NOTA DI LAVORO

50.2010

A Hybrid Approach to the Valuation of Climate Change Effects on Ecosystem Services: Evidence from the European Forests

By **Helen Ding**, Center for Environmental Economics and Management, Dept. of Economics, University of Venice and FEEM, Italy

Silvia Silvestri, Center for Environmental Economics and Management, Dept. of Economics, University of Venice, Italy

Aline Chiabai, FEEM Italy

Paulo A.L.D. Nunes, Center for Environmental Economics and Management, Dept. of Economics, University of Venice and FEEM, Italy

SUSTAINABLE DEVELOPMENT Series
Editor: Carlo Carraro

A Hybrid Approach to the Valuation of Climate Change Effects on Ecosystem Services: Evidence from the European Forests

By Helen Ding, Center for Environmental Economics and Management, Dept. of Economics, University of Venice and FEEM, Italy
Silvia Silvestri, Center for Environmental Economics and Management, Dept. of Economics, University of Venice, Italy
Aline Chiabai, FEEM Italy
Paulo A.L.D. Nunes, Center for Environmental Economics and Management, Dept. of Economics, University of Venice and FEEM, Italy

Summary

In this paper we present a systematic attempt to assess economic value of climate change impact on forest ecosystems and human welfare. In the present study, climate change impacts are downscaled to the different European countries, which in turn constitute the elements of our analysis. First, we anchor the valuation exercise in the Millennium Ecosystem Assessment (MEA) Approach and therefore the link between the different forest ecosystem goods and services, including provisioning, regulating and cultural services, human well-being and climate change. Second, climate change is operationalized by exploring the different storylines developed by the International Panel on Climate Change (IPCC) and applied, downscaled, for each of the European countries under consideration. Third, and bearing in mind the different nature of the benefits provided by the different types of forest ecosystems under examination, we shall explore different economic valuation methodologies so as to shed light on the magnitude of the involved welfare changes. According to the estimation results the four different IPCC scenarios, i.e. A1F1, A2, B1 and B2, are associated to different welfare impacts. First, these reveal to depend on both the nature of the forest ecosystem service. For example, cultural values reveal to be more sensitive to the four IPCC scenarios than the other ones, with the wood forest products being more resilient to climate change. Second, the distributional impacts of climate change on the provision of these goods and services do also depend on the geo-climatic regions under consideration. For the Scandinavian group of countries, B1 is ranked with the highest level of provision of carbon sequestration services, amounting to 46.3 billion dollars. In addition, we can see that cultural services provided by forest ecosystems have their highest levels in the Mediterranean countries, ranging from 8.4 to 9.0 million dollars, respectively in the B2 and B1 scenarios. Finally, we can see that the total value of wood forest products ranges between 41.2 and 47.5 million dollars for Central Europe to 5.4 and 7.2 million dollars in Northern Europe, respectively A1 and A2 scenarios. For this service, Mediterranean Europe provides a relatively weak role in the provision with values ranging from 6.4 million dollars in A1 scenario to 8.7 million dollars in the B2. In short, and to conclude, the valuation results (1) may contribute to a better understanding of the potential welfare loss in the context of climate change and the economic trade-offs between potential mitigation or adaptation strategies; and (2) confirm that climate change will be responsible for a re-distribution of welfare among the European countries, signalling the potential for a(n) agreement(s) among these same countries focus on the re-allocation of potential trade-offs among the countries.

Keywords: Wood Products, Biodiversity, Climate Change, Market and Non-market Valuation Methods, Ecosystem Goods and Services, Millennium Ecosystem Assessment.

JEL Classification: Q57

This report is part of the final output of the research project CLIBIO (Impacts of CLImate change and BIOdiversity effects), carried out under the University Research Sponsorship Programme (Line of research: Financial and Economic Valuation of Environmental Impacts) financed by the European Investment Bank (EIB). The authors and the whole research team at the Department of Economics of the University of Venice are grateful to Peter Carter, Maria Luisa Ferreira and Mateu Turrò for their valuable comments and suggestions. They are also grateful to Dagmar Schroter and the research team Advanced Terrestrial Ecosystem Analysis and Modelling at the Potsdam Institute for Climate Impact Research, as well as to Jeannette Eggers at the European Forest Institute, for having provided important data and modelling tools. This report also benefited from comments by participants at the mid-term CLIBIO Conference, held in Venice in April 2008, ad particularly by Anil Markandya, Pushpam Kumar, Juan Carlos Ciscar and Paul Watkiss. Helpful comments were also provided by participants at the 1st and 2nd Annual Meeting on the EIB-Universities Research Action, at several seminars at the University of Venice, at the 17th European Association of Environmental and Resource Economists (EAERE) Annual Conference in Amsterdam, and at the EIB - Department of Economics session on the "Economic costs of climate related ecosystem services losses and the consequent macro-economic impact" held at the 11th BIO.ECON conference, Venice, September 2009. The research team is also grateful to Martina Marian for having carefully managed the whole project and Sonja Teelucksingh for proofreading the whole report.

Address for correspondence:

Paulo A.L.D. Nunes
Center for Environmental Economics and Management
Department of Economics
University of Venice
S. Giobbe 873
30121 Venice
Italy
E-mail: pnunes@unive.it

A hybrid approach to the valuation of climate change effects on ecosystem services: evidence from the European forests

Helen Ding [1,2]
Silvia Silvestri [1]
Aline Chiabai [2]
and
Paulo A.L.D. Nunes [1,2]*

[1] Center for Environmental Economics and Management, Department of Economics, Ca' Foscari University of Venice, Italy

[2] Fondazione Eni Enrico Mattei, Italy

Acknowledgements:
This report is part of the final output of the research project CLIBIO (Impacts of CLImate change and BIOdiversity effects), carried out under the University Research Sponsorship Programme (Line of research: Financial and Economic Valuation of Environmental Impacts) financed by the European Investment Bank (EIB). The authors and the whole research team at the Department of Economics of the University of Venice are grateful to Peter Carter, Maria Luisa Ferreira and Mateu Turrò for their valuable comments and suggestions. They are also grateful to Dagmar Schroter and the research team Advanced Terrestrial Ecosystem Analysis and Modelling at the Potsdam Institute for Climate Impact Research, as well as to Jeannette Eggers at the European Forest Institute, for having provided important data and modelling tools. This report also benefited from comments by participants at the mid-term CLIBIO Conference, held in Venice in April 2008, ad particularly by Anil Markandya, Pushpam Kumar, Juan Carlos Ciscar and Paul Watkiss. Helpful comments were also provided by participants at the 1st and 2nd Annual Meeting on the EIB-Universities Research Action, at several seminars at the University of Venice, at the 17th European Association of Environmental and Resource Economists (EAERE) Annual Conference in Amsterdam, and at the EIB - Department of Economics session on the "Economic costs of climate related ecosystem services losses and the consequent macro-economic impact" held at the 11th BIO.ECON conference, Venice, September 2009. The research team is also grateful to Martina Marian for having carefully managed the whole project and Sonja Teelucksingh for proofreading the whole report.

----

* Corresponding author. Address: Center for Environmental Economics and Management, Department of Economics, University of Venice S. Giobbe 873, 30121 Venice, Italy. E-mail: pnunes@unive.it

Abstract

In this paper we present a systematic attempt to assess economic value of climate change impact on forest ecosystems and human welfare. In the present study, climate change impacts are downscaled to the different European countries, which in turn constitute the elements of our analysis. First, we anchor the valuation exercise in the Millennium Ecosystem Assessment (MEA) Approach and therefore the link between the different forest ecosystem goods and services, including provisioning, regulating and cultural services, human well-being and climate change. Second, climate change is operationalized by exploring the different storylines developed by the International Panel on Climate Change (IPCC) and applied, downscaled, for each of the European countries under consideration. Third, and bearing in mind the different nature of the benefits provided by the different types of the forest ecosystems under examination, we shall explore different economic valuation methodologies so as to shed light on the magnitude of the involved welfare changes. According to the estimation results the four different IPCC scenarios, i.e. A1F1, A2, B1 and B2, are associated to different welfare impacts. First, these reveal to depend on both the nature of the forest ecosystem service. For example, cultural values reveal to be more sensitive to the four IPCC scenarios than the other ones, with the wood forest products being the more resilient to climate change. Second, the distributional impacts of climate change on the provision of these goods and services do also depend on the geo-climatic regions under consideration. For the Scandinavian group of countries, B1 is ranked with the highest level of provision of carbon sequestration services, amounting to 46.3 billion dollars. In addition, we can see that cultural services provided by forest ecosystems have their highest levels in the Mediterranean countries, ranging from 8.4 to 9.0 million dollars, respectively in the B2 and B1 scenarios. Finally, we can see that the total value of wood forest products ranges between 41.2 and 47.5 million dollars for Central Europe to 5.4 and 7.2 million dollars in the Northern Europe, respectively A1 and A2 scenarios. For this service, the Mediterranean Europe provides a relatively weak role in the provision with values ranging from 6.4 million dollars in A1 scenario to 8.7 million dollars in the B2.

In short, and to conclude, the valuation results (1) may contribute to a better understanding of the potential welfare loss in the context of climate change and the economic trade-offs between potential mitigation or adaption strategies; and (2) confirm that climate change will be responsible for a re-distribution of welfare among the European countries, signaling the potential for a(n) agreement(s) among these same countries focus on the re-allocation of potential trade-offs among the countries.

Keywords: wood products, biodiversity, climate change, market and non-market valuation methods, ecosystem goods and services, millennium ecosystem assessment.

1. Introduction

Climate change due to the increasing in temperature and concentration of greenhouse gases emissions has been proved having significant impacts on natural environment and human health (MEA, 2005). This, in turn, has led to an increasing number of scientific studies focusing on the mapping and identifying the scale of the direct impacts of the climate change on ecosystem performance and respective provision of ecosystem goods and services. More recently, accompanying studies on assessing the role of the ecosystems with respect to their contribution to the economy and human wellbeing were made popular by the Millennium Ecosystem Assessment (MEA). However, to the authors' knowledge, few studies have put their emphasis on estimating human welfare losses related to the changes of biodiversity and ecosystems driven by climate change. In the literature, one can find that the economic costs of climate change mitigation have been relatively well studied by aggregating the data from the sectors and industries most likely to be affected by mitigation policies and measures (e.g. IPCC, 2007). Yet the costs of climate change impacts on biodiversity are not well mapped due to the complex and not fully understood interactions between climate change, ecosystems, and the respective impacts on human well-being (both in utility and productivity/employment terms). For these reasons, the present paper attempts to contribute to this line of research by undertaking an empirical analysis on the European forest ecosystems, addressing the role of biodiversity as it "forms the foundation of the vast array of ecosystem services that critically contribute to human well-being" (MEA, 2005. p.p.18). The results of the present research shall be integrated in the cost-benefit analysis of alternative policy options (e.g. mitigation and adaptation policies) against global warming.

To better understand the question at stake, a conceptual DPSIR (OECD, 1999) framework is applied to capturing the causal relationship between climate change, biodiversity, forest ecosystems and human well-being (see Figure 1). Today, scientific evidence has demonstrated with high certainty that climate change is one of the main drivers that directly alter ecosystem functioning and cause biodiversity losses as the shift of climate condition can change the species distribution, population sizes and the timing of reproduction or migration events and increase the frequency of pest and disease outbreaks (MEA 2005, p.p. 10). As a consequence, increasing in global temperature and greenhouse gases concentrations may be detrimental to the health of forest ecosystem through its disturbance of existing biodiversity and negatively influence the ability of ecosystem to deliver goods and services, both linked to human well-being. These are damages directly caused by climate change and thus associated with certain costs to the human society. Yet it is important to note that forest ecosystem also places feedback effects on climate change due to its important contribution to stocking CO_2 emissions. This actually becomes important benefits that ecosystems provide to humans. Therefore, monetizing the respective costs and benefits associated with climate change through its impact on ecosystems has practical sense in guiding cost-effective policy making for climate change. Moreover, we shall also realize that mitigation and adaptation policy measures can reduce the loss and associated costs, but they also imply economic costs themselves. This shall also be considered in the valuation strategies.

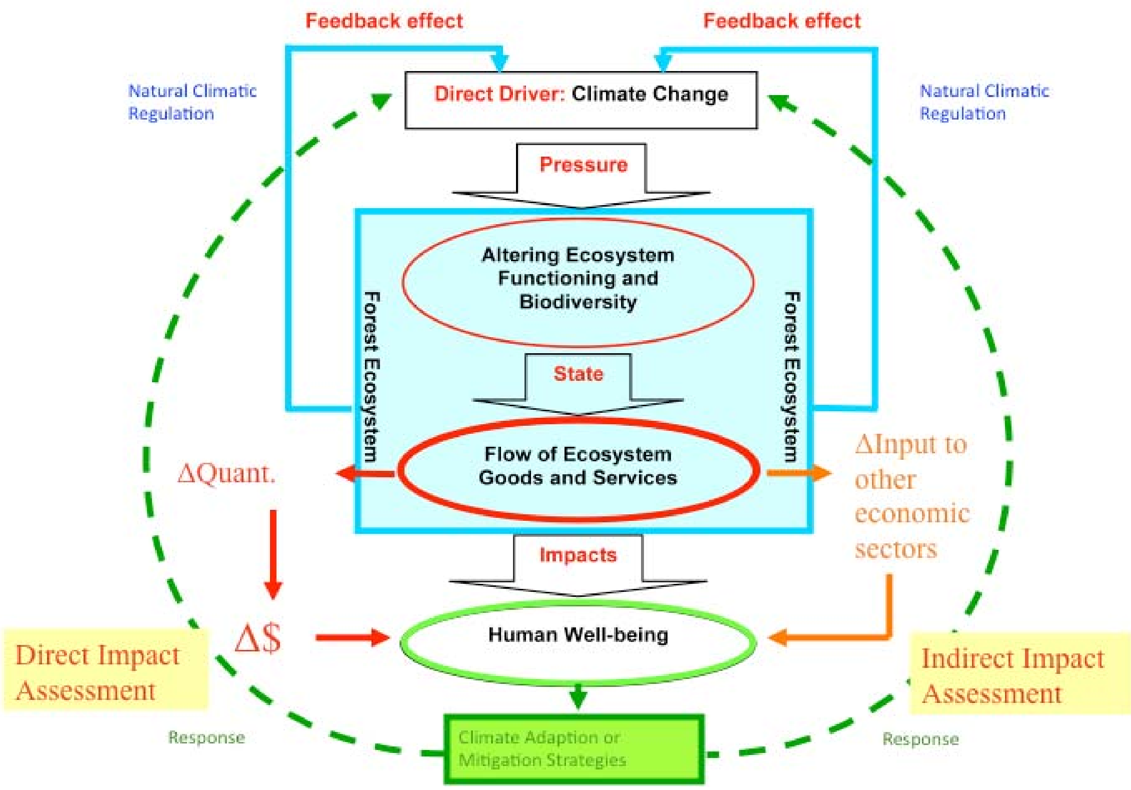

Figure 1.Conceptual model for the climate change, forest biodiversity and human well-being interactions

Against this background, an economic valuation of climate changes impacts on biodiversity and forest ecosystem requires a three-step approach. The first step is the determination of the role of climate in creating relevant forest ecosystem services. The second step is the calculation of the reduced quantity and quality of these ecosystem services resulting in loss of human welfare under alternative IPCC scenarios. And finally, the third step is the (monetary) valuation of that loss. Following these steps, the paper is organized as follows. Section 2 contains a set of comprehensive valuation strategy for quantifying the climate change impacts on forest ecosystem in monetary terms, which is based on projection of physical changes in the flows of EGS under the IPCC storylines. Section 3 presents the current status of European Forests as well as the projection of its future trend, in terms of (1) the current forest areas, (2) total quantity of provisioning services, and (3) total stored carbon in Europe. The results of the study are presented in Section 4. Finally, in Section 5, we apply specific economic valuation methods with respect to each type of ecosystem system services, and present the economic estimates respectively. Section 6 concludes.

2. A hybrid ecosystem-based approach to monetize climate change impacts

2.1 The present status of forests in Europe

The nature of climate change is always associated with long-term and uncertainty and makes any attempt of quantifying its impact in monetary terms ambitious. It requires the study to depart from a solid ground of scientific understanding on the environment state under concern, which is Europe forest in our case. For this reason, before proceeding with the proposed three-step valuation approach, we focus on a systematic mapping of the geo-climatic regions of European countries of our interest, corresponding to a classification of forest ecosystems located in every region. We shall be adopting the regions defined in the *European Forest Sector Outlook Study 1960-2000-2020 main report* (UNECE/FAO, 2005), covering 34[1] European countries located in *Western Europe* and *Eastern Europe* sub-regions. Furthermore, we regroup the same countries into four sub-groups, i.e. (1) Mediterranean Europe (Latitude N35-45°), (2) Central-Northern Europe (Latitude N45-55°), (3) Northern Europe (Latitude N55-65°) and (4) Scandinavian

[1] Three EFSOS sub-regions are presented in the Annex. Note that in this paper, we exclude the CIS sub-region (i.e. Belarus, Republic of Moldova, Russian Federation and Ukraine) in our study for we fear the large forest area and the relative low prices of the forest in these countries may bias our valuation result for the whole Europe.

Europe (Latitude N65-71°), in terms of their climatic-geographical locations in the respective latitude intervals. This new geographical grouping is presented in Table 1.

Table 1. Geographical grouping of the 34 European countries

Geographical groupings	Latitude classification	Countries included
Mediterranean Europe	Latitude N35-45°	Greece, Italy, Portugal, Spain, Albania, Bosnia and Herzegovina, Bulgaria, Serbia and Montenegro, Turkey, TFRY Macedonia
Central-Northern Europe	Latitude N45-55°	Austria, Belgium, France, Germany, Ireland, Luxembourg, Netherlands, Switzerland, Croatia, Czech Republic, Hungary, Poland, Romania, Slovakia, Slovenia
Northern Europe	Latitude N55-65°	Denmark, United Kingdom, Estonia, Latvia, Lithuania
Scandinavian Europe	Latitude N65-71°	Finland, Iceland, Norway, Sweden

The underlying idea of this grouping is based on the assumption that particular types of forests in each country are closely determined by the specific climate conditions, which have been classified in four main groups according to the range of latitude. This way thus allows us to identify the predominant tree species as well as the respective contributions to the local economy at both national and larger regional scales. From an ecological view point, different tree species can play different roles in ecosystem regulating and life supporting functions, which will ultimately influence the provision of forest ecosystem goods and services. Whereas from an economic perspective, different tree species may deliver very different flows of ecosystem goods and services, which thus refer to the various levels of economic importance and respective welfare impacts. Finally, and from a geo-climatic perspective, this way of grouping may also allow us to explore how sensitive are different tree species when reacting to the changes of climate, including increase of temperature and precipitation rate in the countries under consideration.

Based on data from 34 European countries, forests cover a surface of about 185 million ha (FAO, 2005), which accounts for about 32.7% of the territory. By classifying the forest areas in terms of their latitude, it is easy to see that European forests are not uniformly distributed in the four climatic-geographical regions that we have classified above. For instance, in the

Mediterranean Europe, most of the forests are coniferous and broadleaved evergreen forests, which account for 30% of the total forest area in the three regions. The Central-Northern and Northern European regions are home of most of the temperate forests, which account for 35% and 19% of the total forests, respectively. Finally, in the Scandinavian Europe, forest area accounts for the remaining 16% of total forest, in which the identical forest biomes are mainly boreal - see Figure 2. Due to the diverse climate conditions across latitudes, species diversity and dynamics of forest ecosystems differ considerably throughout Europe, as reflected in the numbers and composition of tree species. For instance, Ministerial Conference on the Protection of Forests in Europe MCPFE (2007) reported that about 70% of the forests in Europe are dominated by mixed forest consisting of two or several tree species, and the remaining 30% are dominated by one tree species alone, mainly by conifers. In addition to the natural conditions, the current European forest structure, in part, forest species composition has been heavily influenced by anthropophagic interventions, such as past land use and management (Ellenberg, 1986). In particular, driven by the forest protective management strategy in Europe, a 1.0 percent annual expending rate has been found in the area of mixed forests over the last 15-year period (MCPFE 2007), which partly may be because of the widely acknowledged scientific evidence that mixed forests being composed of several tree species are usually richer in biodiversity than the forests dominated by one tree species.

Figure 2 Classification of European forests

With respect to tree species' sensibilities to temperature changes, it has been studied in terms of specific forest types located in different geographical regions in Europe. For instance, in Mediterranean Europe, most forests consist of *sclerophyllous* and some deciduous species that are adapted to summer soil water deficit. Temperature changes may allow expansion of some *thermophilous* tree species (e.g. *quercus pyrenaica*) when water availability is sufficient (IPCC, 2001). Similarly Garcia-Gonzalo et al. (2007) find that in Scandinavian Europe, the growth of boreal forests is currently limited by a short growing season, low summer temperature and short supply of nitrogen, whereas the changing climate can increase forest productivity and also carbon stock in the forest ecosystem. This is because an increase in temperature can prolong growing season, enhance decomposition of soil organic matter and thus increase the supply of nitrogen. In turn, these changes may have positive impacts on forest growth, timber yield and the accumulation of carbon in the boreal forests (Melillo et al. 1993; Lloyd and Taylor 1994; Giardian and Ryan 2000; Jarvis and Linder 2000; luo et al. 2001; Strömgre 2001).

The main features of forest ecosystems in our study area confirm the plausible reasoning of the current geo-climatic grouping structure. As far as economic valuation is concerned, we are in good conditions to describe each of the three steps in more detail, i.e.,

Step 1 mapping of the ecosystem goods and services provided by European forest;

Step 2 calculation of the reduced quantity and quality of these ecosystem services resulting in loss of human welfare due to climate change impacts;

Step 3 monetary valuation of that loss. Mitigation and adaptation policy measures can reduce the loss and associated costs, but form an economic cost themselves.

2.2 Mapping of the ecosystem goods and services provided by European forests

A concise mapping of ecosystem goods and services (EGS) are basis for conducting high quality ecosystem assessment studies. For this reason, we adopt the MA approach (MEA, 2003), which provides a practical, tractable, and sufficiently flexible classification for categorizing the various types of ecosystem goods and services (EGS). In this context, all EGS can be generally classified into four main categories, i.e. *provisioning, regulating, cultural and supporting services* – see Table 2.

Table 2. A general classification of Ecosystem Goods and Services for European Forests

Types of Ecosystem Services		Examples
Supporting Services	Provisioning Services	Food, Fiber (e.g. timber, wood fuel), ornamental resources, etc.
	Regulating Services	Climate regulation, water regulation, erosion regulation, etc.
	Cultural Services	Recreation and ecotourism, aesthetic values, spiritual and religious values, cultural heritage values, etc.

Source: adapted from MEA 2003

Provisioning Services

In this forest service category, we divide the forest products into seven main groups, including industrial roundwood, wood pulp, recovered paper sawnwood, wood-based panels, paper and paper board, and wood fuel. For all products quantity information on the total annual removal from forests is available on the FAOSTAT-Forestry. We first collected quantity information for all 34 European countries under consideration, and then summed up the total quantities for four individual latitude groupings - see Table 3. These figures, in turn, will be at the basis of the economic valuation exercise.[2]

Table 3. Applied MEA framework for European forest ecosystem

Provisioning Services-(1) Total Removal of Wood Forest Products (WFPs) in 2005							
Latitude Classification	Industrial Roundwood (Million m^3/yr)	Wood pulp (Million t/yr)	Recovered paper (Million t/yr)	Sawnwood (Million m^3/yr)	Wood-based panels (Million m^3/yr)	Paper and paper board (Million t/yr)	Wood fuel (Million m^3/yr)
N35-45°	7.40	0.75	11.85	15.38	17.86	19.60	20.24
N45-55°	48.12	3.20	6.32	18.18	12.48	11.87	14.25
N55-65°	13.75	0.41	8.38	10.98	4.98	6.88	4.96
N65-71°	6.33	25.70	2.62	32.60	3.31	26.35	12.66
Total Europe	75.60	30.06	29.17	77.14	38.63	64.70	75.60

Source: FAOSTAT, year of reference 2005

Regulating Services

As far as regulating service is concerned, two types of ecosystem services are of particular importance provided by European forests: (1) climate regulation (i.e. carbon sequestration) and (2)

[2] The data report from FAOSTAT does not provide an efficient collection of data on non-wood forest products, for this reason, our figures of the forest provisioning services will not embed this provisioning service. We acknowledge that our estimation is underestimated compare to other studies in the literature, if there is less evidence to link the provision of with non-wood forest products climate change (e.g. Merlo and Croitoru, 2005).

water and erosion regulation (i.e. watershed protection). It is important to note that we will focus only on the carbon service due to lack of data. In any case, the role of forest ecosystem in mitigating climate change by storing carbon in forests and its soil is also been more studied and understood in the context of climate change. In any case, given better understanding regarding the complex relationship between watershed protection and climate change, the present work can be further elaborated and improved in the future.

Cultural Services

In Europe, forests are of particular importance in many countries in terms of cultural services. Among all others, recreational service represents the most important value (MCPFE 2007), including hunting, natural park visiting, forest landscape and other spiritual uses. Some of the services always involve both consumptive (e.g. consumption of animal meat) and non-consumptive (e.g. enjoyment derived from hunting activities and forest landscape) uses of forests. To avoid double counting, we refer cultural services to non-consumptive use of forests only. In addition, the passive use value of the forests has an essential role in assessing some particular forest areas. It should be noted that the direct linkage of cultural service with climate change is rather complex to convey. Even though some of the existing literature in general equilibrium modelling has put considerable efforts to analyse the climate-driven changes in tourism demands (Berrittella *et al.*, 2006; Bigano *et al.*, 2008), few studies – if none – are able to embrace in their analysis of non-consumptive use of forests (including forest recreation activities) or passive use values. For this reason, we use forests areas that are designed to recreational and protective purposes, as described by the Global Forest Resources Assessment 2005 (FRA, 2005), as key variables when assessing the welfare changes in terms of changes in the provision of cultural services.

Supporting Services

Finally, with respect to the supporting service, indicators for measuring the respective forest ecosystem changes in response to climate change are not well developed and thus quantity data to measure them are not readily available (MEA 2005). For this reason, we will not directly tackle the valuation study for this service category. However, it is important to realize that the relevant values are implicitly reflected in the valuation of all other three categories of forest ecosystem goods and services.

2.3 Estimate the physical changes of ecosystem services due to climate change

Over the last 30 years, the world has experienced significant temperature increases, particularly in the northern high latitudes (IPCC, 2001). The research results of International Panel on Climate Change (IPCC) show that the average temperature in Europe will increase from 2.1 to 4.4°C by 2050 varying across latitudes with the strongest warming consistently in the height latitudes. In addition, model simulations also suggest a decrease of the precipitations in the south of Europe, particularly in summer, and an increase of precipitation over much of northern Europe (Schöter *et al.*, 2005). In order to quantify the climate change impact on forest ecosystem, both quantitative and qualitative data are needed for describing the state of ecosystem to provide ecosystem goods and services today and to be recalculated in the context of climate change. Moreover, to specify the climate change scenario in the future, we adopted the four major storylines that are developed by IPCC, coupling the circulation models (e.g HadCM) with socio-economic storylines [3] (Nakicenovic and Swart 2000; Schöter et al. 2004; Schöter et al. 2005). This way enables us to describe the change of flows of ecosystem services under different future scenarios, i.e. A1FI, A2, B1 and B2 scenarios. Finally, the undertaken scenario analysis takes into account a plausible assumption of next 50 years departing from the current situation in 2005 and calculates the respective changes in the forest ecosystem in Europe.

2.4 Monetary valuation of forests ecosystems goods and services

Monetizing the loss of environmental services provided by forests under climate change scenarios is the main concern of the CLIBIO project and this however requires the exploration of economic theories and different valuation methodologies. Within the welfare economics framework, two main streams of economic theory are widely applied in the area of climate economics: (1) partial equilibrium theory – to estimate the impacts of climate change on a single market or economic

[3] IPCC experts identify and characterize four storylines, i.e. A1FI, A2, B1, and B2, combined with a general circulation model HadCM3, developed Schöter et al. (2004), that are directly related socioeconomic changes to climatic changes through greenhouse gas concentration and to land use change through climatic and socioeconomic derivers, such as demand for food.

sector and (2) general equilibrium theory – to estimate the influence of climate change over a larger scale economy through the changes of individual markets/sectors. The former requires the investigation of appropriate microeconomic valuation techniques, including market-based economic valuation tools (e.g. Market price analysis) as well as non-market valuation tools (such as Contingent Valuation methods, Travel Costs methods, Meta-analysis, and Value Transfer); the latter on the other hand largely relies on the advancement in computer technology, which has been intensively used in climate economics for simulating the larger scale economic damages under climate change scenarios in the future. The distinction of economic theories therefore clearly states that the present study is anchored in a partial equilibrium analysis, as forest ecosystem only contributes to a portion of entire economy. Moreover, the socio-economic valuation is anchored in the assessment of changes in the productivity of the economic sectors under concern and/or respective consumer's utility – see Figure 3. Once the physical change is identified and assessed, the economic value should reflect the change related to the individuals whose welfare has been affected by it, or the average welfare change of the individuals in a population (Nunes et al. 2003).

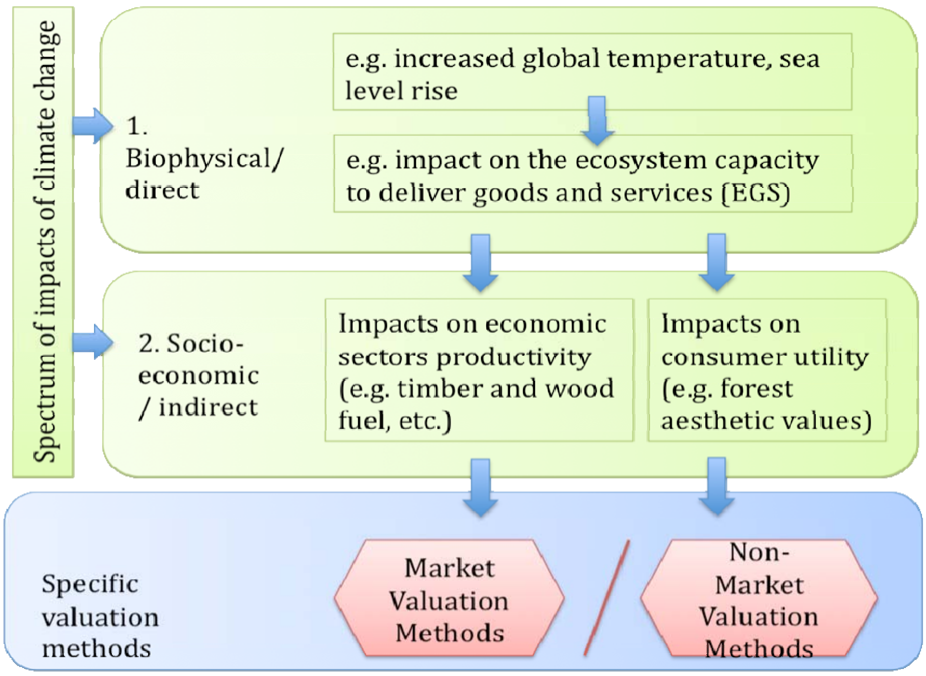

Figure 3 Framework for valuating climate change impacts in welfare economy
Source: Australian Greenhouse Office report (2004), adapted.

Bearing in mind the MA classification of ecosystem goods and services– see Table 2 – it is not difficult to agree that no single valuation method will deliver a the full range of the forest value components under consideration, i.e. wood forest products' values, carbon sequestration values and cultural values. Therefore, a flexible, integrated and generally straightforward approach is needed to estimate the costs of climate change through each of the above-mentioned value components. In Figure 4, we summarized all valuation techniques used for assessing the value of forest ecosystem goods and services that may either involve markets or not, including market price analysis methods, cost assessments methods and valuation methods based on meta-analysis. These techniques are most appropriately applied in the context of regional or national scale climate change impacts, disaggregated by sector or market. The use of the techniques in isolation (sometimes referred to as 'bottom-up studies) is predicated on an assumption that any incremental damage due to climate change will not have large, indirect (non-marginal) impacts, affecting the prices of a range of goods and services that flow through the macro-economy.

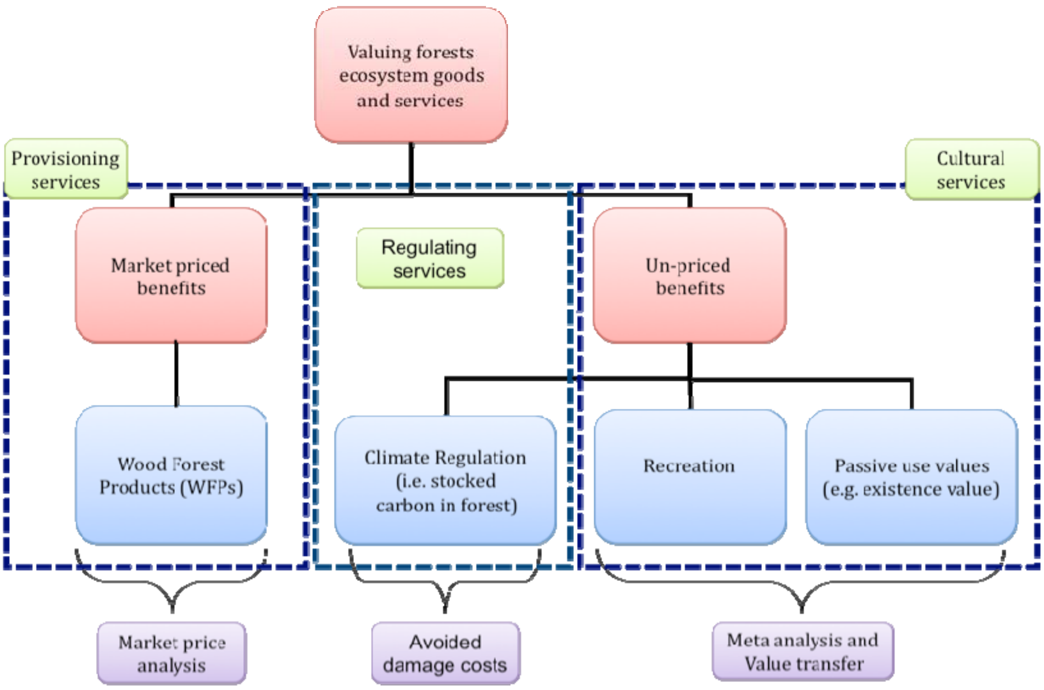

Figure 4: A hybrid economic valuation methodology

3. Assessing bio-physical flows of ecosystems goods and services under climate change

3.1 The advantage of IPCC future scenarios for climate change impact assessment

Given the underlying idea for projecting the future trends of European forest by 2050, this section will elaborate more on how to model and map the impacts of climate change on forest area, production of wood forest products and carbon storage in the existing IPCC storylines, i.e. A1FI, A2, B1 and B2 storylines. The IPCC storylines, as reported by the Special Report on Emission Scenarios, have specific attributes in terms of population growth, CO_2 concentration, degree of temperature changes, and change of precipitation in Europe (Nakicenovic and Swart, 2000) – see summary in Table 4. Thus, each scenario provides a narrative description of alternative futures that goes beyond quantitative scenario features.

Table 4. The specifications of the four IPCC storylines

Indicator	Climatic model - HadCM3 (Scenarios by 2050)			
	Storyline A1FI	Storyline A2	Storyline B1	Storyline B2
Population (10^6)	376	419	376	398
CO_2 concentration (ppm)	779	709	518	567
Δ Temperature (°C)	4,4	2,8	3,1	2,1
Δ Precipitation Europe (%)	-0,5	0,5	4,8	2,7
Socio-economic dimensions	High savings and high rate of investments and innovation	Uneven economic growth, high per capita income	High investment in resource efficiency	Human welfare, equality, and environmental protection

(Source: Schröter *et al*., 2005; IPCC, 2001)

Furthermore, efforts have been placed on the development of a general circulation model – HadCM3 [4] – so as to relate directly socioeconomic changes to climatic changes through greenhouse gas concentration and to relate land use changes through climatic and socioeconomic drivers, such as demand for food (Schröter D. et al. 2004). As a consequence, the IPCC is able to present four brief "future stories" differently developed in economic, technical, environmental and social dimensions (Nakicenovic and Swart, 2000). According to the IPCC specifications,

[4] HadCM3, Hadley Centre Couplet Model Version 3 is a coupled atmosphere-ocean GCM developed at the Hadley Centre and described by Gordon et al. (2000).

A1FI, A2, B1 and B2 storylines are distinguished in terms of four future development paths, i.e. ‘global economic’ oriented, ‘regional economic’ oriented, ‘global environmental’ oriented, and ‘regional environmental’ oriented, respectively. The two economic oriented scenarios (A1FI and A2) focus on ‘material consumption’, but A1 scenarios also consider different combinations of fuel, which is expressed as A1FI. While the two environmental oriented scenarios (B1 and B2) mainly concentrated on the concepts of ‘sustainability, equity and environment’. It is important to point out that, among all others, the storyline A2 and scenarios family describes a very heterogeneous world which is characterized by high population growth, regional oriented economic development and fragmented and slow per capita economic growth and technology, following the current socio-economic development pattern. For this reason, A2 is frequently used by the European Commission as the baseline scenario, opting to run an analysis of the remaining ones *vis a vis* with the A2 storyline. In particular, our focus is mainly on the comparison of A1 vs. A2, assessing the changes towards a more economically focused world. Alternatively, we may also consider B1, and B2, vs. A2, assessing the changes towards a more sustainably orientated world.

3.2 The status of the European forests across the different 2050 IPCC scenarios

In order to project the quantitative changes of forest area and wood products in terms of climate change, we directly adopted the simulation results derived from the Advanced Terrestrial Ecosystem Analysis and Modelling (ATEAM) project. This project was funded by the 5th Framework Programme of the European Commission with a specific emphasis of assessing the vulnerability of human sectors relying on ecosystem services with respect to global change (Schröter D. et al. 2004). In its delivered software, the percentage changes of forest area and wood products are projected regarding the four IPCC storylines, but only for EU-17. For the remaining 17 European countries, the respective forest areas are projected on the basis of IMAGE 2.2 program (IMAGE 2001). The values are in reference to the period 2050. The results of our projection for: forest area, wood products and carbon services. These will be discussed in detail in following paragraphs.

Forest area

In the A1FI and A2 scenarios, forest areas decrease about 21% and 9% by 2050, respectively - see Table A1a in Appendix for more details. A1FI scenario shows the biggest impact because of no-migration assumption and most severe climate change, with Δ temperature (C°) equal to 4.4 degree (Thuiller *et al*., 2005). Both B1 and B2 scenarios present an increase in forest area, of about 6% for the former and 10% for the latter. The higher increasing rate of forest area in scenarios B2 highlights major change due to the hypothesis of afforestation that is associated to the higher levels of precipitation in this same scenario (Schöter *et al*., 2005). As we can see from Table A1, the impacts of climate changes on forest land use vary significantly across latitudes. For example, Mediterranean Europe (N35-45°) is facing a general negative forest growth in scenario A1FI and A2, but a significant expansion in scenario B1 and B2. Central-Northern Europe (N45-55°) and Northern Europe (N55-65°) region present negative growth only in the A1FI scenario, in correspondence with the more severe climatic conditions. Scandinavian Europe (N+65°) always presents a decrease in the forest growth. Finally, A2 scenario shows the future projections by taking into account the historical trend: forest area tends to increase in the countries located at latitude inferior to 65 degree of latitude. This implies that Scandinavian Europe both under currents conditions and under influence of climate change reduces its extension. We have also looked into forest areas designated to recreational and conservation use, which corresponds to 7.8% and 10.2%, respectively of the total area - Table A1b in Appendix for more details. As we shall see, this data shall be of crucial relevance when computing the economic value of cultural services, including recreation and passive use values provided by forest ecosystems.

Wood forest products

Have shown before, we consider the assessment of the climate impact on the bio-physical levels of production of the wood forest products, including wood pulp, industrial roundwood, recovered paper sawnwood, wood-based panels, paper and paper board, and wood fuel. – see Tables A2a to A2g in Appendix for detailed projection results. Given different socio-economic and climatic assumptions for the IPCC storylines (as listed in Table 4), the projection of the quantitative changes of wood forest products varies across different IPCC scenarios in the next 50 years. Putting all these tables together, it is easy to find that the impacts of climate change are unevenly distributed across European forest, depending on the regions where the forests are located, the types of forest products as well as the scenarios in which either socio-economic or environmental policy is the focus.

All in all, our results do show some significant trends of climate change impacts on the classified regions. For instance, the productivity of most of the wood products in Mediterranean and Scandinavian Europe will be negatively affected by climate change, but the magnitudes of the impacts are subject to the assumptions of climate policies. However by comparing the quantitative assessment results among the four scenarios, there might be a policy option to mitigate the climate change impact through forest ecosystems in these two regions under the B-type scenarios. And for some of the forest products, we may observe some slightly positive impacts of climate change in Mediterranean Europe. Moreover, with respect to the countries located in both Central and Northern Europe, the direction of climate change impact is even ambiguous to interpret. Generally speaking, the production of most of forest products will be increased in A2 and B2 scenarios as a result of the joint effects of both climate change and socio-economic changes in the future. In other words, climatic influence may in part affect the natural growth rate of forests in those two regions, but the existence policies may also play an important role in terms of their influence on the land use pattern.

Carbon Storage

Carbon cycle connects forests and climate change as total carbon stored in forests has a very important role in determining any climate stabilization path. As a matter of fact, the quantity of carbon stocked in trees biomass corresponds approximately at 77% of the carbon contained in the global vegetation, while forest soil stores 42% of the global 1m top soil carbon (Bolin et al., 2000). Forests exchange large quantities of carbon in photosynthesis and respiration, they contribute to the global carbon cycle becoming source of carbon when they are disturbed, and sink when recovering and regrowing after disturbances. In turn, climate change may also influence the forest ecosystems' capacity of storing carbon dioxide in the future. Against this background, we construct projections for carbon sequestration in forests for all the European countries across the four IPCC storylines – see Table A3 in Appendix for more details. Our finding shows that the average carbon stock tends to increase in all scenarios, but the respective magnitudes are different. For instance, in the A1FI scenario, which represent a world orientated toward 'global economic' growth, but along with the highest CO_2 concentration and temperature, the total carbon sequestrated by forests appeared to be the lowest compared to other three scenarios. This result is consistent with results reported by Schröter et al. (2005), who highlighted that for most ecosystem services the A1FI produces the strongest negative impacts. On the other hand, B-type storylines, which are sustainable development oriented, contribute to an increase in forest area and a consequently large quantity of carbon stock. These figures, in turn, will be at the basis of the economic valuation exercise, which shall be discussed in details in the following sections.

4. Economic valuation European forest ecosystems

4.1 Methodological background and data mining

Following Figure 4, different economic valuation methods are exercised for capturing the values of three types of ecosystem services under consideration. First of all, for the provisioning services provided by European forests, we can infer that the economic values are the direct use values obtained from trading wood forest products in the market. Therefore, market prices are used to value this ecosystem service and its information is derived from Food and Agriculture Organization of the United Nations (FAO) database[5] on forests. Second, in order to evaluate the welfare changes associated to the carbon regulation we shall be using the avoided damage cost methods that were undertaken by the recent EC funded project, CASES[6] to estimate the marginal damage cost of per additional unit of CO_2 emission. Economic theory tells us the optimal emission level is determined by the intersection of the marginal damage cost of emissions and the marginal benefit from damage mitigation (or marginal abatement costs). Thus the crossing point is corresponding to the unit value of carbon sequestration, which gives rise to the optimal policy to incentivise the necessary abatement for achieving the global carbon stabilization goal, and can be used to calculate the total economic value of carbon stored in forests. Finally, with respect to the cultural service, meta-analysis and value transfer methods are jointly used. These two

[5] http://faostat.fao.org/site/381/default.aspx

[6] CASES stands for "Cost Assessment of Sustainable Energy Systems" for EU countries and the selected non-EU countries, including Turkey, Brazil, India and China. The study aimed at providing a comprehensive and dynamic assessment of the full costs of electricity generation based on the state-of-the art methodologies, taking into account both geographical and temporal extend of the impacts and social economic impacts, such as health and safety, economic production and consumption, recreation, and environmental and natural assets caused by climate change.

methods are anchored in non-market valuation methodologies and rely on the existing databases[7] of non-market valuation studies for forests in Europe. All values are estimated under four IPCC scenarios in 2050 and expressed in 2005 US$. However, the specific nature and availability of data as well as the different valuation procedures embraced according to the nature of the ecosystems services under consideration will merit a separate discussion.

4.2 The Economic Valuation of Provisioning Services

4.2.1 Methodology

The valuation framework undertaken for Wood Forest Products (WFPs) consists of the following two steps:

i) Calculating the current productivity value of forests in terms of provisioning of 7 types of WFPs, i.e. industrial roundwood, wood pulp, and recovered paper, other processed wood products, sawnwood, wood-based panels, paper and paperboard and wood fuel;

$$ProductivityValue^{provisioning\ service}_{geo\text{-}climatic\ region} = \sum_{n=1}^{N}\sum_{i=1}^{7} ExportValue_{in} \Bigg/ \sum_{n=1}^{N} ForestArea_{n} \qquad (1)$$

Equation (1) shows the formula that has been used for the computation, where i and n represent the type of forest product and the number of countries located in each geo-climatic region. The export values used here are published by FAOSTAT in year 2005. The values are first collected and summed up across all the 7 forestry sectors under consideration at country level and then divided by the quantity of each type of WFPs in the country so as to get the respective market prices of each single commodity. Furthermore, we aggregate the total values of WFPs at the scale of geo-climatic groupings. By dividing those values by the forest size located in the same area, we therefore can compare the productivity values (in $/ha term) of the forest biomes in terms of the profits associated with the types of WFPs they can deliver to the market (see Table 5). Therefore, the productive values can vary among the 4 geographical groupings as they reflect the different contributions of various forest biomes to the local economy.

---

[7] The popular databases for non-market valuation study include: Environmental Valuation Reference Inventory (EVRI), Envalue, and the Ecosystem Services Database.

Table 5. Projection of Total Productivity Value of WFPs (US$/ha/yr, measured in 2005)

Scenarios	latitude 35-45	latitude 45-55	latitude 55-65	latitude 65-71
A1 2050	168 (+5.3%)	824 (+0.6%)	749 (+60.8%)	749 (+64.2%)
A2 2050	139 (-12.8%)	777 (-5.1%)	682 (+46.4%)	730 (+60.0%)
B1 2050	134 (-16.1%)	584 (-28.7%)	401 (-13.9%)	668 (+46.4%)
B2 2050	141 (-11.9%)	633 (-22.7%)	503 (+8.0%)	701(+53.6%)

NB: Percentage variation from initial benchmark 2005 are showed in parentheses.

ii) Estimating the future values of forest productivity derived from the same forestry sectors in 2050.

To project the future trends of real wood price in 2050, we refer to two studies (Clark, 2001; Hoover and Preston, 2006) that analyze long-term historical data. Clark (2001) offers a theoretical analysis and an empirical examination of wood prices, based on aggregated global wood market data over the last three decades. Hoover and Preston (2006) analyses trends of prices of Indiana (USA) forest products using statistical data from 1957 to 2005. Although different in the spatial scale of the analyses, both papers lead to a similar conclusion that: there is no evidence of increase in real prices for wood in the near future. We therefore assume that real prices of wood products will remain stable in the next 50 years, while allowing different prices to exist across countries and continents. As a consequence, we can get the future total value of WFPs under different IPCC storylines by multiplying the real price of each wood product by the projected quantities of WFPs in 2050. These values are finally summed up over all the WFPs commodities and countries located at each geo-climatic regions, expressed in 2005 US$. The computation is expressed by Equation (2).

$$TV_n^{\ S} = \sum_{i=1}^{7} p_{in} \cdot Q_{in}^{S} \qquad (2)$$

where *TV* is the total value of WFPs in Country *n* under IPCC Scenario *S*.

4.2.2 Results

The finally valuation results are summarized in Table 6 (See Appendix-Table 4a-4g, and Appendix-Table 5 for the detailed projection results at a disaggregated level). In short, the table shows that climate change impacts on the productivity value of WFPs vary depending on the respective geo-climatic groupings. For example, among all others, the Mediterranean Europe has a lower sensitivity to climate change in terms of the total productivity value. In other words, the lowest variations in total productivity value of WFPs are registered in Mediterranean Europe, while the highest variations are reported in Northern and Scandinavian Europe.

Table 6. Projection of Total Value of WFPs for European Forests (Million$, 2005)

IPCC scenarios	Mediterranean Europe	Central Europe	Northern Europe	Scandinavian Europe	Total Europe
A1 2050	6,413	41,250	5,413	35,540	88,616
A2 2050	6,453	47,556	7,215	33,943	95,167
B1 2050	8,018	41,441	4,712	31,772	85,943
B2 2050	8,736	48,742	6,810	31,943	96,231

Another important finding is that the total productivity values of WFPs are generally higher in the scenarios A1 and A2 ("material consumption" specific scenarios) than in the scenarios B1 and B2 ("sustainability, equity and environment" specific) in all latitudes – see Table 7.

Table 7. Comparison of Total Value of WFPs for European Forests

Benchmark A2 Scenario		Mediterranean Europe (N35-45)	Central Europe (N45-55)	Northern Europe (N55-65)	Scandinavian Europe (N65-71)	Europe
Absolute value difference (Million$, 2005)	A1vs.A2	-40	-6,306	-1,802	1,597	-6,551
	B1vs.A2	1,565	-6,115	-2,503	-2,171	-9,223
	B2vs.A2	2,283	1,186	-405	-1,999	1,065
Percentage change	A1vs.A2	-0.6%	-13.3%	-25.0%	4.7%	-6.9%
	B1vs.A2	24.3%	-12.9%	-34.7%	-6.4%	-9.7%
	B2vs.A2	35.4%	2.5%	-5.6%	-5.9%	1.1%

As we can see, the A1 scenario, with higher concentration of CO2 and increasing temperature (ºC), will result in a welfare loss to all European countries, except Scandinavian Europe. But in the B-type scenarios, the enhanced consciousness of sustainable development and environmental protection may lead to a reduction of the total extracted forest resources for WFPs to be sold in the market and thus a decrease in the total benefits. Moreover, our valuation result also suggests that a local or national oriented sustainable development strategy (i.e. B2 scenario) may have positive impact on the social welfare as B2 scenario shows an average higher welfare gain in almost all geo-climatic regions than those in the B1 scenario.

4.3 The Economic Valuation of Regulating Services

Forest conservation or prevention of deforestation in order to stabilize Green House Gas (GHG) emissions – questions not originally included in the Kyoto Protocol – have been officially recognized in COP13 in Bali in December 2007 as important issues. The estimation of economic value of climate regulating services (i.e. carbon storage) provided by forest ecosystem is therefore considered to have very important impacts on policy making for CO_2 stabilization in Europe. However, it is important to note that our economic value estimates for regulating service in the present paper are underestimated as we will not tackle the other regulating services, e.g. watershed protection and soil nutrient cycling, due to the limited knowledge about how to quantify those services in physical terms with respect to climate change impact as well as to projecting the respective future changes. As we have shown that the carbon stocks in forests are projected to be increased on average in Europe under all 4 IPCC storylines (see section 4) in the next 50 years, we may therefore expect to obtain some benefits from forest regulating services. However, the magnitudes of those benefits may vary across different forest biomes.

4.3.1 Methodology

The methodological framework for valuing the regulating services consists of two steps: we first compute the marginal value of carbon storage in forests (2005US$/tC), which will then be used to estimate the total economic values that can be obtained in different geo-climate regions under IPCC scenarios. First of all, the marginal value of carbon storage refers to the benefits from avoided damages[8] caused by incremental of CO_2 or CO_2-equivalent GHG emissions in the atmosphere due to the carbon sequestration function of forest ecosystem. In the present paper, we built our analysis upon a existing project, "Cost Assessment for Sustainable Energy Systems" - CASES[9], funded by EU but targeting at a worldwide study.

One of the main features of CASES is that it is built upon the Integrated Assessment Models (IAMs), which by definition combine the dynamics of global economic growth with the dynamics of geophysical climate dynamics, to estimate the cost of GHG emissions under different energy evolution paths in 2020, 2030 and 2050. The existing literature on IAM has been intensively reviewed under the project and various available estimates in the recent years were taken into account in its finally delivered value estimates. Among all others, the value of social costs of carbon estimated by UK's Department for Environment, Food and Rural Affairs (DEFRA 2005) was adopted for it is reflexive to the policy context in which the values are used, and it combines the results of a number of IAM's in a transparent matter. As a consequence, CASES project was able to obtain three levels of estimates of marginal damage costs, i.e. lower, upper and central estimates[10], respectively. For instance, as reported in CASES final report, the lower estimates of marginal damage costs evolve from € 4/tCO_2 in 2000 to € 8/tCO_2 in 2030; the upper estimates evolve from € 53/tCO_2 in 2000 to € 110/tCO_2 in 2030; and the central estimate evolves from € 23/tCO_2 in 2000 to € 41/tCO_2 in 2030.

In the CLIBIO project, we adopted a value estimate of 96,1 Euro/tC from the CASES report, referring to the central estimate of the avoided cost of 1 ton of carbon in 2080. The value is first adjusted to our paper by discounting to the real Euro value in 2005, using a 3% discount rate, and then converted to 2005US$ taking into account the real exchange rate and the Purchasing Power

---

[8] The avoided damage costs assessment method has been widely used in the literature (see Cline, 1992; Nordhaus, 1993a,b; Merlo&Croitoru, 2005; CASES, 2008) to calculate indirectly the benefits from carbon sequestrated in forests, but it is important to note that the concept is different from the market price of carbon (obtained via emission trading scheme) and the marginal abatement cost (involves the costs of technological R&D for facilitating the emission abatement), although under certain restrictive assumptions the three measures would be broadly equal, at the margin (DEFRA, 2007).

[9] CASES, Project No.518294 SES6, (2006-2008). Project official website: http://www.feem-Project.net/cases/

[10] The values are based on full *Monte Carlo* runs of the *FUND* and *PAGE* models, in which all parameters varied to reflect the uncertainty surrounding the central parameter values in both models. The lower and upper bounds are the 5% and 95% probability values of the *PAGE* model, while the central guidance value is based on the average of the mean values of the *FUND* and *PAGE* models. A declining discount rates is use as suggested by the UK Government 'Green Book'. The equity weighting of damages in different regions is applied to aggregate the regional damage costs to global damages, in other words, damages in richer regions receive lower weights and damages in poorer regions receive higher weights.

Parity (PPP). Finally, future economic benefits (measured in 2005 US$) of carbon stocks in the each country's forests are calculated by multiplying the US$/tC value by the projected quantity of carbon totally stored in the same forests in 2050 (see section 4), following the IPCC storylines and then aggregated as to compute the regional total benefits for the four large geo-climatic groupings.

4.3.2 Results

The results of our valuation are presented in table 8, which implies that the predominant tree species in addition to the forest area may have a dominant role in determining the carbon sequestration capacity in a geographical region, the thus the respective economic benefits. For instance, the forests in Central Europe contribute to the largest portion of benefits from the carbon regulating services in Europe. But this matter of fact does not only depend on the fact that this area occupies the largest forest areas in Europe, but also because the type of forests in this area may has tolerance and capacity in terms of carbon sequestration. This conclusion however needs more sophisticated scientific proof from forest study.

Table 8. Projection of Total Benefits of Carbon Storage in European Forests (Million$, 2005)

Scenarios	Mediterranean Europe	Central Europe	Northern Europe	Scandinavian Europe	Europe
A1 2050	37,176	117,241	11,489	32,817	198,722
A2 2050	45,790	159,453	17,362	32,605	255,210
B1 2050	66,575	190,755	22,679	46,310	326,320
B2 2050	63,609	190,341	23,546	35,733	313,229

In addition, the productivity value of climate regulating services ($/ha) is also calculated based on the projected forest areas under different future scenarios (See Table 9 and/or Appendix-Table 6 for disaggregated data). The results show clearly the marginal benefit of carbon regulating services provided by different forest lands. Moreover, different forest management scheme may also influence these values. For instance, *ceteris paribus*, the B1 scenario shows the highest marginal value of regulating services provided by European forests.

Table 9. Projection of the Productivity Value of Carbon Sequestration (US$/ha/yr, measured in 2005)

Scenarios	Mediterranean Europe	Central Europe	Northern Europe	Scandinavian Europe	Europe
A1 2050	927	2,712	1,563	748	927
A2 2050	950	2,795	1,625	763	950
B1 2050	1,093	2,879	1,913	992	1,093
B2 2050	990	2,684	1,720	836	990

To better interpret the results, we perform a comparison study among all four IPCC scenarios. Table 10 shows the comparison results of three IPCC scenarios (i.e. A1, B1 and B2) with respect to the A2 (BAU) storyline. Our results suggest a loss of benefits of carbon storks from forests in the whole Europe in the A1 scenario, compared to the A2 scenario. This may be the result of intensive harvesting of forest products to meet the rapid progress of economic development that is proposed in the A1 scenario. In contrast, consciousness of sustainable development and environmental protection in the B-type scenarios may lead to the extension of protective forest area and thus consequent welfare gains in most of the geo-climatic regions. As shown in Table 10, in the B1 scenario, the worldwide efforts for sustainable development result in high welfare gain in all regions; whereas in the B2 scenario, these effects are unevenly distributed in different latitudes as local planning may play a more essential role here.

Table 10. Projection of Total Benefits of Carbon Storage in European Forests

Benchmark A2 Scenario		Mediterranean Europe (N35-45)	Central Europe (N45-55)	Northern Europe (N55-65)	Scandinavian Europe (N65-71)	Europe
Absolute value difference (Million$, 2005)	A1vs.A2	-8,614	-42,212	-5,874	212	-56,489
	B1vs.A2	20,785	31,303	5,317	13,705	71,109
	B2vs.A2	17,819	30,888	6,183	3,128	58,018
Percentage Change	A1vs.A2	-18.8%	-26.5%	-33.8%	0.6%	-22.1%
	B1vs.A2	45.4%	19.6%	30.6%	42.0%	27.9%
	B2vs.A2	38.9%	19.4%	35.6%	9.6%	22.7%

4.4 The Economic Valuation of Cultural Services

4.4.1 The methodology

The cultural services provided by forest ecosystems consist of two components in our analysis: recreational use (e.g. nature-based *tourism* in forests) and passive use (e.g. existence and bequest value of forests and biodiversity). Not being traded in regular markets, recreation and passive use values are usually measured as willingness to pay (WTP) figures using non-market valuation approaches (namely: travel cost method, contingent valuation and choice experiments). According to previous literature reviews on cultural values, a simple expected utility specification can be used to describe how individuals are willing to trade wealth for increases or decreases of forest cultural services, under the assumption that the estimated marginal value of the service decreases with an increase in the size of the forest site, and increases with an increase of the income level of the country where the forest is located (e.g., Hammitt, 2000; Markandya *et al.,* 2008). The driving force of changes in future forest areas is considered to be climate change in the present paper, therefore the expressed WTP estimate for trading-off the forest resources also reflects the fact that individual's preference to enjoy a certain kind of culture service may shift from one forest to another driven by the changed future climate conditions.

Due to the large scale of the current study, it is impossible to conduct new original studies for all 34 countries under consideration. Therefore, a meta-analysis based value transfer method is preferred to estimate the total cultural value of forest situated in each geo-climatic region, whereas the future changes of these values driven by climate change are projected according to the change in forest areas, in GDP and population under different IPCC storylines. The change in tourism demands for recreation in forests driven by climate change is not considered in the present analysis due to the lack of information and relevant studies in the literature. This leaves us to focus on valuing the average WTP estimates (expressed in 2005$/ha) for obtaining cultural services (either recreational use or passive use) from forests in each geo-climatic region. For each region, we assume that one major forest biome can be identified as a representative forest type that survives the local climate. The main advantage of such an assumption is that we can select a few 'best' original non-market valuation studies that have been conducted in any country located in the same geo-climate region to undertake the value transfer within the same region.

The meta-analysis enables us to explain the variance of the available WTPs (Willingness-To-Pay) as a function of a few statistically significant explanatory variables[11]. In particular, main explanatory factors for forest recreation and passive use are: i) size of recreational forest sites; and for passive use, size of forest areas designated to biodiversity conservation; and ii) income level in the study area. The utility model can be expressed by:

(1) $$V = f(S, I)$$

where:

V is the marginal value of a given forest site designated to recreation or conservation of biodiversity.

S is the size of the forest area designated to recreation or conservation (hectares).

I is the income level of the country where the forest is located (measure as PPPGDP).

By running the regression function expressed by equation (1):

(2) $$\log V = \alpha + \beta \log S + \gamma \log I$$

we estimate the marginal effect on V of the forest size (β) and the income level of the country where the site is located (γ). The WTP figures included in the regression are selected from an extensive literature review process focusing on all existing valuable studies. The estimated coefficients are then used for the geographical value transfer (in different geo-climate regions) as well as for the inter-temporal value-transfer under different IPCC scenarios.

For the geographical value transfer, a few representative studies are selected in each European geo-climate region (tables 11 and 12).

[11] A similar approach is used by the authors in another recent research project (COPI) concerning a worldwide valuation of forest ecosystems in the context of policy inaction rather climate change (see Markandya et al. 2008 for more details).

Table 11. Selected studies on recreational use for geographical value-transfer

Country	Reference study	Forest biome	Geo-climatic region
United Kingdom	Scarpa, R., S. M. Chilton, W. G. Hutchinson, J. Buongiorno (2000)	Temperate broadleaf and mixed forests	Northern Europe
The Netherlands	Scarpa, R., S. M. Chilton, W. G. Hutchinson, J. Buongiorno (2000)	Temperate broadleaf and mixed forests	Central-Northern Europe
Finland	Bostedt, G. and L. Mattsson (2005)	Boreal	Scandinavian Europe
Italy	Bellu, L. G. and Cistulli V. (1994)	Mediterranean and Temperate Broadleaf	Mediterranean Europe

Table 12. Selected studies on passive use for geographical value-transfer

Country	Reference study	Forest biome	Geo-climatic region
United Kingdom	Garrod, G.D. and Willis, K. G. (1997) Hanley, N., Willis, K, Powe, N, Anderson, M. (2002) ERM Report to UK Forestry Commission (1996)	Temperate	Northern and central-northern Europe
Finland	Kniivila, M., Ovaskainen, V. and Saastamoinen, O. (2002) Siikamaki, Juha (2007)	Boreal	Scandinavian Europe
Spain	Mogas, J., Riera, P. and Bennett, J. (2006)	Mediterranean	Mediterranean Europe

The WTP figures selected from these studies[12] are then scaled up to the corresponding higher geo-climatic region and forest biome, by taking into account the effect of the size of the forest area under valuation, *β*, according to the following formula:

(3) $$V_{EU,l} = V_{i,l}\left(\frac{S_{i,l}}{S_{EU,l}}\right)^{\beta}$$

[12] When several representative case studies and values are available, the mean marginal value is used.

where

$V_{EU,l}$ = estimated WTP/ha for Europe by geo-climatic region l

$V_{i,l}$ = WTP/ha of country i by geo-climatic l (from representative case studies)

$S_{i,l}$ = forest area designated to recreation or conservation in country i by geo-climatic region l

$S_{EU,l}$ = forest area designated to recreation or conservation in Europe by geo-climatic region l

i = country

l = geo-climatic region

Data on forest areas designated to recreation and biodiversity conservation by country are taken from FAO/FRA2005. This procedure allows to estimate marginal values corresponding to the main identified geo-climatic regions in Europe.

For the inter-temporal value transfer, finally, the estimated marginal values in 2005 are projected in 2050 using population and PPPGDP growth rates, and taking into account the effect of forest size[13], under different IPCC scenario, as illustrated below:

$$(4) \qquad V_{i,T_1} = V_{i,T_0}\left(\frac{H_{i,T_1}}{H_{i,T_0}}\right)\left(\frac{S_{i,T_0}}{S_{i,T_1}}\right)^{\beta}\left(\frac{PPPGDP_{i,T_1}}{PPPGDP_{i,T_0}}\right)^{\gamma}$$

where:

$V_{i,T1}$ = estimated value/ha/year for country i in year T_1

$V*_{i,00}$ = estimated value/ha/year for country i in year T_0

T_1 = year 2050

T_0 = baseline year 2005

i = country

Finally, by multiplying the WTP estimates V($/ha) for recreational or passive use of forests by the sizes of forest area S that have been designated for recreation or conservation following the different climate change scenarios (See Appendix-Table 10 for the computation results), we can obtain the total recreational or passive use value for each region under each IPCC storyline. For

[13] We assume no variation over time in the percentage of forest area designated to recreation or conservation.

each individual IPCC storyline, the total cultural value of a geo-climatic region is the sum of the respective recreational and passive use value of the forests.

4.4.2 Results

The results of the meta-analyses confirm our expectations both for forest recreation and passive use values: income level and size of forest areas are the main statistically significant factors explaining variation in WTP estimates for changes in forest cultural services (Table 13). The β coefficient on forest recreation size (logSIZE) is negative and significant for both recreation and passive use, showing that the marginal value of these services decreases with a marginal increase in forest area. The coefficient on income γ (logINCOME) is positive and significant, revealing a negative correlation of marginal values and income. The coefficients on passive use values are higher compared with those of recreation, showing a higher sensitivity of forest size and income on marginal values.

Table 13. Results of the meta-regression function for recreational and passive use values

Dependent variable	***Recreation use***		***Passive use***	
	Coefficient (std.error)	T-value	Coefficient (std.error)	T-value
LogWTP				
Explanatory factors:				
constant	3.274 (3.698)	0.89	3. 972 (2.835)	1.40
LogSIZE	-0.445 (0.073)	-6.14	-0.603 (0.079)	-7.58
LogINCOME	0.599 (0.352)	1.70	0.889 (0.255)	3.49
Nobs	59		23	
R^2	0.452		0.797	
Adj R^2	0.433		0.797	

Final results about cultural services show that marginal values might differ widely according to the latitude (or geo-climatic region) where the forest is located (Tables 14 and 15). For recreational values, the highest estimates can be seen in Northern Europe followed by Central-Northern Europe, probably due to the facilities provided for forest recreation in these countries. The lowest values are registered in the Scandinavian countries. For passive use values, instead, the highest estimates are registered in the Mediterranean countries, which have a higher potential for biodiversity and ecosystem conservation. As regards the projected total cultural economic values, Mediterranean Europe appears to have the highest values, followed by Central and Scandinavian Europe (Table 16). Within the same geo-climatic region, climate change might have a different impact on the cultural services provided in the local economy. By comparing the different IPCC scenarios, we can see that total values are generally higher for scenarios B1 and B2 which are environmental oriented than for the economic oriented scenarios (A1 and A2).

Table 14. Projections of marginal recreational values of European forests (US$/ha/yr, measured in 2005).

Scenarios	Mediterranean Europe	Central-Northern Europe	Northern Europe	Scandinavian Europe
Initial 2000	1.06-3.06	0.43-2.61	1.88-7.10	0.16-1.05
A1 2050	1.25-7.87	1.07-8.15	4.17-99.92	0.23-0.53
A2 2050	1.26-7.91	0.68-5.17	4.03-96.55	0.23-0.54
B1 2050	1.20-9.24	0.81-8.08	3.97-124.34	0.27-0.73
B2 2050	1.03-6.77	0.65-4.83	2.97-62.55	0.22-0.44

Table 15. Projections of marginal passive use values of European forests (US$/ha/yr, measured in 2005).

Scenarios	Mediterranean Europe	Northern and Central-Northern Europe	Scandinavian Europe
Initial 2000	356-615	123-182	123-255
A1 2050	898-1,552	361-534	219-454
A2 2050	902-1,558	344-509	220-457
B1 2050	748-1,292	342-506	262-543
B2 2050	678-1,171	230-340	203-421

Table 16. Projection of Cultural Values of European Forest Ecosystem (Million$, 2005)

Scenarios	Mediterranean Europe	Central Europe	Northern Europe	Scandinavian Europe	Europe
A1 2050	3,988	2,123	305	1,204	7,620
A2 2050	4,850	2,475	425	1,185	8,936
B1 2050	9,006	4,270	818	2,993	17,088
B2 2050	8,457	3,108	608	2,223	14,396

Finally, we compare the total values of forest cultural services among the different IPCC scenarios, using scenario A2 as a benchmark for the analysis (Table 17). This scenario is characterized by the largest population and the highest GDP per capita. By comparing the remaining scenarios with the benchmark, we can capture the costs associated with a change from one scenario to another, and from environmental oriented scenarios towards economically oriented scenarios.

Table 17. Comparison of Total Value of Cultural Values for European Forests

Benchmark A2 Scenario		Mediterranean Europe (N35-45)	Central Europe (N45-55)	Northern Europe (N55-65)	Scandinavian Europe (N65-71)	Europe
Absolute value difference (Million$, 2005)	A1vs.A2	-862	-352	-121	18	-1,317
	B1vs.A2	4,156	1,795	393	1,808	8,152
	B2vs.A2	3,607	633	182	1,038	5,460
Change in %	A1vs.A2	-17.8%	-14.2%	-28.3%	1.5%	-14.7%
	B1vs.A2	85.7%	72.5%	92.3%	152.5%	91.2%
	B2vs.A2	74.4%	25.6%	42.9%	87.5%	61.1%

Our comparative analysis of IPCC scenarios shows results which are consistent with our previous findings. For instance, as far as biodiversity and ecosystem conservation are concerned, the A1 scenario is worse off when comparing to the A2 scenarios, an opposite result compare to the ones that we obtained for the provisioning service. This is because the harvesting of the forest resources for WFPs production may result in a reduction of forests available to other uses, such as recreational or educational use of the forests. On the contrary, in all B-type scenarios climate change has positive impacts on the social economy as the management efforts in sustainable development and environmental production may halt or compensate the negative impacts of climate change. This finding therefore suggests that moving from B-type scenarios to A2 scenario will involve costs of policy inaction, because the economic oriented policy may reduce the welfare gain from forest cultural services, such as the enjoyment of natural environment and the knowledge of existence of biodiversity in the forests.

5. Conclusions

This paper reported an original economic valuation of climate change impacts on forest ecosystem goods and services and biodiversity. On one hand, we provide a comprehensive classification, and mapping, of the different European countries according to their contribution in the supply of forest goods and services. The proposed analysis is anchored in the well-known classification proposed by the MA Approach. On the other hand, we investigate in detail the role of each country in the provision of forest provisioning services, regulating services and cultural services.

In order to value the climate change impact, we first identified four different climate scenarios that we refer to the A1FI, A2, B1 and B2 scenarios, which are corresponding to the four IPCC storylines and evaluated here by the year 2050. Secondly, we proceed with the analysis and evaluation of climate change impacts on the total forest area (for each country) as well as on the provisioning quantities (in bio-physical terms) across all the forests goods and services under consideration. The projections of future trends of forest areas and the provision of wood forest products in 2050, in terms of four IPCC storylines, were constructed by exploring the use of global climate models, including HADCM3, and simulating the response of the global climate system to increasing greenhouse gas concentrations. Moreover, considerable impacts of differentiated latitudes on the variability of forest EGS were taken into account by carefully regrouping the 34 selected countries located in different latitude intervals. As a consequence, it enables us not only to identify the respective forest productivity related to predominantly forest types situated in each latitude interval, but also to assess and compare the sensitivity of the differentiated forest types in response to climate change impacts. Both of the two aspects have been included when projecting the future trends of forest areas and forest products flows by 2050, in terms of four IPCC storylines – see Appendix-Table 7 for a summary of the results. Finally, we applied various economic valuation methods (including market and non-market valuation methods, primary and value transfer methods) to estimate the values of the three MA service categories under concern, i.e. the provisioning services, regulating services and cultural services provided by European forests.

Figures 5a-5c summarise the economic valuation results from three different types of ecosystem goods and services provided by forest ecosystem in Europe across four IPCC scenarios.

As we can see, scenario B's are associated to the highest levels of provision in all ecosystem services under consideration, i.e. wood products, carbon sequestration and cultural services. As far as the carbon sequestration services are concerned, we can see that the stock of carbon that is stored in the European regions varies from 37.2 to 45.8 billion dollars in the Mediterranean countries, respectively in the A1 and A2 scenarios, to 63.6 billion, in the B2 scenario, and 66.6 billion in the B1 scenario. Therefore, B1 scenario is ranked as the one with the highest level of provision. The same ranking holds for the Central-North Europe and Northern Europe, where B1 scenario is associated to the provision of 190.3 and 23.5 billion dollars, respectively. Finally, for the Scandinavian group of countries, B1 is ranked with the highest level of provision of carbon sequestration services, amounting to 46.3 billion dollars. In addition, we can see that cultural services provided by forest ecosystems have their highest levels in the Mediterranean countries, ranging from 8.4 to 9.0 million dollars, respectively in the B2 and B1 scenarios, to 3.9 to 4.8 million dollars, in the A1 and A2 scenarios. For the Scandinavian group of countries, B1 is also ranked with the highest level of provision of carbon sequestration services, but now amounting to 2.9 million dollars, followed by the B2 scenario, which is tagged with a total cultural value of 2.2 million dollars. Finally, we can see that the total value of wood forest products ranges between 41.2 and 47.5 million dollars for Central Europe to 5.4 and 7.2 million dollars in the Northern Europe, respectively A1 and A2 scenarios. For this service, the Mediterranean Europe provides a relatively weak role in the provision with values ranging from 6.4 million dollars in A1 scenario to 8.7 million dollars in the B2. In short, we can conclude that the magnitude of the values of forest ecosystem goods and services varies according to the nature of service under consideration, with the carbon sequestration being ranked among the most valuable service. Furthermore, the impact of the climate change on biodiversity, and its welfare evaluation in terms of the respective changes on the provision of forest ecosystem goods and services, is multifaceted. First, it depends on the nature of the forest good and service under consideration. For example, cultural values reveal to be more sensitive to the four IPCC scenarios than the remaining ones, with the wood forest products being the more *resilient* to climate change. Second, the distributional impacts of climate change on the provision of these goods and services do also depend on the geo-climatic regions under consideration. In other words, these impacts are not distributed in a uniform way across the European countries under consideration. This evidence is particularly clear from the analysis of Table 18.

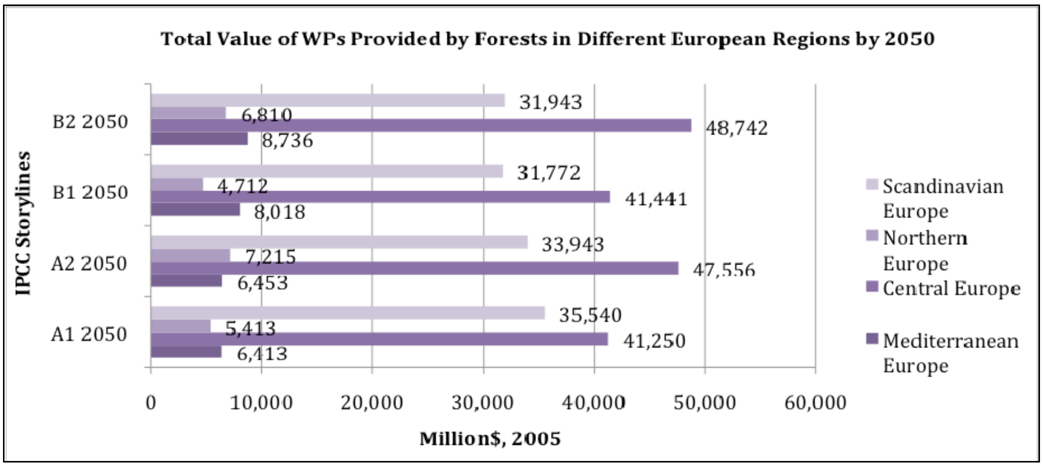

Figure 5a: Forest wood products value

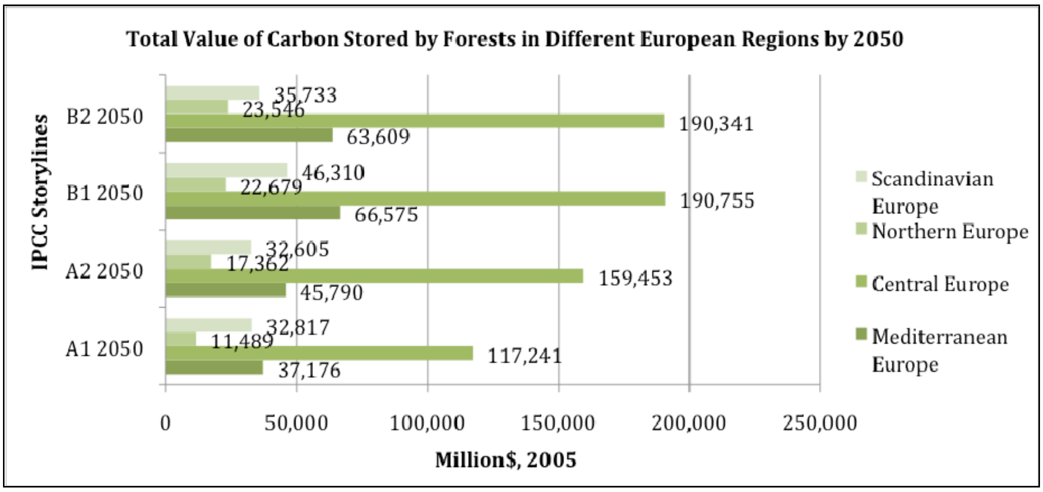

Figure 5b: Forest carbon sequestration values

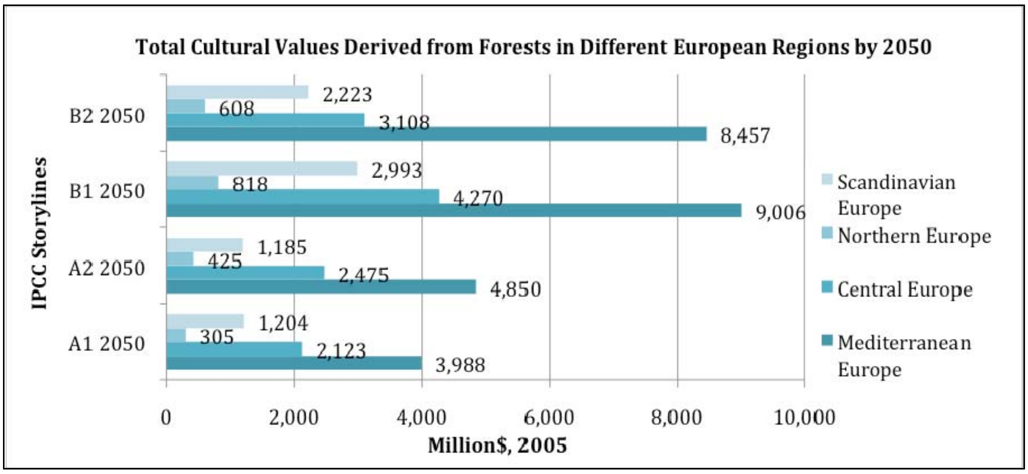

Figure 5c: Forest cultural values

Table 18 depicts the welfare changes associated to a potential deviation from the A2 scenario, which is characterized by a high population, strong economic growth and high income per capita. This scenario is often interpreted by the European Commission as the benchmark scenario and translated by assuming no intentional action in response to global warming. For these reasons, we propose to evaluate the (comparative) welfare changes do to climate change having this scenario as reference. In this context, one can clear see that the countries within the Mediterranean Europe (Greece, Italy, Portugal, Spain, Albania, Bosnia and Herzegovina, Bulgaria, Serbia and Montenegro, Turkey and Yugoslav) is the geo-climatic zone that will benefit the highest welfare gain in moving towards a B1 or B2 storyline. In fact, this geo-climatic can assist to a welfare gain amounting to a 86% increase in the value of cultural values when moving from a A2 towards a B2 scenario. This is followed by an increase of 45% in the value of the carbon sequestration services and 24% increase in the value of the wood provision services. In other words, the no adoption of a B2 storyline, and instead moving towards a A2 scenario, will be associated to a high welfare loss in the Mediterranean Europe due the reduced quantity and quality of the forest ecosystem services under consideration.

Table 18 Comparison of Total Value of Forest Ecosystem Goods and Services in Europe across the four IPCC storylines

		Absolute value difference		(Million$, 2005)	Change in %		
Geographical regions	EGS	A1vs.A2	B1vs.A2	B2vs.A2	A1vs.A2	B1vs.A2	B2vs.A2
Mediterranean Europe (N35-45)	WFPs Provision	-40	1,565	2,283	-1%	24%	35%
	Carbon Stock	-8,614	20,785	17,819	-19%	45%	39%
	Culture Service	-862	4,156	3,607	-18%	86%	74%
Central Europe (N45-55)	WFPs Provision	-6,306	-6,115	1,186	-13%	-13%	2%
	Carbon Stock	-42,212	31,303	30,888	-26%	20%	19%
	Culture Service	-352	1,795	633	-14%	73%	26%
Northern Europe (N55-65)	WFPs Provision	-1,802	-2,503	-405	-25%	-35%	-6%
	Carbon Stock	-5,874	5,317	6,183	-34%	31%	36%
	Culture Service	-121	393	182	-28%	92%	43%
Scandinavian Europe (N65-71)	WFPs Provision	1,597	-2,171	-1,999	5%	-6%	-6%
	Carbon Stock	212	13,705	3,128	1%	42%	10%
	Culture Service	18	1,808	1,038	2%	153%	88%

Alternatively, moving from a A2 towards an A1 scenario will always involve a welfare loss for the Mediterranean Europe. In short, for Mediterranean Europe As scenarios will always be associated to reduced quantity and quality of forest ecosystem services and thus resulting in loss of human welfare. On the contrary, storyline B1 is ranked as the most preferred scenario for this geo-climatic area. On the other hand, Scandinavian Europe (including Finland, Norway and Sweden) presents mixed results. First, moving from an A2 towards an A1 will not involve any welfare loss, on the contrary small welfare gains can be registered, even if not statistically significant from zero. Furthermore, the adoption of any B type scenario will always be associated to a welfare loss when considering the provision of wood products. Finally, Scandinavian Europe will also present significant welfare gains in the provision of the cultural and carbon sequestration services when moving towards a B type scenario. The respective welfare gains are, however, much lower when compared to the Mediterranean Europe, *ceteris paribus*. Having the Mediterranean and the Scandinavian Europe as two 'corner situations', we can observe that Central Europe and Northern Europe present intermediate state of affairs. In any case, it is important to remark that moving from an A2 towards an A1 scenario will be always associated to high welfare losses in all the three services under consideration, having the highest losses registered among the Northern Europe countries (Denmark, United Kingdom, Estonia, Latvia and Lithuania). Unlike the Mediterranean and Scandinavian countries, for Central Europe the B type scenario present mixed results on climate change-caused changes in wood provision services. On the contrary, for Northern Europe this scenario, when compared to A2, always provides lower values on wood provision services, which is a comparable situation to the one of the Scandinavian countries. Finally, both Central Europe and Northern Europe show a similar profile for carbon sequestration and cultural values: any B type scenario is characterized by a welfare gain from the perspective of these two ecosystem services, welfare impact that in accordance to what is also registered in the Mediterranean and Scandinavian Europe.

Finally, and in conclusion, to the authors' knowledge the current paper represents the first systematic attempt to estimate human well-being losses with respect to changes in biodiversity and forest ecosystems services that are directly driven by climate change. However, we acknowledge the complexity in mapping, modeling and estimating the relationships between climate change, biodiversity, ecosystem functioning, ecosystems services and human welfare.

Against this background, we subscribe to the ongoing 'Potsdam Initiative'[14] for biodiversity, also suggesting that it is imperative to continue further with a global study so as to have a better understanding of the linkages between biodiversity and human well being, especially in the context of global change.

[14] At the meeting of the environment ministers of the G8 countries and the five major newly industrialising countries that took place in Potsdam in March 2007, the German government proposed a study on 'The economic significance of the global loss of biological diversity' as part of the so-called 'Potsdam Initiative' for biodiversity. The following was agreed at Potsdam: 'In a global study we will initiate the process of analysing the global economic benefit of biological diversity, the costs of the loss of biodiversity and the failure to take protective measures versus the costs of effective conservation.'

6. References

Australian Government (2004) "Australian Greenhouse Office – Annual Report 2003-2004)"

Barbier, E.B. (1994) "Valuing Environmental Functions: Tropical Wetlands", *Land Economics*, 70(2), pp. 155-173

Bigano, A., Bosello, F., Roson, R. and R.S.J. Tol (2008) "Economy-wide impacts of climate change: a joint analysis for sea level rise and tourism", *Mitigation and Adaptation Strategies for Global Change, Vol. 13, n. 8.*

Berrittella, M., Bigano, A., Roson, R. and R.S.J. Tol (2006), "A general equilibrium analysis of climate change impacts on tourism", *Tourism Management vol 25*.

Bolin B., Sukumar R. et al., 2000. Global perspective. Land use, land-use change, and forestry. In: Watson, R. T. et al. (Eds.). A Special Report of the IPCC. Cambridge University Press, 23-51.

Braden, J. B. and C. D. Kolstad (eds) (1991) "Measuring the Demand for Environment Quality", Elsevier Science Publishers, North-Holland.

Carson, R. T., L. Wilks and D. Imber (1994) "Valuing the Preservation of Australia's Kakadu Conservation Zone", *Oxford Economic Papers*, Oxford, 46(5), pp. 727-749.

Clark, J (2001) "the global wood market, prices and plantation investment: an examination drawing on the Australian experience", Environmental Conservation 28 (1): 53-64

Cline, W.R. (1992) "The Economics of Global Warming", *Institute for International Economics*, Washington, DC.

Costanza Robert, d'Arge Ralph, de Groot Rudolf, Farber Stephen, Grasso Monica, Hannon Bruce, Limburg Karin, Naeem Shahid, O'Neill Robert V., Paruelo Jose, Raskin Robert G., Sutton Paul, van den Belt Marjan (1997) "The value of the world's ecosystem services and natural capital", *Ecological Economics*, 25, pp. 3-15.

DEFRA (2007) "The Social Cost of Carbon and The Shadow Price of Carbon: What They Are, and How to Use Then in Economic Appraisal in the UK", Economics Group of the Department for Environment, Food and Rural Affairs, UK. Available online at:

http://www.opsi.uk/click-use/value-added-licence-information/index.htm

FAO/FRA 2005 (2006), *Global Forest Resources Assessment 2005: Progress towards sustainable forest management,* FAO Forestry Paper no.147, available on website: ftp://ftp.fao.org/docrep/fao/008/A0400E/A0400E00.pdf

Garcia-Gonzalo J., Peltoa H., Gerendiain A. Z., Kellomäki S., 2007. Impacts of forest landscape structure and management on timber production and carbon stocks in the boreal forest ecosystem under changing climate, Forest Ecology and Management, 241: 243-257.

GBA (1995) Global Biodiversity Assessment, published for the United Nation Environment Programme, Cambridge University Press

Giardina, C.P., and M.G., Ryan (2000), 'Evidence that decomposition rates of organic carbon in mineral soil do not vary with temperature', Nature 404: 858-861

Hammitt, J.K. (2000). Valuing mortality risk: theory and practice. *Environmental Science and Technology* 34: 1394–1400.

IEEP – Institute for European Environmental Policy (2006) "Value of Biodiversity: Documenting EU Examples Where Biodiversity Loss Has Led to the Loss of Ecosystem Services", ENV.G.1/FRA/2004/0081, Final Report

IMAGE (2001) Integrated Model to Assess the Global Environment, Netherlands Environmental Assessment Agency – RIVM, available at http://www.rivm.nl/image/

IPCC, 2007. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M.Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

IPPC, 2001. Intergovernmental Panel on Climate Change, Climate Change 2001: The Scientific Basis. Cambridge University Press, Cambridge, UK, pp. 881

Jarvis, P.G. and S., Linder (2000), 'Botany-constraints to growth of boreal forests', Nature 405: 904-905

Lloyd, J. and J.A. Taylor (1994), 'On the temperature dependence of soil respiration', Funct.Ecol.8: 315-323

Luo, Y.Q., Wan, S.Q., Hui, D.F., Wallance, L.L. (2001), 'Acclimatization of soil respiration to warming in a tall grass prairie', Nature 413: 622-625

Markandya, A., Chiabai, A., Ding, H., Nunes P.A.L.D and C. Travisi (2008) " Economic Valuation of Forest Ecosystem Services: Methodology and Monetary Estimates", in "Cost of Policy Inaction" Final report for the European Commission, Brussels, Belgium.

Mäler, K-B. (1988) "Production function approach in developing countries", in Valuing Environmental Benefits in Developing Countries, Vincent et al. (eds), Special Report, Michigan State University, pp. 11-32.

MCPFE and UNECE/FAO (2003) State of Europe's Forests 2003 - Report on Sustainable Forest Management in Europe, Vienna, Austria.

MCPFE (2007), State of Europe's forests 2007: The MCPFE report on sustainable forest management in Europe, Ministerial Conference on the Protection of Forests in Europe, Liaison Unit Warsaw, Poland. ISBN: 83-922396-8-7 or 978-83-922396-8-0

MEA (2003) "Ecosystems and Human Well-being: A Framework for Assessment", World Resources Institute, Washington, D.C.

MEA (2005) "Ecosystems and Human Well-being: Biodiversity Synthesis", World Resources Institute, Ashington, D.C.

Melillo, J.M., McGuire, A.D,, Kicklighter,D.W., Moore III, B., Vorosmarty, C.J., Schloss, A.L. (1993), 'Global climate change and terrestrial net primary production', Nature 363: 234-239

Merlo, M. and L. Croitoru (2005) *Valuing Mediterranean Forests: Towards Total Economic Value*, CABI Publishing-CAB International, Wallingford, Oxfordshire, UK.

Mitchell, R.C. and R.T. Carson (1989), Using Surveys to Value Public Goods: The Contingent Valuation Method (Washington, DC: Resources for the Future).

Nakicenovic N., Swart R., 2000. IPCC Special Report on Emission Scenarios (Cambridge University Press, Cambridge.

NOAA - National Oceanic and Atmospheric Administration (1993) "Report of the NOAA Panel on Contingent Valuation", Federal Register, 58(10), pp. 4601-4614, US.

Nordhaus, W.D (1991a) "A Sketch of the Economics of the Greenhouse Effect", *American Economic Review, Papers and Proceedings* 81: 146-150.

Nordhaus, W.D (1991b) "To Show or Not to Slow: the Economics of the Greenhouse Effect", *Economic Journal* 101: 920-937.

Nordhaus, W.D (1993a) "Optimal Greenhouse Gas Reductions and Tax Policy in the 'DICE' model", *American Economic Review, Papers and Proceedings* 83: 313-317.

Nordhaus, W.D (1993b) "Rolling the 'DICE': an Optimal Transition Path for Controlling Greenhouse Gases", *Resources and Energy Economics* 15: 27-50.

Nunes, P.A.L.D., J.C.J.M. van den Bergh and P. Nijkamp (2003) "The Ecological Economics of Biodiversity: Methods and Policy Applications", Edward Elgar Publishing (UK).

OECD (1999) "Environmental Indicators for Agriculture: Volume 1 Concepts and Frameworks", Organization for Economic Co-operation and Development, Pairs.

Pearce, D. and D. Moran (1994) "The Economic Value of Biodiversity", Earthscan Publications Limited, London, UK.

Perrings, C.A., Mäler, D.-G., Folke, C., Holling, C.S. and B.-O. Jansson (1995) Biodiversity Conservation, Kluwer Academic Publishers, The Netherlands

Riou-Nivert P., 2005. Les temps changent, la forêt doit s'adapter, Forêt-entreprise, 162: 12.

Schöter D. et al., 2004. ATEAM (Advanced Terrestrial Ecosystem Analyses and Modelling) final report (Potsdam Institute for Climate Impact Research, 2004).

Schöter D., Cramer W., Leemans R., Prentice I. C., Araùjo M. B., Arnell N. W., Bondeau A., Bugmann H., Carter T. R., Gracia C. A.,. de la Vega-Leinert A. C, Erhard M., Ewert F., Glendining M., House J. I., Kankaanpää S., Klein R. J. T., Lavorel S., Lindner M., Metzger M. J., Meyer J., Mitchell T. D., Reginster I., Rounsevell M., Sabaté S., Sitch S., Smith B., Smith J., Smith P., Sykes M. T., Thonicke K., Thuiller W., Tuck G., Sönke Zaehle, Bärbel Z., 2005. Ecosystem Service Supply and Vulnerability to global change in Europe. Science, 310: 1333-1337.

Tavoni, M. B. Sohngen, et al. (2007). "Forestry and Carbon Market Market Response to Stablize Climate". *Climate Change Modeling and Policy Working Papers*. Fondazione Eni Enrico Mattei (FEEM):17.

Thuiller W., Lavorel S., Araùjo M. B., Sykes M. T., Prentice I. C., 2005. Climate change threats to plant diversity in Europe. PNAS, vol. 102, n° 23: 8245-8250.

UNECE/FAO, 2005. European Forest Sector Outlook Study, 1960 – 2000 – 2020, Main report, United Nation Publications, pp. 265

Walker B. H., Steffen W. L., Canadell J., IngramJ. S. I. (eds), 1999. The terrestrial biosphere and global change: implication for natural and managed ecosystems. Synthesis volume. IGBP Book Series 4, Cambridge University Press, pp. 450

Appendix – Projections of the forest EGS in 2050 in both physical and monetary terms

Table 1: Projection of European Forest Area (Estimates in 1000 ha)

Latitude	Country	2005[a]	2050 A1FI [b]	2050 A2[b, c]	2050 B1 [b]	2050 B2 [b]
35 to 45	Greece	3 ,752	2,292	2,360	3,762	3,598
	Italy	9,979	8,346	8,253	11,677	11,893
	Portugal	3,783	2,170	2,174	3,254	3,283
	Spain	17,915	12,052	11,969	17,389	17,633
	Albania	794	519	835	918	991
	Bosnia and Herzegovina	2,185	1,476	2,372	2,609	2,817
	Bulgaria	3,625	2,279	3,664	4,030	4,351
	Serbia and Montenegro	2,694	1,789	2,876	3,163	3,415
	Turkey	10,175	6,788	10,912	12,002	12,959
	TFRY Macedonia	906	612	984	1,082	1,168
	Regional Total	55,808	38,324	46,399	59,885	62,108
45 to 55	Austria	3,862	5,298	5,177	5,199	5,471
	Belgium	667	526	545	698	842
	France	15,554	15,094	16,056	20,080	21,926
	Germany	11,076	10,049	10,075	12,696	14,033
	Ireland	669	442	379	638	656
	Luxembourg	87	80	78	103	94
	Netherlands	365	151	421	333	413
	Switzerland	1,221	1,985	1,913	2,113	2,121
	Croatia	2,135	1,438	2,311	2,542	2,745
	Czech Republic	2,648	1,781	2,863	3,149	3,400
	Hungary	1,976	1,288	2,070	2,277	2,458
	Poland	9,192	6,118	9,834	10,816	11,679
	Romania	6,370	4,299	6,911	7,601	8,207
	Slovakia	1,929	1,297	2,085	2,294	2,477
	Slovenia	1,264	837	1,345	1,479	1,597
	Regional Total	59,015	50,682	62,064	72,017	78,118
55 to 65	Denmark	500	414	677	434	839
	UK	2,845	1,986	2,145	2,780	3,476
	Estonia	2,284	1,515	2,435	2,678	2,892
	Latvia	2,941	1,948	3,132	3,445	3,719
	Lithuania	2,099	1,364	2,193	2,412	2,604
	Regional Total	10,669	7,227	10,582	11,749	13,530
65 to 71	Finland	22,500	18,224	17,999	16,517	17,079
	Iceland	46	30	29	28	28
	Norway	9,387	6,478	6,277	5,141	5,761
	Sweden	27,528	22,704	22,198	25,884	22,704
	Regional Total	59,461	47,435	46,503	47,569	45,572

Notes: [a] data from FAO; [b] projections by ATEAM and CLIBIO on the basis of the Integrated Model to Assess the Global Environment (IMAGE), developed by Netherlands Environmental Assessment Agency; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction.

Table 2a. Projections of wood pulp (Estimates in Mt/yr)

Latitude	Country	2005[a]	2050 A1FI [b]	2050 A2[b, c]	2050 B1 [b]	2050 B2 [b]
35 to 45	Greece	0.00	0.32	0.33	0.52	0.50
	Italy	0.52	0.26	0.26	0.33	0.37
	Portugal	1.93	1.52	1.59	1.97	1.99
	Spain	1.97	1.33	1.32	1.72	1.94
	Albania	0.00	0.00	0.00	0.00	0.00
	Bosnia and Herzegovina	0.02	0.01	0.02	0.02	0.02
	Bulgaria	0.14	0.08	0.14	0.14	0.15
	Serbia and Montenegro	0.02	0.02	0.03	0.03	0.03
	Turkey	0.23	0.15	0.24	0.24	0.27
	TFRY Macedonia	0.00	0.00	0.00	0.00	0.00
	Regional Total	4.82	3.68	3.92	4.97	5.27
45 to 55	Austria	1.93	3.25	3.13	2.24	2.98
	Belgium	0.51	0.42	0.44	0.46	0.56
	France	2.50	1.95	2.10	2.26	2.47
	Germany	2.88	2.25	2.25	2.23	2.63
	Ireland	0.00	0.00	0.00	0.00	0.00
	Luxembourg	0.00	0.00	0.00	0.00	0.00
	Netherlands	0.12	0.04	0.16	0.09	0.11
	Switzerland	0.26	0.47	0.45	0.46	0.41
	Croatia	0.10	0.08	0.13	0.08	0.12
	Czech Republic	0.75	0.61	0.99	0.61	0.91
	Hungary	0.00	0.00	0.00	0.00	0.00
	Poland	1.05	0.84	1.36	0.84	1.26
	Romania	0.16	0.13	0.21	0.13	0.20
	Slovakia	0.61	0.49	0.80	0.49	0.74
	Slovenia	0.15	0.12	0.20	0.12	0.18
	Regional Total	10.88	10.53	12.01	9.89	12.39
55 to 65	Denmark	0.00	0.00	0.00	0.00	0.00
	United Kingdom	0.34	0.27	0.32	0.28	0.37
	Estonia	0.07	0.05	0.10	0.06	0.08
	Latvia	0.00	0.00	0.00	0.00	0.00
	Lithuania	0.00	0.00	0.00	0.00	0.00
	Regional Total	0.41	0.33	0.42	0.33	0.45
65 to 71	Finland	11.13	10.93	10.53	8.92	9.74
	Iceland	0.00	0.00	0.00	0.00	0.00
	Norway	2.46	1.51	1.22	1.11	1.28
	Sweden	12.11	12.70	12.25	12.49	11.58
	Regional Total	25.70	25.14	24.00	22.51	22.60

Notes: [a] data from FAO; [b] projections by ATEAM and CLIBIO on the basis of the Integrated Model to Assess the Global Environment (IMAGE), developed by Netherlands Environmental Assessment Agency; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction.

Table 2b. Projections of industrial roundwood (Estimates in million m3/year)

Latitude	Country	2005[a]	2050 A1FI [b]	2050 A2[b, c]	2050 B1 [b]	2050 B2 [b]
35 to 45	Greece	0.52	0.32	0.33	0.52	0.50
	Italy	2.69	1.35	1.33	1.74	1.92
	Portugal	10.51	8.27	8.66	10.71	10.81
	Spain	13.35	8.98	8.92	11.65	13.12
	Albania	0.08	0.05	0.08	0.08	0.09
	Bosnia and Herzegovina	2.44	1.33	2.17	2.15	2.42
	Bulgaria	3.18	1.99	3.25	3.22	3.61
	Serbia and Montenegro	1.32	0.87	1.42	1.40	1.58
	Turkey	11.20	7.42	12.12	12.01	13.50
	TFRY Macedonia	0.00	0.00	0.00	0.00	0.00
	Regional Total	45.28	30.57	38.27	43.49	47.55
45 to 55	Austria	12.79	21.50	20.72	14.85	19.74
	Belgium	4.30	3.55	3.69	3.88	4.75
	France	31.62	24.64	26.50	28.53	31.17
	Germany	50.91	39.82	39.73	39.44	46.58
	Ireland	2.63	1.43	1.19	1.45	1.84
	Luxembourg	0.26	0.24	0.24	0.31	0.29
	Netherlands	0.82	0.31	1.13	0.62	0.77
	Switzerland	3.98	7.09	6.82	7.01	6.18
	Croatia	3.11	2.51	4.08	2.51	3.77
	Czech Republic	14.29	11.51	18.70	11.52	17.30
	Hungary	2.80	2.19	3.56	2.19	3.29
	Poland	28.53	22.75	36.95	22.78	34.19
	Romania	11.54	9.33	15.16	9.34	14.03
	Slovakia	9.01	7.26	11.79	7.26	10.91
	Slovenia	1.79	1.42	2.31	1.42	2.13
	Regional Total	176.58	154.13	190.23	151.69	194.81
55 to 65	Denmark	1.03	0.92	1.88	0.72	1.26
	United Kingdom	8.27	6.67	7.73	6.72	8.88
	Estonia	5.50	4.08	7.60	4.37	6.57
	Latvia	11.89	8.81	16.41	11.44	12.10
	Lithuania	4.92	3.57	6.65	4.64	4.90
	Regional Total	31.60	24.04	40.26	27.89	33.71
65 to 71	Finland	47.12	46.25	44.56	37.74	41.22
	Iceland	0.00	0.00	0.00	0.00	0.00
	Norway	8.49	5.23	4.21	3.82	4.42
	Sweden	91.70	96.18	92.79	94.57	87.69
	Regional Total	147.31	147.66	141.56	136.13	133.33

Notes: [a] data from FAO; [b] projections by ATEAM and CLIBIO on the basis of the Integrated Model to Assess the Global Environment (IMAGE), developed by Netherlands Environmental Assessment Agency; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction.

Table 2c. Projections of recovered paper (Estimates in Mt/yr)

Latitude	Country	2005[a]	2050 A1FI[b]	2050 A2[b, c]	2050 B1[b]	2050 B2[b]
35 to 45	Greece	0.35	0.32	0.33	0.52	0.50
	Italy	5.49	2.76	2.72	3.55	3.92
	Portugal	0.60	0.47	0.49	0.61	0.61
	Spain	4.32	2.91	2.89	3.77	4.25
	Albania	0.00	0.00	0.00	0.00	0.00
	Bosnia and Herzegovina	0.00	0.00	0.00	0.00	0.00
	Bulgaria	0.08	0.05	0.08	0.08	0.09
	Serbia and Montenegro	0.00	0.00	0.00	0.00	0.00
	Turkey	1.02	0.00	0.00	0.00	0.00
	TFRY Macedonia	0.00	0.67	1.10	1.09	1.22
	Regional Total	11.85	7.18	7.61	9.62	10.60
45 to 55	Austria	1.42	7.18	7.61	9.62	10.60
	Belgium	2.14	2.39	2.30	1.65	2.19
	France	5.95	1.77	1.83	1.93	2.36
	Germany	14.41	4.64	4.99	5.37	5.87
	Ireland	0.44	11.27	11.25	11.17	13.19
	Luxembourg	0.06	0.24	0.20	0.24	0.31
	Netherlands	2.46	0.06	0.06	0.07	0.07
	Switzerland	1.24	0.93	3.38	1.87	2.32
	Croatia	0.00	2.42	2.36	1.46	2.04
	Czech Republic	0.48	0.39	0.63	0.39	0.58
	Hungary	0.37	0.29	0.47	0.29	0.43
	Poland	1.20	0.96	1.55	0.96	1.44
	Romania	0.30	0.24	0.39	0.24	0.36
	Slovakia	0.21	0.17	0.28	0.17	0.26
	Slovenia	0.00	0.00	0.00	0.00	0.00
	Regional Total	30.69	25.76	29.68	25.80	31.42
55 to 65	Denmark	0.44	0.39	0.80	0.31	0.53
	United Kingdom	7.76	6.25	7.25	6.30	8.33
	Estonia	0.05	0.04	0.07	0.04	0.06
	Latvia	0.06	0.04	0.08	0.06	0.06
	Lithuania	0.08	0.06	0.11	0.07	0.08
	Regional Total	8.38	6.78	8.31	6.78	9.06
65 to 71	Finland	0.60	0.59	0.57	0.48	0.52
	Iceland	0.01	0.01	0.01	0.01	0.01
	Norway	0.44	0.27	0.22	0.20	0.23
	Sweden	1.57	1.64	1.59	1.62	1.50
	Regional Total	2.62	2.51	2.38	2.30	2.26

Notes: [a] data from FAO; [b] projections by ATEAM and CLIBIO on the basis of the Integrated Model to Assess the Global Environment (IMAGE), developed by Netherlands Environmental Assessment Agency; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction.

Table 2d. Projections of sawnwood (Estimates in Mm3/yr)

Latitude	Country	2005[a]	2050 A1FI [b]	2050 A2[b, c]	2050 B1 [b]	2050 B2 [b]
35 to 45	Greece	0.19	0.32	0.33	0.52	0.50
	Italy	1.59	0.80	0.79	1.03	1.14
	Portugal	1.01	0.80	0.83	1.03	1.04
	Spain	3.66	2.46	2.44	3.19	3.60
	Albania	0.10	0.06	0.10	0.10	0.11
	Bosnia and Herzegovina	1.32	0.72	1.17	1.16	1.30
	Bulgaria	0.57	0.36	0.58	0.58	0.65
	Serbia and Montenegro	0.50	0.33	0.54	0.53	0.60
	Turkey	6.45	4.27	6.97	6.91	7.77
	TFRY Macedonia	0.00	0.00	0.00	0.00	0.00
	Regional Total	15.38	10.11	13.75	15.05	16.70
45 to 55	Austria	11.07	18.62	17.94	12.86	17.10
	Belgium	1.29	1.06	1.10	1.16	1.42
	France	9.95	7.75	8.34	8.98	9.81
	Germany	22.12	17.30	17.26	17.14	20.24
	Ireland	0.89	0.49	0.41	0.49	0.62
	Luxembourg	0.13	0.12	0.12	0.16	0.14
	Netherlands	0.28	0.11	0.38	0.21	0.26
	Switzerland	1.59	2.84	2.73	2.80	2.47
	Croatia	0.62	0.50	0.82	0.50	0.76
	Czech Republic	4.00	3.23	5.24	3.23	4.85
	Hungary	0.22	0.17	0.27	0.17	0.25
	Poland	3.93	3.13	5.09	3.14	4.71
	Romania	4.32	3.49	5.68	3.50	5.25
	Slovakia	2.62	2.11	3.43	2.11	3.17
	Slovenia	0.46	0.37	0.59	0.37	0.55
	Regional Total	63.04	60.93	68.81	56.45	71.07
55 to 65	Denmark	0.20	0.18	0.36	0.14	0.24
	United Kingdom	2.86	2.31	2.68	2.33	3.07
	Estonia	2.20	1.63	3.04	1.75	2.63
	Latvia	4.23	3.13	5.83	4.07	4.30
	Lithuania	1.50	1.09	2.03	1.42	1.50
	Regional Total	10.98	8.33	13.93	9.69	11.74
65 to 71	Finland	12.27	12.04	11.60	9.83	10.73
	Iceland	0.00	0.00	0.00	0.00	0.00
	Norway	2.33	1.44	1.15	1.05	1.21
	Sweden	18.00	18.88	18.21	18.56	17.21
	Regional Total	32.60	32.36	30.97	29.44	29.16

Notes: [a] data from FAO; [b] projections by ATEAM and CLIBIO on the basis of the Integrated Model to Assess the Global Environment (IMAGE), developed by Netherlands Environmental Assessment Agency; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction.

Table 2e. Projections of wood-based panels (Estimates in Mm3/yr)

Latitude	Country	2005[a]	2050 A1FI [b]	2050 A2[b, c]	2050 B1 [b]	2050 B2 [b]
35 to 45	Greece	0.87	0.32	0.33	0.52	0.50
	Italy	5.61	2.82	2.79	3.63	4.01
	Portugal	1.31	1.03	1.08	1.33	1.34
	Spain	4.84	3.26	3.24	4.23	4.76
	Albania	0.04	0.02	0.04	0.04	0.04
	Bosnia and Herzegovina	0.00	0.00	0.00	0.00	0.00
	Bulgaria	0.35	0.22	0.35	0.35	0.39
	Serbia and Montenegro	0.07	0.05	0.08	0.07	0.08
	Turkey	4.77	3.16	5.16	5.12	5.75
	TFRY Macedonia	0.00	0.00	0.00	0.00	0.00
	Regional Total	17.86	10.87	13.06	15.29	16.88
45 to 55	Austria	3.45	5.81	5.60	4.01	5.33
	Belgium	2.80	2.32	2.40	2.53	3.10
	France	6.40	4.99	5.36	5.77	6.31
	Germany	16.98	13.28	13.25	13.15	15.54
	Ireland	0.88	0.48	0.40	0.48	0.61
	Luxembourg	0.45	0.42	0.41	0.53	0.49
	Netherlands	0.01	0.00	0.02	0.01	0.01
	Switzerland	0.97	1.72	1.65	1.70	1.50
	Croatia	0.13	0.10	0.17	0.10	0.16
	Czech Republic	1.49	1.20	1.95	1.20	1.81
	Hungary	0.67	0.53	0.85	0.53	0.79
	Poland	6.74	5.37	8.73	5.38	8.07
	Romania	1.01	0.82	1.33	0.82	1.23
	Slovakia	0.61	0.49	0.79	0.49	0.73
	Slovenia	0.41	0.33	0.53	0.33	0.49
	Regional Total	42.58	37.52	42.91	36.71	45.67
55 to 65	Denmark	0.35	0.31	0.63	0.24	0.42
	United Kingdom	3.40	2.74	3.18	2.76	3.65
	Estonia	0.41	0.30	0.57	0.33	0.49
	Latvia	0.43	0.32	0.59	0.41	0.43
	Lithuania	0.40	0.29	0.54	0.38	0.40
	Regional Total	4.98	3.96	5.50	4.12	5.39
65 to 71	Finland	1.99	1.95	1.88	1.59	1.74
	Iceland	0.00	0.00	0.00	0.00	0.00
	Norway	0.58	0.36	0.29	0.26	0.30
	Sweden	0.75	0.78	0.76	0.77	0.71
	Regional Total	3.31	3.09	2.92	2.62	2.75

Notes: [a] data from FAO; [b] projections by ATEAM and CLIBIO on the basis of the Integrated Model to Assess the Global Environment (IMAGE), developed by Netherlands Environmental Assessment Agency; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction.

Table 2f. Projections of paper and paperboard (Estimates in Mt/yr)

Latitude	Country	2005[a]	2050 A1FI [b]	2050 A2[b, c]	2050 B1 [b]	2050 B2 [b]
35 to 45	Greece	0.53	0.32	0.33	0.52	0.50
	Italy	10.00	5.03	4.96	6.46	7.14
	Portugal	1.58	1.24	1.30	1.61	1.62
	Spain	5.70	3.83	3.81	4.97	5.60
	Albania	0.00	0.00	0.00	0.00	0.00
	Bosnia and Herzegovina	0.08	0.04	0.07	0.07	0.08
	Bulgaria	0.33	0.20	0.33	0.33	0.37
	Serbia and Montenegro	0.23	0.15	0.25	0.24	0.27
	Turkey	1.15	0.76	1.25	1.24	1.39
	TFRY Macedonia	0.00	0.00	0.00	0.00	0.00
	Regional Total	19.60	11.58	12.30	15.45	16.98
45 to 55	Austria	4.95	8.32	8.02	5.75	7.64
	Belgium	1.90	1.57	1.63	1.71	2.10
	France	10.33	8.05	8.66	9.32	10.19
	Germany	21.68	16.96	16.92	16.80	19.84
	Ireland	0.05	0.02	0.02	0.02	0.03
	Luxembourg	0.00	0.00	0.00	0.00	0.00
	Netherlands	3.47	1.32	4.77	2.63	3.27
	Switzerland	1.75	3.12	3.00	3.08	2.72
	Croatia	0.59	0.48	0.78	0.48	0.72
	Czech Republic	0.97	0.78	1.27	0.78	1.17
	Hungary	0.57	0.45	0.72	0.45	0.67
	Poland	2.73	2.18	3.54	2.18	3.27
	Romania	0.37	0.30	0.49	0.30	0.45
	Slovakia	0.86	0.69	1.12	0.69	1.04
	Slovenia	0.56	0.44	0.72	0.44	0.66
	Regional Total	50.22	44.24	50.93	44.20	53.11
55 to 65	Denmark	0.42	0.38	0.77	0.30	0.52
	United Kingdom	6.24	5.03	5.83	5.07	6.70
	Estonia	0.07	0.05	0.09	0.05	0.08
	Latvia	0.04	0.03	0.05	0.04	0.04
	Lithuania	0.11	0.08	0.15	0.11	0.11
	Regional Total	6.88	5.57	6.90	5.56	7.45
65 to 71	Finland	12.39	12.16	11.72	9.93	10.84
	Iceland	0.00	0.00	0.00	0.00	0.00
	Norway	2.22	1.37	1.10	1.00	1.16
	Sweden	11.74	12.31	11.87	12.10	11.22
	Regional Total	26.35	25.84	24.70	23.03	23.22

Notes: [a] data from FAO; [b] projections by ATEAM and CLIBIO on the basis of the Integrated Model to Assess the Global Environment (IMAGE), developed by Netherlands Environmental Assessment Agency; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction.

Table 2g. Projection of woodfuel (Estimates in Mm3/yr)

Latitude	Country	2005[a]	2050 A1FI [b]	2050 A2[b, c]	2050 B1 [b]	2050 B2 [b]
35 to 45	Greece	1.00	0.32	0.33	0.52	0.50
	Italy	5.36	2.69	2.66	3.46	3.83
	Portugal	0.60	0.47	0.49	0.61	0.62
	Spain	2.18	1.47	1.46	1.90	2.14
	Albania	0.22	0.14	0.23	0.23	0.26
	Bosnia and Herzegovina	1.36	0.74	1.21	1.20	1.35
	Bulgaria	2.68	1.67	2.73	2.71	3.04
	Serbia and Montenegro	1.85	1.22	2.00	1.98	2.22
	Turkey	4.98	3.30	5.39	5.34	6.00
	TFRY Macedonia	0.00	0.00	0.00	0.00	0.00
	Regional Total	20.24	12.03	16.50	17.96	19.96
45 to 55	Austria	3.69	6.20	5.97	4.28	5.69
	Belgium	0.65	0.54	0.56	0.59	0.72
	France	2.80	2.18	2.35	2.53	2.76
	Germany	6.04	4.73	4.71	4.68	5.53
	Ireland	0.02	0.01	0.01	0.01	0.01
	Luxembourg	0.01	0.01	0.01	0.02	0.01
	Netherlands	0.29	0.11	0.40	0.22	0.27
	Switzerland	1.07	1.90	1.83	1.88	1.65
	Croatia	0.91	0.61	0.98	1.08	1.17
	Czech Republic	1.23	0.99	1.60	0.99	1.48
	Hungary	3.14	2.45	3.98	2.45	3.68
	Poland	3.41	2.72	4.42	2.72	4.09
	Romania	2.96	2.39	3.89	2.40	3.60
	Slovakia	0.30	0.24	0.39	0.24	0.36
	Slovenia	0.94	0.75	1.22	0.75	1.12
	Regional Total	26.50	25.07	31.09	24.07	31.03
55 to 65	Denmark	1.26	1.13	2.31	0.89	1.54
	United Kingdom	0.32	0.26	0.30	0.26	0.34
	Estonia	1.30	0.96	1.80	1.03	1.55
	Latvia	0.95	0.70	1.31	0.91	0.97
	Lithuania	1.13	0.82	1.53	1.07	1.13
	Regional Total	4.96	3.87	7.24	4.16	5.53
65 to 71	Finland	4.48	4.40	4.24	3.59	3.92
	Iceland	0.00	0.00	0.00	0.00	0.00
	Norway	1.18	0.72	0.58	0.53	0.61
	Sweden	7.00	7.34	7.08	7.22	6.69
	Regional Total	12.66	12.47	11.91	11.34	11.23

Notes: [a] data from FAO; [b] projections by ATEAM and CLIBIO on the basis of the Integrated Model to Assess the Global Environment (IMAGE), developed by Netherlands Environmental Assessment Agency; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction.

Table 3. Projection of carbon stock in European forest (Estimates in Mt/year)

Latitude	Country	1990[a]	2005[b]	2050[d] A1FI	2050[d] A2	2050[d] B1	2050[d] B2
35 to 45	Greece	293.23	305.53	190.46	201.11	368.57	319.44
	Italy	1,315.59	1,389.67	1,186.02	1,200.24	1,826.60	1,770.73
	Portugal	161.08	170.08	99.55	101.92	218.21	169.31
	Spain	987.42	1,076.28	738.83	758.43	1,224.48	1,162.31
	Albania	62.62	64.66	43.15	71.14	89.95	88.03
	Bosnia and Herzegovina	177.93	177.93	122.61	202.14	255.58	250.11
	Bulgaria	274.83	295.19	189.39	312.23	394.78	386.33
	Serbia and Montenegro	215.71	219.38	148.65	245.07	309.86	303.23
	Turkey	818.55	828.57	564.07	929.94	1,175.81	1,150.64
	TFRY Macedonia	73.78	73.78	50.84	83.82	105.98	103.71
	Regional Total	4,380.75	4,601.05	3,333.57	4,106.03	5,969.82	5,703.84
45 to 55	Austria	937.51	943.37	1,454.04	1,440.26	1,549.25	1,562.36
	Belgium	72.87	72.87	64.56	67.19	97.03	103.55
	France	1,702.22	1,724.73	1,880.61	2,135.35	3,134.30	3,099.40
	Germany	1,257.57	1,257.57	1,281.98	1,395.33	2,233.45	2,130.37
	Ireland	71.30	78.33	58.13	51.71	99.80	94.39
	Luxembourg	23.50	23.50	24.40	24.53	31.68	27.03
	Netherlands	52.10	52.82	24.57	69.80	61.58	71.22
	Switzerland	294.63	300.04	547.99	540.40	653.70	620.48
	Croatia	575.06	576.68	436.35	722.68	779.21	788.89
	Czech Republic	712.27	715.24	540.47	895.12	965.14	977.12
	Hungary	515.09	533.73	390.85	647.32	697.96	706.63
	Poland	2,446.89	2,482.82	1,856.69	3,075.03	3,315.58	3,356.76
	Romania	1,719.50	1,720.58	1,304.75	2,160.91	2,329.95	2,358.88
	Slovakia	518.87	521.03	393.72	652.07	703.08	711.81
	Slovenia	334.66	341.41	253.94	420.57	453.47	459.10
	Regional Total	11,234.04	11,344.72	10,513.04	14,298.25	17,105.17	17,068.00
55 to 65	Denmark	60.92	62.68	53.44	91.68	71.13	121.77
	United Kingdom	409.39	417.01	300.10	334.64	498.37	568.02
	Estonia	304.98	310.55	212.33	354.77	459.44	446.08
	Latvia	392.27	399.88	273.10	456.31	590.95	573.76
	Lithuania	274.66	285.40	191.22	319.50	413.77	401.73
	Regional Total	1,442.21	1,475.52	1,030.20	1,556.89	2,033.65	2,111.36
65 to 71	Finland	1,040.16	1,041.32	869.50	903.69	1,219.41	991.76
	Norway	786.34	793.61	564.61	560.76	511.91	535.89
	Sweden	1,770.79	1,774.27	1,508.58	1,459.27	2,421.32	1,676.58
	Regional Total	3,597.29	3,609.20	2,942.69	2,923.71	4,152.64	3,204.23

Notes: [a] data from Karjalainen et al. (2003) and Advanced Terrestrial Ecosystem Analysis and Modelling (ATEAM), PIK; [b] EIBURS projections ; [c] projections by Karjalainen et al. (2003); [d] projections by ATEAM and EIBURS need to add the Finland study.

Table 4a. Economic value of wood pulp (Estimates in $/ha/year, $2005)

Latitude	Country	2005[a]	2050 A1FI [b]	2050 A2[b, c]	2050 B1 [b]	2050 B2 [b]
35 to 45	Greece	n.a.	n.a.	n.a.	n.a.	n.a.
	Italy	1.56	0.94	0.94	0.86	0.94
	Portugal	102.35	140.45	146.85	121.32	121.40
	Spain	29.49	29.48	29.48	26.52	29.45
	Albania	n.s.	n.s.	n.s.	n.s.	n.s.
	Bosnia and Herzegovina	n.s.	n.s.	n.s.	n.s.	n.s.
	Bulgaria	6.88	8.43	8.31	5.93	7.50
	Serbia and Montenegro	0.09	0.09	0.09	0.08	0.08
	Turkey	0.02	0.02	0.02	0.02	0.02
	TFRY Macedonia	n.s.	n.s.	n.s.	n.s.	n.s.
	Regional Average	16.25	19.66	16.54	16.01	16.56
45 to 55	Austria	33.80	41.43	40.86	29.16	36.85
	Belgium	590.07	618.64	412.76	339.12	344.33
	France	15.63	12.55	12.69	10.93	10.93
	Germany	38.92	33.55	33.39	26.31	28.11
	Ireland	n.s.	n.s.	n.s.	n.s.	n.s.
	Luxembourg	n.s.	n.s.	n.s.	n.s.	n.s.
	Netherlands	865.81	794.10	1,031.84	721.28	721.20
	Switzerland	70.23	77.01	76.84	71.49	62.80
	Croatia	6.24	5.84	6.07	5.05	5.12
	Czech Republic	65.77	61.57	63.95	53.22	53.88
	Hungary	n.s.	n.s.	n.s.	n.s.	n.s.
	Poland	2.28	2.13	2.21	1.84	1.86
	Romania	0.95	0.89	0.93	0.77	0.78
	Slovakia	23.77	29.13	28.73	20.50	25.91
	Slovenia	16.98	15.89	16.51	13.74	13.91
	Regional Average	31.89	32.16	34.38	24.13	26.27
55 to 65	Denmark	n.s.	n.s.	n.s.	n.s.	n.s.
	United Kingdom	0.96	1.11	1.19	0.80	0.85
	Estonia	n.a.	n.a.	n.a.	0.00	n.a.
	Latvia	n.s.	n.s.	n.s.	0.00	n.s.
	Lithuania	n.s.	n.s.	n.s.	n.s.	n.s.
	Regional Average	0.29	0.43	0.28	0.22	0.26
65 to 71	Finland	45.60	55.26	53.91	49.75	52.56
	Iceland	n.s.	n.s.	n.s.	n.s.	n.s.
	Norway	39.79	35.52	29.48	32.70	33.75
	Sweden	68.66	87.32	86.15	75.30	79.60
	Regional Average	55.32	90.20	87.33	81.53	84.41

Notes: [a] data from FAO; [b] EIBURS projections; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction; n.a. not available; n.s. not significant

Table 4b. Economic value of industrial roundwood (Estimates in $/ha/year, $2005)

Latitude	Country	2005[a]	2050 A1FI [b]	2050 A2[b, c]	2050 B1 [b]	2050 B2 [b]
35 to 45	Greece	0.01	0.02	0.02	0.02	0.02
	Italy	0.67	0.37	0.37	0.34	0.36
	Portugal	22.63	37.34	39.05	32.26	32.28
	Spain	0.78	0.77	0.77	0.70	0.77
	Albania	0.18	0.23	0.15	0.18	0.17
	Bosnia and Herzegovina	3.92	9.29	5.57	3.63	4.47
	Bulgaria	5.16	9.66	5.79	3.78	4.65
	Serbia and Montenegro	2.84	3.34	2.17	2.84	2.62
	Turkey	0.28	0.35	0.22	0.26	0.25
	TFRY Macedonia	n.s.	n.s.	n.s.	n.s.	n.s.
	Regional Average	2.48	3.59	3.03	2.64	2.72
45 to 55	Austria	20.59	18.81	18.55	13.24	16.73
	Belgium	138.03	175.94	117.39	96.44	97.93
	France	16.76	11.77	11.90	10.24	10.25
	Germany	40.66	34.32	34.15	26.91	28.75
	Ireland	19.65	17.61	17.13	12.37	15.22
	Luxembourg	193.71	195.07	194.93	194.38	194.58
	Netherlands	61.83	103.89	135.00	94.37	94.36
	Switzerland	95.31	62.05	61.91	57.60	50.59
	Croatia	17.57	22.89	17.72	15.64	16.03
	Czech Republic	67.52	88.29	68.35	60.32	61.82
	Hungary	29.62	36.67	28.39	25.06	25.68
	Poland	4.56	5.87	4.54	4.01	4.11
	Romania	2.27	2.98	2.31	2.04	2.09
	Slovakia	49.69	94.39	56.58	36.87	45.41
	Slovenia	20.12	25.30	19.58	17.28	17.71
	Regional Average	25.48	25.78	22.44	18.33	19.20
55 to 65	Denmark	87.92	100.33	148.98	89.39	80.45
	United Kingdom	14.66	23.62	21.34	14.32	15.13
	Estonia	41.71	67.97	68.94	34.21	49.28
	Latvia	62.65	101.85	103.30	51.26	73.84
	Lithuania	27.16	44.20	44.82	22.24	32.04
	Regional Average	39.57	62.28	69.58	34.08	45.87
65 to 71	Finland	2.86	4.65	4.54	4.19	4.42
	Iceland	n.s.	n.s.	n.s.	n.s.	n.s.
	Norway	3.05	4.79	3.98	4.41	4.55
	Sweden	6.33	10.24	10.10	8.83	9.33
	Regional Average	4.49	7.34	7.11	6.73	6.88

Notes: [a] data from FAO; [b] EIBURS projections; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction; n.a. not available; n.s. not significant

Table 4c. Economic value of recovered paper (Estimates in $/ha/year, $2005)

Latitude	Country	2005[a]	2050 A1FI [b]	2050 A2[b, c]	2050 B1 [b]	2050 B2 [b]
35 to 45	Greece	3.60	3.60	3.60	3.60	3.60
	Italy	8.27	4.97	4.96	4.57	4.96
	Portugal	7.29	1n.s.	10.46	8.64	8.64
	Spain	3.40	3.40	3.40	3.06	3.40
	Albania	n.s.	n.s.	n.s.	n.s.	n.s.
	Bosnia and Herzegovina	n.s.	n.s.	n.s.	n.s.	n.s.
	Bulgaria	0.02	0.03	0.03	0.02	0.02
	Serbia and Montenegro	n.s.	n.s.	n.s.	n.s.	n.s.
	Turkey	0.03	0.03	0.03	0.03	0.03
	TFRY Macedonia	n.s.	n.a.	n.a.	n.a.	n.a.
	Regional Average	3.15	2.98	2.48	2.52	2.61
45 to 55	Austria	7.40	9.07	8.94	6.38	8.07
	Belgium	358.45	375.81	250.74	206.01	209.17
	France	12.94	10.39	10.51	9.05	9.05
	Germany	31.41	27.08	26.95	21.23	22.69
	Ireland	83.27	68.56	66.68	48.15	59.28
	Luxembourg	50.28	50.38	50.35	50.20	50.26
	Netherlands	905.42	830.43	1,079.05	754.28	754.20
	Switzerland	36.79	40.34	40.26	37.45	32.90
	Croatia	n.a.	n.a.	n.a.	n.a.	n.a.
	Czech Republic	7.52	7.04	7.32	6.09	6.17
	Hungary	3.38	3.16	3.29	2.73	2.77
	Poland	3.06	2.86	2.98	2.48	2.51
	Romania	0.09	0.08	0.08	0.07	0.07
	Slovakia	1.88	2.30	2.27	1.62	2.05
	Slovenia	n.s.	n.s.	n.s.	n.s.	n.s.
	Regional Average	22.38	20.64	25.56	17.05	18.68
55 to 65	Denmark	108.69	117.50	146.88	88.13	79.31
	United Kingdom	177.73	205.26	220.34	147.77	156.21
	Estonia	2.02	2.26	2.62	1.66	1.63
	Latvia	1.02	1.14	1.32	0.84	0.82
	Lithuania	0.61	0.68	0.79	0.50	0.49
	Regional Average	53.32	87.10	65.70	45.87	54.27
65 to 71	Finland	1.10	1.34	1.30	1.20	1.27
	Iceland	6.87	7.73	7.28	6.89	7.24
	Norway	2.76	2.47	2.05	2.27	2.34
	Sweden	1.28	1.63	1.60	1.40	1.48
	Regional Average	1.45	2.28	2.15	1.97	2.11

Notes: [a] data from FAO; [b] EIBURS projections; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction; n.a. not available; n.s. not significant

Table 4d. Economic value of sawnwood (Estimates in $/ha/year, $2005)

Latitude	Country	2005[a]	2050 A1FI[b]	2050 A2[b, c]	2050 B1[b]	2050 B2[b]
35 to 45	Greece	1.81	1.81	1.81	1.81	1.81
	Italy	12.62	7.58	7.58	6.97	7.56
	Portugal	19.58	26.88	28.10	23.22	23.23
	Spain	2.76	2.76	2.76	2.49	2.76
	Albania	5.42	5.38	5.47	4.93	5.13
	Bosnia and Herzegovina	64.75	79.37	78.26	55.85	70.59
	Bulgaria	9.93	12.17	12.00	8.57	10.83
	Serbia and Montenegro	16.15	16.04	16.29	14.69	15.28
	Turkey	1.41	1.40	1.42	1.28	1.33
	TFRY Macedonia	n.s.	n.s.	n.s.	n.s.	n.s.
	Regional Average	8.40	11.50	9.41	7.39	8.19
45 to 55	Austria	384.74	471.59	465.02	331.85	419.42
	Belgium	625.39	655.66	437.47	359.42	364.94
	France	24.70	19.83	20.05	17.26	17.27
	Germany	145.36	125.32	124.71	98.25	104.99
	Ireland	101.69	83.73	81.44	58.80	72.39
	Luxembourg	128.85	129.12	129.03	128.67	128.80
	Netherlands	545.68	500.48	650.32	454.59	454.54
	Switzerland	37.06	40.63	40.55	37.72	33.13
	Croatia	71.22	66.67	69.25	57.63	58.35
	Czech Republic	124.31	116.37	120.88	100.59	101.85
	Hungary	34.17	31.99	33.23	27.65	28.00
	Poland	19.21	17.98	18.68	15.54	15.74
	Romania	79.43	74.35	77.23	64.27	65.07
	Slovakia	130.64	160.13	157.90	112.68	142.42
	Slovenia	64.45	60.33	62.67	52.15	52.81
	Regional Average	98.03	108.13	95.41	70.80	78.50
55 to 65	Denmark	109.74	118.64	148.29	88.98	80.08
	United Kingdom	38.67	44.66	47.94	32.15	33.99
	Estonia	106.66	119.24	138.18	87.58	85.79
	Latvia	189.99	212.41	246.14	156.01	152.81
	Lithuania	95.41	106.67	123.61	78.35	76.74
	Regional Average	109.43	173.30	189.22	94.61	126.62
65 to 71	Finland	71.84	87.07	84.94	78.39	82.81
	Iceland	n.s.	n.s.	n.s.	n.s.	n.s.
	Norway	10.06	8.98	7.45	8.27	8.53
	Sweden	103.43	131.53	129.78	113.43	119.92
	Regional Average	76.66	127.15	124.72	116.63	119.56

Notes: [a] data from FAO; [b] EIBURS projections; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction; n.a. not available; n.s. not significant

Table 4e. Economic value of woodbased panels (Estimates in $/ha/year, $2005)

Latitude	Country	2005[a]	2050 A1FI [b]	2050 A2[b, c]	2050 B1 [b]	2050 B2 [b]
35 to 45	Greece	15.89	15.89	15.89	15.89	15.89
	Italy	54.97	33.03	32.99	30.35	32.94
	Portugal	69.76	95.74	100.10	82.70	82.75
	Spain	37.17	37.16	37.16	33.42	37.12
	Albania	n.a.	n.a.	n.a.	n.a.	n.a.
	Bosnia and Herzegovina	7.07	6.74	6.89	6.10	7.71
	Bulgaria	25.85	31.68	31.24	22.29	28.18
	Serbia and Montenegro	4.45	4.42	4.48	4.04	4.21
	Turkey	13.62	13.53	13.74	12.39	12.89
	TFRY Macedonia	n.s.	n.s.	n.s.	n.s.	n.s.
	Regional Average	30.45	32.27	26.74	25.77	27.17
45 to 55	Austria	299.23	366.78	361.67	258.10	326.20
	Belgium	1,550.94	1,626.02	1,084.90	891.35	905.04
	France	68.95	55.37	55.99	48.19	48.22
	Germany	238.34	205.48	204.47	161.09	172.15
	Ireland	437.58	360.28	350.44	253.02	311.51
	Luxembourg	935.74	937.72	937.06	934.41	935.40
	Netherlands	369.83	339.19	440.75	308.09	308.06
	Switzerland	251.11	275.34	274.75	255.60	224.52
	Croatia	31.85	29.82	30.97	25.77	26.10
	Czech Republic	95.17	89.09	92.55	77.01	77.98
	Hungary	79.14	74.08	76.96	64.04	64.84
	Poland	83.11	77.80	80.81	67.25	68.09
	Romania	38.31	35.86	37.26	31.00	31.39
	Slovakia	62.83	77.01	75.94	54.19	68.49
	Slovenia	105.95	99.18	103.03	85.73	86.81
	Regional Average	143.31	147.03	123.51	99.57	107.17
55 to 65	Denmark	147.78	159.76	199.70	119.82	107.84
	United Kingdom	65.68	75.86	81.43	54.61	57.73
	Estonia	47.47	53.07	61.50	38.98	38.18
	Latvia	54.90	61.38	71.12	45.08	44.16
	Lithuania	24.63	27.54	31.91	20.23	19.81
	Regional Average	54.58	86.57	88.67	46.91	61.16
65 to 71	Finland	38.95	47.20	46.05	42.50	44.89
	Iceland	n.s.	n.s.	n.s.	n.s.	n.s.
	Norway	10.47	9.34	7.75	8.60	8.88
	Sweden	2.93	3.73	3.68	3.22	3.40
	Regional Average	17.75	28.88	28.02	23.69	26.73

Notes: [a] data from FAO; [b] EIBURS projections; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction; n.a. not available; n.s. not significant

Table 4f. Economic value of paper and paperboard (Estimates in $/ha/year, $2005)

Latitude	Country	2005[a]	2050 A1FI [b]	2050 A2[b, c]	2050 B1 [b]	2050 B2 [b]
35 to 45	Greece	15.38	15.38	15.38	15.38	15.38
	Italy	245.11	147.28	147.11	135.33	146.86
	Portugal	269.59	369.96	386.82	319.58	319.77
	Spain	112.38	112.35	112.35	101.06	112.24
	Albania	n.s.	n.s.	n.s.	n.s.	n.s.
	Bosnia and Herzegovina	10.53	12.90	12.72	9.08	11.48
	Bulgaria	21.48	26.33	25.96	18.53	23.41
	Serbia and Montenegro	27.21	27.02	27.44	24.74	25.74
	Turkey	9.80	9.74	9.89	8.91	9.27
	TFRY Macedonia	n.s.	n.s.	n.s.	n.s.	n.s.
	Regional Average	98.44	97.00	80.62	79.47	83.24
45 to 55	Austria	784.74	961.90	948.49	676.88	855.48
	Belgium	3,941.70	4,132.52	2,757.27	2,265.35	2,300.15
	France	323.32	259.64	262.54	225.96	226.12
	Germany	1,007.18	868.32	864.06	680.74	727.46
	Ireland	113.45	93.40	90.85	65.60	80.76
	Luxembourg	n.s.	n.s.	n.s.	n.s.	n.s.
	Netherlands	7,362.62	6,752.78	8,774.50	6,133.54	6,132.89
	Switzerland	1,148.93	1,259.79	1,257.07	1,169.44	1,027.28
	Croatia	26.90	25.18	26.16	21.77	22.04
	Czech Republic	227.07	212.56	220.81	183.74	186.04
	Hungary	197.81	185.17	192.35	160.06	162.07
	Poland	118.69	111.11	115.42	96.04	97.25
	Romania	11.68	10.94	11.36	9.46	9.57
	Slovakia	262.27	321.48	317.00	226.22	285.91
	Slovenia	323.68	303.00	314.75	261.91	265.20
	Regional Average	495.49	487.19	472.55	352.27	380.78
55 to 65	Denmark	469.47	507.54	634.42	380.65	342.59
	United Kingdom	637.08	735.78	789.82	529.71	559.96
	Estonia	22.26	24.89	28.84	18.28	17.91
	Latvia	19.84	22.18	25.70	16.29	15.96
	Lithuania	19.06	21.31	24.69	15.65	15.33
	Regional Average	205.87	334.83	263.56	176.94	211.92
65 to 71	Finland	375.95	455.64	444.51	410.23	433.36
	Iceland	n.s.	n.s.	n.s.	n.s.	n.s.
	Norway	132.38	118.16	98.08	108.79	112.28
	Sweden	296.77	377.42	372.39	325.49	344.09
	Regional Average	300.55	493.29	480.48	437.27	461.16

Notes: [a] data from FAO; [b] EIBURS projections; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction; n.a. not available; n.s. not significant

Table 4g. Economic value of wood fuel (Estimates in $/ha/year, $2005)

Latitude	Country	2005[a]	2050 A1FI[b]	2050 A2[b, c]	2050 B1[b]	2050 B2[b]
35 to 45	Greece	0.28	0.28	0.28	0.28	0.28
	Italy	0.01	0.01	0.01	0.01	0.01
	Portugal	0.16	0.21	0.22	0.18	0.18
	Spain	0.30	0.30	0.30	0.27	0.30
	Albania	1.33	1.32	1.34	1.21	1.26
	Bosnia and Herzegovina	4.73	5.80	5.72	4.08	5.16
	Bulgaria	1.36	1.67	1.64	1.17	1.48
	Serbia and Montenegro	0.01	0.01	0.01	0.01	0.01
	Turkey	n.s.	n.s.	n.s.	n.s.	n.s.
	TFRY Macedonia	n.s.	n.s.	n.s.	n.s.	n.s.
	Regional Average	0.40	0.65	0.53	0.35	0.42
45 to 55	Austria	20.59	25.23	24.88	17.76	22.44
	Belgium	2.37	2.49	2.41	1.36	1.38
	France	0.84	0.67	0.68	0.59	0.59
	Germany	0.14	0.12	0.12	0.10	0.10
	Ireland	0.06	0.05	0.05	0.03	0.04
	Luxembourg	14.13	14.16	14.15	14.11	14.12
	Netherlands	5.51	5.05	6.56	4.59	4.59
	Switzerland	1.32	1.44	1.44	1.34	1.18
	Croatia	4.62	4.32	4.49	3.74	3.78
	Czech Republic	4.84	4.53	4.71	3.92	3.97
	Hungary	6.46	6.05	6.28	5.23	5.29
	Poland	0.51	0.48	0.50	0.42	0.42
	Romania	0.46	0.43	0.44	0.37	0.37
	Slovakia	0.09	0.10	0.10	0.07	0.09
	Slovenia	5.92	5.54	5.75	4.79	4.85
	Regional Average	2.56	3.14	2.74	1.94	2.17
55 to 65	Denmark	6.35	6.86	8.58	5.15	4.63
	United Kingdom	2.10	2.42	2.60	1.75	1.85
	Estonia	2.99	3.34	3.87	2.46	2.41
	Latvia	3.75	4.19	4.85	3.08	3.01
	Lithuania	1.52	1.70	1.97	1.25	1.22
	Regional Average	2.83	4.47	4.79	2.44	3.23
65 to 71	Finland	0.02	0.03	0.03	0.02	0.03
	Iceland	n.s.	n.s.	n.s.	n.s.	n.s.
	Norway	0.01	0.01	0.01	0.01	0.01
	Sweden	0.10	0.12	0.12	0.11	0.11
	Regional Average	0.05	0.09	0.09	0.09	0.09

Notes: [a] data from FAO; [b] EIBURS projections; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction; n.a. not available; n.s. not significant

Table 5. Total economic value of wood forest products (Estimates in $/ha/year, $2005)

Latitude	Country	2005[a]	2050 A1FI [b]	2050 A2[b, c]	2050 B1 [b]	2050 B2 [b]
35 to 45	Greece	38	44	44	44	44
	Italy	323	176	175	161	175
	Portugal	491	811	848	700	701
	Spain	186	184	184	165	183
	Albania	8	11	7	8	7
	Bosnia and Herzegovina	75	173	104	69	85
	Bulgaria	71	132	79	52	64
	Serbia and Montenegro	51	60	39	51	47
	Turkey	25	32	20	23	23
	TFRY Macedonia	0	0	0	0	0
	Regional Average	160	168	139	134	141
45 to 55	Austria	1,551	1,418	1,398	997	1,261
	Belgium	7,207	9,186	6,130	5,036	5,113
	France	463	325	329	283	283
	Germany	1,502	1,268	1,262	994	1,062
	Ireland	756	677	659	476	586
	Luxembourg	2,485	1,332	1,331	1,327	1,329
	Netherlands	10,117	16,999	22,088	15,440	15,439
	Switzerland	1,641	1,068	1,066	991	871
	Croatia	160	206	160	141	145
	Czech Republic	592	774	599	529	542
	Hungary	351	434	336	297	304
	Poland	231	297	230	203	208
	Romania	133	175	135	119	122
	Slovakia	531	1,009	605	394	485
	Slovenia	541	675	523	461	473
	Regional Average	819	824	777	584	633
55 to 65	Denmark	930	1,061	1,576	945	851
	United Kingdom	937	1,509	1,364	915	967
	Estonia	223	364	369	183	264
	Latvia	332	540	548	272	391
	Lithuania	168	274	278	138	199
	Regional Average	466	749	682	401	503
65 to 71	Finland	536	873	852	786	830
	Iceland	17	14	13	12	13
	Norway	199	312	259	287	296
	Sweden	479	775	765	669	707
	Regional Average	456	749	730	668	701

Notes: [a] data from FAO; [b] EIBURS projections; [c] interpreted by the European Commission as the baseline scenario, i.e. the scenario characterized by policy inaction; n.a. not available; n.s. not significant

Table 6. Economic value of carbon sequestration (Estimates in $/ha/year, $2005)

Latitude	Country	2005[a]	2050 A1FI [b]	2050 A2[b, c]	2050 B1 [b]	2050 B2 [b]
35 to 45	Greece	1,629	927	950	1,093	990
	Italy	2,785	1,585	1,622	1,744	1,660
	Portugal	899	512	523	748	575
	Spain	1,202	684	707	785	735
	Albania	1,629	927	950	1,093	990
	Bosnia and Herzegovina	1,321	927	950	1,093	990
	Bulgaria	1,629	927	950	1,093	990
	Serbia and Montenegro	1,629	927	950	1,093	990
	Turkey	1,629	927	950	1,093	990
	TFRY Macedonia	407	927	950	1,093	990
	Regional Average	1,476	927	950	1,093	990
45 to 55	Austria	4,885	3,061	3,102	3,323	3,185
	Belgium	2,185	1,369	1,374	1,551	1,371
	France	2,218	1,389	1,483	1,741	1,576
	Germany	2,271	1,423	1,544	1,962	1,693
	Ireland	2,342	1,467	1,523	1,744	1,605
	Luxembourg	5,402	3,385	3,487	3,418	3,205
	Netherlands	2,894	1,813	1,851	2,065	1,923
	Switzerland	4,915	3,079	3,150	3,450	3,263
	Croatia	5,402	3,384	3,487	3,418	3,205
	Czech Republic	5,402	3,384	3,487	3,418	3,205
	Hungary	5,402	3,385	3,487	3,418	3,205
	Poland	5,402	3,384	3,487	3,418	3,205
	Romania	5,402	3,384	3,487	3,418	3,205
	Slovakia	5,402	3,384	3,487	3,418	3,205
	Slovenia	5,402	3,385	3,487	3,418	3,205
	Regional Average	4,328	2,712	2,795	2,879	2,684
55 to 65	Denmark	2,507	1,441	1,510	1,827	1,618
	United Kingdom	2,932	1,685	1,740	1,999	1,822
	Estonia	2,719	1,563	1,625	1,913	1,720
	Latvia	2,719	1,563	1,625	1,913	1,720
	Lithuania	2,719	1,563	1,625	1,913	1,720
	Regional Average	2,719	1,563	1,625	1,913	1,720
65 to 71	Finland	926	532	560	823	648
	Norway	1,691	972	996	1,111	1,037
	Sweden	1,289	741	733	1,043	824
	Regional Average	1,302	748	763	992	836

Notes: [a] projections by Tavoni et al. (2007).
[b] projections by CLIBIO based on CASES (reference)

Table 7. A comparison of the physical changes of forest areas, forestry production and carbon stock under IPCC storylines in 2050

Physical indicators	Latitude classification	A1 vs. A2 (2050)	B1 vs. A2 (2050)	B2 vs. A2 (2050)
Extent of forest area	Mediterranean Europe	82.6%	129.1%	133.9%
	Central-Northern Europe	81.7%	116.0%	125.9%
	Northern Europe	68.3%	111.0%	127.9%
	Scandinavian Europe	102.0%	102.3%	98.0%
Production of industrial roundwood	Mediterranean Europe	79.9%	113.6%	124.2%
	Central-Northern Europe	81.0%	79.7%	102.4%
	Northern Europe	59.7%	69.3%	83.7%
	Scandinavian Europe	104.3%	96.2%	94.2%
Production of wood pulp	Mediterranean Europe	94.0%	126.8%	134.4%
	Central-Northern Europe	87.7%	82.4%	103.2%
	Northern Europe	78.7%	80.1%	108.3%
	Scandinavian Europe	104.8%	93.8%	94.2%
Production of recovered paper	Mediterranean Europe	94.3%	126.4%	139.2%
	Central-Northern Europe	86.8%	86.9%	105.8%
	Northern Europe	81.6%	81.6%	109.1%
	Scandinavian Europe	105.6%	96.8%	95.0%
Production of sawnwood	Mediterranean Europe	73.5%	109.4%	121.4%
	Central-Northern Europe	88.5%	82.0%	103.3%
	Northern Europe	59.8%	69.6%	84.2%
	Scandinavian Europe	104.5%	95.0%	94.2%
Production of wood-based panels	Mediterranean Europe	83.3%	117.1%	129.3%
	Central-Northern Europe	87.4%	85.6%	106.4%
	Northern Europe	71.9%	74.8%	98.0%
	Scandinavian Europe	105.8%	89.8%	94.3%
Production of paper and paper board	Mediterranean Europe	94.2%	125.6%	138.1%
	Central-Northern Europe	86.9%	86.8%	104.3%
	Northern Europe	80.6%	80.6%	107.9%
	Scandinavian Europe	104.6%	93.2%	94.0%
Production of wood fuel	Mediterranean Europe	72.9%	108.9%	121.0%
	Central-Northern Europe	80.6%	77.4%	99.8%
	Northern Europe	53.5%	57.5%	76.4%
	Scandinavian Europe	104.7%	95.2%	94.3%
Carbon stock	Mediterranean Europe	78.0%	119.6%	120.7%
	Central-Northern Europe	74.3%	110.6%	78.8%
	Northern Europe	61.7%	104.0%	87.7%
	Scandinavian Europe	98.4%	130.3%	106.9%

Table 8. A comparison of total economic value ($/yr) changes derived from Forest EGS under IPCC storylines in 2050

Forest EGS	Geographical groupings	A1 vs. A2 (2050)	B1 vs. A2 (2050)	B2 vs. A2 (2050)
Industrial roundwood	Mediterranean Europe	98.0%	112.5%	120.5%
	Central-Northern Europe	93.8%	94.8%	107.7%
	Northern Europe	61.1%	54.4%	84.3%
	Scandinavian Europe	105.3%	182.4%	94.8%
Wood pulp	Mediterranean Europe	96.7%	125.2%	135.3%
	Central-Northern Europe	82.1%	86.1%	100.2%
	Northern Europe	86.2%	86.9%	114.9%
	Scandinavian Europe	104.9%	95.8%	94.5%
Recovered paper	Mediterranean Europe	99.4%	131.1%	141.7%
	Central-Northern Europe	76.4%	84.3%	98.3%
	Northern Europe	79.2%	78.3%	105.9%
	Scandinavian Europe	107.4%	94.3%	95.7%
Sawnwood	Mediterranean Europe	75.4%	99.1%	118.4%
	Central-Northern Europe	89.2%	84.9%	102.8%
	Northern Europe	55.5%	68.8%	76.0%
	Scandinavian Europe	103.9%	95.9%	93.9%
Wood-based panels	Mediterranean Europe	90.8%	121.0%	134.4%
	Central-Northern Europe	93.4%	92.2%	107.2%
	Northern Europe	60.4%	68.1%	82.1%
	Scandinavian Europe	104.8%	86.5%	93.3%
Paper and paper board	Mediterranean Europe	96.4%	125.9%	138.0%
	Central-Northern Europe	88.5%	89.6%	103.9%
	Northern Europe	76.5%	76.5%	102.4%
	Scandinavian Europe	104.5%	40.2%	93.9%
Wood fuel	Mediterranean Europe	69.9%	89.9%	114.6%
	Central-Northern Europe	90.6%	79.5%	97.6%
	Northern Europe	57.5%	67.6%	78.4%
	Scandinavian Europe	103.9%	99.3%	94.3%
Carbon stock	Mediterranean Europe	81.2%	145.4%	138.9%
	Central-Northern Europe	73.5%	119.6%	119.4%
	Northern Europe	66.2%	130.6%	135.6%
	Scandinavian Europe	100.6%	142.0%	109.6%

Table 9. A comparison of productivity value ($/ha/yr) changes derived from Forest EGS under IPCC storylines in 2050

Forest EGS	Latitude classification	A1 vs. A2 (2050)	B1 vs. A2 (2050)	B2 vs. A2 (2050)
Industrial roundwood	Mediterranean Europe	118.7%	87.1%	90.0%
	Central-Northern Europe	114.9%	81.7%	85.6%
	Northern Europe	89.5%	49.0%	65.9%
	Scandinavian Europe	103.2%	94.7%	96.7%
Wood pulp	Mediterranean Europe	118.9%	96.8%	100.1%
	Central-Northern Europe	93.5%	70.2%	76.4%
	Northern Europe	150.0%	78.3%	89.8%
	Scandinavian Europe	103.3%	93.4%	96.6%
Recovered paper	Mediterranean Europe	120.2%	101.7%	105.5%
	Central-Northern Europe	80.8%	66.7%	73.1%
	Northern Europe	132.6%	69.8%	82.6%
	Scandinavian Europe	106.3%	91.8%	98.2%
Sawnwood	Mediterranean Europe	122.2%	78.5%	87.0%
	Central-Northern Europe	113.3%	74.2%	82.3%
	Northern Europe	91.6%	50.0%	66.9%
	Scandinavian Europe	102.0%	93.5%	95.9%
Wood-based panels	Mediterranean Europe	120.7%	96.3%	101.6%
	Central-Northern Europe	119.0%	80.6%	86.8%
	Northern Europe	97.6%	52.9%	69.0%
	Scandinavian Europe	103.1%	84.5%	95.4%
Paper and paper board	Mediterranean Europe	120.3%	98.6%	103.3%
	Central-Northern Europe	103.1%	74.5%	80.6%
	Northern Europe	127.0%	67.1%	80.4%
	Scandinavian Europe	102.7%	91.0%	96.0%
Wood fuel	Mediterranean Europe	124.3%	67.3%	80.1%
	Central-Northern Europe	114.4%	70.8%	79.3%
	Northern Europe	93.4%	50.8%	67.4%
	Scandinavian Europe	101.9%	96.9%	96.3%
Carbon stock	Mediterranean Europe	97.5%	115.0%	104.2%
	Central-Northern Europe	97.0%	103.0%	96.0%
	Northern Europe	96.2%	117.7%	105.9%
	Scandinavian Europe	98.1%	130.0%	109.6%

Table 10. Projection of Forest Areas for Recreational Use or Conservation in Europe (1000 ha)

	Initial 2005	A1 2050	A2 2050	B1 2050	B2 2050	Initial 2005	A1 2050	A2 2050	B1 2050	B2 2050
N35-45	Forest areas designated for recreational use					Forest areas designated for conservation				
Greece	293.03	179.01	184.31	293.83	280.97	382.70	233.79	240.71	383.74	366.96
Italy	779.36	651.84	644.59	911.99	928.87	1,017.86	851.32	841.84	1,191.08	1,213.13
Portugal	295.45	169.47	169.82	254.13	256.40	385.87	221.33	221.79	331.90	334.86
Spain	1,399.16	941.28	934.80	1,358.05	1,377.12	1,827.33	1,229.32	1,220.87	1,773.64	1,798.54
Albania	62.01	40.56	65.20	71.71	77.43	80.99	52.97	85.15	93.65	101.12
Bosnia and Herzegovina	210.40	115.24	185.25	203.75	220.00	274.79	150.51	241.94	266.10	287.32
Bulgaria	283.11	178.01	286.14	314.72	339.81	369.75	232.48	373.71	411.03	443.80
Serbia and Montenegro	210.40	139.72	224.59	247.02	266.72	274.79	182.47	293.32	322.61	348.34
Turkey	794.67	530.17	852.24	937.35	1,012.09	1,037.85	692.42	1,113.04	1,224.20	1,321.81
Yugoslav	283.11	47.79	76.81	84.48	91.22	369.75	62.41	100.32	110.34	119.14
Total	**4,610.71**	**2,993.09**	**3,623.76**	**4,677.05**	**4,850.63**	**6,021.67**	**3,909.03**	**4,732.69**	**6,108.31**	**6,335.02**
N45-55	Forest areas designated for recreational use					Forest areas designated for conservation				
Austria	301.62	413.76	404.33	406.06	427.26	393.92	540.38	528.07	530.32	558.01
Belgium	52.09	41.08	42.59	54.48	65.77	68.03	53.65	55.63	71.16	85.90
France	1,214.77	1,178.86	1,253.96	1,568.23	1,712.41	1,586.51	1,539.61	1,637.69	2,048.13	2,236.44
Germany	865.04	784.82	786.89	991.56	1,095.97	1,129.75	1,024.99	1,027.69	1,294.99	1,431.36
Ireland	52.25	34.51	29.58	49.83	51.24	68.24	45.07	38.63	65.08	66.92
Luxembourg	6.79	6.28	6.13	8.07	7.34	8.87	8.20	8.00	10.54	9.59
Netherlands	28.51	11.80	32.84	25.97	32.25	37.23	15.41	42.89	33.92	42.12
Switzerland	95.36	155.01	149.41	165.01	165.64	124.54	202.44	195.13	215.51	216.33
Croatia	166.74	112.29	180.50	198.53	214.36	217.77	146.65	235.74	259.28	279.96
Czech Republic	206.81	139.08	223.57	245.90	265.51	270.10	181.65	291.99	321.15	346.76
Hungary	154.33	100.58	161.68	177.83	192.01	201.55	131.36	211.16	232.25	250.77
Poland	717.90	477.80	768.05	844.76	912.11	937.58	624.02	1,003.09	1,103.27	1,191.24
Romania	497.50	335.76	539.73	593.63	640.97	649.74	438.51	704.90	775.30	837.11
Slovakia	150.65	101.32	162.87	179.13	193.42	196.76	132.33	212.71	233.95	252.61
Slovenia	98.72	65.35	105.05	115.54	124.75	128.93	85.35	137.19	150.89	162.93
Total	**4,609.07**	**3,958.30**	**4,847.18**	**5,624.54**	**6,101.01**	**6,019.53**	**5,169.61**	**6,330.51**	**7,345.75**	**7,968.03**
N55-65	Forest areas designated for recreational use					Forest areas designated for conservation				
Denmark	39.05	32.30	52.88	33.90	65.53	51.00	42.18	69.06	44.28	85.58
United Kingdom	222.19	155.11	167.54	217.15	271.48	290.19	202.57	218.81	283.60	354.56
Estonia	178.38	118.30	190.17	209.16	225.84	232.97	154.51	248.36	273.17	294.95
Latvia	229.69	152.16	244.60	269.03	290.48	299.98	198.73	319.45	351.36	379.37
Lithuania	163.93	106.54	171.26	188.37	203.39	214.10	139.14	223.67	246.01	265.63
Total	**833.25**	**564.41**	**826.45**	**917.61**	**1,056.72**	**1,088.24**	**737.13**	**1,079.36**	**1,198.41**	**1,380.09**
N65-71	Forest areas designated for recreational use					Forest areas designated for conservation				
Finland	1,757.25	1,423.29	1,405.73	1,289.95	1,333.84	2,295.00	1,858.84	1,835.91	1,684.70	1,742.02
Iceland	3.59	2.31	2.26	2.21	2.18	4.69	3.02	2.95	2.88	2.85
Norway	733.12	505.93	490.22	401.48	449.93	957.47	660.75	640.23	524.34	587.62
Sweden	2,149.94	1,773.15	1,733.67	2,021.52	1,773.21	2,807.86	2,315.76	2,264.20	2,640.15	2,315.84
Total	**4,643.90**	**3,704.67**	**3,631.88**	**3,715.15**	**3,559.17**	**6,065.02**	**4,838.36**	**4,743.29**	**4,852.06**	**4,648.34**

Note: the projection of forest areas for 2050 is computed based on the ATEAM projection of total forest areas changed under IPCC scenarios, assuming constant proportions of total forest areas designated for recreational use (7.81%) or conservation use (10.2%), which are the average of the real data of the designated forest composition recorded by FAO/FRA 2005.

NOTE DI LAVORO DELLA FONDAZIONE ENI ENRICO MATTEI

Fondazione Eni Enrico Mattei Working Paper Series

Our Note di Lavoro are available on the Internet at the following addresses:

http://www.feem.it/getpage.aspx?id=73&sez=Publications&padre=20&tab=1
http://papers.ssrn.com/sol3/JELJOUR_Results.cfm?form_name=journalbrowse&journal_id=266659
http://ideas.repec.org/s/fem/femwpa.html
http://www.econis.eu/LNG=EN/FAM?PPN=505954494
http://ageconsearch.umn.edu/handle/35978
http://www.bepress.com/feem/

NOTE DI LAVORO PUBLISHED IN 2010

GC	1.2010	Cristina Cattaneo: Migrants' International Transfers and Educational Expenditure: Empirical Evidence from Albania
SD	2.2010	Fabio Antoniou, Panos Hatzipanayotou and Phoebe Koundouri: Tradable Permits vs Ecological Dumping
SD	3.2010	Fabio Antoniou, Panos Hatzipanayotou and Phoebe Koundouri: Second Best Environmental Policies under Uncertainty
SD	4.2010	Carlo Carraro, Enrica De Cian and Lea Nicita: Modeling Biased Technical Change. Implications for Climate Policy
IM	5.2010	Luca Di Corato: Profit Sharing under the threat of Nationalization
SD	6.2010	Masako Ikefuji, Jun-ichi Itaya and Makoto Okamura: Optimal Emission Tax with Endogenous Location Choice of Duopolistic Firms
SD	7.2010	Michela Catenacci and Carlo Giupponi: Potentials and Limits of Bayesian Networks to Deal with Uncertainty in the Assessment of Climate Change Adaptation Policies
GC	8.2010	Paul Sarfo-Mensah and William Oduro: Changes in Beliefs and Perceptions about the Natural Environment in the Forest-Savanna Transitional Zone of Ghana: The Influence of Religion
IM	9.2010	Andrea Boitani, Marcella Nicolini and Carlo Scarpa: Do Competition and Ownership Matter? Evidence from Local Public Transport in Europe
SD	10.2010	Helen Ding and Paulo A.L.D. Nunes and Sonja Teelucksingh: European Forests and Carbon Sequestration Services : An Economic Assessment of Climate Change Impacts
GC	11.2010	Enrico Bertacchini, Walter Santagata and Giovanni Signorello: Loving Cultural Heritage Private Individual Giving and Prosocial Behavior
SD	12.2010	Antoine Dechezleprêtre, Matthieu Glachant and Yann Ménière: What Drives the International Transfer of Climate Change Mitigation Technologies? Empirical Evidence from Patent Data
SD	13.2010	Andrea Bastianin, Alice Favero and Emanuele Massetti: Investments and Financial Flows Induced by Climate Mitigation Policies
SD	14.2010	Reyer Gerlagh: Too Much Oil
IM	15.2010	Chiara Fumagalli and Massimo Motta: A Simple Theory of Predation
GC	16.2010	Rinaldo Brau, Adriana Di Liberto and Francesco Pigliaru: Tourism and Development: A Recent Phenomenon Built on Old (Institutional) Roots?
SD	17.2010	Lucia Vergano, Georg Umgiesser and Paulo A.L.D. Nunes: An Economic Assessment of the Impacts of the MOSE Barriers on Venice Port Activities
SD	18.2010	ZhongXiang Zhang: Climate Change Meets Trade in Promoting Green Growth: Potential Conflicts and Synergies
SD	19.2010	Elisa Lanzi and Ian Sue Wing: Capital Malleability and the Macroeconomic Costs of Climate Policy
IM	20.2010	Alberto Petrucci: Second-Best Optimal Taxation of Oil and Capital in a Small Open Economy
SD	21.2010	Enrica De Cian and Alice Favero: Fairness, Credibility and Effectiveness in the Copenhagen Accord: An Economic Assessment
SD	22.2010	Francesco Bosello: Adaptation, Mitigation and "Green" R&D to Combat Global Climate Change. Insights From an Empirical Integrated Assessment Exercise
IM	23.2010	Jean Tirole and Roland Bénabou: Individual and Corporate Social Responsibility
IM	24.2010	Cesare Dosi and Michele Moretto: Licences, "Use or Lose" Provisions and the Time of Investment
GC	25.2010	Andrés Rodríguez-Pose and Vassilis Tselios (lxxxvi): Returns to Migration, Education, and Externalities in the European Union
GC	26.2010	Klaus Desmet and Esteban Rossi-Hansberg (lxxxvi): Spatial Development
SD	27.2010	Massimiliano Mazzanti, Anna Montini and Francesco Nicolli: Waste Generation and Landfill Diversion Dynamics: Decentralised Management and Spatial Effects
SD	28.2010	Lucia Ceccato, Valentina Giannini and Carlo Gipponi: A Participatory Approach to Assess the Effectiveness of Responses to Cope with Flood Risk
SD	29.2010	Valentina Bosetti and David G. Victor: Politics and Economics of Second-Best Regulation of Greenhouse Gases: The Importance of Regulatory Credibility
IM	30.2010	Francesca Cornelli, Zbigniew Kominek and Alexander Ljungqvist: Monitoring Managers: Does it Matter?
GC	31.2010	Francesco D'Amuri and Juri Marcucci: "Google it!" Forecasting the US Unemployment Rate with a Google Job Search index
SD	32.2010	Francesco Bosello, Carlo Carraro and Enrica De Cian: Climate Policy and the Optimal Balance between Mitigation, Adaptation and Unavoided Damage

SD 33.2010 Enrica De Cian and Massimo Tavoni: The Role of International Carbon Offsets in a Second-best Climate Policy: A Numerical Evaluation
SD 34.2010 ZhongXiang Zhang: The U.S. Proposed Carbon Tariffs, WTO Scrutiny and China's Responses
IM 35.2010 Vincenzo Denicolò and Piercarlo Zanchettin: Leadership Cycles
SD 36.2010 Stéphanie Monjon and Philippe Quirion: How to Design a Border Adjustment for the European Union Emissions Trading System?
SD 37.2010 Meriem Hamdi-Cherif, Céline Guivarch and Philippe Quirion: Sectoral Targets for Developing Countries: Combining "Common but Differentiated Responsibilities" with "Meaningful participation"
IM 38.2010 G. Andrew Karolyi and Rose C. Liao: What is Different about Government-Controlled Acquirers in Cross-Border Acquisitions?
GC 39.2010 Kjetil Bjorvatn and Alireza Naghavi: Rent Seekers in Rentier States: When Greed Brings Peace
GC 40.2010 Andrea Mantovani and Alireza Naghavi: Parallel Imports and Innovation in an Emerging Economy
SD 41.2010 Luke Brander, Andrea Ghermandi, Onno Kuik, Anil Markandya, Paulo A.L.D. Nunes, Marije Schaafsma and Alfred Wagtendonk: Scaling up Ecosystem Services Values: Methodology, Applicability and a Case Study
SD 42.2010 Valentina Bosetti, Carlo Carraro, Romain Duval and Massimo Tavoni: What Should We Expect from Innovation? A Model-Based Assessment of the Environmental and Mitigation Cost Implications of Climate-Related R&D
SD 43.2010 Frank Vöhringer, Alain Haurie, Dabo Guan,Maryse Labriet, Richard Loulou, Valentina Bosetti, Pryadarshi R. Shukla and Philippe Thalmann: Reinforcing the EU Dialogue with Developing Countries on Climate Change Mitigation
GC 44.2010 Angelo Antoci, Pier Luigi Sacco and Mauro Sodini: Public Security vs. Private Self-Protection: Optimal Taxation and the Social Dynamics of Fear
IM 45.2010 Luca Enriques: European Takeover Law: The Case for a Neutral Approach
SD 46.2010 Maureen L. Cropper, Yi Jiang, Anna Alberini and Patrick Baur: Getting Cars Off the Road: The Cost-Effectiveness of an Episodic Pollution Control Program
IM 47.2010 Thomas Hellman and Enrico Perotti: The Circulation of Ideas in Firms and Markets
IM 48.2010 James Dow and Enrico Perotti: Resistance to Change
SD 49.2010 Jaromir Kovarik, Friederike Mengel and José Gabriel Romero: (Anti-) Coordination in Networks
SD 50.2010 Helen Ding, Silvia Silvestri, Aline Chiabai and Paulo A.L.D. Nunes: A Hybrid Approach to the Valuation of Climate Change Effects on Ecosystem Services: Evidence from the European Forests

(lxxxvi) *This paper was presented at the Conference on "Urban and Regional Economics" organised by the Centre for Economic Policy Research (CEPR) and FEEM, held in Milan on 12-13 October 2009.*