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## Abstract

The present document reports on progress in the preparation of a special issue for a scientific journal, including a series of complementary articles (10) on sustainability impact assessment of forest management alternatives in Europe. The background for this special issue is based on the specific module work conducted on different aspects of sustainability in the context of EU forestry-wood chains and for various forest management alternatives. The report presents abstracts of the different papers that will be submitted before the end of the EFORWOOD project and the next steps that will be followed for final publication.

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# 1 Introduction

The present document reports on progress in the preparation of a special issue for a scientific journal, derived from deliverables and specific work conducted in module 2 of EFORWOOD on forest resources management in the context of European forest-wood chains.

The objective of this special issue is to present, in the framework of the EFORWOOD project, the methodologies used and the results obtained for sustainability impact assessment (SIA) of forest resource management, covering economic, social and environmental aspects, as well as risk dimension. SIA has been conducted at different spatial scales from local to EU levels, and temporal horizons in the context of future scenarios.

The report documents the contents and authors of the different papers that will be submitted before the end of the EFORWOOD project and the next steps that will be followed for final publication

## 2 Contents

The proposed special issue will contain the following contributions and papers:

### 2.1 Editorial - Introductory Background and Framework

*Carnus, Hengeveld, Mason, Duncker, Jactel, Poissonnet, Rasmussen, Spiecker, Tomé*

European forests are highly diverse and belong to the forests with the longest tradition in being managed in the world. This management however is changing as an ever wider variety of products and services (timber and non-timber) needs to be produced for a society that desires these products at an ever faster rate. While climate change impacts are still unclear, the society asks for a closer to nature forestry, but also desires wood for paper and construction, carbon sequestration, biodiversity conservation, and soil and water protection. The sustainability (ecological, economic, and social) of all these demands is certainly not guaranteed, and often unknown.

The background for this special issue is the EU FP6 integrated project EFORWOOD on the sustainability of the Forestry Wood chain. A framework of Forest Management Alternatives (FMAs) has been elaborated for the forest resource and management part of the chain. These FMAs are documented for key tree species and forest sites within regional case studies in Europe, and for the whole of the EU. The FMAs have been integrated into prospective scenarios and reference futures, and cross-analysed for their impacts on economic viability, environmental services, key social and cultural values, and sensitivity to biotic and abiotic hazards.

This special issue on European forests presents in 10 complementary articles methodologies, tools and results obtained from sustainability impact assessment (SIA) of forest resources management at various spatial scales from regional to EU levels.

Article 2.2 sets the concepts of the Forest Management Alternatives. In order to arrive at consistent analyses, scenarios were set up; these are described in article 2.3. These forest management alternatives concepts are then first tested in article 2.4 where they are applied to reference forest types across Europe.

Articles 2.5 -2.8 elaborate further on the impact of forest management, exploring the synergies between production and ecological services of forests (article 2.5), the response of the public to different types of forest management (article 2.6 and 2.7), and the risk of damage to forests (article 2.8).

Articles 2.6 -2.11 presents results from predictive approaches and simulations run at regional and EU levels. Article 2.9 present a regional forest resource simulator and assess sustainability impacts of increased use of woody biomass in the future for bioenergy; articles 2.10 and 2.11 analyse the FMA concept for Europe at a

coarser regional scale (article 2.10), and explore the possibilities that the FMA concept provides for a fully harmonized high resolution model (article 2.11).

## **2.2 Forest Management Alternatives for comparable analysis of European Forestry – A Conceptual Introduction**

*Duncker, Barreiro, Hengeveld, Lind, Spiecker, Skovsgaard, et. al.*

The choice between alternative forest management strategies is a crucial step in short as well as long term decision-making in forestry practice and reflects the frames set by a regional or national forest policy. The decision has to be made in a broad context which can only be influenced to a limited extent. Forest management alternatives are defined by essentially coherent sets of forest operation processes at a stand level. In principle, this scheme for decision-making includes a range of silvicultural options along the management cycle throughout the stand development phases. The options for applying operational processes, as well as for describing their limitations, may be defined by a set of so-called basic principles.

Within the scope of the EFORWOOD project, five forest management alternatives along a gradient of intensity of intervention into natural processes, have been described by such specific sets of basic principles. The management alternatives were tested against regional European approaches for different tree species to provide an intensity grading scheme enabling comparison across all of Europe.

In spite of being arranged along an intensity gradient, the forest management alternatives were not considered completely mutually exclusive. In contrast, they rather allow for an increasing degree of freedom in potential silvicultural options. Since derived goods and services are clearly affected; the five forest management alternatives have implications on all three dimensions of sustainability.

## **2.3 Downscaling socio-economic and trade scenarios for more strategic policy support and management planning in the European forestry sector**

*Arets, Nabuurs, Mason, Schelhaas, Moiseyev, van Vuuren*

Sustainability of wood supply from forests in the future largely depends on present day management decisions. An important question for forest management is thus how this future will look like. What are the demands and needs for wood and other goods and services in 2050?

The only thing that will be certain is that by 2050 the world will have changed in ways that are difficult to imagine. A way to encompass a significant portion of the large uncertainties in main driving forces like demographic change, socio-economic development, and technological change, is to develop contrasting scenarios based on divergent visions on the future. These are used to explore the different ways in which the future may develop and its impacts on the sustainability of wood production in Europe.

Here we downscale and quantify the trends on demographic, socio-economic and trade developments from two contrasting global IPCC SRES scenarios (A1 and B2) to the situation of the European forestry wood chain. In order to do this we used literature, expert knowledge and large scale models as IMAGE, EFI GTM and EFISCEN. Shifts in forest management alternatives are used to quantify changed attitudes and policies towards the intensity of forest management.

## **2.4 Impact analysis of forest management intensity alternatives on production based on simulations for European reference forest types**

*Duncker, Barreiro, Hengeveld, Lind, et al.*

Forests provide many goods and services. Often, wood production is commercially the most important good requested from forest ecosystems. Its quantity and corresponding economic return can be augmented by intervening with natural processes, i.e. by forest management.

Standardized forest management alternatives (FMAs) are selected along a gradient of management intensity and are applied to various European reference forest types. FMAs consist of coherent sets of combined appropriate actions at the stand level. Thus, among other features, FMAs control the stand's density pattern and its species composition over time.

The different FMAs' implementation over time is achieved using stand level forest simulators which predict stands' development, its growth rates and volume production as well as the resulting cash flows. The effect of the FMAs' simulations is assessed focusing on wood volume produced and on land expectation value at perpetuity.

This standardized approach allows for cross-comparison of the natural and economical results within the considered reference forest types as well as between the European regions. Observed variations in the productivity ranking and in land expectation value of the various forest management alternatives are set in relation to tree species growth dynamics, preferences for specific assortments as expressed in stumpage prices, and of time as expressed through interest rate, respectively.

## **2.5 Synergies and trade-offs between production, land expectation value and ecological services like water, carbon sequestration, biodiversity, and soil fertility in relation to forest management.**

*Duncker, Raulund-Rasmussen, et al.*

Forests provide multiple functions and services among which society traditionally tends to have a high interest in wood production. In consequence, forest management aims at increasing the volume produced and the economic return through intervening with natural processes. However, forests serve further aims and functions like carbon sequestration and protection of biodiversity and water quantity and quality. In order to develop and implement sustainable forest management strategies, it is of importance to anticipate the long term effects of forest management alternatives on the status and dynamics of processes in forest ecosystems. Thus, the management objective might emphasize the commercial interest possibly at the expense of an accordingly higher impact on the environmental services. However, this is to be ascertained for the multiple services addressed.

By use of realistic but virtual data-sets the effects of alternative forest management strategies forming an intensity gradient are as far as possible quantified for multiple services. For the environmental services the untouched natural forest reserve will serve as reference. Wherever possible, response functions are deduced to couple the various services via stand level data to demonstrate trade-off and harmonic relationships between the services. One site is considered, a relative fertile loamy soil in a Central European climate. It includes Norway spruce and European beech as the dominating tree species.

Today, only few attempts have been made to illustrate and evaluate quantitatively synergies and trade-offs between the goods and services. It is clearly illustrated that mainly high amounts of volume production and carbon sequestration rates may be in contrast to maintaining protection of authentic biodiversity, but also that slightly modified operations can have very positive effects on biodiversity and water protection without high costs. We also illustrate that water quality and quantity, and maintenance of future soil fertility may be affected either positively or negatively by several forest management activities.

## **2.6 Public Preferences for Forest Attributes: Towards a European Synthesis**

*David Edwards, Mariella Marzano, Frank S. Jensen, Beatriz Lucas, Marion Jay, Claire Montagne, Mart-Jan Schelhaas and Gerhard Weiss*

The paper presents the findings from a comprehensive literature review of public preferences for different forest attributes in Europe. The following attributes were examined: a) stand structure (tree size, visual accessibility, structural diversity), b) stand quality (species composition, residue, deadwood, ground vegetation), c) landscape-level attributes (diversity between stands, size of stand, stand edges and shapes, and forest cover), and d) non-land use related attributes (recreational facilities). The findings were refined through a Delphi survey with a network of European experts. The paper indicates the contribution of each attribute to the overall recreational value of a forested landscape in terms of: a) the overall direction of its relationship to recreational value, b) its relative importance, c) the extent to which generalisations can be made about its impact across different geographical regions, social groups, and recreational activities, and d) how its impact varies according to phase of development, forest management alternative, and species composition. The discussion considers how the findings may be used to support a robust assessment of the recreational value of different forest stand types in Europe.

## **2.7 A Delphi Approach To Assess The Impacts Of Forest Management On The Recreational Value Of European Forests**

*David Edwards, Mariella Marzano, Frank S. Jensen, Beatriz Lucas, Marion Jay, Claire Montagne, Mart-Jan Schelhaas and Gerhard Weiss*

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 20 forest stand types in each of four case study areas. The case studies were chosen to represent contrasting European regions: Scotland, to represent the Atlantic Region; Västerbotten, to represent the Nordic Region; Baden-Württemberg, to represent the Central and Eastern European Regions, and Catalonia, to represent 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 significance of differences in recreational value between forest stand types, tree species, and case study areas. 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 in different European regions. The discussion considers the opportunities and risks associated with use of this approach in a European context to guide policy decisions and planning.

## **2.8 Risks for European forests under new management alternatives: a Multi Criteria Analysis**

*Jactel, Branco, Carnus, Gonzalez, Grodzki, Langstrom, Moreira, Netherer, Nicoll, Orazio, Piou, Santos, Schelhaas, Tojic*

Multi Criteria Decision Analysis (MCDA) has been developed to help decision makers choose between actions making a best compromise between different criteria of different weights. This method has been transposed 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 hazard likelihood and vulnerability to the hazard. Specific forest vulnerabilities to a series of abiotic (wind and fire) and biotic (pest insects, pathogenic fungi and mammal herbivores) hazards are used as so many criteria and hazard likelihoods are used to weight these criteria. Multi Criteria Analyses are then

performed in several European forests ecosystems to rank FMAs according to their potential effect on forest health at the stand level. A comparison of the rankings is made across forest ecosystems. The shortening of the forestry cycle, in very intensive management alternatives, overall reduces the risk through a lower stand susceptibility to the most damaging hazards. On the opposite side of the management intensity gradient, close to nature systems reduce the risk via lower stand exposure to damage. These outcomes are discussed according to the robustness of the method of ranking and to the available knowledge on the relationship between stand management and susceptibility. Implications for the sustainable management of European forests are listed.

## **2.9 Assessing impacts of increasing the use of eucalyptus biomass for energy in wood available for pulp industry in Portugal**

*Susana Barreiro , Margarida Tomé et al*

The use of biomass for energy has become an important topic over the last decades. In the scope of energetic diversification and profitable forest resources exploitation, increasing the use of biomass residues for energy can play an important role by using local sources of energy, reducing carbon emissions and fossil energy use, providing additional revenue for the forest sector as well as reducing the risk of occurrence of forest wildfires. Part of the biomass for energy comes from biomass residues that can be defined as the material resulting from forest operations, but it can also come from stands specifically planted and managed with this purpose. At present there is also a high pressure on stands that were planted or used for round wood or pulp production. This competition may have strong impact on wood available for pulp and high quality wood products. In order to assess the impacts of increasing use of eucalyptus for energy production a regional forest simulator, SIMPLOT, was improved so that it accommodates the use of biomass for energy coming from three sources: i) biomass from forest residues, ii) plantation of new areas specifically for energy; iii) allocation of wood from existing stands to biomass for energy. To include forest residues as an output of simulation runs biomass functions for estimation of residues were incorporated into the growth models used in SIMPLOT. The GLOBULUS model was validated and calibrated for energy plantations using data from a set of spacing trials available for eucalyptus plantations in Portugal. A new approach was developed to include the option of managing stands as dendro-biomass production forests, into a growth model developed for pure even-aged stands (GLOBULUS). The simulator, mainly driven by wood demand, has now two wood demands to be met for the horizon of simulation: the wood demand for pulp and paper production and the wood demand for bio-energy production.

## **2.10 Impacts of different Natura2000 implementation levels on European forest resources**

*Schelhaas, Hengeveld, Nabuurs, Mason, Lindner, et al.*

Currently, about 7% of the EU forest area is designated for biodiversity conservation. According to the Natura 2000 Agenda, 15% of EU territory should be designated as conservation area by 2025. Although a certain level of harvesting will probably be allowed in these areas, a reduced total wood production is likely. On the other hand, wood consumption is expected to increase further, especially given the increased attention to woody biomass for energy generation. Increased imports or more intensive forestry on the remaining areas could be the consequence. With the forest scenario model EFISCEN, we explored the impact of different Natura 2000 implementation levels on the state of the forest resource in Europe. Development of variables 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 Natura2000 implementation levels.

## **2.11 Implementation of FMA's in a high resolution European Forest Resource model – EFISCEN-space**

*Hengeveld, Nabuurs, van den Wyngaert., Schelhaas*

A key issue in simulating European forest development is the assignment of FMAs to simulated forests. When moving to a higher resolution of European forest modelling the resolution of forest management is also increased. EFISCEN-space is a forest resource simulation model that covers the whole of Europe at 1km<sup>2</sup> resolution. Incorporating forest management spatially into forest resource simulation, several policy and economic factors, such as NATURA2000 sites and transport costs, can be taken into account explicitly, enabling a better assessment of these factors in modelling.

We present a framework for defining forest management at the European scale and assigning FMAs to the simulated forests at a 1km<sup>2</sup> resolution. This framework will allow users to define regional or continental FMAs and provide the simulator with rules to dynamically assign these FMAs to simulated forest stands.

### 3 Next Steps

The special issue has been submitted and accepted by Ecology and Society journal for publication in 2009.

The editorial team for the special issue includes Bill Mason, Geerten Hengeveld and Jean-Michel Carnus. A list of internal M2 reviewers has been appointed for all articles.

The following timeline will be followed:

- month 48 (October 2009): first draft submitted for internal M2 review
- month 49 (November 2009): internal reviewer comments back to authors
- month 51 (mid-January 2010): submission to Ecology & Society through internet portal.

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