in connection with the economic, environmental and social sustainability of forest-wood chains. The Tool for Sustainability Impact Assessment (ToSIA) was applied to evaluate the environmental, social, and economic sustainability of typical Scandinavian bio-energy value chains. In an example for the region of northern Karelia, the implementation of small-scale versus large-scale forest biomass use in district heating plants was investigated. ToSIA was used to calculate impacts on sustainability indicators in relation to the material flow through production processes in the alternative bio-energy chains. The effects on rural society and on ecosystems were assessed in terms of economic (e.g., production costs, value added), social (e.g., employment, wages, occupational safety) and environmental (e.g., energy use, greenhouse gas emission, carbon sequestration, biodiversity) sustainability aspects. Both positive and potentially negative socio-economic and environmental impacts on sustainability were expected of this additional extraction of biomass from the forests. Potential drawbacks such as decreasing nutrient returns to the soil and the affiliated potential reduction in future stand productivity were analysed. Fertilisation might be needed to maintain sustainable forest growth on poor sites. Differences between the implications of the alternative bio-energy chains were discussed in relation to regional development targets.

**Lars Wilhelmsson** is leader of the 'wood utilisation' research programme at Skogforsk, Sweden. His R&D activities relate primarily to market requirements and the integration of harvesting into industrial processes and products, the characterisation of yield and the properties of forest resources including models based on new techniques for forest inventories, etc.

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# Economic and Environmental Improvements to Wood Supply in the Context of Whole Forest-Wood Chains by Means of Operative Predictions of Costs and Benefits in Monetary, Environmental and Working-Hour Units – A Connection Between Eforwood and Indisputable Key

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The objectives of Indisputable Key (EC-6 thematic priority 2) are related to the objectives of Eforwood, targeting detailed supply chain management with respect to solid wood products. The underlying hypothesis is that considerable improvements to value chains can be achieved by analysing the predicted costs and benefits in monetary units, as well as in environmental and workload units. We have used simulation as a tool to evaluate possible improvements in the efficiency of a wood supply chain with respect to integration with production processes and quality shares of some solid wood products. Wood suppliers commonly deal with a number of parallel supply chains, simultaneously serving different customers and products. Therefore, we include brief reflections on the possible impacts on efficiency of these complementary and/or competitive production chains. Our concept starts with inventory information on the distributions of individual tree sizes, tree ages, spatial distributions and generic stand conditions. The simulations are based on real sample tree data supplied by the Swedish national forest inventory. To avoid overestimations of sawlog proportions we have added statistically based assumptions of damage rates resulting in a downgrading of logs. Finally, we added gatherable stand information to estimate harvesting and haulage costs for alternative assortments and customers. Based on this information and on the pricing of different assortments and dimensions we tested alternative bucking simulations. The results include distributions of log dimensions and characterisations of other properties of possible importance for manufacturing processes and the resulting proportions of end-products. This was the basis for comparative cost analyses of the forest to industry operations, including monetary, environmental and working hour units, typically accounted per $m^3$ of logs. By adding predicted benefits from alternative log supplies to predicted effects on alternative consecutive products and customers the prerequisites to make cost benefit analyses will be there. Our preliminary results indicate that there are considerable differences in monetary cost, environmental impact and working hours spent on different logs and supply alternatives. Based on our first results, it appears reasonable to assume that significant effects can be achieved at different stages further along in the different production chains. The valuation of possible impacts on process and product benefits within the integrated wood supply should be further analysed in cooperation with our R&D partners. Production statistics derived from traceable sample logs (RFID-tags providing individual associated data) will connect log properties at harvesting with process efficiency and product shares in a sawmill case study.

**Jean-Baptiste Chesneau** holds a master's degree in international economics (Universty of Cergy-Pontoise, 2005). Prior to the Eforwood project he worked on international trade and development economics issues, in which he focused on the distribution of solid wood products and transport processes.

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# How to Deal with Transport within the FWC

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Aiming to assess the sustainability impact of the forest-wood chain in Europe, Eforwood gathers information on processes from the forest to the final consumer. Transport represents a substantial activity along the chain, and is crucial with regard to sustainability. Indeed, the transport sector is responsible for consuming 70 % of all petrol in the EU. Furthermore, transport has been identified as the major sector for which $CO_2$ emissions are forecast to increase over the next twenty years.

In order to assess its impact on the forest-wood chain, an ad hoc approach integrating two dimensions has been developed:

- *The measure of transport as an indicator*: providing estimates of transport intensity and the modal split, two major impacts on sustainability;
- *The identification of transport as a process*: tracking the product streams along the chain. For each flow, the requested information is: the transport mode, the geographical level (national, international), the distance, and the load. Using this information, the 'Eforwood transport tool' calculates values for 30 indicators (economic, social and environmental) for all EU-27 countries.

The poster will describe the choices made for these two dimensions. A focus will be placed on the method, the tool and the assumptions used to integrate some logistics concepts. Two applications will be presented in order to identify the hotspots in the transport process and the relevance of the results.

**Hans Verkerk** (MSc) is a researcher at the European Forest Institute. He is specialised in forest resource modelling, particularly with the EFISCEN model. Within various projects (EXIOPOL, FOBIT, EUwood, SENSOR), Mr. Verkerk focuses on the use of forests (e.g. biomass production, biodiversity protection) and potential trade-offs between the different uses.

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# Economic valuation of the impacts of intensified biomass production and biodiversity protection on forest land use in Europe

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Forests provide a broad range of goods and services to society, but demand for certain goods and services may conflict with the provision of other goods and services. In Europe, the intensified use of forest biomass for renewable energy production and the protection of forest biodiversity are two important topics related to forest land use. However, the combination of policies related to biodiversity and to bio-energy may result in a classical dilemma between wood production and forest biodiversity, but also in relation to other important goods and services, including carbon storage and recreation. The aim of this study was to analyse possible trade-offs between forest biomass production and biodiversity protection in Europe's forests.

The large-scale European Forest Information SCENario (EFISCEN) model was used to simulate forest resource development in 24 European Union countries and Norway and Switzerland up to 2050. The scenarios analysed were a baseline scenario (no policy changes, a moderate increase in wood extraction and no extraction of residues), a bio-energy scenario (wood and residue removal intensified to the potential maximum), a biodiversity protection scenario (set aside 10% of forest area, with strong restrictions on harvesting in the protected areas), and multiple scenarios in which both biomass removals were intensified and the area of protected forests was increased. The impacts of these scenarios were assessed by means of an economic valuation of the marketed (biomass production, carbon storage) and the non-marketed (forest biodiversity and recreation) goods and services. The economic value of the non-marketed goods was estimated on the basis of a benefit transfer employing the results of a meta-regression performed on data from 49 studies carried out in 8 countries across Europe.

The modelling results for all goods and services are presented separately, and combined in the economic valuation. Conclusions on how to optimally accommodate the need for the intensified use of forest biomass and for increased biodiversity protection are drawn, and on how this may affect the multiple goods and services provided by Europe's forests.

**Jaroslaw Oktaba** is a forestry graduate of the Warsaw Life Science University, and completed a Ph.D. in forestry in 2001. Since 1993 he has been the assistant professor at the Department of Forest Utilisation, Faculty of Forestry, Warsaw Life Science University. He has been the Chairman of the PEFC Polska Council since 2004. His fields of interest include wood science, forest policy and the cross-sectoral aspects of forestry.

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# Forest Certification (FSC, PEFC) as a Tool to Evaluate the Sustainability of Forestry – A Case Study from Poland

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The paper presented will focus on an original, comparative analysis of measurements of the sustainability of forestry used by two of the main, and globally recognised, forestry certification schemes, Pan-European Forest Certification (PEFC) and the Forest Stewardship Council (FSC). The PEFC and the FSC have created their own set of national standards for Poland.

An assessment of the usefulness of the criteria and indicators of the sustainability of forest management contained within the FSC and PEFC certification systems was carried out, evaluating their worth as tools for sustainability impact assessment.

Forestry certification systems are voluntary, non-governmental initiatives which use the output of the Rio Summit as a starting point to develop and enforce a new, socially accepted joint management idea within forestry, in order to ensure the sustainable development of forestry.

Base for Polish FSC sustainable forestry criteria and indicators was determined by FSC 10-th, the same around the world rules for forestry sustainability, whereas the PEFC is based on regional political processes such as the Ministerial Conference on the Protection of Forests in Europe (MCPFE). Both describe the main goals of sustainable forestry with respect to the necessity to take into account the demands of society, but each uses a different set of tools for sustainability impact assessment.

The FSC system relies on minimum levels of the indicators assessed, whereas the PEFC is based on a rather open analysis of criteria and indicators.

The results and consequences of these two philosophies will be highlighted.

**Ana Cláudia Dias** is a researcher at the University of Aveiro, Portugal. She has a degree in environmental engineering and a PhD in environmental applied sciences from the University of Aveiro. Her research focuses on greenhouse gas balances in the forest sector, as well as on life-cycle thinking tools.

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# The Greenhouse Gas Balance of the Eucalyptus and Maritime Pine Forest Sectors in Portugal

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The forest sector has the potential to mitigate climate change, because forests are important carbon pools and act as carbon sinks when managed in a sustainable manner. On the other hand, forest products, both in use and in landfills, contribute to the storage of carbon, are alternative fuels to fossil fuels at the end of their life, and as construction materials represent alternatives to more energy-intensive materials used for the same purposes. Furthermore, the energy consumed in the forest-based industry is largely based on biofuels, namely by energetic valorisation of forest waste and forest product waste.

The objective of this study was to quantify the net balance of greenhouse gases (GHG), namely carbon dioxide ($CO_2$) and methane ($CH_4$), for the Portuguese eucalyptus (Eucalyptus globulus) and maritime pine (Pinus pinaster) forest sectors in the year 2000. The removals and emissions of $CO_2$ and $CH_4$ were quantified along the whole chain, including the forest ecosystem, the industrial processing of wood and the stages of use and final disposal of wood products. Fossil carbon emissions from both forest management operations and industrial wood processing were included in the study. The net GHG balance was calculated by subtracting the fossil carbon emissions and the additional emissions of carbon as $CH_4$ from the net carbon removal by forest and wood products. Two approaches were applied to estimate the net carbon removal in the sector: the stock-change approach and the atmospheric-flow approach. These approaches differ in the way carbon stocks or emissions are allocated to countries that consume and produce wood products. The stock-change approach estimates the net change in carbon stocks within national boundaries, whereas the atmospheric-flow estimates the flow of carbon between the forest sector and the atmosphere within national boundaries.

The total GHG balance in the eucalyptus and maritime pine sectors in the year 2000 was a net removal of carbon, the magnitude of which varied with the approach considered, ranging from 400 to 1030 Gg Ceq year-1 in the eucalyptus sector, and from 40 to 450 Gg Ceq year-1 in the maritime pine sector (higher values correspond to the atmospheric-flow approach). Forest played a major role in carbon accumulation in the eucalyptus sector, while the wood products were more important than forest in the maritime pine sector. Fossil carbon emissions accounted for 8 % and 13 % of the total carbon emissions in the eucalyptus and maritime pine sectors, respectively.

**Clemens Kurth** is currently a master's student of the mountain forestry programme at the University of Natural Resources and Applied Life Sciences (BOKU), Vienna. He started to work on the topic during an internship at the European Forest Institute, Joensuu, Finland in 2008.

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# Assessing the Sustainability Impacts of the Setting Aside of Forest Areas in a Regional Forest-Wood Chain (FWC) in Baden-Württemberg (Germany) using ToSIA and a Multi-Criteria Analysis (MCA) Method

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In this study the quantitative decision support tool ToSIA (Tool for Sustainability Impact Assessment) will be used to assess sustainability impacts on an entire forest-wood chain (FWC) by using a set of 9 sustainability indicators. ToSIA structures a FWC into processes, the performances of which are characterised by the set of sustainability indicators. Indicator values are generated by simulating the flow of wood material through the processes of a FWC. To enrich the analytical and decision making power of sustainability impact assessments, the multi-criteria analysis method PROMETHEE II will be employed to analyse the effects of different hypothetical stakeholder perspectives on the advantages of alternative FWCs.

ToSIA and MCA will be applied to a forest-wood chain in the Federal State Baden-Württemberg (Germany) to analyse the impacts of management changes on the sustainability of a regional forest-wood chain. In this context, it is assumed that forests on steep slopes are set aside, as is 5 % of the total forest area, which is devoted to nature conservation, and comparisons to current 'business as usual' forest management are made.

The analysis includes the variability in ranking as affected by the different preference profiles of stakeholders.

**Francesco Carbone** has degree in Forestry Science by University of Tuscia (Viterbo – Italy), and Ph.D the obtained in Economic Mountain and Environmental-Wood-Forest Systems by the University of Trento (Italy). His research area involves different topics, as economic forestry firms and wood working, wood market and the relationship between law and economics of good with relevant social interested.

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# Improve the Environmental Value of Forest Using Financial Incentives: An Italian Case Study

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The role of the forests in the public and private spheres is the standard against which foresters must measure their activities in outlining models for the use of forest resources.

The actions of legislators and public administrations are aimed at identifying the intrinsic nature of forests in and of themselves (internal limits), from which flows the identification of their optimal use in terms of society and its economic interests.

Additional measures have reinforced a new set of goals, which has shown a need for a new management approach with an emphasis on environmental uses, in turn calling for an indemnification to land owners for loss of income (external limits).

The workings of law 43/1974 for the Lazio region (Italy) are reconcilable with this emerging model. An analysis of its 30 years of practice shows both its intrinsic potential for improving the environment, and the seriousness of its influence when it is mistakenly used to intervene in precarious ecosystems. In conclusion, I will outline criteria for trying to overcome the misguided nature of these interventions.

**Hervé Jactel** has a PhD in Forest Entomology. He is a head of Entomology research lab at BIOGECO, the joint research Unit between INRA (Institut National de la Recherche Agronomique) and University of Bordeaux I.

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# Risks for European Forests under new Management Alternatives: A Multi-Criteria Analysis

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Multi-criteria decision analysis (MCDA) has been developed to help decision makers choose between actions that require a compromise between criteria of different weights. We adapted this method to evaluate the effect of new forest management alternatives (FMA) – as defined by the European Collaborative Project Eforwood – on risks for forest health. Risk is defined as the interaction between forest vulnerability (a combination of susceptibility and exposure) to a hazard and the likelihood of the hazard occurring. Specific forest vulnerabilities to a series of abiotic (wind, fire and snow) and biotic (insect pests, pathogenic fungi and herbivores) hazards were defined and subsequently weighted by corresponding hazard likelihood. Multi-criteria analyses were applied to eight types of European managed forest (three forest biomes: Atlantic, continental and boreal, and five tree species: Scots pine, maritime pine, Norway spruce, Sitka spruce and Eucalyptus) to rank FMAs according to their potential effect on forest health at the stand level. Overall, risk was lower in intensively managed short rotation forests, designed to produce wood biomass, because of the reduced susceptibility of stands to the most damaging hazards. At the opposite end of the management intensity gradient, close-to-nature systems also had low overall risk, this time due to lower stand exposure to damage. Intensive even-aged forestry appeared to be subject to the greatest risk, irrespective of tree species and bioclimatic zone. These results are discussed according to the robustness of the ranking method and the knowledge available on the relationship between stand management and susceptibility. Implications for the sustainable management of European forests are discussed.

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# Uses of Biodiversity Indicators by Forestry Actors in the Context of Sustainable Forest Management in the Southwest of France

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The Programme for the Endorsement of **Forest Certification** schemes (PEFC) is a management tool that develops forest management indicators towards a sustainable impact assessment. In the Aquitaine region this management tool for economic, social and environmental functions is now being used at different management scales (plot, forest, area) in the production forest of the Landes de Gascogne by various actors, and in different ways. Recent storms in the area (1999 and 2009) have revealed the need to change the management model.

The objective of our study is to understand how different actors are using these indicators that were set up 8 years ago, and reviewed in 2008. The understanding of sustainable forest management practices (SFMP) is going to improve our knowledge of how management tools are used and how communication between actors occurs. The aim is to improve the collective management of the forests at the forest-based sector level.

As biodiversity is one of the criteria most often cited by all forestry sector actors, we observed how biodiversity indicators are implemented. Users, managers and stakeholders agree that a great effort must be made to improve the number of species in the one million monospecific hectares of maritime pine in the region. Fifty questionnaires and interviews were collected from a representative panel of different users, managers and stakeholders of different organisations, who were chosen for the significant role they play in the whole wood chain.

Our results show that the actors share the belief that the PEFC biodiversity criterion is essentially a good tool for use in the management of forests. However, the decision support system is not as collegial and cooperative as it should be. Furthermore, the lack of a full understanding of the biodiversity concept is leading to management practices that deviate from the genuine concept of biodiversity supported by the PEFC. Therefore, in order to achieve the objective of real sustainable management at the regional scale, we suggest a reshaping of biodiversity indicators to reach a common understanding and interactive implementation by the various actors. We analysed the differences between the norms and the practices in the way actors within the forest-based sector use their authority in the process of democratic dialogue for real SFMP shared by everybody inside the wood chain. The reduction of the differences currently observed between norms and practices will require the initiation of a democratic dialogue between the various wood chain actors.

**Vasileios Drosos** teaches in the Postgraduate Studies Programme of the Department of Forestry and Management of the Environment and Natural Resources. He teaches a course entitled 'Sustainable management of the environment and natural resources. He has over 60 publications/contributions in Greek and foreign magazines and conferences.

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# Evaluation of the Forest Infrastructure Development in Mountainous Greek Forests Using Multi-Criteria Analyses

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As a consequence, both direct and indirect, of one-dimensional economic development activities that thoughtlessly destroyed the environment, over the past few years the notion that development should occur in harmony with the natural and cultural environment has grown in importance. This applies equally to economic, social, technological and cultural developments.

The development of mountainous areas is the main objective of the forest policy implemented in Greece today. However, development entails human intervention in the natural environment, leading to its alteration, and often its degradation. One of the most important human interventions in a forest ecosystem is the construction of a network of transport facilities (forest roads, trails, skidding roads, etc), which contribute not only to the transportation of forest products, but also to the development of tourism and also to forest protection.

Ascertaining 'compatibility with the environment' means to define, describe and assess the effects of a road construction project on the environment, and to take measures for its protection. The primary concern of a forest engineer should be the compatibility of such infrastructural projects with the environment. For this reason, the assessment criteria for forest infrastructural works are used to examine and evaluate the impact on the natural environment of such projects, as well as to choose the best (compatible) environmental solution from various alternatives before undertaking the project.

A combination of digital photogrammetry and GIS technology was used to evaluate the compatibility between the general forest infrastructural works and the natural environment. In order to evaluate the compatibility, practical criteria of the intensity of the human influence as well as criteria of the environment resilience to such interventions were used. The digital maps and the spatial analysis allowed for the efficient and reliable evaluation of these criteria. The results prove that this method provides a means to evaluate the compatibility of the existing infrastructural works with the natural environment, and offers the possibility to choose the most compatible solutions for the environment in future.

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# Implementation of Environmentally Sound Forest Road Construction in Sensitive Greek Mediterranean Forests

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The environment-friendly construction of forest roads must incorporate not only technical and economic parameters, but also the (direct and indirect) effects of construction upon the natural and social environment. When constructing environment-friendly forest roads in sensitive areas such as one finds in large parts of southern Greece, the forester and the road builder are called upon to study the environmental resources of the area, to evaluate the impacts of the construction and to choose using rational estimation methods the friendliest (compatible) solution for the natural environment.

The focus of this paper is on the opening-up of a sensitive Greek Mediterranean forest. The environmental resources were identified, the impacts were evaluated and the criteria by which to estimate the impacts of the alternative solutions were set out following the grouping of the environmental resources. A form of cost benefit analysis was conducted to evaluate alternative solutions. Furthermore, an investigation was carried out in order to determine the environmental impacts of the construction work associated with the two alternative solutions identified. Another important objective of construction measures is to facilitate the supervision and protection of the area, allowing for timely intervention in the event of fire, and also the development and utilisation of forest lands and abandoned fields.

From the results of the research it may be concluded that:

- It is very useful to have alternative road construction solutions clearly mapped out for comparison before road construction begins. These solutions should be based on the newest planning techniques and according to the aims of forest infrastructure development, the terrain conditions and the protection of the forest ecosystem.
- In sensitive ecological systems such as Mediterranean forest areas it is very important, from a technical and an economic design perspective, to have a realistic concept, within the framework of an environmental impact assessment (EIA).
- It will very practical and useful for the assessment by the E.I.A. to have a list of serviceable criteria, and their weights to evaluate the absorption of road construction in order to make a profile form for every forest road.

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# Multiple Impact Assessment of Forest Projects in the Context of Sustainable Development: A Cross-Country Application of Forest Projects in Mountain Mediterranean Forest Areas

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Forest planners, managers and policy makers are often confronted with difficulties when they attempt to evaluate ex-ante, ex-post or ongoing forest projects in the context of sustainable development. This is due to the fact that either appropriate impact evaluation tools are missing, or the existing ones fail to incorporate all of the different types of project impacts, such as environmental, social and economic, as these are usually different at different spatial scales, time scales and levels of aggregation. In addition, most of the attributes related to the forest project impacts are vague, subjective, intangible or uncertain.

This paper presents a fuzzy multi-criteria rule-based model, which uses spatially referenced natural and socio-economic indicators to assess the contribution of the forest projects to sustainability. The model has been tested with cross-country real forest projects in mountain Mediterranean forest areas.

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# Comparing the Life Cycle Environmental Performance of Biodiesel Production from Tropical Biofuel Trees: Jatropha and Oil Palm

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Biofuels essentially need to meet two minimum requirements: (*i*) be produced from renewable feedstock, and (*ii*) have an impact that is less negative than that of the fossil alternative. Evaluating biofuels with respect to these two requirements needs in-depth analysis. For the first requirement a sustainability evaluation of the cultivation practices for feedstock production has to be performed (e.g., impacts on soil, water, biodiversity). For the second the life cycle environmental performance of the biofuel has to be compared with that of the fossil alternative. Life cycle assessment (LCA) is the appropriate tool to perform both investigations. LCA produces generic and non-site specific results in relation to the environmental impacts (energy balance, global warming potential, eutrophication, etc.) of production processes. We developed a method to assess the land use impact on structural and functional ecosystem quality and to incorporate that in the LCA framework. The life cycle impacts caused by alternative production scenarios are easily compared.

In this poster we (*i*) present our land use impact method and (*ii*) compare LCA results of two booming tropical biofuels: (*a*) *Jatropha* biodiesel and (*b*) oil palm biodiesel. Both feedstocks have their specific potentials and risks. *Jatropha* (*Jatropha curcas*) is a drought tolerant tree producing seeds bearing inedible oil. It is also claimed that *Jatropha* simultaneously reclaims wasteland. Oil palm (*Elaeis guineensis*) is a perennial tree of the humid tropics.

The study presents the positive and negative effects of shifting from fossil diesel to either of the biodiesel production systems. The environmental impacts of both *Jatropha* and oil palm biodiesels are calculated against a reference system, which is a fossil based system producing the same amount of energy as the systems of interest. The generic and non-site specific character of the results of this method allows for comparison of the environmental impact of the two biodiesel production systems.

**Geerten M. Hengeveld** obtained his Ph.D. in ecological modelling in 2007. Since then he has been working on forest resource modelling at Alterra, Wageningen UR, where he is involved in the development of the high resolution forest resource model EFISCEN-SPACE.

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# High Resolution Tree Species Map of European Forests

Geerten Hengeveld[1], Gert-Jan Nabuurs[2], Dick Brus[1], Nanny Heidema[1], Paul Goedhart[1], Dennis Walvoort[1], Isabel van den Wyngaert[1], Mart-Jan Schelhaas[1], Katja Tröltzsch[2], Jo van Brusselen[2], Andreas Schuck[2]

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Basic dendrometric data were gathered for 260 000 national forest inventory plot locations. From this dataset a high resolution tree species map featuring 20 tree species was created. This high resolution map will facilitate new analyses and a more accurate approach to study in relation to topics such as carbon, wood availability, biodiversity, NATURA 2000 sites, distances to industry, disturbances, and climate change. This map summarises the separate distribution maps for 20 tree species. These distribution maps are built in two steps, with compositional kriging used to interpolate between the plots. For the rest of Europe a multinomial logistic regression model of various abiotic factors was fitted for the ICP-level-I plots. The regression results were scaled to fit NUTS-II statistics. The total result was scaled to the European forest map (EFI). The GIS database behind the map also contains basic dendrometric variables per 1x1 km grid; e.g., diameter distribution, admixed tree species, height, increment, and growing stock.

**Acknowledgements**

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# High Resolution Forest C-Balance Estimation

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NFI plot data were gathered for 18 European countries. Basic dendrometric data were collected from a total of 260 000 plots. A new, independent estimate of the C balance was calculated on the basis on these data using CO2FIX. This estimate was compared with the existing C balance estimates from previous work, including detailed forest inventory bookkeeping models, remotely sensed data, and inversion techniques.

This new estimate is a first step towards a high resolution European forest model, in which European scale output is calculated through aggregated small scale forestry and the integrated use of GIS.

**Staffan Berg**, Dr of forestry. Skogforsk, Sweden. Berg is active in environmental management and forest engineering, and is a member of national ISO 14000 committees. He has contributed to EU efforts in COST, ALTENER and is currently involved in Eforwood. Berg has a record as an IUFRO-officer.

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# Labour Requirement, Costs and Environmental Impact of Harvesting Operations Evaluated in the Eforwood Case Studies

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This paper describes the technical systems employed for tree felling and the forwarding of roundwood to landing places at the roadside in the case studies conducted as part of the Eforwood project (Västerbotten, Baden-Württemberg and the Iberian Peninsula). The results will be expressed in harvested cubic metres as the main reference unit, and per system and case study area. The results will be presented and discussed relative to the following:

- man-hours used;
- costs;
- the impact of operations on global warming potential, acidification and eutrophication.

This will provide a balanced view necessary for the evaluation of harvesting systems depending on the prevailing conditions (terrain difficulty, tree size and density of road network) and the priorities of the observer with respect to their contribution to the forest-wood chain, highlighted in the context of occupation, costs and environmental impact.

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# How to Apply the Tool for Sustainability Impact Assessment (ToSIA) – Case Study Examples

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In this poster we present how the Tool for Sustainability Impact Assessment (ToSIA) can be applied to assess the sustainability impacts of forest-wood chains (FWC) in different applications of the Eforwood and Northern ToSIA projects. The tool is very flexible and can be applied with a forest-defined, product-defined, industry-defined and consumer-defined perspective. It can also assess forest value chains in different geographical regions such as at the province, country, or continental scale; for example, the comparison of a regional bioenergy FWC in northern Karelia or the assessment of the European forest value chain.

Furthermore, ToSIA is able to quantify the impacts of different forest policies on the sustainability of a FWC. One such example is the Baden-Wuerttemberg Case Study, where an increase in the demand for woody biomass triggered by EU policies will be assessed, as will the effects on sustainability of an increase in set aside forest areas due to Natura 2000 regulations.

We present some typical examples using case studies from the ongoing projects and propose suitable applications that could be realised after these projects have ended. Differences in system boundaries and data needs will be highlighted.

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# Sustainability Assessment of Two Sites With Caatinga Vegetation in Forests Managed for Charcoal and Firewood Production in the Semi-Arid Region of Brazil

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In 2006 in Brazil's Caatinga biome, two managed forests with caatinga vegetation reached the end of their rotation. This event made possible the assessment of the performance of the adopted forest management systems in terms of conserving natural resources and promoting socio-economic benefits; the first time this has been done in the Caatinga biome. The assessment started with the selection of key field studies to be carried out on the forest properties. Four field studies were implemented: a forest inventory; a fauna evaluation (amphibians, reptiles, mammals and native bees); a phytosociological study and a soil quality assessment. The next step was to analyse the results of the field studies in an integrated way, in order to translate the results of each into a single sustainability performance indicator for not only the forest management systems but also for each property as a whole. This process demanded that the researchers all worked to achieve the same common goal, as opposed to focusing the assessments solely on their specific area of research. This was challenging because each researcher had a particular vision in relation to sustainability, and its goals and references, all of which were particular to each area of research. To overcome this situation, the researchers defined the common goal for the sustainability of the properties in a workshop. The workshop included presentations of the individual perceptions of sustainability, supported by an illustration of each researcher's own view of a sustainable landscape. No pre-established concept of sustainability was used. The purpose of this was to stimulate reflection on what sustainability really means, as opposed to the mere acceptance of an established concept. This exercise allowed the researchers to contemplate the role of different land uses in a sustainable landscape, including the role of areas under forest management. Based on the common goal of sustainability derived, two real landscapes – the ones in which the properties were located – were analysed. This allowed for a comparison of the ideal sustainable landscape with real landscapes; the definition of the important aspects to be considered in sustainability assessment and an assessment of the feasibility of analysing them. After these exercises, the forest properties were assessed using the barometer of sustainability. One of the properties exhibited a high degree of sustainability and the other a good degree of sustainability. These results can be used to develop policies to support the implementation of forest management in the Caatinga biome, such as mechanisms for payments for the environmental services provided.

**Konstantin Olschofsky**

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# Future National Carbon Potentials According to Different Forest Management Objectives for Germany

Potentials and Dynamics of Carbon Sequestration in Forests and Timber (CSWH)

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A complex modelling approach was developed to simulate future carbon sequestration potentials of the German forestry and timber sector for the period 2000-2100. Comprehensive data sources such as the national forest inventory (BWI[2]), the climate-model WETTREG, and the soil map (BÜK) of Germany were merged. The forest growth model SILVA, the biomass model BALANCE, and the soil model CBM were combined to create virtual forest enterprises. Applying the virtual forest enterprises to a set of the most representative forest stands in Germany facilitated the simulation of the potential above and below ground carbon stores subject to varying climatic conditions and forest management objectives. The forest management objectives were defined by economic rules and subject to roundwood prices. The carbon sequestration potential of wood products was modelled under different timber price scenarios, but did not take into account foreign timber trade. A life span of 60 years was selected for wood products and followed a regressive development.

The complex simulations of the German forest and timber sector allowed for the quantification of different national and regional carbon potentials according to different C pools in forests (living woody biomass, dead organic matter, soil carbon) and additionally in wood products. Depending on the forest management objectives, the carbon sequestration potentials in forests and wood products were modelled for the period 2005 to 2100, showing considerable variation. A management objective targeting profit maximisation led to high harvesting rates and, therefore, a lower potential for carbon sequestration in forests. However, the carbon pool of wood products was comparable to that of forests where the guiding forest management objectives incorporated lower harvesting rates.

A second management objective concerned the maximisation of the net timber yield of forests, which resulted in large forest carbon pools. Under a third management objective timber harvesting occurred when the trees reached a pre-defined DBH-threshold. This alternative operated independently of any price developments. The potential carbon sequestration is greatest where a balance between all three forest management objectives existed.

**Mark van Oorschot** (Ph.D.) is working on biodiversity assessments and scenario studies at the Netherlands Environmental Assessment Agency (PBL). He graduated as a biologist and environmental scientist.

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# Assessment of Alternative Global Wood Production Scenarios on Meeting Future Wood Demand While Minimising Biodiversity Loss and Carbon Emissions

Mark van Oorschot[1], Eric Arets[2], Elke Stehfest[1], Geerten Hengeveld[2], Liesbeth de Waal[1], Alexander Moiseyev[1]

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Using the IMAGE-GLOBIO integrated environmental assessment model, we explored the impact of different wood production scenarios on biodiversity, carbon emissions and carbon retention on a global scale. The scenarios we used differed in terms of the relative contribution of different production sources to global wood production. In this study we distinguished three main forest management types for wood production; clear felling , selective logging , and wood plantations . The model parameters on productivity for each geographical region, biome and management type are based on a review of the scientific literature, combined with FAO data on global roundwood production and deforestation statistics. In the model framework, the world is divided into 24 regions with 14 different ecosystem types (biomes).

The global demand for wood in 2005 of 3.6 billion m3 will grow to a projected 5.6 billion m3 in 2050 under a business-as-usual scenario (baseline). Total demand is made up of roundwood and fuelwood. An estimated total area of about 30 million km2 is required to meet this demand, using the three forestry types indicated. The required area is projected to grow to about 50 million km2 in 2050. However, this neglects the contribution of wood harvested from forests converted to other land uses.

Alternative scenarios are used to explore ways to minimise the loss of forest biodiversity and carbon emissions. Intensifying wood production by increasing the area of wood plantations is often put forward as a possible solution. In the short term, the impact on biodiversity of a plantation scenario is even stronger than evidenced in the baseline, especially when plantations are established in (semi-natural) forested areas. However, over the longer term, biodiversity losses will be lower under this scenario, as plantations gradually take over the global production role, while semi-natural forests are left to recover to a more natural state The impact of the plantation scenario on the total carbon content of forests will also be explored.

This exercise shows that in the long term, wood plantations may be helpful in terms of lessening the pressure on semi-natural forests, and so may stimulate an increase in forest biodiversity. It is essential, however, that semi-natural forests are sufficiently safeguarded against further exploitation and illegal logging.

**Sebastian Rüter** holds a degree in forest science and has worked as a scientist in the areas of life cycle assessment, harvested wood products, climate policies and sustainable building assessment at the Johann Heinrich von Thünen-Institute (vTI), the Federal Research Institute for Rural Areas, Forestry and Fisheries in Germany since 2005.

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# Consideration of Carbon Storage in Harvested Wood Products under a Post-2012 Climate Regime

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Harvested wood products (HWP) serve as substitutes for products that cause more $CO_2$-emissions, and also act as carbon pools. Under Article 1 of the United Nations Framework Convention on Climate Change (UNFCCC), which was adopted in 1992, a reservoir or pool is defined as 'a component or components of the climate system where a greenhouse gas is stored.' Wood products are not a carbon sink, but they extend the natural carbon cycle by their respective service lifetime.

The default assumption proposed within the 1996 IPCC guidelines is that all carbon in harvested biomass is oxidised in the removal year. This assumption is based on the perception that carbon stocks in most countries stay constant. However, in cases where the consumption of wood products increases, UNFCCC allows countries to report these in their national GHG emission inventories using different approaches to those that have been suggested so far.1

Contrary to the reporting of HWPs in the LULUCF sector, the inclusion of HWPs under a post-2012 climate regime requires a common agreement on one accounting approach. This is currently being discussed by the parties to the convention and to the Kyoto Protocol. A number of criteria should be met by any HWP accounting scheme.

In the presentation the current state of the negotiations in relation to the different HWP accounting approaches is addressed, as are the possible incentives related to accounting. An insight into the methods used is provided and the impact and the effects of the availability of HWP accounting identified.