The Finnish Environment 707

LAND USE

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HELSINKI 2004

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This publication is also available in the Internet
www.environment.fi/publications

ISBN 952-11-1736-2
ISBN 952-11-1737-0
ISSN 1238-7312

Cover picture: BMLF Austria,
Esko Kuusisto, Pekka Muuttomaa, Erkki Oksanen
Page layout: Ritva Koskinen

Printing: Edita Prima Ltd, Helsinki 2004

Abstract

This study is a contribution to an exercise to construct land use change scenarios for Europe as part of the European Commission funded ATEAM (Advanced Terrestrial Ecosystem Analysis and Modelling) project. The purpose of the study is to examine recent trends in land use change as they relate to forests in the pre-enlargement European Union member countries, Switzerland and Norway, and to construct narratives and preliminary quantitative estimates of future trends in forest land use that are consistent with the four storylines presented by the Intergovernmental Panel of Climate Change (IPCC) in the Special Report on Emissions Scenarios (SRES). These storylines describe different types of future worlds during the 21st century defined according to societal values (ranging between consumerist/individualist and community-minded values) and according to scales of governance (between globalised and localised). Several quantitative scenarios are associated with each storyline.

The analysis indicates a continuous growth of forest area in most parts of Europe in recent years, with an average annual increase of about 0.3 percent. For the future, the study estimates decreasing forest area in the consumer-orientated worlds and slightly accelerated area growth rates in the community-orientated worlds. The scenarios are at a national scale, and could not be used directly as projections on the regular geographical grid employed in ATEAM. Rather, they were intended to serve as reliability or consistency checks for more comprehensive scenarios incorporating urban and agricultural land uses, protected areas and biofuels, constructed within the project. A firm conclusion of the study is that national forest policies currently play a central role in determining future land use in Europe. Future work on scenario development will require a comprehensive framework that integrates policies as key driving forces of land use change.

Contents

Abbreviations

ACCELERATES	Assessing Climate Change Effects on Land use and Ecosystems; from Regional Analysis to The European Scale
AT	Austria
ATEAM	Advanced Terrestrial Ecosystem Analysis and Modelling
BE	Belgium
CH	Switzerland
CIESIN	The Center for International Earth Science Information Network
DE	Germany
DK	Denmark
ES	Spain
EUROSTAT	Statistical Office of the European Communities
FAO	The Food and Agriculture Organization of the United Nations
FI	Finland
FR	France
GDP	Gross Domestic Product
GR	Greece
IE	Ireland
IMAGE	Integrated Model to Assess the Greenhouse Effect
IPAT	Impact = Population x Affluence x Technology
IPCC	Intergovernmental Panel on Climate Change
IT	Italy
LUC	Land use change
NL	The Netherlands
NO	Norway
NUTS	Nomenclature of Territorial Units for Statistics
PELCOM	Pan-European Land Use and Land Cover Monitoring
PT	Portugal
SE	Sweden
SRES	Special Report on Emissions Scenarios
UCL	Universite´Catholique de Louvain, Belgium
UK	The United Kingdom
UN	The United Nations

Background

This study is a contribution to the development of land use change scenarios as part of the European Commission funded ATEAM (Advanced Terrestrial Ecosystem Analysis and Modelling[1]) project. The main objective of ATEAM is[2]:

"... to assess the vulnerability of human sectors relying on ecosystem services with respect to global change. Ecosystem services are the conditions and processes through which ecosystems, and the organisms that make them up, sustain and fulfil human life. Vulnerability is the degree to which an ecosystem service is sensitive to global change plus the degree to which the sector that relies on this service is unable to cope with the changes.".

The construction of land use change scenarios in ATEAM was co-ordinated by the Université Catholique de Louvain (UCL), Belgium[3]. The scenarios were developed collectively, in an internally consistent way. The aim of the work was to construct alternative scenarios of future land use in Europe up to 2100 that were quantitative and spatially explicit on the basis of a 10′ geographic grid (Rounsevell et al. 2003). The ATEAM area covers the European Union member states (excluding Luxembourg) and Switzerland and Norway.
The aims of this study are:

- to examine land use changes as they relate to forests and their recent trends in the European countries covered by ATEAM
- to investigate methods of quantifying forest land use scenarios for Europe within the ATEAM framework of land use change scenario development and using information obtained from a literature review
- to construct preliminary quantitative estimates and qualitative narratives relating to future trends in forest land use associated with the stroylines presented in the Intergovernmental Panel on Climate Change (IPCC) Special Report on Emissions Scenarios (SRES – Nakicenovic et al., 2000).

The forest land use change estimates were intended to serve as a reliability and consistency check for the overall land use change scenarios developed in the ATEAM project (see section 1.3). To provide background material for the development of forest land use change scenarios, current and past trends in forest area and national policies in Europe were studied. The results of the overview of forest policies are described in a separate report (Kankaanpää and Carter 2004).

1.1 Definitions

The definition of *forest* is central in the determination of afforestation and deforestation and other forest land use changes. There is no one uniformly accepted definition of forest, and concepts vary between developed and developing nations

[1] Project No. EVK2-2000-00075, see: www.pik-potsdam.de/data/ateam/

[2] www.pik-potsdam.de/ateam/ateam_objectives.html

[3] The research group consists of researchers from the Université Catholique de Louvain, Belgium; Wageningen University, the Netherlands; Potsdam Institute for Climate Impact Research, Germany and the Finnish Environment Institute, Finland, with assistance from members of a parallel EC-funded project, ACCELERATES.

and within Europe. Nevertheless, there are some international definitions for forests, notably those used by the Food and Agriculture Organization of the United Nations (FAO) and the United Nations (Palo and Uusivuori 1999, p. 4; Päivinen et al. 1999, p. 13).

There are several definitions for *forest* in the literature. They can be grouped into three categories: administrative or legal unit, land cover, and land use. A definition of forest land use should specify a minimum area to consider and a minimum closure threshold (Lund 1999, p. 127). The FAO Global forest resource assessment 2000 (2001, p. 363) uses the following definition for forest:

"Forest includes natural forests and forest plantations. It is used to refer to land with a tree canopy of more than 10% and an area of more than 0.5 ha. Forests are determined both by the presence of trees and the absence of other predominant land uses. The trees should be able to reach a minimum height of 5 m. Young natural stands that have not yet but are expected to reach a crown density of 10% and tree height of 5 m are included under forest, as are temporarily unstocked areas. The term includes forests used for purposes of production, protection, multiple-use or conservation (i.e. forest in national parks, nature reserves and other protected areas), as well as forest stands on agricultural lands (e.g. windbreaks and shelterbelts of trees with width of more than 20 m), and rubber wood plantations and cork oak stands. The term specifically excludes stands of trees established primarily for agricultural production, for example fruit tree plantation. It also excludes trees planted in agroforestry systems".

Exploitable forest is forest on which there are no legal, economic or technical restrictions on wood production. It includes areas where, although there are no such restrictions, harvesting is not currently taking place, for example areas included in long-term utilisation plans or intentions (Päivinen et al. 1999, p. 13).

The distinction between land use and land cover is important for determining how the term forest is interpreted. Lund (1999, p. 126) defines *land use* as follows:

"Land use is the predominant purpose for which an area is employed. Land use can be defined as the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it. A given land use may take place on one, or more than one, pieces of land and several land uses may occur on the same piece of land. Land-use changes are always human-induced."

The definition of land use in this way provides a basis for precise and quantitative economic and environmental impact analysis and permits precise distinctions between land uses. Land use is more difficult to determine, especially on private lands, than land cover. The relative permanency of land use also depends in part on the land owner's management objectives and on legislation and policies.

Land cover is the (bio)physical cover on the earth's surface. The term also embraces features of the land itself in addition to its cover. Changes in land cover may be due to natural or human-induced phenomena (Lund 1999).

To determine if an issue concerns land cover or land use, two questions can be asked:

- Can the land be covered with trees and be called something other than forest?
- Can the land be void of trees and still be called forest?

If the answer to either of these questions is yes, then the definition is of land use; otherwise the definition is of land cover. (Lund 1999)

Three changes in forest land use can affect ecosystem services: afforestation, deforestation and reforestation.

Afforestation refers to establishing trees on non-treed land, which has been without tree cover for a long period of time or is not historically forested (Noble et al. 2000, pp. 65, 69). From a land cover perspective, afforestation would be the establishment of tree cover where it previously was non-existent regardless of how the land and resource is to be used afterwards. If land use were included, then the land would also have to be used for forest purposes (Lund 1999, p. 128).

Reforestation refers to the establishment of trees on land that has been cleared of forest within the relatively recent past (Noble 2000, p. 66). In terms of land use, reforestation may be interpreted as a change of lands formerly classed as forest, but currently classed for another use, back to use for forestry purposes. From a land cover perspective, reforestation may be regarded as the establishing of tree cover where it previously existed (Lund 1999, p. 129). The term reforestation is commonly used for regeneration of trees either by planting or natural regeneration after harvesting. In this case the land use remains the same all the time even though the land cover changes, at least for some period of time. Reforestation and afforestation can be defined as the conversion of non-forested lands to forests with the only difference being the length of time during which the land was without forest (Watson et al. 2000, p. 6).

Deforestation can be defined as the conversion of forest land to non-forest land (Noble et al. 2000, pp. 66-69). From the point of view of land cover, deforestation would be the removal of the overstory tree cover. From a land use perspective, overstory removal must also be accompanied by a change in land use (Lund 1999, p. 129).

In this report, no uniform definition of forest is attempted, but the country specific definitions of forest, and therefore of forest area, are used. Here the focus is on land use, and not so much on land cover, and therefore it is sufficient to define forest according to each individual country's definition.

Forestry is the science, art and practice of managing and using for human benefit the natural resources of forest lands. Forestry includes a wide range of activities in addition to those associated with silviculture, which refers to the planting and tending of growing trees, such as the production of non-timber products, watershed management, wildlife protection, and eco-tourism as well as pest control and fire management (Watson et al. 2000, p. 62).

Forestry is one of society's many land use systems. Concepts of forestry may vary markedly between different social systems. However, in order to function, forestry as part of the social system has to be consistent and contingent with the other parts of the system and the system as a whole. In this sense, perspectives on forestry are to a large extent predetermined by their specific surrounding social systems. As a result, any changes in the social system inevitably lead to changes in forestry and *vice versa*. Due to the mediating role between forest ecosystems and needs and demands of societies assigned to forestry, changes in forestry have been interpreted mainly as a reaction towards direct changes in forest uses in society. However, other social changes whose relationship to forestry is more indirect (such as changes in political structure and level of democracy, economic changes, and changes in values) may also have the potential to affect forestry (Schanz 1999, pp. 61-62; Mather et al. 1998).

Scenarios can be defined as "images of the future, or alternative futures" that are neither predictions nor forecasts, but images of how the future might unfold (Nakicenovic et al., 2000). Scenarios assist in the understanding of possible future developments of complex systems. They can be viewed as a linking tool that integrates qualitative narratives of the future and quantitative formulations based on formal modelling.

Scenarios can be classified in different ways (Alcamo 2001, pp10-13) . Scenarios can be *qualitative* or *quantitative*. Qualitative scenarios describe possible futures in the form of narrative texts or storylines or in the shape of diagrams or outlines. An example of qualitative narratives is the IPCC Special Report on Emissions Scenarios

(SRES) storylines. Quantitative scenarios provide numerical information in the form of tables and graphs (e.g. scenarios by the IMAGE model – Alcamo et al., 1998; IMAGE Group, 2001).

Scenarios can also be described as exploratory or normative (Alcamo, 2001; Carter et al., 2001). *Exploratory* (or descriptive) scenarios begin in the present and explore trends into the future. They describe sequences of emerging events. Examples of these are the SRES emissions scenarios. *Normative* scenarios, by contrast, start with a prescribed version of the future and then work backwards in time to depict how this future could emerge. The distinction between exploratory and normative scenarios is not always clear, and elements of both are often used in developing scenarios.

Another helpful distinction is between baseline and policy scenarios (Alcamo, 2001). *Baseline* scenarios present the future state of the environment and society, in which environmental policies either do not exist or do not influence the environment and society. They are useful for evaluating the consequences of no new policy intervention and for accounting for the uncertainty of environmental conditions and of the driving forces of environmental change. On the other hand, *policy* scenarios depict the future effects of environmental policies. Policy scenarios are also known as mitigation or intervention scenarios.

1.2 Land use change scenario methodology

Quantitative and spatially explicit alternative scenarios of future land use in Europe were developed in the ATEAM project to support analyses of ecosystem vulnerability and biodiversity (Rounsevell et al. 2003). The base year for the land use change scenario framework is 2000, and it is represented by the PELCOM[4] (Pan-European Land Use and Land Cover Monitoring) 1 km resolution land cover data set combined with EUROSTAT[5] (Statistical Office of the European Communities) statistical data at NUTS2 level[6]. The scenarios were constructed for three time slices: 2020, 2050 and 2100 and for four land use types: urban, agriculture, forestry and protected areas.

The study area of the ATEAM project covered by the land use scenarios includes the pre-enlargement European Union member states (excluding Luxembourg), Switzerland and Norway. The methodology for the construction of the ATEAM land use scenarios in general and the forest land use scenarios described in this report in particular is based on three levels:

1. Global driving forces
2. European sector driving forces
3. Changes in land use areas for each land use type or regionally-specific values of input parameters

The global driving forces (level 1) are based on the scenario storylines described in the IPCC Special Report on Emission Scenarios (SRES – Nakicenovic et al. 2000). Each storyline describes a possible future world and represents different plausible demographic, social, economic, technological and environmental developments. The SRES storylines are described in section 3.2.

The level 2 analyses translate the global driving forces into sector-specific driving forces for Europe for each of the land use types in a qualitative way. The SRES storylines are extended to the European region and the land use type. The analysis is based on the current literature, on an understanding of the land use change processes and driving forces that are important for Europe, and on

[4] *http://cgi.girs.wageningen-ur.nl/cgi/projects/eu/pelcom/index.htm; http://www.geo.ucl.ac.be/LUCC/research/endorsed/04-pelcom/PELCOM.HTML*

[5] *http://europa.eu.int/comm/eurostat/*

[6] *Nomenclature of Territorial Units for Statistics*

knowledge of past and present national policies and trends. Distinct regional trends in driving forces have been identified based on countries or country groups for some land use sectors (forestry and protected areas). The level 2 analyses are qualitative descriptions of each land use type change and they also provide a check of internal consistency between each of the land use sectors and storylines. The level 2 European forestry sector driving forces and extension of SRES storylines are presented in section 3.3. and in Annex 1.

At level 3 in the scenario construction process, the methodologies for the different land use types diverge. This reflects both the differences in the inherent characteristics of each land use type and the existence of quantitative models of land use change processes that can be used in the assessment. The approach is to derive regionally specific values of input parameters for land use models or directly estimate changes in land use areas for each land use type. In the case of forest land use, direct estimates of forest land area are derived based on the level 1 and 2 analyses (expressed as percentage changes in the share of forest area out of the total land area in a country or region). The level 2 analysis of forest land use was based on a study of past and present trends and policies in the European forest sector (Kankaanpää and Carter 2004). Policies were considered to be one of the major driving forces of forest land use change in Europe, and the study of current policies offers a clear indication of the direction of change and, in many cases, of the magnitude of change as well.

Protected forest areas are classified as strict protection areas (Parviainen et al. 2000) in the "Protected areas" land use type. This is done to avoid overlapping of different land use types and also because the term "protected forest" is not a uniformly defined concept. Most forests in Europe are protected in a sense that it is prohibited by law to convert them to any other land use, but a much smaller area of forests are conserved for purposes of maintaining biodiversity and excluded from wood production. Construction of the forest land use change estimates are described in section 4.1. and the estimates are presented in section 4.2. and Annex 2.

Competition between the different land uses is also addressed in the scenario construction process. A simple land use competition hierarchy is used, which is reflected in the following order of precedence:

Protected areas > urban > biofuels > agriculture > forests > not actively managed

An expansion of a higher order land use type at a given location will cause a land use lower in the hierarchy to contract at the same location. Land use decisions tend, in general, to reflect a range of nearly optimal solutions to choices of different land use types within a geographical area. At any one location, one land use will have physical, economic or political advantage over other land use types. Biofuels are rather high in the hierarchy because of the importance and weight given to them in the SRES storylines. Forest land use is treated in the hierarchy as a residual. As the forest and environmental policies are not considered explicitly in the land use model employed (the ACCELERATES model[7]) the importance of agriculture can be overemphasised in some regions. In many cases forests will not be the last in the hierarchy, but will be preferred over other land uses for political, environmental or social reasons. The purpose of this forest land use change analysis is therefore to act as a reliability and consistency check for the overall land use change scenarios.

[7] *http://www.geo.ucl.ac.be/accelerates*

2 Forest land use change variables

The extent of forest in a country depends on climatic and other environmental determinants as well as human activities. Groups of factors, including population, economic growth, technological change, political-economic institutions and attitudes and beliefs, have been suggested as drivers of forest land use change and especially deforestation. Close but complex interrelationships exist between these groups and serious problems of multicollinearity can arise when attempting to explain land use change. The same human activity can have different effects in different environments. Conversely, under similar climatic and demographic conditions, different responses and impacts can occur depending on economic and political circumstances. The search for close and universal relationships between environmental impacts and measures of human activity at the global scale may therefore be futile. Forests are simply more vulnerable to human activities in some parts of the world than in others. The problem of identifying the main socio-economic drivers of change is often complex, as the interactions of explanatory variables can be strong, both at a given point in time and over time. There are no precise definitions of the main concepts or the empirical data required to describe the dependent or independent variables involved. In addition, there are usually several theories to choose from for explaining the causes of change (Mather et al 1998, p. 1989; Bouma et al 1998, p. 109; Solberg 1998, p. 21).

2.1 Underlying driving forces of forest land use change

2.1.1 Population

Over the span of human history, population can be viewed as a primary driver of deforestation. There are two theoretical reasons for expecting the forest area to decline as human population increases. The first one is the expectation that growth in population stimulates an increased demand for arable land. Potential arable land usually carries forest under natural conditions and expansion of arable land is thus likely to mean reduction in forest area. Secondly, harvesting of wood and other forest products, if carried beyond a certain threshold, is likely to result in a reduction of forest extent. Such harvesting may increase with population (Mather et al 1998).

Approximately half of the variation in the extent of deforestation is explained in statistical terms by variation in population. However, over the last 150 years the nature of the relationship between population growth and forest reduction appears to have changed fundamentally, at least in some parts of the world. The sustained and steep declines of forest cover have been followed by a period of stabilisation and then a gradual increase in forest area. In Europe, the historical relationship between population and forest appears to have flipped. Forest shrinkage has given way to forest expansion, while population has continued to grow. However, the new forests often differ from the forests they replace in their species composition, so that natural forests in many countries of Europe are scarce or non-existent. However, in some other respects – from wood production to protection of soils and watersheds – the new forests have the same functions as the original primary ones (Mather et al 1998; Union of Concerned Scientists 1999).

There has been some movement away in the literature from the simplistic view of the relationship between human population and forest trends, and there is a growing awareness that factors other than population are likely to be significant in relation to forest change. Political factors such as access to forest and land resources mediate and complicate the relationship (Mather et al 1998, pp. 1987-1988; Lambin et al. 2001).

2.1.2 Economic growth

The view that economic growth is a powerful driver of deforestation is widespread. Evidence from Europe and other developed countries, however, shows that stability or expansion of forest area is associated with high levels of economic, social and political development. Development, at least in the long run, is beneficial rather than detrimental to forest trends. Forest trends tend to become more favourable with increasing income; for environmental impact the sign of "affluence" in the IPAT ((Impact = Population x Affluence x Technology) equation (Ehrlich and Holden, 1971) should be reversed. In their study of the underlying causes of variations in forest area in the tropics, Uusivuori et al. (2002) found a dichotomous pattern in the distribution of forest area and GDP data. At lower levels of per capita GDP, forest cover was negatively related to income, whereas at higher income levels this relationship was positive. This trend has been evident in Europe for much of the 20th century (Mather and Needle 1999, p. 105, 107, 109; Mather 2000b, p. 26; Palo 1999).

Concerning rates of economic growth, it also appears that countries enjoying rapid economic growth generally have more favourable trends in forest area than those with slower growth. The variables of change may also be indicators of a broader, multi-dimensional societal or cultural change, rather than a significant variable in their own right. Trends in income or population may simply be a manifestation of development or of broader societal or cultural change (Mather et al 1998, p. 1991).

According to a study by Wernick et al. (1998), during the 20th century, with rare exceptions, the intensity of use of solid wood products fell in the US. This means that the use of solid wood products slowed relative to the rise of population and personal wealth. Partly this can be explained by the substitution of wood with other materials (steel, concrete, plastic) and new preservation methods for wood preventing fire and decay. Recently the intensity of paper use has also fallen in the US. Hence, despite the growth of population and GDP, the forest area of the US can remain constant or grow and the area of logging could be reduced from present levels. This would require that consumers lower the intensity of use of wood products through recycling, millers adopt new innovations that utilise wood more efficiently and foresters increase the growth rates of trees by improved management.

2.1.2 Political and cultural factors

Bouma et al (1998, p. 103-104) argue that major changes in land use may be anticipated in the future as a result of technological, socio-economic and political developments as well as global environmental change. Types and effects of land use changes in Europe will strongly depend on policy decisions, which are governed by:

- an increasing agricultural productivity
- increasing realisation of the need to conserve biodiversity and environmental quality
- pressure from an increasing urban population to emphasise non-agricultural forms of land use in terms of nature and landscape conservation

- increased market-driven demands for high-quality produce made with environmentally friendly forms of management
- increasing food demand on the world market

The importance of state intervention and forest policies in forest transition is stressed in the studies of Mather et al. (1998, 1999). The concept of forest transition refers to the shift from declining to expanding forest trends that has characterised many developed countries over the last two centuries.

In a study of the French forest transition, Mather et al. (1999) found that a simple linear model of cause and effect offered inadequate explanation for forest transition. Several factors acted in combination and operated at different levels. In the case of France, the cultural and political climates were highly significant in facilitating effective state intervention. Crises faced in the early 19th century (severe floods, serious shortages of wood and timber) triggered state intervention. Once initiated, forest expansion was correlated with various factors such as declining trends in rural population, rising agricultural yields, and availability of alternative fuels.

Forest trends are associated with various political factors, including type of government and the general political climate. Political factors such as democracy, political rights, corruption, civil liberties and the rule of law appear to influence forest trends (Mather and Needle 1999, pp. 112-114).

Cultural factors such as human perceptions of the forest seem to undergo radical change from time to time and influence forest transition. An affluent urban-based population may value forest as an environment for recreation and wildlife rather than in terms of potential agricultural land and fuel wood. The human drivers of forest trends are complex and manifold, and some – such as changing political and philosophical climates – are not readily quantifiable. The influences of drivers of forest land use change such as population are mediated through particular cultural and political milieu as well as through particular modes of production (Mather et al. 1998, p. 1990; 1999b, p. 84).

2.2 Other factors influencing forest land use

2.2.1 Changes in agricultural production

At national scale in Europe, there is no apparent direct relationship between forest expansion and agricultural contraction. Both the relationship of afforestation to shrinking agriculture and the role and purpose of new forests are matters of debate at present (Mather 2000a, p. 11). Land use change in Europe seems mainly to involve changes in production systems (crops, fertiliser and pesticide use) rather than large-scale changes in land cover, such as a shift from agriculture to forestry. The latter process is slow, even though forests are permitted to be grown on agricultural land that has been taken out of production (Dolman et al. 2003).

Expansion of forest areas is usually linked to change and adjustment in agriculture, in particular to rising yields. In practice yield increases tend to be greatest on more fertile land, and with relatively static demand for food, land of more marginal productivity may be abandoned. Afforestation may follow, either through natural regeneration or by planting, often by state-promoted afforestation schemes. The underlying motives for such schemes may be related to timber production, but more often their primary function has been agricultural production control and, increasingly, securing environmental and recreational functions of forests. Opposition to afforestation may come from traditional farmers or from environmental groups, especially if exotic species are to be planted or valuable landscapes transformed. Field afforestation in many countries (e.g. Finland and

Ireland) has also taken place in lands considered to be marginal for agricultural production. This has resulted in afforestation being associated with rural decline and marginalisation, with strong opposition to it by farmers and local population (Mather 2000a, p.12; Madsen 2002; Shelby and Petäjistö 2000).

Expansion of forest area in Europe in 1990-95 amounts to little more than one-third of the apparent area of agricultural contraction, and patterns of forest expansion and agricultural contraction by country are not correlated in a statistically significant manner. Afforestation is linked to agricultural retrenchment, but not closely (Mather 2000a, p. 14).

2.2.2 *Location of the new forests*

The changing purpose and composition of new forests, in particular the changed goals of afforestation, have consequences for the locational pattern of forests. When woodlands were only seen as an alternative to agricultural production, the location of woodland areas was regarded of little consequence as long as other values of the countryside were undisturbed. However, as afforestation has become a tool to secure environmental and recreational interests that are often linked to physical elements of the landscape, the location of new forests has become a central factor in fulfilling these goals. From the point of view of maintaining ecological networks and biodiversity, the location of woodlands in the landscape can be of crucial importance. Recreational needs and the protection of groundwater demand forests of a certain size. Recreational areas may also be in higher demand close to urban centres and not in the remote and upland areas where afforestation has traditionally taken place (Madsen 2002, p. 243, 252).

2.2.3 *Ecological and general socio-economic factors*

Solberg (1998, p. 22-23) identifies ecological and socio-economic factors influencing the forest sector in Europe (Figure 1). There are two main ecological factors: 1) the actual forest situation (area of old growth forest, yield of roundwood, harvesting volume, species distribution, mosaic patterns etc.) and 2) the general environmental situation (issues such as acid rain, air pollution, water pollution, soil degradation etc.). Socio-economic factors include a wide range of factors: economic situation, technology, urbanisation/industrialisation, forest management practices, forest research, forest and environmental policies, international agreements, environmental standards, non-governmental organisations' activities, general environmental awareness and globalisation of the economy and the environment.

The factors influencing the forest sector are interdependent and connected both at a given point in time and over time. They form a hierarchical structure: first there is a set of factors specific to the forest sector (C1-C8 in Figure 1), next factors that are more generally applicable to several sectors (B1-B5), then factors that influence all sectors of society (A1-A4) and finally global factors (the globalisation of economy and the environment) (Solberg 1998, p. 24).

There are uncertainties involved in evaluating the relative importance of these different factors. Almost all of them are characterised as being qualitative and few studies of their relative strengths for a specific country or situation exist. The demand and supply for wood products for forest industries is uncertain but a greater uncertainty today lies in the demand and supply of environmental services provided by forests. Harvesting in natural forests has become more difficult and the demand for research on the impact of forest management practices on biodiversity has increased (Solberg 1998, p. 24).

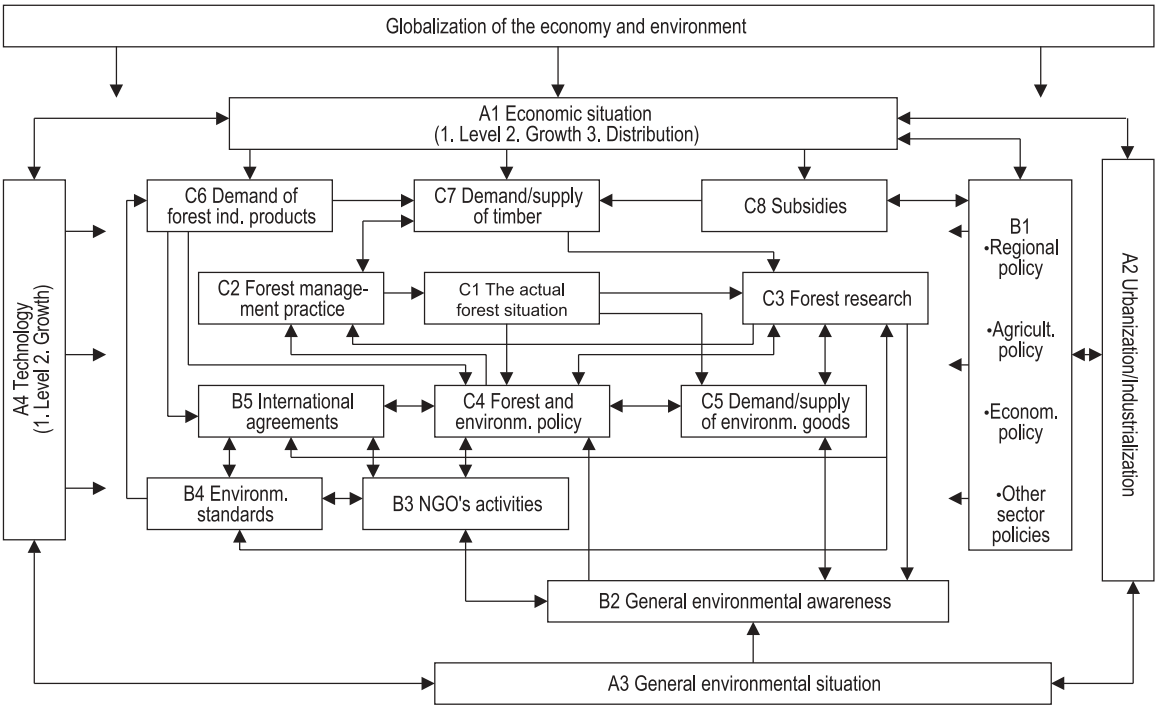

Figure 1. The main ecological and socio-economic driving factors and interactions influencing the forest sector of Europe (Solberg 1998, p. 23)

2.2.4 Summary of factors influencing forest land use change

A general list of variables of forest land use change is presented in Table 1. The variables are gathered from a number of sources (Briassoulis 2001; Geist and Lambin 2001; Mather 1999b, 2000a; Wilson 2001; Lund 1999, Solberg 1999), and the list is by no means exhaustive. Deforestation, especially tropical deforestation, is a more widely studied issue than forest land use change in Europe, but some factors may be influential in both cases. Here the view is adopted that problems of deforestation and forest land use change in general are complex and have multiple causes. The factors influencing land use change are considered to be different in different continents and regions. The processes and particular mixes of causes of land use change vary by place. It might also be difficult to generalise in concluding that one or more factors are the most important (Rudel and Roper 1996, Murali and Hedge 1997 in Geist and Lambin 2001, p. 2).

The factors influencing forest land use change are broken down to proximate causes, underlying causes and other causes according to a classification in Geist and Lambin (2001). Proximate causes are defined as human activities (land uses) that directly affect the environment and thus constitute direct sources of change. Proximate causes connect changes in land cover and land use. They reflect the human activities comprising the underlying social driving forces. In terms of scale, proximate causes are seen to operate at the local level (Geist and Lambin 2001, pp. 5-6).

Underlying driving forces or social processes are seen to be fundamental forces that support the proximate causes. They are a complex of social, political, economic, technological and cultural variables that constitute initial conditions in the human

– environmental relations that are structural or systemic in nature. In terms of spatial scale, underlying causes may operate directly at the local level, or indirectly from national or global levels (Geist and Lambin 2001, p. 8).

The group "Other causes" is composed of predisposing environmental factors, biophysical drivers and social trigger events. The group consists of heterogeneous variables concerning the temporal and spatial dynamics of land cover and land use change (Geist and Lambin 2001, p. 13).

The present study concentrates on the institutional factors (mainly forest policies) determining land use and the recreational use of forests. Underlying changes in attitudes and culture are reflected in policies and the institutional structure. Recreational use of forests is assumed to increase in importance in the future. Both the institutional and legal framework and the changing purposes of forests are assumed to be important factors in determining forest land use change in Europe. Many of the factors are difficult to examine quantitatively or in a modelling framework; they are included in the list, however, in an effort to identify most of the significant variables in forest land use change.

Table 1. Causal factors influencing forest land use change (Sources: Briassoulis 2001; Geist and Lambin 2001; Mather 1999, 2000; Wilson 2001; Lund 1999; Solberg 1998)

	Causal factor	Cause
	Demographic	
population growth/change	population density	Underlying
rural population change	migration, in-migration	
	Economic	
timber demand/supply	other wood products demand/supply	Underlying
change in the production/industrial structure	trade: imports and exports; "eco-predation"	
economic growth/development	non-wood products	
consumption structure	income distribution	
living standard/quality of life	tourism	
employment		
	Institutional	
policies: forest, agricultural,	state intervention in forestry	Underlying
rural development, environmental	level of democracy/participation	
political regime	land ownership	
institutional structure and change	land tenure arrangements	
property rights defined		
access to forests (everyman's rights)		
	Cultural and social	
attitudes and preferences towards forests of	environmental awareness	Underlying
urban population, rural population,	scenery values	
decision-makers (agricultural, environmental,	other forest services (amenity)	
landscape		
historical/cultural values		
	Technological	
technological progress	forest management practises	Underlying
	Crises	
war	abrupt economic changes	Other/social triggers
abrupt political changes		
	Environmental	
biodiversity	carbon sequestration	Other
storms	fire	
floods	pests	
pollution		
	Land quality	
productivity	land degradation	Other
species distribution	suitability for forest land	
soil quality	topography	
	Land use	
land use intensity	availability of land	Proximate
agricultural land use change	urban land use change	
infrastructure change	protected areas/other restricted areas	
recreation	hunting	
flood control	forest fragmentation	

3 Scenario storylines

3.1 Special Report on Emissions Scenarios (SRES)

The four scenario storylines used for the estimation of land use change in Europe are the storylines described in the IPCC Special Report on Emissions Scenarios (Nakicenovic et al. 2000, pp. 169-183). The storylines are short narratives of possible future developments during the 21st century. Their titles are simple: A1, A2, B1, B2, and there is no particular order among the storylines. Each storyline represents different plausible demographic, social, economic, technological and environmental developments. The SRES storylines are described as branches of a two-dimensional tree (Figure 2). The two dimensions indicate the relative orientation of the different scenario storylines toward economic or environmental concerns and global or regional development, respectively. The narratives of the four scenario storylines are described in the following sections.

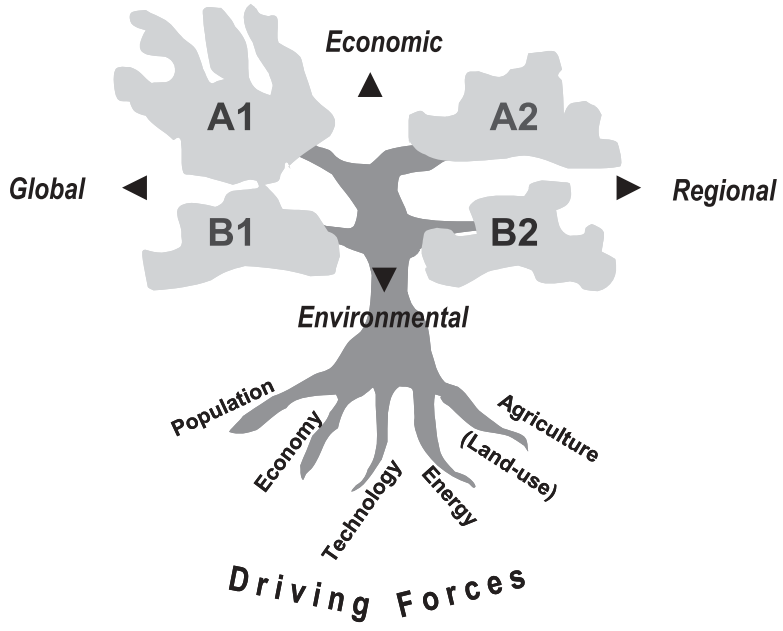

Figure 2. The SRES storylines (Nakicenovic et al. 2000, p. 170)

3.2 Global driving forces

3.2.1 The A1 storyline

The A1 storyline describes a world of rapid and successful economic development. Differences in per capita income between the different world regions converge and economic distinctions between developing and developed countries eventually dissolve.

There is strong commitment to market-based solutions to social and environmental issues. At the household level there are high levels of savings and there is a strong commitment to education. The societies invest in education, technology and institutions and consequently there are high rates of innovation in these fields. International mobility of people, ideas and technology is easy and widespread. The transition to economic convergence between the world regions results from advances in transport and communication technology, shifts in national policies on immigration and education, and the cooperation of national and international institutions that enhance productivity growth and technology diffusion.

Demographic and economic trends are closely linked, as affluence is correlated with low mortality and fertility. Global population grows to nine billion by 2050 and declines to seven billion by 2100. Average life expectancy increases.

The global economy expands at an average annual rate of about 3% to 2100. Global per capita income reaches US$ 21 000 by 2050. The high level of income per capita contributes to an improvement in the overall health and social conditions of the majority of the world population. Social problems such as social exclusion may prevail in some regions and income growth could produce increased pressure on the environment and other social goods.

Economic development in the A1 world follows the patterns of the most successful historical examples of economic development. Free trade, continued innovation and stable political and social climate enable developing regions to gain knowledge, technology and capital. As a by-product of rapid economic development and fast demographic transition, income inequalities between world regions are eradicated. However, even if relative income differences are reduced drastically, absolute differences remain large.

There is rapid technical progress, which reduces the demand for resources and increases the supply of economically recoverable reserves. Final energy intensity (energy use per unit of GDP) decreases at an average annual rate of 1.3%. Energy resources are taken to be plentiful in the A1 world assuming a large future availability of coal, unconventional oil and gas. Rapid economic growth leads to high energy demand. Structural changes in the energy supply become effective only in the longer term because of the inertia caused by long periods of capital turnover.

Environmental amenities are valued and the current concept of environmental quality changes from an emphasis on conservation of nature to active management of natural and environmental services, which increases ecological resilience.

High incomes bring about increased private car ownership and traffic, extended suburbs, and dense traffic networks, both nationally and internationally.

3.2.2 The A2 storyline

The A2 world is characterised by self-reliance of regions in terms of resources and less emphasis on economic, social and cultural interactions between regions. Economic growth is uneven and the income cap between developed and developing countries does not narrow. Disparities in income and productivity between different

world regions are largely maintained or increased in absolute terms. There are lower trade flows and relatively slow capital stock turnover. Technological change is slower than in the A1 world and it is also more heterogeneous, more rapid in some regions and slower in others. There is less international cooperation and people, ideas and capital are less mobile. Technology transfer and diffusion is slower than in the other storylines.

Fertility rates decline slowly and in consequence the A2 world's population, 15 billion by 2100, is the largest of the four storylines. Global average income per capita is low compared to other storylines. The average global income per capita is US$ 7200 by 2050 and $ 16000 in 2100. The global average growth rate in per capita income (1990-2100) is 1.3%, which is somewhat higher than the growth rate observed in 1970-1995. The lower per capita incomes reflect both the fragmented economic outlook of the A2 world and the slow pace of the demographic transition. The slowest growth rate in per capita income occurs in the OECD90 region (on average 1.0%/year). The A2 world is also characterised by a slow convergence of incomes among world regions.

The energy fuel mix in the regions in determined primarily by resource availability. High-income but resource-poor regions shift toward advanced non-fossil technologies, nuclear or renewable energy sources, while low-income and resource-rich regions rely on fossil fuels. Final energy intensities decline at between 0.5 and 0.7% a year.

Social and political institutions diversify in the A2 world. Some regions move toward stronger welfare systems and reduced income inequality, while others move toward weaker governments and more heterogeneous income distribution.

Demand for food is high and agricultural production is one of the main focus areas for research, development and deployment efforts. Environmental concerns are central in agricultural production as well. More sustainable agriculture is developed locally and initially high levels of soil erosion and water pollution are eventually alleviated.

Environmental damages are not uniform across all regions. Global environmental concerns are weak, but on the regional level attempts are made to control regional pollution and other environmental problems and to maintain environmental amenities.

In the A2 world alternative energy technologies develop relatively slowly and fossil fuels maintain their dominant position in the energy supply mix.

3.2.3 The B1 storyline

The central elements in the B1 future world are a high level of environmental and social consciousness combined with a globally coherent approach to sustainable development. Governments, businesses, the media, and the public pay increased attention to the environmental and social aspects of development. Technological change plays an important role.

Economic development in B1 is balanced and efforts to achieve equitable income distribution are effective. B1 describes a fast changing and convergent world. The B1 world invests a large share of its gains from increased productivity and know-how in improved efficiency of resource use (dematerialisation), equity, social institutions and environmental protection. The heightened environmental consciousness might be brought about by clear evidence that the adverse impacts of natural resource use pose a serious threat to the continuation of human life on earth. The storyline does not describe explicitly the decision making structures, institutions and types of governance required for such a transition, but a rather

high level of regulation by governments has to be assumed in order for environmental and social benefits and an equitable distribution of income to materialise.

A strong welfare net prevents social exclusion on the basis of poverty in the B1 world. Massive income redistribution and presumably high taxation levels may adversely affect the economic efficiency and functioning of world markets. Particular efforts are devoted to increasing resource efficiency in order to achieve economic, environmental and social goals. Incentive systems, combined with advances in international institutions, permit the rapid diffusion of cleaner technology. To this end, research and development is also enhanced, together with education and capacity building for clean and equitable development. The combination of technical and organisational change yields large savings of material and energy, as well as a reduction in pollution. Labour productivity also increases.

There is a demographic transition to low mortality and fertility motivated, in part, by social and environmental concerns. Global population reaches 9 billion by 2050 and declines to 7 billion by 2100, as in the A1 world. The population growth rate of the B1 world is considerably smaller than the present rate of growth. The B1 world has high levels of economic activity and significant and deliberate progress toward international and national income equality. Per capita income is US$ 15 600 by 2050 and US$ 46 600 by 2100. The growth rate of income per capita is 2.2% for 1990-2100.

In the B1 world a higher proportion of the income is spent on services rather than on material goods, and on quality rather than quantity, due to a reduced emphasis on material goods and increased resource prices through environmental taxation.

There is a relatively smooth transition to alternative energy systems as conventional oil and gas resources decline. During the transition there is extensive use of gas as the cleanest fossil resource, but the major push is toward post-fossil technologies, driven largely by environmental concerns.

Environmental quality is high and most potentially negative environmental aspects of rapid development are anticipated and effectively dealt with locally, nationally and internationally. Land use is managed carefully to counteract the impacts of activities potentially damaging the environment. Cities are compact and designed for public and non-motorised transport, with suburban developments tightly controlled. There are strong incentives for low-input, low-impact agriculture, along with maintenance of large areas of wilderness. The proactive local and regional environmental measures and policies lead to relatively low greenhouse gas emissions, even in the absence of explicit interventions to mitigate climate change.

3.2.4 The B2 storyline

In the B2 world there is significant concern for environmental and social sustainability at local and regional levels. Human welfare, equality and environmental protection all have high priority in society.

There is a trend toward local self-reliance and strong communities. The level of participation in decision-making is high and government policies and business strategies are influenced by citizen participation. Environmental and social concerns are addressed through community-based solutions. International institutions decline in importance and decision-making is focused on local and regional institutions.

The rate of development in general is relatively slow in the B2 world. Global income per capita grows at an intermediate rate to about US$ 12 000 by 2050 and US$ 22 600 by 2100. International income differentials decrease, though not as rapidly as in the A1 and B1 storylines. Per capita income differences are smaller than those

in A2, but higher than those in A1 and B1. Global GDP is assumed to increase at an average annual growth rate of 2.2%. Locally inequity is reduced considerably because of the development of strong community support networks. The general level of education is high – education and welfare programmes are pursued, which reduces mortality and to some extent fertility. World population reaches 10 billion by 2100. Stabilisation of global population at less than double current levels, combined with a sustained pace of development implies that the B2 world generally achieves high levels of affluence.

Environmental protection and development are both promoted in the B2 world. Global environmental issues are addressed internationally, but local and regional environmental problems are dealt with more successfully at the local level.

At the global level, investments in research and development decline. Mechanisms for international diffusion of technology are weaker than in the A1 and B1 storylines. Technical change and innovations are unevenly distributed among the regions. The energy intensity of GDP declines at about 1% per year.

Land use management is integrated at the local level and particular emphasis is put on urban and transport infrastructure planning. This contributes to a low level of private car dependence and the spread of urban areas. Local products are favoured in food consumption, with regional self-reliance in agricultural production emphasised. Meat consumption declines in countries with high population densities.

Energy systems are varied and based on regional conditions and the local availability of natural resources. Some transboundary environmental problems are dealt with regionally. The need to use energy resources more efficiently spurs the development of non-fossil technology in some regions. Globally the energy system in the B2 world remains predominantly hydrocarbon-based to 2100, but a gradual change occurs away from the use of fossil fuels. The dynamics of technological change continue along historical trends, while the exploitation of comparative regional advantages in energy resources and technologies leads to regionally different mixes of clean fossil and non-fossil supply.

3.3 European forest sector driving forces

In this section, the driving forces of land use change in Europe's forest sector (level 2 in the ATEAM scenario construction methodology) are described as storyline narratives. The present situation is described first, based on current trends and policies. Future storylines are then developed by merging recent trends with subjective interpretations by the authors of this report of the SRES storylines. The driving forces of agricultural, urban and protected areas land uses (Rounsevell et al. 2003) were also taken into account in the process of developing the forest sector storylines and possible contradictions were checked. The forest sector driving forces are presented in tables in Appendix 1.

3.3.1 Present situation

The baseline for the scenario storylines is the present (approximately year 2000) situation in the European forest sector. The scenarios developed in this report are based, in part, on the general situation, trends and policies of the European forest sector described elsewhere (Kankaanpää and Carter 2004).

General trends in the growth and area of European forest resources and institutional and social trends in the forest sector include (FAO 1997, in Mery et al 1999, p. 266; Päivinen et al. 1999; Mather 2000a, p. 14; Slee 2000, p. 81):

- The European forest resources covered a total area of slightly more than 150 million ha in 1995.
- The average forest coverage of the continent as a percentage of total land area was 31% in 1995; forest coverage was largest in Northern Europe (46%) and lowest in Western Europe (24%)
- Between 1990 and 1995 the average annual rate of increase of European forest areas was 0.3 %.
- The total forest area of European countries (excluding the former USSR) increased from 135.6 million ha in 1950 to 149.3 million ha in 1990 but the area of exploitable forests has remained rather stable.
- The growing stock of exploitable forest has increased by 43% and the net annual increment by 55% in 1950-1990.
- Recorded fellings have always been below the net increment and, as a consequence, the forest balance has been positive in Europe during 1951-1990.
- There are two major trends apparent in the functions and composition of forests in Europe. There has been a shift towards multi-functionality of forests and forests have also become providers of environmental and amenity-related goods instead of being solely providers of wood raw materials.
- Locational patterns of the new forests have changed. Lowland habitats suitable for broadleaved species and areas close to urban centres have been afforested as opposed to the previous afforestation of uplands and remote areas.

3.3.2 Social change in SRES narratives

Social change and its driving forces are not explicitly expressed in the SRES narratives. However, the construction of forest land use scenarios and the estimation of future forest land use change in Europe requires an understanding of the processes and directions of social change. The view of social change adopted in a scenario will determine the range of envisaged development and constrains the possible futures the scenario can depict. It is also useful to be as explicit as possible about the underlying idea of social change so that the assumptions on which the scenarios are based are as transparent as possible and the scenarios could be extended to other areas of social life that are not described explicitly in the scenario narratives.

In order to develop forest land use change narratives for this study, an interpretation was made of the implicit assumptions of social change and its driving forces in the SRES storylines. Social change – and also change in land use – is assumed in SRES to occur smoothly, with no abrupt breaks, reversals or major conflicts such as wars. In this study, social change in European countries is assumed to be progressive, following a path or a pattern in qualitative accord with the SRES narrative storyline descriptions, and consistent with SRES socio-economic and land use indicators that were quantified for OECD Europe.

3.3.3 Forest land use change in an A1 Europe

A1 is a very affluent world with a moderate population growth. The income disparities between world regions are virtually removed. There is free mobility of people and capital.

Part of the wood based industries of Europe move to where the markets are, to the present developing countries. However, Europe continues to be one of the major wood producing areas of the world, especially northern Europe, and the IMAGE 2.2 model (2001) estimates wood products demand to increase in Europe. Economic growth in the present developing countries leads to deforestation at first, but later

the present trends of simultaneous economic growth and increasing forest areas come true in many of these countries as well. Depending on the rate of deforestation in the developing countries, Europe becomes a major wood products exporter at some time in the first half of the 21st century.

The population of Europe increases to some degree. Even though there is less immigration for economic reasons, Europe is attractive for its educational, cultural or innovative characteristics. There is some environmental immigration as well. For the most part Europe remains densely populated and, as traffic is assumed to increase, air pollution is still prevalent, though other environmental problems are dealt with efficiently. In other regions of the world the intensive use of fossil fuels, fast growing economies and traffic cause severe environmental problems.

Agricultural production in Europe increases and becomes increasingly concentrated, industrialised and global in scope. Farm sizes increase. Marginal agricultural areas are abandoned.

Tourism continues to increase, which creates pressure on the European environment, especially in the Mediterranean region. In the A1 world the emphasis is on management of the environment and not conservation. The wilderness areas of the north of Europe are not as valued as the more easily accessible recreational areas and parks in central or southern Europe. Recreational use of the forests increases, but only in the forest areas that are close to the urban centres and that have good facilities.

Strict protection of forests decreases and there are no new conservation programmes. Urbanisation increases and there are large areas, especially in the north, abandoned from agricultural use. Wood production continues in these areas, but the most remote areas are left untouched. Part of the wood needed is produced in plantations, another part internationally, and natural forests are preserved because of this development.

Land use is intensive in most parts of Europe because of population pressure, urbanisation, increased infrastructure and development of the transport network, and the building of tourism and recreational facilities. In the A1 Europe, forest area is estimated to decrease as a result of heavy competition from other land uses, less emphasis on conservation, moderately high population pressure and increased recreational use and tourism. Wood production decreases in importance in Europe, as large plantations in other world regions produce timber with lower costs and part of the wood based industries have moved from Europe. Large areas of forests remain in the north, but in central and southern Europe, many forests fail to compete with other, more pressing land uses like urbanisation and the development of infrastructure.

3.3.4 Forest land use change in an A2 Europe

The A2 Europe strives for self-reliance in resources and production. It is a more protectionist region compared to the present Europe. The mobility of people, capital and technological innovations are less than in the A1 storyline, and less than in the world today. Population growth in the world is quite large, but immigration to Europe is regulated and the population of Europe remains stable or grows only moderately.

The growth rate of income per capita is less than at present in Europe, but A2 is still an affluent world. Regional welfare systems and income distribution diversify. The European Union grows in importance in a more protectionist world and, with a strong central government, social and environmental programmes are easier to carry out.

Agricultural production is estimated to increase in the A2 Europe and, as environmental concerns are also addressed, more agricultural land is needed as production cannot be intensified with increased use of fertilizers and pesticides alone. There is a moderate trend towards large farms.

The forest area of Europe decreases as a consequence of increased agriculture. Wood production in Europe increases as well. The increase can be covered in the first few decades by the increased growth rates of European forests, but in the latter part of the century, overexploitation of forests occurs as well. Forest loss as a result of urbanisation, tourism and infrastructure building is moderate compared to storyline A1.

3.3.5 Forest land use change in a B1 Europe

The B1 storyline describes a different world from the present situation in some aspects. The most notable differences are the globally balanced economic development, an equitable income distribution, the wide consensus on environmental protection and social equity and general global affluence and well-being. Environmental quality is high and adverse environmental effects are dealt with effectively.

The forest area in B1 Europe increases as a continuation of the present forest trends and policies. The rate of increase accelerates from the current rate of 0.3% per year, as environmental consciousness is high and environmental protection is efficiently promoted. B1 is an affluent world, which would also indicate a tendency towards an increase in forest area according to present trends in Europe.

Population growth is moderate compared to the A2 and B2 storylines and, as global economic and social equity is strongly promoted, it can be expected that the population of Europe remains quite stable in the absence of great in-migration. The areas of forests that offer services to people such as recreation, hunting, wilderness experiences, etc. as well as protected forests increase due to the general affluence of society and the overall environmental consciousness and values.

Growth in GDP in B1 is substantial but is qualitatively different from the other storylines, as in B1 concepts of "green" GDP apply and socially desirable activities like household work are included. The use of fuel wood is insignificant or non-existent and even though the GDP is high, the B1 world is orientated towards dematerialisation. Economic activity measured by GDP is increasingly a monetisation of human activities previously not included in the GDP accounts. However, the production of wood products remains stable because in a more equitable world trade, export of wood products from developing countries ("eco-predation") is considerably lower than today. The increase in forest area implies that Europe will be able to produce all the wood products needed in the continent, especially if there is reduced demand. Moreover, management practices in productive forests are environmentally friendly and biodiversity aspects are taken into consideration.

The agricultural land area increases to begin with as the emphasis is on natural production, which requires more land. However, in the long run technological improvements result in increased agricultural production with lower pesticide use and, at the same time, decreased land area.

Cities are compact and scattered settlements and suburban development are regulated. In the B1 world recreation based around second homes in the countryside is discouraged and strictly regulated. On the other hand, social aspects and equity are emphasised and rural development is a priority issue. Rural villages are

developed and employment opportunities there ameliorated. As a result, the quality of forests improves, as there are human resources in the rural areas for forest management work.

Forest conservation areas and forest reserves are estimated to increase. Decision-making and planning are centralised functions in B1 Europe, and the level of regulation by governments is high. The government effectively carries out decisions on even large nature conservation areas, and opposition is likely to be mild in an environmentally aware Europe.

3.3.6 Forest land use change in a B2 Europe

Self-reliance in agricultural and wood production is emphasised in the B2 Europe, with local products favoured in consumption. At the local level, self-reliance is a major aim and strong communities are promoted. Environmental and social sustainability are priority issues and environmental protection is valued highly in the society. Environmental concerns are dealt with at the local level and decision-making is characterised by strong citizen participation at the local and regional levels. International institutions and agreements decline in importance.

Land use is managed and regulated at the local level. Urban expansion is restricted and the development of transport infrastructure is limited. Public transportation and railways are promoted.

International forestry agreements and dialogue decline in importance and local approaches to the management of forests are adopted. Wood production in Europe grows in importance as fewer wood products are imported. Wood-based industries also remain in Europe as the capital is less mobile, world trade is regulated and restricted and the emphasis is on self-reliance on resources.

The total area of agricultural land is relatively stable. Food is increasingly produced locally and large-scale farming is not encouraged.

Tourism as an industry is not as important as it is today. Forest recreation areas increase close to the urban centres. Distant recreation areas are not favoured as private cars are discouraged. Forest reserves and conservation areas increase in area, as environmental protection has a high priority in society. Large national or regional nature protection programmes are difficult to carry out as decision-making is focused on local and regional institutions. Central governments are relatively weak. Local opposition to some forest conservation programmes can also be strong if local agricultural or timber production interests are in conflict with the plans of central government.

3.3.7 Summary of the scenario storylines for Europe

In Figure 3 the relative direction of different driving factors of forest land use change in the four SRES worlds (A1, A2, B1, B2) is presented. The assumptions are based on the level 2 European forest sector driving forces presented in section 3.3 and tables in Annex 1.

Driving factors	A1	A2	B1	B2
Economic, GDP				
Timber demand				
Population				
Institutions	Global	Regional	Global	Regional
Technological change				
Forest management	Timber	Timber	Mixed	Mixed
Land use intensity				
Agricultural land use				
Timber production				
Recreation				
Biodiversity				

Figure 3. Relative direction of the driving factors determining forest area in Europe, 2001-2100, in the four SRES worlds. For instance, a tilted straight arrow denotes steady growth or decline throughout the century; a curved arrow indicates a change in rate of growth or decline.

Estimation of forest land use change in Europe

4

4.1 Construction of estimates

4.1.1 Preamble

The trends in forestry and forests of today are assumed in this study to continue in the future until 2020 and the current forest strategies and policies and their targets are assumed to be implemented. These are simplified assumptions, but it was beyond the scope of this study to assess the actual outcome and likely impact of current policies. Rather, the position is taken that the policies are at least a clear indication of the direction of change and, in many cases, of the magnitude as well. An overview of European forest policies affecting land use is presented in a separate report (Kankaanpää and Carter 2004). The 2020 scenarios were estimated for each country either by assuming that policy targets for 2020 were achieved or by extrapolating nearer-term (5- or 10-year) targets out to the year 2020 (Table 2). Many countries have explicit plans for the location and species composition of afforested or reforested areas. In these cases the locations and species are included in the scenario tables as well.

The changed circumstances described in the SRES storylines are taken into consideration in scenarios for two subsequent periods: 2020–2050 and 2050–2100. Scenarios were constructed for five country groups (described in section 4.1.2. – see Tables 2-4 and Figures 4-9). It should be noted that forests have long rotation times in some regions, and trees planted today may only reach their harvesting age in 2080 or 2100. Even though the storylines describe rapid changes in society, these changes may not be reflected in the forests immediately, but will take decades to materialise. It is assumed that the underlying driving forces that are thought to be relevant in forest land use change today will also apply in the future worlds described in the storylines, even though cultural values and attitudes differ from the present.

Several assumptions were required in the storylines describing the development of forests in future worlds, where these were not expressed in the original SRES narratives. The SRES storylines are not explicit about the theoretical framework on which the narratives are based. Many of the forest land use change variables are qualitative in nature and are difficult or impossible to describe in quantitative form. The possible causalities between the factors affecting forest land use change are not well known and it is justified to assume that they can be different in different regions and vary over time and location. In the following, percentage changes of forest area, the location of forests and changes in forest composition (species) were estimated, where possible. However, in some countries no quantitative estimates of planned forest areas are available.

4.1.2 Country groups

The European countries studied in this report were divided into five groups for the estimation of future forest land use change according to similarities in their current forest situation and forestry sector targets expressed in their national forest strategies, policies and plans. The groups and their characteristics are:

- Group I (Austria, Finland, Norway, Sweden):
  - wood production is a key forest function
  - forestry is an important sector in the national economy
  - forest areas of the countries are large, both relatively and absolutely
- Group II (Belgium, the Netherlands):
  - agricultural sector is strong/agricultural land use dominates
  - high population pressure
  - forestry is a marginal sector in the national economy
  - forest areas are small, forest properties fragmented
  - other land uses dominate forest land use
- Group III (Denmark, Ireland, Switzerland, United Kingdom)
  - other forest functions than wood production also important (such as protection function in Switzerland)
  - other forest products than timber important (Christmas trees, foliage etc.)
  - forestry of little importance in national economy
  - afforestation/forest area increase emphasised
  - forest areas small, relatively and in absolute terms
- Group IV (Greece, Italy, Portugal, Spain)
  - Mediterranean/southern European countries
  - parcelled forests
  - forestry sector weak
  - other forest functions than wood production important
  - non-timber and non-wood forest products important
  - forest fires and drought are major problems
- Group V (France, Germany)
  - large forest areas in absolute terms, forests parcelled
  - per capita forest area less than in the northern countries
  - other land uses dominate forest land use
  - high population pressure
  - wood production an important forest function

4.1.3 Assumptions

The assumptions made for each storyline to translate the scenario narratives into estimates of forest land use change were the following (Kankaanpää and Carter 2004; IMAGE team 2001; CIESIN 2002; Rounsevell et al. 2003):

- Storyline A1

  - Group I: Wood production increases somewhat in Europe. Part of the wood products demand is satisfied by production in other world regions, but production in Europe increases as well. The IMAGE 2.2 model estimates wood products demand to increase in Europe by over 20% in 2020-2050 and sharply from 2060 onwards (IMAGE team 2001). Protected forest areas decrease as some areas are taken into production. Population declines in the latter half of the century. Forest degradation may occur as forests are overexploited to meet the increased wood products demand.
  - Group II: Agricultural production remains at the present level or increases somewhat. Population pressure is high as well as pressures from other land uses such as urbanisation, transport network construction. Protected forest areas decrease as they are taken into wood production and as a result of population pressure and competition from other land uses. Population declines in the latter half of the century.

– Group III: Agricultural production stays at the present level, but all marginal agricultural areas are abandoned. Recreational use of forests increase. Urbanisation is high and population density increases. Protected forest areas decrease, production increases somewhat and protected forest areas decrease. Recreational use of forests increases. From 2050 onwards the forest area remains stable, but forest degradation may occur as a result of overexploitation. Protected forest area decreases.
– Group IV: Tourism increases and pressure from other land uses such as urbanisation is high as well. Forest fires increase. Agricultural production remains at the present level, but marginal areas are abandoned. Protected forest areas decrease as a result of population pressure, tourism and other land uses dominating. In the latter part of the century forest area decreases slightly, wood products demand is covered partly by creating new plantations. The area of protected forests decreases slightly.
– Group V: Wood products demand increases in Europe, but other land uses compete with forests and the forest area is estimated to decrease moderately. Wood production increases somewhat and protected forest areas decrease. Recreational use of forests increases. From 2050 onwards the forest area remains stable, but forest degradation may occur as a result of overexploitation. Protected forest area decreases.

• Storyline A2

– Group I: Self-reliance is emphasised and wood production increases. Wood exports decline because of protectionist trade policies. Wood products demand increases, but less steeply than in A1 (IMAGE team 2001). Protected forest areas decrease as part of the areas is taken into production and population pressure increases. Wood production also increases in the latter part of the century and forest areas might be degraded or deforested because of over-exploitation of the resource. Forest area decreases because of high population pressure.
– Group II: Agricultural area increases as self-reliance on food production is a priority. Population increases. Protected forest areas decrease as land is taken into other uses; ecological reserve networks are diminished.
– Group III: Population pressure is high. Agricultural production increases and marginal areas are utilised. Wood production increases and protected forest areas decrease, but forest reserves remain in remote and mountain areas where forests serve a protective function
– Group IV: Tourism decreases, there is an emphasis on environmental conservation, agricultural production increases and marginal areas are utilised. Population decreases somewhat, wood production increases and plantations are created. Protected forest areas decrease, forest reserves remain in mountain areas and in areas where forests have soil protection and erosion control functions. From 2050 onwards population pressure continues to be high and forest fires increase. Total forest area and protected forest area decrease.
– Group V: Wood production increases but other land uses compete effectively with forests. Marginal agricultural lands are utilised. Population pressure is high. From 2050 onwards forest area decreases slightly. Wood production increases which might lead to degraded forests or deforestation. Protected forest areas decline.

- Storyline B1

– Group I: Wood production remains stable or decreases a little. Wood products demand decreases by more than 20% in Europe over 2020-2050 (IMAGE team 2001). The area under agriculture increases towards the margins because natural production requires more land. Land use is regulated and cities are compact. Protected forest areas increase. Existing forest reserves are extended and new forest reserves are established close to urban centres. In the latter part of the century the demand for wood products declines in Europe (IMAGE team 2001). Total forest area remains stable and protected forest areas increase moderately.
– Group II: Total forest area and protected forest areas increase. Existing forest reserves are extended and new areas are created close to urban areas. Land use is regulated
– Group III: Wood production remains stable. The area under recreational and protected forests increases. Population declines and timber demand decreases in the latter part of the century. Forest area and protected forest area are estimated to increase.
– Group IV: Tourism pressure is low and land use is regulated. There is great emphasis on forest conservation and recreational forests. Population declines 1.3 -16% depending on the country. Forest fires decrease. Protected forest areas increase.
– Group V: Wood production remains stable while agricultural area increases. Land use and urbanisation are regulated and traffic networks restricted. Protected forest areas increase slightly. From 2050 onwards population density declines. Timber production decreases and forest and protected forest areas are estimated to increase slightly.

- Storyline B2

– Group I: Wood production for regional and local use increases. Wood products demand in Europe increases until 2040, then decreases back to 2020 levels by 2055. Tourism decreases and urban growth and traffic networks are regulated. Agricultural production increases. There is a slight increase in forest protection areas. Wood products demand continues decreasing after 2050, but less than in B1 (IMAGE team 2001). Forest area and protected forest area remain stable. Population increases a little.
– Group II: Agricultural and wood production increase. Land use is regulated. Recreational forest area increases as well as protected forests.
– Group III: Agricultural and wood production increase. Recreational forests increase in area. From 2050 wood production decreases as demand goes down. Protected forest areas increase slightly. Population increases slightly (1.7%).
– Group IV: Agricultural production increases and marginal lands are utilised. Urban spread is controlled. Tourism decreases. Population decreases by between 11 and 26%. Forest fires decrease slightly. Protected forest areas increase slightly. In the latter part of the century total forest area and protected forest area continue to increase.
– Group V: Wood production increases. Land use is regulated. Protected forest area increases and existing forest reserves are extended. Wood production decreases after 2050 and population increases at a moderate rate. Protected forest areas remain stable.

4.2 Forest land use change in 2020-2100

Estimates for forest land use change for three time slices (2020, 2050 and 2100) are presented in Tables 2-4 and Figures 4-9 for the country groupings described above. Table 2 also summarises the baseline situation, which approximates the year 2000 and is based on a survey of national forest policies presented elsewhere (Kankaanpää and Carter, 2004), Detailed estimates for each country are also presented in Annex 2.

Table 2. Present-day (ca. 2000) areas of forest and protected forest in Europe by country grouping and estimations of forest land use change for 2020 based on current trends (source: Kankaanpää and Carter 2004). Countries are grouped according to similarities in their current forest situation and forest policies.

Country	Present (ca. 2000)	2000-2020
Group I		
Austria	Forest: 3.9 million ha (47%)	increase in higher altitudes
	Protected: 49 000 ha	
Finland	Forest: 26 million ha (76%)	protected areas + 1% in Southern Finland
	Protected: 2.44 million ha	afforestation 10 000 ha/year (0.8-0.9% by 2020)
Norway	Forest: 12 million ha (37%)	stable
	Protected: 199 500 ha	
Sweden	Forest: 27.134 million ha (65%)	stable
	Protected: 1.4 million ha	900 000 ha changed into protected areas
Group II		
Belgium	Forest: 672 000 ha (22%)	Flanders + 20 000 ha (10 000 ha agr.land)
	Protected: 5000 ha	increase 3000 ha protected (+60% Belgium)
		Wallonia stable
Netherlands	Forest: 375 000 ha (11%)	increase 75 000 ha (10 000 ha near cities)
	Protected: 18 500 ha	(+20%)
Group III		
Denmark	Forest: 445 000 ha (12%)	increase 800 ha/yr state forest
		increase 89 000 ha total by 2020 (19.6%)
	Protected: 92 000 ha	protected + 9000 ha
Ireland	Forest: 650 000 ha (9%)	20 000 ha/year to 2035
		increase forest area to 17% by 2030
	Protected: 5736 ha	increase 400 000 ha by 2020 (61%)
Switzerland	Forest: 1.26 million ha (31%)	stable (maintaining the existing forests)
	Protected:13 530 ha	
UK	Forest: 2.3 million ha (11%)	England and Wales moderate increase
		Scotland increase forest cover to 25% by 2050
	Protected: 128 700 ha	+ 338 000 ha (+28%)
Group IV		
Greece	Forest: 6.5 million ha (44%)	increase 47 000 ha by 2020 (0.7%)
	Protected: 951 700 ha	species resistant to fire
Italy	Forest: 8.7 million ha (29%)	+ 130 000 ha by 2020 (1.5%)
	Protected: 560 400 ha	
Portugal	Forest: 3.666 million ha (40%)	+520 000 ha by 2020 (14%)
	Protected: 560 400 ha	
Spain	Forest: 14.37 million ha (29%)	Galicia +6% by 2032
	Protected: 2.5 million ha	Spain +574 800 ha (+ 4%)
Group V		
France	Forest: 15.34 million ha (27.9%)	+ 190 000 ha by 2020
	Protected: 180 000 ha	+1.2%
Germany	Forest: 10.74 million ha (30%)	est. + 93 000 ha by 2020
	Protected: 400 000 ha	+0.8%

Table 3. Forest land use change estimates 2020-2050, for five groups of European countries based on the four SRES storylines. Slight increase/decrease = 0-5%; moderate increase/decrease = 5-10%; increase/decrease = 10-15%; stable = no change.

	Forest land use change for 2020 - 2050		
A1	A2	B1	B2
	Group I *(Austria, Finland, Norway, Sweden)*		
slight increase	moderate increase	slight decrease	slight increase
	Group II (Belgium, the Netherlands)		
moderate decrease	decrease	increase	moderate increase
	Group III *(Denmark, Ireland, Switzerland, UK)*		
slight decrease	slight decrease	increase	increase
	Group IV *(Greece, Italy, Portugal, Spain)*		
decrease	moderate decrease	increase	moderate increase
	Group V *(France, Germany)*		
moderate decrease	slight decrease	moderate increase	increase

Table 4. Forest land use change estimates, 2050-2100, for five groups of European countries based on the four SRES storylines. Slight increase/decrease = 0-5%; moderate increase/decrease = 5-10%; increase/decrease = 10-15%; stable = no change.

	Forest land use change for 2050 - 2100		
A1	A2	B1	B2
	Group I *(Austria, Finland, Norway, Sweden)*		
moderate increase	slight decrease	stable	stable
	Group II *(Belgium, the Netherlands)*		
slight decrease	decrease	increase	moderate increase
	Group III *(Denmark, Ireland, Switzerland, UK)*		
stable	moderate decrease	increase	moderate increase
	Group IV *(Greece, Italy, Portugal, Spain)*		
slight decrease	decrease	increase	moderate increase
	Group V *(France, Germany)*		
stable	slight decrease	slight increase	moderate increase

Tables 3 and 4 are depicted in graphs in Figures 4-8. The estimates of the changes in forest land area are based on the scenario storylines and assumptions (described in section 4.1.3.).

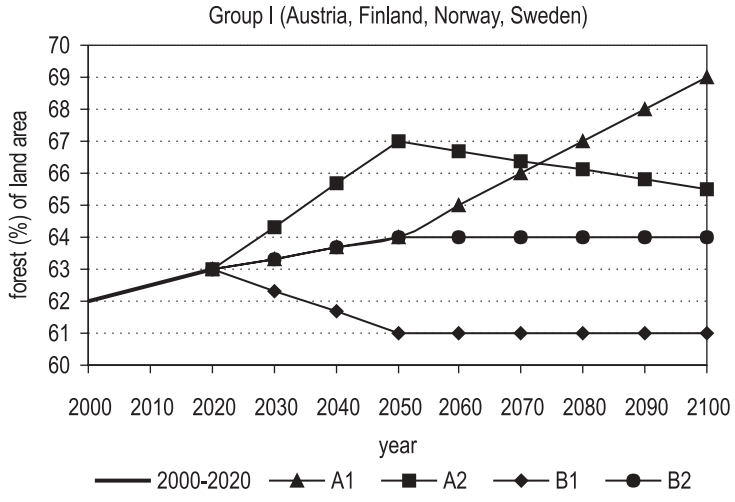

Figure 4. Estimated forest area for Group I countries: 2000-2100

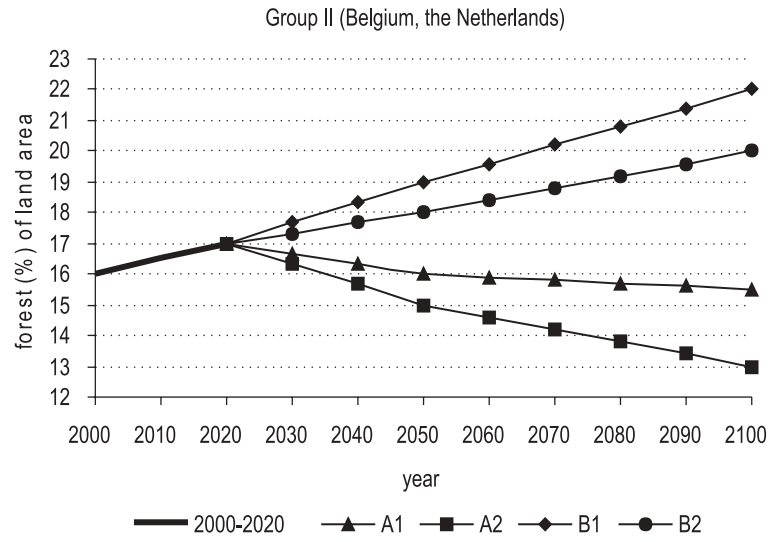

Figure 5. Estimated forest area for Group II countries: 2000-2100

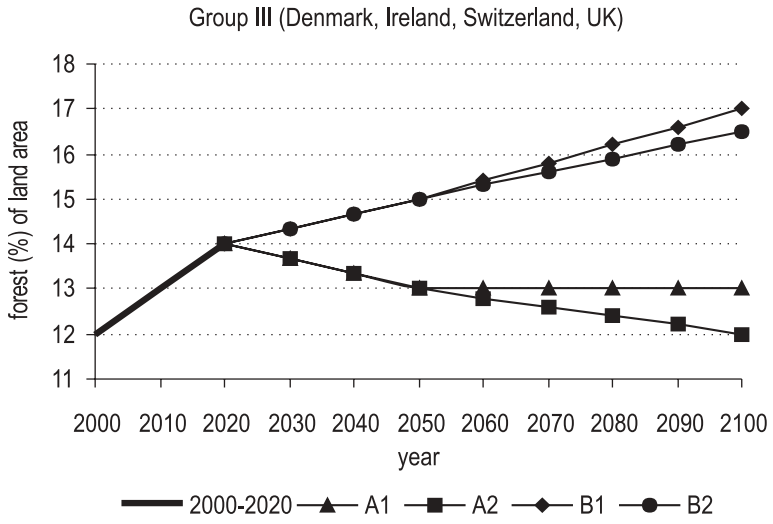

Figure 6. Estimated forest area for Group III countries: 2000-2100

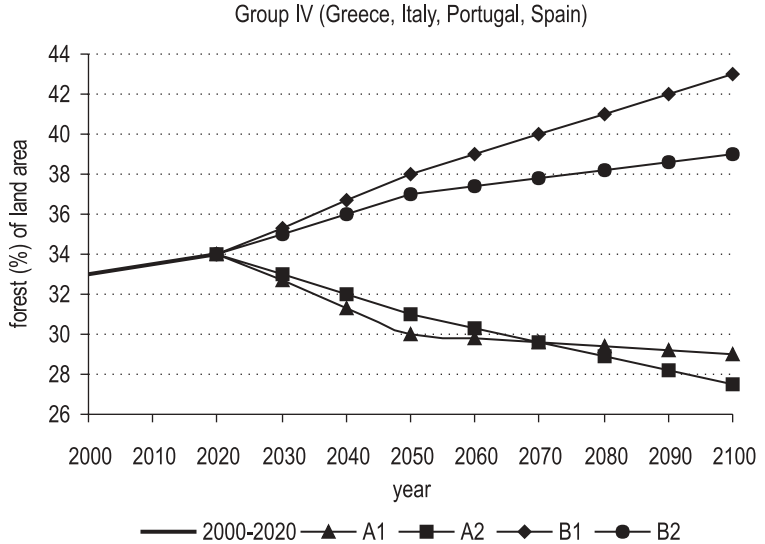

Figure 7. Estimated forest area for Group IV countries: 2000-2100

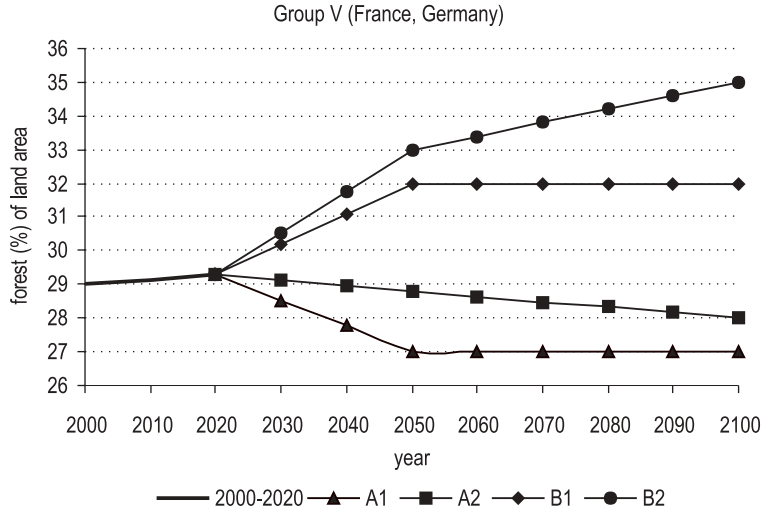

Figure 8. Estimated forest area for Group V countries: 2000-2100

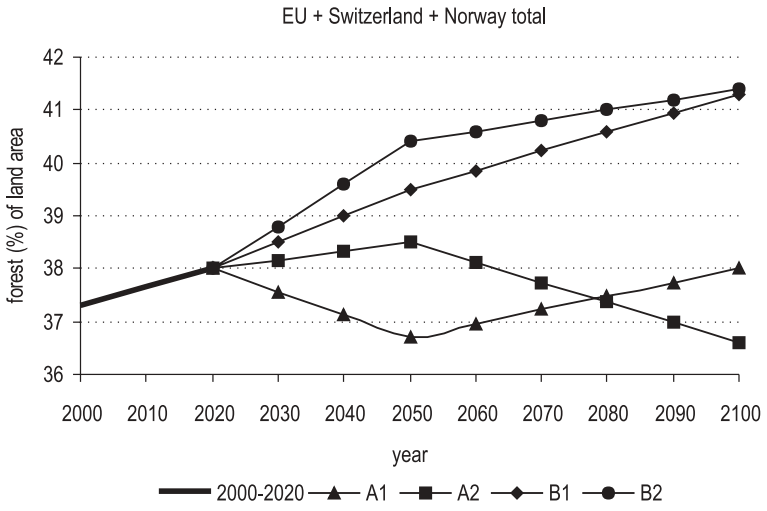

Figure 9. Estimated forest area in the pre-enlargement European Union (excluding Luxembourg) plus Switzerland and Norway: 2000-2100

4.3 Discussion

The present trends in European forest area and forest policies seem to point to a continuous growth of forest areas in most parts of Europe. Most countries have adopted forest strategies that set the expansion of forest areas as one of their key targets. Forest area in Europe has grown at a moderate rate (currently on average 0.3% per year) during recent years. Growth rates of many European forests have accelerated substantially during the last few decades. The forest land use change estimates drafted in this report project either decreasing forest areas (in storylines A1 and A2) or somewhat greater forest area growth rates than the present (in B1 and B2).

Forest land use change is a complex issue. It is widely studied, especially in connection with tropical deforestation, but general and uniform understanding of the causes of it are so far lacking. There can be multiple causes and the factors influencing forest land use change are different in different regions. The processes and particular mixes of causes of land use change vary by place and time, and it is often difficult to identify the dominant factors among them. This study concentrated on institutional factors (mainly forest policies) as they were considered to be one of the major factors determining forest land use in Europe. There are other factors (e.g. demographic, economic, institutional, cultural and technological) affecting

forest land use change that are not explicitly covered in the analysis. Therefore the forest land use change estimates presented here are trend setting rather than full projections of possible futures.

The estimates serve as a reliability and consistency check for the overall land use change scenarios developed in the ATEAM project. The scenarios for the period after 2020 are constructed without explicitly considering national forest policies as a driving force of land use change. The land use hierarchy that accords forest land use a lower priority than protection, urban, biofuel and agricultural uses can also be criticised, as in many cases and in the different storylines forests may not be the residual of all other land uses, but in fact will be preferred for political, social or environmental reasons. Therefore it is important to revise the land use change scenarios for inconsistencies with the separate estimates of forest land use change.

There are some limitations to the SRES storyline descriptions that complicate the translation of the narratives to forest land use change driving forces for Europe. The SRES storylines are based on a literature review and the personal experience and creativity of the writing team (Nakicenovic et al. 2000, pp. 171-172). The theoretical framework of the storyline development is not explicit and it is not clear, how social change and development are understood in the SRES storylines. Deriving social changes other than those explicitly narrated in the storylines, yet compatible with them, is problematic in the absence of a defined theoretical framework. The SRES storylines include little description of the type of government and decision making structures of the future worlds. However, these structures will have a great impact on future societies and, therefore, on the environment as well.

The ATEAM project incorporated a stakeholder dialogue to enhance the dissemination of project results and to ensure feedback on their usefulness. The group of stakeholders comprises European natural resource managers, planners, consultants, researchers, decision-makers and their advisers. In an ATEAM Stakeholder Workshop held in Potsdam, Germany in September 2002, stakeholders discussed the development of forest land use change scenarios within the project. It was pointed out that a different overall land use hierarchy might be more realistic than the one applied in the project. The stakeholders had the opinion that increased forest productivity has little effect on the spatial dimension of forest land use unless there is a substantial shift in the revenue obtained. Trends in urbanisation and agriculture are more likely to be significant drivers of forest land use distribution. The wider driving forces such as EU enlargement, government subsidies, and public and policy pressures need to be considered more fully in future research. Forest management strategies can have an important impact on forest land use and should be considered in land use scenarios (de la Vega-Leinert et al. 2003).

The approach to forest land use change scenarios adopted here requires further development. Other driving forces, such as forest management regimes, should be included explicitly in the analysis and "location rules" for the new forests specified. The role of policies in determining forest land use is central. Therefore, further study to assess the impact of policies is needed – to what extent and under which circumstances are the targets of the policies implemented and what is their impact on forest land use change. Eventually the aim should be the development of a comprehensive land use change scenario framework that would integrate policies as important driving forces of land use change. Quantitative scenarios, based on results of computer models, can be useful tools in predicting the future but they have their limitations as well. The exactness of their numbers can sometimes be taken as a sign that we know more about the future than we actually do. Computer models also contain many implicit assumptions about the future that can be unnecessarily narrow in view. It can also be difficult for non-specialists to understand the basis of the modelling (Alcamo 2001, p. 10). Nevertheless, quantitative scenarios are often more transparent in their assumptions and their implicit assumptions are

not hidden in the computer models. Quantitative scenarios can also be more understandable in describing the direction of change and future trends. On the other hand, the inevitable uncertainty of any projection of the future is usually more openly expressed in qualitative scenarios than in scenarios based on computer models. Many socio-economic factors are difficult if not impossible to express in quantitative form and to be included in mathematical models. Therefore, there will always be a need for partly qualitative and descriptive analyses of land use changes, and the approach described in this report can be one starting point for the further development of these types of scenarios.

5 Acknowledgements

We are grateful for the valuable comments of Professor Timo Karjalainen and Dr. Juhani Tirkkonen. This work was conducted as part of the European Commission-funded ATEAM project (Advanced Terrestrial Ecosystem Analysis and Modelling), contract no. EVK2-CT2000-00075, under sub-contracts to the Université Catholique de Louvain, Belgium and Wageningen University, the Netherlands.

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Appendix I

Table A1.1-A1.4. European forestry sector driving forces (Level 2 in the ATEAM scenario construction methdology) for the four SRES storylines (A1, A2, B1, B2) (Sources: Nakicenovic et al. 2000; IMAGE team 2001; CIESIN 2002; Kankaanpää and Carter 2004; Rounsevell et al. 2003)

Table A1.1. A1 level 2: Forest land use change

Driving forces	Group I AT, FI, NO, SE	Group II BE, NL	Group III DK, IE, CH, UK	Group IV GR, IT, PT, ES	Group V FR, DE
Economic **GDP** **income distribution** **de/materialization**	very rapid economic growth convergence between world regions, income inequalities also eradicated within Europe material consumption, increase in income/capita leads to increased use of nat. resources				
Wood products demand	total demand increases (A1F) from 285 mill. m3/year in 2000 to 711 mill.m3/yr 2100, pulpwood & particles demand great increase, saw logs & veneer slight increase (IMAGE)				
Population **growth** **2000-2050**	NO + 20.2% FI + 0.25% SE – 2 % AT - 10.2%	increase 4 – 9.8 %	IE +51.9% UK + 4.7% DK + 9.5% CH –12.1%	decline 1.3% to 15.9%	FR + 15.4% DE –3.5%
2050-2100	population decline between 5.2 % and 9.5%				
density	stable, except NO	increases	increases	decreases	increase FR
rural population	decrease, but suburban population increases, marginal and remote areas pop. decrease				
migration	increase (NO) other countries: no immigration	moderate increase	increase (IE) mod. increase decrease (CH)	decrease	increase (FR)
Institutions **government participation, self-sufficiency, decision-making**	Governments weak; strong commitment to market based solutions. International co-operation. Stable political and social climate, also social welfare high in terms of health care, education. Self-sufficiency not an issue; free trade emphasised.				
rural development	Focus on centres and international connections, rural development not a focus area. Increased affluence has "spill over" effects to the rural and remote areas, rural development policy not exercised				
Technology **change**	High investments in technology, high rates of innovation. Rapid technological change				
forest management	wood production a priority	recreational use a priority	wood prod. and recreation priorities	recreation a priority use	wood prod. a priority, also recreation
Land use **intensity**	increases except in remote and marginal agricultural areas				
agricultural LUC	decline at margins	increase	increase	increase	increase
urban LUC **infrastructural LUC; traffic**	slight increase mod. increase mod. increase	increase increase	increase increase increase	slight decrease slight increase mod. increase	increase France increase increase
accessibility: rural	improved access due to more dense traffic network, remote areas difficult access				
accessibility: forest	Access improved. Forests close to population centres damaged due to over use, productive may be forests overexploited after 2050				
recreation, tourism	increase close to urban centres, wilderness areas less attractive, facilities appreciated increase, more in the Mediterranean region and C. Europe than in the north (wilderness experiences not as valued as urban centres, beach resorts, built tourism facilities)				
Life style **forest services**	forest amenity valued but easy accessibility and facilities demanded				
Environment **biodiversity**	decreases due to pop pressure, increased agr. production, less conservation except in remote areas				
fires	stable	stable	stable	increase	slight increase
protection mgmt.	less emphasis on env. conservation, more on management of env. resources				
Energy **wood based**	fuel wood demand slight decrease (IMAGE)				
biofuels	IMAGE estimates				
Forests **wood production**	increases	stable	increase in suitable areas.	increase (plantations)	increase in suitable areas
species distribution	conifers	deciduous	conifers, decid	decid., evergrns	decid., conifers

Table A1.2. A2 level 2: Forest land use change

Driving forces	Group I AT, FI, NO, SE	Group II BE, NL	Group III DK, IE, CH, UK	Group IV GR, IT, PT, ES	Group V FR, DE
Economic **GDP** **income distrib.** **de/materialization**	Economic development regionally oriented and uneven. Income gap between developed and developing countries does not narrow. Disparities in income and productivity between different world regions largely maintained or increased in absolute terms. Capital stock turnover relatively slow.				
Wood products demand	total demand increases from 285 mill. m3/yr (2000) to 482 mill m3/yr (2100) (IMAGE)				
Population **growth** **2000-2050**	NO + 22.6% FI + 1.8% SE -3.0 AT –12.7%	increase 4.3 to 12%	IE + 62.6% DK +7.5% UK + 13.9% CH –13.6%	decrease between 0.6 and 18.4%	FR +18.4% DE -4.8%
2050-2100	population increase between 14 % and 19.1% 2050-2100				
density	NO increase mod. increase	increase	increase except CH (decrease)	mod. decrease then mod. increase	FR increase DE mod. increase
rural population	increases as local/regional food and timber production emphasised				
migration	increases after 2050; some countries increases 2000-2050 (NO, IE, FR) but in general mobility of people is less than in A1 and immigration regulated				
Institutions **government** **participation** **self-sufficiency** **decision-making**	Self-reliance of regions, less mobility of people, ideas and capital. Social and political institutions diversify. Central national governments weak, "markets first" approach. A more protectionist Europe compared to the present, which might mean a stronger EU.				
rural development	Rural development results as a by-product of stress on regional self-reliance				
Technology **change**	Slower than in A1 and more heterogeneous, technology transfer and diffusion slower than in other storylines				
forest management	wood production a priority	recreational use a priority	wood prod. a priority, 2nd recreation	non wood, non timber products a priority	wood production a priority
Land use **intensity**	Increases, agricultural land used more intensively; marginal lands also taken into agr. use				
agricultural LUC	mod. increase	increases/ intensifies	increases	increases	increases
urban LUC **infrastructural LUC** **traffic**	stable, after 2050 increases (AT, FI, SE); NO increase from 2000	increase	increase (IE, DK,UK); CH declne to 2050 then increase	decrease, after 2050 increase	FR increase DE decrease to 2050 then increase
accessibility: rural	Accessibility increases				
accessibility: forest	Accessibility increases, also to remote forests as they are used for wood production. Some destruction of near urban forests can occur and overexploitation of productive forests				
recreation **tourism**	Tourism decreases, recreation increases as population increases. Demand for near urban recreation areas increases, but areas distant from the centres also used for recreation as population is dispersed. Facilities are valued, wilderness areas less popular.				
Life style **forest services**	Recreational services of forests valued, nature conservation not a prime issue. Supply of forest services market driven, only marketable services valued.				
Environment **biodiversity**	decreases due to pop pressure, increased agricultural and timber production				
fires	slight increase	stable	slight increase	mod. increase	slight increase
protection mgmt.	Environmental management aims at creating services for people				
Energy **wood based**	use decreases (IMAGE)				
biofuels	IMAGE estimates				
Forests **wood production**	increases	stable	increases	mod. increase	increases
species distribution	conifers	deciduous	conifers, decid.	decid. conifers, evergreens	decid., conifers

Table A1.3. B1 level 2: Forest land use change

Driving forces	Group I AT, FI, NO, SE	Group II BE, NL	Group III DK, IE, CH, UK	Group IV GR, IT, PT, ES	Group V FR, DE
Economic **GDP** **income distrib.** **de/materialization**	High levels of economic activity, an affluent world and a deliberate progress toward international and national income equality. GDP growth substantial but qualitatively different from other storylines; dematerialisation emphasised.				
Wood products demand	total demand first slight increase (2000-2010) then decreases from 294 mill m3/yr in 2010 to 176 mill. m3/yr in 2100 (IMAGE)				
Population **growth** **2000-2050**	NO + 20.2% FI +0.25% SE –2% AT –10.2%	increase 4 – 9.8%	IE +51.9% DK + 9.5% UK + 4.7% CH. –12.1%	decline 1.3 to 15.9%	FR + 15.4% DE - 3.5%
2050-2100	population decline between 5.2% and 9.5% in European countries				
density	stable NO increases	mod. increase	mod. increase IE large increase	decrease	FR increase DE stable
rural population	slight increase (equity, environmental values)				
migration	Some immigration to Europe, esp. to NO, IE, FR				
Institutions **government participation; self-sufficiency decision-making**	Central governments strong, planning is restrictive, high level of regulation. International institutions and cooperation central.				
rural development	Rural development a key issue (equitable income distribution and development a priority)				
Technology **change**	rapid technological change				
forest management	wood prod. one function, but close-to-nature mgmt	close-to-nature mgmt, protection	wood prod, recreation, protection, close-to-nature mgmt	protection, recreation, close-to-nature mgmt	wood prod, recreation, protection, close-to-nature mgmt
Land use **intensity**	Urban areas compact, rural areas village centres, other areas low intensity				
agricultural LUC	area increases, (natural prod.)	increases (trade)	increases (nat. prod. & trade)	increases (nat.prod, trade)	increases (nat.prod, trade)
urban LUC **infrastructural LUC; traffic**	Urban sprawl regulated, scattered settlements and suburban development restricted. Public transport encouraged.				
accessibility: rural	Rural centres easy access, remote areas difficult				
accessibility: forest	Recreational forests close to settlements easy access, remote areas more difficult				
recreation tourism	Tourism decreases, recreation increases both at near-urban centres and in remote, wilderness areas				
Life style **forest services**	Environmental conservation and protection priority issues, forest amenity valued highly				
Environment **biodiversity**	Increase; large areas of protected forests, settlements regulated				
fires	stable	stable	stable	decrease	slight decrease
protection management	Nature conservation a priority				
Energy **wood based**	Fuel wood demand decreases from 36 mill m3/yr (2000) to 15 mill. m3/yr (2100)				
biofuels	IMAGE estimates				
Forests **wood production**	decrease after 2010	decrease after 2010	stable	decrease (plantations decrease)	decrease after 2010
species distribution	conifers, decid., indigenous	deciduous, indigenous	decid., indigenous	decid. indigenous	decid. indigenous

Table A1.4. B2 level 2: Forest land use change

Driving forces	Group I AT, FI, NO, SE	Group II BE, NL	Group III DK, IE, CH, UK	Group IV GR, IT, PT, ES	Group V FR, DE
Economic **GDP** **income distrib.** **de/materialization**	GDP growth in Europe 2.6%/yr up to 2010, 1.45/yr to 2020 then slows down to 0.4 - 0.8%/yr 2020-2070. 2070-2100 the GDP growth rate is 1.3%/yr Rate of development generally slow, international income differences decrease at a slower rate than in A1, B1. Education and welfare programmes pursued.				
wood products demand	first total wood products demand increases to 2030 then decreases from 338 mill. m3/yr. to 291 mill. m3/yr (2199) (IMAGE)				
Population **growth** **2000-2050**	NO + 6.5% SE + 7.6% FI –0.1% AT – 10%	decrease 4.8-5.8%	UK + 0.7 IE + 6.6% DK – 0.8% CH – 6.4%	decrease 11.1 – 26.4%	decrease 1.2 – 15.9%
2050-2100	population increase 1.7% in all Europe				
density	slight increase	slight decrease	slight increase	decrease	decrease
rural population	increases in villages, scattered settlement discouraged				
migration	decreases				
Institutions **government participation self-sufficiency decision-making**	Local self-reliance and strong communities. Citizen participation in decision making at local level is high, also government policies and business strategies influenced by public participation. Decision making at local/regional level, central government weak.				
rural development	Increases: agr.and timber production increase, self-reliance emphasised, local products				
Technology **change**	technical change and innovation unevenly distributed				
forest management	wood prod. and protection, close-to-nature mgmt	protection, close-to-nature mgmt	wood prod. and protection, close-to-nature	protection, recreation, close-to-nature	wood prod. and protection, close-to-nature
Land use **intensity**	decreases, agricultural lands used more intensively				
agricultural LUC	increases	increases/ intensified	increases	increases	increases/ intensified
urban LUC **infrastructural LUC** **traffic**	Urban expansion restricted and transport infrastructure building limited concerning motorways. Rail traffic promoted as well as all kinds of public transportation. Private cars discouraged. Compact settlement patterns in small and medium size cities.				
accessibility: rural	Increases as agr. and timber prod. increases, recreational use of rural areas situated by railways and main roads increases				
accessibility: forest	Increases: both because of increased timber prod. and recreational use				
recreation tourism	Tourism decreases. Recreation increases, more in near urban areas and rural villages with access by public transportation.				
Life style **forest services**	Environmental protection a high priority				
Environment **biodiversity**	Increases because of protection networks, decreases in intensified agr. and timber production areas				
fires	stable	stable	stable	slight decrease	stable
protection management	environmental protection and conservation key issues				
Energy **wood based**	Fuel wood demand decreases from 36 mill. m3/yr (2000) to 14 mill. m3/yr (2100) (IMAGE)				
biofuels	IMAGE estimates				
Forests **wood production**	slight decrease after 2030	stable	increases, then decreases after 2030	stable	increases then decreases after 2030
species distribution	conifers, deciduous	deciduous	decid.; slight increase conif.	decid.	conifers, decid.

Appendix 2

Table A2.1-A2.4. Estimates of forest land use change by 2020 for Group I countries in Europe. Estimates are based on present policies and trends described in Kankaanpää and Carter 2004. The present species composition of each country is taken from Pelkonen et al. (1999). Blanks in the tables indicate that the country in question had no policies concerning that issue or that no information could be found.

Table A2.1. Austria: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	increase slightly	higher altitudes	coniferous forests 77% (spruce 62%)	slight increase of deciduous tree species, mixed stands
productive forest/ wood production	stable			species of economic profitability emphasised
protected forest/ nature reserve	slight increase network of natural forest reserves established (8000 ha in 5 years); 600 000 ha nominated for Natura 2000	higher altitudes all parts of the country		all types of forest ecosystems covered
recreational forest	stable			

* Generally conversions of forest land are prohibited by Austrian Forest Law. Exceptions are regulated very strictly, the possible motives are listed in the law (e.g. a strong public interest) and have to be approved by forest authorities. (Sources: The Austrian Forest Reserves http://fbva.forvie.ac.at/100/1306.html; Forstwirtschaft http://www.lebenministerium.at/forst)

Table A2.2. Finland: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	slight increase 10 000 ha of afforestation/yr	abandoned agricultural land	conifers cover over 80% of forest area, birch 7.5%, above northern timberline only fell birch	biodiversity and ecological sustainability of forests ensured
productive forest/ wood production	slight increase			pine, spruce, European white birch, a slight deciduous mix in the coniferous forests
protected forest/ nature reserve	stable, possible increase (150 000 - 400 000 ha)	southern Finland, Ostrobothnia		slight increase in deciduous tree species native species
recreational forest	stable			

* The Forest Act requires regeneration after clear felling. The Act does not forbid converting forest land to other uses, but if the land is not converted to other uses after five years of clear felling, the area has to be reforested. Other legislation includes restrictions for use of land and land use conversions. (Sources: Finland's National Forest Programme 1999 http://www.mmm.fi/kmo/english/; Metsätalouden ympäristöohjelma 1994 (Environmental programme of forestry) Ministry of Agriculture and Forests; Metsätalouden ympäristöopas 1997 (Environmental guidelines of forestry), National Board of Forests)

Table A2.3. Norway: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	stable		conifers cover 73% of total forest area, deciduous 27% South-Mid-East 84%/16% West 59%/41% North 28%/72%	slight increase in deciduous tree species
productive forest/ ting	stable	Vestlandet		area of spruce is expected to grow (substitu-
wood production		Northern Norway		other species, on non-forested lands), slight increase in deciduous tree species
protected forest/ nature reserve	slight increase 12 000 ha			conifers
recreational forest	stable			

* Generally conversion of forest land to other uses is forbidden by law. Permission from forest authorities is required for converting forest land to other uses. (Sources: Ministry of Agriculture http://odin.dep.no/ld/norsk/Ansvarsomraader/Skogbruk/index-b-n-a.html; Verdiskaping og miljø 1998 St. meld. 17 http://odin.dep.no/ld/norsk/publ/stmeld/020005-040003/index-dok000-b-n-a.html)

Table A2.4. Sweden: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	stable		deciduous trees present share 16%	share of deciduous trees increase to 17-18% by 2010
productive forest/ wood production	decrease by 900 000 ha by 2010	rural areas Småland region, northern highlands		share of deciduous forests increase, share of Scots Pine and Norway Spruce decrease
protected forest/ nature reserve	increases by 900 000 ha by 2010	remote areas rural areas		share deciduous increase, amount of dead wood in forests increase, area of old-growth forests increase
recreational forest	stable			

* Felling on forest land must be performed in order to promote the establishment of a new stand, or to benefit the existing stand. Selected valuable broad leaved forests must be permanently maintained and regenerated. (Gustafsson and Thuresson 1999 http://www.svo.se/ska99/resultat/popska99ENG.pdf; Swedish EnviroNet 2002 http://miljomal.nu/om_miljomalen/miljomalen/mal12.php)

Appendix 3

Table A3.1-A3.2. Estimates of forest land use change by 2020 for Group II countries in Europe. Estimates are based on present policies and trends described in Kankaanpää and Carter (2004). The present species composition of each country is taken from Pelkonen et al. (1999). Blanks in the tables indicate that the country in question had no policies concerning that issue or that no information could be found.

Table A3.1. Belgium: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	Wallonia: stable or slight decrease (0.2% in 10 years current rate). Flanders: afforestation 20 000 ha	avoiding fragmentation and parcelling of forests, some afforestation on marginal agr. lands agricultural land forest networks	Wallonia: deciduous 50%, conifers 50% of forest area Flanders: deciduous 50%, conifers 39%, mixed 11% of forest area (poplar plantations about 30% of forest area)	balance between deciduous and coniferous species, mixed stands, indigenous, site-adapted species preferred indigenous site-adapted species, uneven-aged stands
productive forest/ wood production	Wallonia: stable or slight increase. Flanders: increase 10 000 ha		usually mono-species plantations (Picea abies, Pinus sylvestris, Pinus Nigra, Fagus sylvatica, Populus)	
protected forest/ nature reserve	Flanders: increase 3000 ha (2002) + 10 000 ha ecologically sound afforestation	forest networks		
	Wallonia: stable	forest networks		
recreational forest	Flanders: increase Wallonia: stable			native species, deciduous

* In Flanders transformation of forests into other land uses is prohibited by the Forest decree. In Wallonia permits are needed for both deforestation (change in land use of forest lands) and for afforestation of non-forested lands. (Sources: Portail Environnement de Wallonie http://environnement.wallonie.be/cgi/dgrne/platforme_dgrne/visiteur/frames.cfm; L'Or Vert http://www.cape.be/studio/overt/index.cfm; Ministry of Small Enterprises, Traders and Agriculture http://www.cmlag.fgov.be ; Country Submissions to the 5th and 8th Sessions of the UN Commission on Sustainable Development 1997-2000 http://www.un.org/esa/agenda21/natlinfo/countinf.htm; http://www.vlaanderen.be/ned/sites/landbouw)

Table A3.2. The Netherlands: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	increment in 1990-2000 0.3% increase, afforestation 75 000 ha (2020)	abandoned agricultural land (30 000 ha), 10 000 ha close to urban or peri-urban areas, interlinking existing forest areas	Scots pine dominates in 35% of forests, other conifers in about 25% of forests, mono-species plantations converted into mixed forests	increase the proportion of mixed and broad-leaved forests of all forests
productive forest/ wood production	increase/stable by 2020 70% of forests under sustainable forestry (timber production)			
protected forest/ nature reserve	increases 18% (60 000 ha) of forests primarily for conservation purposes (2020)	National Ecological Network areas and around cities		
recreational forest	increases by 10 000 ha	close to urban or peri-urban areas		native species, deciduous

* There are provisions in the forest law preventing the conversion of forests to other land uses. In many cases, if the use of the forest land is changed, the same area of forest has to be planted elsewhere. (Sources: Ministry of Agriculture, Nature Management and Fisheries http://www.minlnv.nl; Nature for people 2000 http://www.minlnv.nl/international/policy/green/pna; Nature Balance 2001 http://www.rivm.nl/index_en.html)

Appendix 4

Table A4.1-A4.4. Estimates of forest land use change by 2020 for Group III countries in Europe. Estimates are based on present policies and trends described in Kankaanpää and Carter (2004). The present species composition of each country is taken from Pelkonen et al. (1999). Blanks in the tables indicate that the country in question had no policies concerning that issue or that no information could be found.

Table A4.1. Denmark: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	increases by 89 000 ha by 2020	near urban areas; areas where forest cover is low creation of landscape corridors and amenity	conifers cover 60% of forest area, deciduous 32%, about 8% of forest area uncovered permanently or temporarily	broad leaved species predominant in new forests, mixture of tree species promoted, share of indigenous tree species 50% by 2080
productive forest/ wood production	increases			
protected forest/ nature reserve	increases by 9000 ha before 040 10% of total forest area has biodiversity conservation as primary mgmt objective			
recreational forest	increases	near urban areas	native species	

* Forest reserves (85% of forests) must be permanently used for forestry; they cannot be parcelled or diminished by changing the size of the forest. After clear felling, they have to be reforested. (Sources: Danish national forest programme 2002 http://www.sns.dk/inter; Danish Forest and Nature Agency http://www.sns.dk)

Table A4.2. Ireland: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	increase, afforestation 20 000 ha/year	agricultural land, establishment of amenity and urban woodlands	no indigenous conifers species, deciduous afforestation: 1995 4500 ha or 20% of total afforestation (25% of private and 3% of Coillte afforestation); 80% of afforestation conifers	decrease in share of Sitka Spruce (to max. 65%); 10% of broadleaves in annual planting, native species used, dominant species should account for no more than 80% of the mix; Estimation by 2035: 60% Sitka Spruce, 20% other conifers, 20% deciduous
productive forest/ wood production	increase (20 000 ha/year)		Sitka spruce about 60%	mixed stands encouraged, Sitka Spruce continues as the main species, deciduous favoured as much as possible
protected forest/ nature reserve	15% of forests treated with regard to biodiversity	Native Woodland Scheme	5200 ha of indigenous forests	native species, mixtures of native and non-native species (at least 2 species in the mix), broadleaves favoured
recreational forest	use increases			

(Sources: Forest Service http://marine.gov.ie; The Irish National Forest Standard 2000 http://dcmnr.gov.ie/display.asp/action=category/loc=250; Forest Biodiversity Guidelines http://marine.gov.ie/display.asp/action=category/loc=194; Coillte http://www.coillte.ie)

Table A4.3. Switzerland: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	slight increase 0.4%/year	mountainous regions, abandoned pastureland; Central Plateau status quo maintained	of all trees 60% are coniferous and 40% deciduous; conif. predominant in the Alps (78%) and pre-Alps (68%), Plateau conif./decid. almost 50/50	natural regeneration, site-specific species
productive forest/ wood production	stable			
protected forest/ nature reserve	slight increase up to 2030 150 000 ha of forest reserves			rare forest types, endangered species
recreational forest	use increases			

* The Law on Area Planning and the Law on Forests only permit the conversion of forests or changes in their use when there is no other option as far as location is concerned, the clearing of forest does not involve serious risks for the environment, and when such a measure is decidedly in the public interest. No forested areas may be classified as building areas without prior authorisation by the forest authorities. The Law on Forests also regulates clear felling. (Sources: Swiss Agency for the Environment, Forests and Landscape http://www.umwelt-schweiz.ch/buwal/eng/info/buwal/index.html; Environment-Switzerland 2002 http://www.umwelt-schweiz.ch/buwal/eng/medien/umweltbericht/genulzte/index.htm#sprungmarke3; Country Submissions to the 5th and 8th Sessions of the UN Commission on Sustainable Development 1997-2000 http://www.un.org/esa/agenda21/natlinfo/countinf.htm)

Table A4.4. United Kingdom: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	increase (targets up to 14% increase in woodland cover); Scotland: increase forest area to 25% of total land area (2050)	urban areas (100 000 ha 2020) agricultural land lowland afforestation (long-term target), derelict lands, former industrial areas, inter-linking existing forests	conifers cover 63% of forest area (in England 39%, Scotland 83%), most coniferous plantations are exotic species, Sitka spruce covers 28% of forest area	broadleaved forests increased, conifer plantations must have min. 5% of broadleaves and 10% for natural regeneration, establishment of semi-natural forests, more mixed forests
productive forest/ wood production	increase	agricultural land lowlands and better soils, larger woodland units		
protected forest/ nature reserve	Habitat Action Plan UK 30 000 – 40 000 ha (5000 ha/year)	new woodlands for revising the fragmentation of existing woodlands, developing Forest Habitat Networks		native woodland, local provenances Scotland: upland oak 3000 ha, native pine 30 500 ha; upland mixed ash 2000 ha; wet woods 2200 ha (by 2005-2015)
recreational forest	increase	urban areas; tourism areas; landscape enhancement		trees of high visual impact

* Felling is strictly controlled by a system of felling licences in England and Wales.
(Sources: Forestry Commission http://www.forestry.gov.uk/; England Forestry Strategy 1998 http://www.forestry.gov.uk/forestry/hcou-4uef8j, http://www.forestry.gov.uk/website/pdf.nsf/pdf/fcefs.pdf/$FILE/fcefs.pdf; Scottish Forestry Strategy 2000 http://www.forestry.gov.uk/website/Oldsite.nsf/byunique/HCOU-4U4J98; Woodlands for Wales 2001 http://www.forestry.gov.uk/website/pdf.nsf/pdf/woodwaleseng.pdf/$FILE/woodwaleseng.pdf; Woodland Grant Scheme http://www.forestry.gov.uk/forestry/HCOU-4U4J2n)

Appendix 5

Table A5.1-A5.4. Estimates of forest land use change by 2020 for Group IV countries in Europe. Estimates are based on present policies and trends described in Kankaanpää and Carter (2004). The present species composition of each country is taken from Pelkonen et al. (1999) Blanks in the tables indicate that the country in question had no policies concerning that issue or that no information could be found.

Table A5.1. Greece: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	increase afforestation by 47 000 ha (2020)	agricultural land	coniferous 22%, deciduous 30% of forest area, non-productive forest 48% (deciduous)	species resistant to fire
productive forest/ wood production	stable			
protected forest/ nature reserve	increase to 10% of forest area (2000)	Natura 2000 list		
recreational forest	stable			

* The Greek constitution protects the forests by prohibiting any changes in forest land use. There are some exceptions to the rule concerning the social infrastructure and transportation system networks. (Sources: Hellenic Ministry of the Environment, Physical Planning and Public Works http://www.minenv.gr/; Country Submissions to the 5th and 8th Sessions of the UN Commission on Sustainable Development 1997-2000 http://www.un.org/esa/agenda21/natlinfo/countinf.htm; EFC reports 2000 http://www.unece.org/trade/timber/docs/tc-58/efc-reports/efc-reports.htm)

Table A5.2. Italy: Forest land use change 2000-2020

land use	area	location	speciescomposition present	species composition estimated
forest total	increase by afforestation	agricultural land, non-agricultural land (for biodiversity, landscape, combating desertification, reconstruction of damaged areas)	forest area covered by high forest 25% (of which conifers 56%), coppice 40% (deciduous), plantations 35% (conifers and non-timber products)	multi-species stands, naturalisation of pine forests
productive forest/ wood production	slight increase	agricultural land	coniferous forests in the Alps, Southern Apennines	
protected forest/ nature reserve	stable			
recreational forest	slight increase	close to urban areas		

* The 1985 Landscape Act states that all forests play, above all, an environmental role. Cutting is allowed as far as it is useful for the care of the forests, with the exception of plantations. The Law on the Protection of Forests against Fires includes a prohibition to build on land destroyed or damaged by fire (Sources: Ministerio dell'Ambiente e della Tutela del Territorio http://www.minambiente.it/Sito/home.asp; Cirelli and Schmithüsen 2000)

Table A5.3. Portugal: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	increases (annual growth 1.7% in 1990s) afforestation 25 000 ha/year	abandoned and marginal agricultural land, pasture land, plantations	pines and other conifers cover 34% of forest area, cork oak 21,5%, eucalyptus 21%	maritime pine, cork oak, other broad leaved species, evergreens
productive forest/ wood production	increases	agricultural areas, plantations		
protected forest/ nature reserve	stable/ slight increase	national network of protected areas, Natura 2000 areas, areas prone to erosion		
recreational forest	stable/decrease	deforestation on the coast, tourism areas		

(Sources: Directorate General on Forests http://www.dgf.min-agricultura.pt/v4/dgf/ area.php? areaaid=PF, http://www.minenv.gr/; Country Submissions to the 5th and 8th Sessions of the UN Commission on Sustainable Development 1997-2000 http://www.un.org/esa/agenda21/natlinfo/countinf.htm)

Table A5.4. Spain: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	increase, afforestation and improvement of forestland 85 000 ha/year; regeneration of cork forests (122 000 ha on the whole Iberian peninsula)	agricultural land, mountain areas, erosion prone areas, marginal areas (rural development); potential cork forest areas	conifers cover about 755 of wooded forest area, Eucalyptus 9,5%; Plantations cover about 10% of total area of forests (Pinus pinaster, Eucalyptus, Pinus radiata, Populus)	conversion of species structure of abandoned production forests in low mountains, diversification of stands; cork trees
productive forest/ wood production	increase, 0.6%/year			
protected forest/ nature reserve	increase, Natura 2000 network will cover 25% of forest area (approx. 125 000 ha increase)	erosion control, soil protection areas, mountain areas, natural networks, biodiversity conservation areas		
recreational forest	increase	rural tourism areas		

(Sources: The Ministry of Environment http://www.mma.es/; Plan Forestal Español 2002 http://www.mma.es/conserv_nat/planes/planifor/pfe.pdf; Country Submissions to the 5th and 8th Sessions of the UN Commission on Sustainable Development 1997-2000 http://www.un.org/esa/agenda21/natlinfo/countinf.htm)

Appendix 6

Table A6.1-A6.2. Estimates of forest land use change by 2020 for Group V countries in Europe. Estimates are based on present policies and trends described in Kankaanpää and Carter (2004). The present species composition of each country is taken from Pelkonen et al. (1999). Blanks in the tables indicate that the country in question had no policies concerning that issue or that no information could be found.

Table A6.1. France: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	increases planned afforestation 9500 ha/year; average annual expansion rate 25 000 ha	agricultural land rural areas	70% of forests are mixed stands, 94% of forested land covered with native species, conifers cover about 25% of forest area, oak almost 30%	mixed forests
productive forest/ wood production	increases 30 000-40 000 ha/yr	agricultural areas rural areas		
protected forest/ nature reserve	slight increase	biological reserves network		
recreational forest				

* Logging is strictly controlled; a management plan defines the felling permitted. (Sources: Ministry of Agriculture http://www.agriculture.gouv.fr/spip/; Forest info http://www.boisforet.info/bfi2/pge_doss_0_menu.asp?art=1917; Forest Inventory 1998 http://www.inf.fr/pages/index_gb.html; ; Country Submissions to the 5th and 8th Sessions of the UN Commission on Sustainable Development 1997-2000 http://www.un.org/esa/agenda21/natlinfo/countinf.htm)

Table A6.2. Germany: Forest land use change 2000-2020

land use	area	location	species composition present	species composition estimated
forest total	increase, afforestation 18 500 ha/year	agricultural land, interlinking existing forests	coniferous forests cover 2/3 of total forest area (40% of the coniferous forests are monocultures, 25% mixed with an admixture up to 10% of other species, 35% conifer dominated mixed)	structural diversity increases, share of deciduous species increaes clearly, mixed stands, transformation of coniferous stands into mixed stands
productive forest/ wood production	increase 18 500 ha/year	agricultural land		
protected forest/ nature reserve	slight increase, no national targets to increase the area	linking existing areas, forming ecosystem networks		
recreational forest	use increases			

* The Federal Forest Act (1975) requires all forest owners to conserve forests because of their multifunctional importance, to expand the forests if required, and to ensure their proper management on a sustainable basis. There is an obligation to reforest after final harvesting and authorisation is required in the case of conversion of firest stands. (Sources: Federal Ministry of Food, Agriculture and Forestry http://www.verbraucherministerium.de/; National Forest Programme 2000 http://www.verbraucherministerium.de/englisch/nfp.htm; Country Submissions to the 5th and 8th Sessions of the UN Commission on Sustainable Development 1997-2000 http://www.un.org/esa/agenda21/natlinfo/countinf.htm)

Documentation page

Publisher	Finnish Environment Institute (SYKE)
Date	October 2004
Author(s)	Susanna Kankaanpää and Timothy R. Carter
Title of publication	Construction of European forest land use scenarios for the 21st century
Parts of publication/ other project publications	Kankaanpää, S. and Carter, T.R. 2004. An overview of forest policies affecting land use in Europe. The Finnish Environment 706, Finnish Environment Institute, Helsinki. This publication is also available in the Internet www.environment.fi/publications
Abstract	This study was part of a European land use change scenarios construction exercise within the European Commission funded ATEAM (Advanced Terrestrial Ecosystem Analysis and Modelling) project. The purpose of the study was to examine land use changes as they relate to forests and their trends in the pre-enlargement European Union member countries and Switzerland and Norway, and to construct preliminary estimates and narratives of future trends in forest land use associated with the Intergovernmental Panel of Climate Change (IPCC) SRES-scenarios. Present trends in European forests and forest policies seem to indicate a continuous growth of forest areas in most parts of Europe. During the past years the forest area in Europe has grown with a moderate rate (on average 0.3% per year). The forest land use change estimates drafted in this study project either decreasing forest areas (in the worlds described by A-type scenario storylines) or somewhat greater forest area growth rates than the present ones (in the B-type worlds). The forest land use scenarios constructed in this study are not intended as full projections of possible futures but rather serve as a reliability or consistency check for the overall land use scenarios constructed within the ATEAM project. The role of policies in determining future forest land use is central in Europe. Eventually the aim should be the development of a comprehensive land use change scenario framework that would integrate policies as important driving forces of land use change.
Keywords	land use change, scenarios, forestland
Publication series and number	The Finnish Environment 707
Theme of publication	Land use
Project name and number, if any	ATEAM EVK2-CT2000-00075
Financier/ commissioner	European Commission
Project organization	
ISSN	1238-7312
ISBN	952-11-1736-2 952-11-1737-0 (PDF)
No. of pages	57
Language	English
Restrictions	Public
Price	8 e
For sale at/ distributor	Edita Publishig Ltd., P.O. Box 800, FIN-00043 Edita Finland, Phone +358 20 450 00 Mail orders: Phone +358 20 450 05, telefax +358 20 450 2380 Internet: www.edita.fi/netmarket
Financier of publication	Finnish Environment Institute, P.O. Box 140, FIN-00251 Helsinki, Finland
Printing place and year	Edita Prima Ltd., Helsinki 2004

Kuvailulehti

Julkaisija	Julkaisuaika Suomen ympäristökeskus (SYKE) — Lokakuu 2004
Tekijä(t)	Susanna Kankaanpää ja Timothy R. Carter
Julkaisun nimi	Construction of European forest land use scenarios for the 21st century Euroopan metsämaankäytön skenaarioiden kehittäminen 2000-luvulle
Julkaisun osat/ muut saman projektin tuottamat julkaisut	Kankaanpää, S. ja Carter, T.R. 2004. Yleiskatsaus maankäyttöön vaikuttavista metsäpolitiikoista Euroopassa, Suomen ympäristö 706, Suomen ympäristökeskus, Helsinki Julkaisu on saatavana myös internetistä www.environment.fi/publications
Tiivistelmä	Tämä selvitys tehtiin osana Euroopan komission rahoittaman ATEAM (Advanced Terrestrial Ecosystem Analysis and Modelling)-hankkeen maankäytön skenaarioiden kehittämistyötä. Selvityksen tarkoituksena oli tutkia maankäytön muutoksia sekä kehityskulkuja metsien osalta Eurioopan Unionin jäsenvaltioissa ja Sveitsissä ja Norjassa sekä tehdä alustavat arviot metsämaankäytön tulevista muutoksista ja kehityksen suunnasta Hallitusten välisen ilmastopaneelin (IPCC) SRES-skenaarioiden perusteella. Nykyiset kehityskulut Euroopan metsissä ja metsäpolitiikoissa näyttävät osoittavan metsäalueiden jatkuvaa kasvua suurimmassa osassa Eurooppaa. Viime vuosien aikana Euroopan metsäala on kasvanut keskimäärin 0,3% vuodessa. Tässä selvityksessä metsämaan arvioidaan vähenevän A-tyypin skenaarioiden maailmoissa tai lisääntyvän hieman nykyistä enemmän B-tyypin skenaarioissa. Tässä työssä tehdyt metsämaan muutoksen skenaariot eivät pyri olemaan valmiita arvioita mahdollisista tulevaisuuden tiloista, vaan niiden avulla on tarkoitus tarkistaa ATEAM-hankeessa kehitettyjen maankäytön muutoksen skenaarioiden johdonmukaisuus ja luotettavuus. Politiikkojen merkitys metsämaankäytön muutosessa on keskeinen Euroopassa. Lopulta tavoitteena tulisi olla kattavan maankäytön muutosten skenaarioiden viitekehys, johon politiikat olisi liitetty merkittävinä muutokseen vaikuttavina tekijöinä.
Asiasanat	maankäytön muutos, skenaario, metsämaa
Julkaisusarjan nimi ja numero	Suomen ympäristö 707
Julkaisun teema	Alueiden käyttö
Projektihankkeen nimi ja projektinumero	ATEAM EVK2-CT2000-00075
Rahoittaja/ toimeksiantaja	Euroopan komissio
Projektiryhmään kuuluvat organisaatiot	
	ISSN 1238-7312 — ISBN 952-11-1736-2 — 952-11-1737-0 (PDF)
	Sivuja 57 — Kieli Englanti
	Luottamuksellisuus Julkinen — Hinta 8 e
Julkaisun myynti/ jakaja	Edita Publishing Oy, PL 800, 00043 Edita, vaihde 020 450 00 Asiakaspalvelu: puh. 020 450 05, telefax 020 450 2380 Sähköposti: asiakaspalvelu@edita.fi, www.edita.fi/netmarket
Julkaisun kustantaja	Suomen ympäristökeskus, PL 140, 00251 Helsinki
Painopaikka ja -aika	Edita Prima Oy, Helsinki 2004

Presentationsblad

Utgivare	Finlands miljöcentral (SYKE)	Datum Oktober 2004
Författare	Susanna Kankaanpää och Timothy R. Carter	
Publikationens titel	Markanvändningsscenarier för skogsmarken i Europa i det 21 århundradet	
Publikationens delar/ andra publikationer inom samma projekt	Kankaanpää, S. ja Carter, T.R. 2004. Skogspolicy och inverkan på markanvändingen i Europa: en översikt. Miljön i Finland 706, Finlands Miljöcentral, Helsingfors Publikationen finns tillgänglig också på internet www.environment.fi/publications	
Sammandrag	Arbetet var en del av utvecklingen av markanvändningsscenarier inom ATEAM-projektet (Advanced Terrestrial Ecosystem Analysis and Modelling), som finansierades av Europeiska kommissionen. Målsättningen var att undersöka förändringar och trender i markanvändningen vad gäller skogsmark i EU-länderna före utvidgningen samt i Schweiz och i Norge. Vi utvecklade preliminära uppskattningar och skildringar av framtida trender i skogsmarkens användning i anslutning till IPCC (Intergovernmental Panel of Climate Change) SRES-scenarier. Nuvarande trender i europeisk skog och skogspolitik antyder en kontinuerlig ökning av skogsarealen i största delen av Europa. Under de senaste åren har skogsarealen i Europa ökat med en moderat hastighet (i medeltal 0.3% per år). I dethär arbetet skisserade vi upp projektioner för förändringar i användningen av skogsmarken. Våra uppskattningar baserar sig på antaganden om å ena sidan minskande skogsareal (i de världar som beskrivs av A-typens scenarioskildringar) eller å andra sidan (i B-typens världar) en ökning av skogsarealen som är aningen snabbare än den nuvarande. De scenarier för skogsmarkens användning som här har byggts upp avser inte att vara uttömmande beskrivningar av olika framtidsutvecklingar utan närmast att fungera som kontroll för tillförlitligheten eller konsistensen för de allmänna markanvändningsscenarier som gjorts upp inom ATEAM. Policybesluten har en central roll för utformandet av den framtida användningen av skogsmark i Europa. I sista hand borde målsättningen vara att utveckla en alltomfattande ram för markanvändningsscenarier som skulle integrera policybesluten som viktiga drivande faktorer för förändringar i markanvändningen.	
Nyckelord	markanvänding, scenario, skogsareal	
Publikationsserie och nummer	Miljön i Finland 707	
Publikationens tema	Markanvändning	
Projektets namn och nummer	ATEAM EVK2-CT2000-00075	
Finansiär/ uppdragsgivare	Europeiske kommissionen	
Organisationer i projektgruppen		
	ISSN 1238-7312	ISBN 952-11-1736-2 952-11-1737-0 (PDF)
	Sidantal 57	Språk Engelska
	Offentlighet Offentlig	Pris 8 e
Beställningar/ districution	Edita Publishing Ab, PB 800, FIN-00043 Edita, Finland, växel +358 20 450 00 Postförsäljningen: Telefon +358 20 450 05, telefax +358 20 450 2380 Internet: www.edita.fi/netmarket	
Förläggare	Finlands miljöcentral, PB 140, FIN-00251 Helsingfors, Finland	
Tryckeri/ tryckningsort och -år	Edita Prima Ab, Helsingfors 2004	

LAND USE

Construction of European forest land use scenarios for the 21st century

This study was part of an exercise to construct land use change scenarios for Europe within the European Commission funded ATEAM (Advanced Terrestrial Ecosystem Analysis and Modelling) project. The purpose of the study was to examine land use changes as they relate to forests, their trends and forest policies in the pre-enlargement European Union member countries and Switzerland and Norway, and to construct preliminary estimates and narratives of future trends in forest land use associated with the Intergovernmental Panel of Climate Change (IPCC) SRES-scenarios.

This publication is also available in the Internet
www.environment.fi/publications

ISBN 952-11-1736-2
ISBN 952-11-1737-0 (PDF)
ISSN 1238-7312

FINNISH ENVIRONMENT INSTITUTE P.O. BOX 140, FIN-00251 HELSINKI