Future wood supply from European forests

Confederation of European Paper Industries

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Implications for the pulp and paper industry

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ABSTRACT

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The aim of this study is to provide quantitative insight into future actual supply of wood as a raw material (between 2005 and 2060) from European forests (36 countries). To do so, the degree to which apparent demand can be met is quantified with a forest resource model (resulting in the actual supply). This actual supply is tested for two sets of management regimes: 'projection of historical management' and 'new management trends'.
The results indicate that if new trends in forest management and supply behaviour continue to develop as in the recent past, an additional theoretical shortfall of 195 million m^3 roundwood per year can be expected by 2060 in 36 European countries. The European part of Russia is not able to reduce the shortfall, because of its own demand developing. These shortfalls have to be understood as theoretical shortfalls; they visualise what may happen if no market adaptations occur in the future. Under this projected shortfall, the total growing stock in European forests (incl. European part of Russia) still increases from 51 billion m^3 in 2005 to 62 billion m^3 in 2060.

Keywords: nature oriented forest management, Kyoto protocol, bio-energy, European forests, wood supply, EFISCEN

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Summary

European forests increasingly have to fulfil a wider variety of demands while at the same time meeting increases in demand for conventional wood products. Thus, the long-term availability of wood as a raw material is of some concern. This concern is driven by a combination of factors, but notably by a restricted future wood supply due to the following:

1. trends towards nature-oriented forest management (NOM);
2. the EU policies on energy (European Commission 1997) leading to an extra demand for roundwood for bio-energy needs;
3. the Kyoto Protocol leading to the rewarding of carbon credits for further build-up of growing stock in the forest.

The aim of this study is to provide quantitative insight into the actual future supply of wood as a raw material (between 2005 and 2060) from European forests (36 countries). To do so the degree to which apparent demand can be met is quantified using a forest resource model (resulting in the actual supply). This actual supply is calculated using two sets of management regimes: 'projection of historical management' and 'new management trends'. The 'projection of historical management' consists of a continuation of forest management as it was applied until the nineteen-eighties. The scenario 'new management trends' incorporates effects of the three issues mentioned above.

The study looks at the problem from a resource and management perspective. The model does not have any endogenous econometric variables; it is assumed that the impacts of the three issues can be incorporated through changes in forest resource management.

The results indicate that if these new trends in forest management and supply behaviour continue to develop, as in the recent past, an additional theoretical shortfall of 195 million m^3 of roundwood per year (of which 155 million m^3/y is coniferous) can be expected by 2060 in 36 European countries. This shortfall is in addition to the shortfall under the historic forest management scenario (which would amount to 36 million m^3/y by 2060 (excl. Russia)). The total shortfall therefore amounts to 231 million m^3/y by 2060. The relative size of the shortfall differs very much between countries. The European part of Russia is unable to reduce the theoretical shortfall. This is because of Russia's own domestic demand developing, and because of rather tight management restrictions. These shortfalls have to be understood as theoretical shortfalls; they visualise what may happen if no market adaptations or adaptive policies develop in the future.

In parallel with this projected shortfall, the total growing stock in European forests (incl. the European part of Russia) increases from 51 billion m^3 in 2005 to 62 billion m^3 in 2060 under the 'new trends' scenario with the actual supply reaching 1.1 billion m^3/y in 2060. The current study confirms the paradigm of more and more resources,

but points to and projects one of the reasons for this: a reduced interest in supplying wood to the industry.

It is clear that the pulp and paper industry is going to be affected by the projected shortfall relatively strongly. An indication of this is the large proportion of the much needed coniferous wood (79%) in the total projected shortfall. Other reasons, which suggest that the trends in forest management are going to hit the pulp and paper industry relatively strongly are as follows:

1. European forest resources are ageing, and the associated larger diameters will yield less pulplog dimensions. The pulp and paper industry might therefore depend to a greater extent on the sawmilling industry in the future;
2. One of the components of NOM is a trend in the forest towards increased use of deciduous species in some regions in Europe. A species group less preferred by the pulp and paper industry;
3. The reduced interest to supply wood is especially strong for thinnings, an aspect of management that the pulp and paper industry depends on to a large extent;
4. The decreasing interest for (traditional) forestry and forest management.

A curbing trend may be the often-reported notion that owner behaviour is to a large extent determined by the state of his forest (see section 3.3.2). With growing stocks building up in Europe, the overall supply-willingness may slightly increase in the (far) future. A positive fact for the pulp and paper industry is that this sector has shown large flexibility to adapt to trends in the past, and still has one of the better earning capacities of the whole sector.

The study shows that a huge potential exists in European forest resources for ample wood supply. However, all partners involved in the process of multi-functional and sustainable forest management (owners, industry, policy-makers, researchers, consumers, and NGOs) have to show their willingness to contribute to this process allowing for all the functions of European forests. Such a partnership allows us to look at European forests in a holistic way, fulfilling a multitude of functions and as being an integral part of the rural areas of Europe.

1 Introduction

European forests[1] are the most intensively managed forests in the world; they (excl. Russia) comprise only 5% of the worlds' forests, but provide 12% of the current global fellings of roundwood and 23% of global industrial roundwood (FAO 2002). Also, the European forest sector's output is about a quarter of the current world industrial production of forest products, accounting for almost 30% in wood panels, paper and paperboard (Mery et al. 1999).

Europe without the Russian Federation has 192 million ha of forest (or some 160 million ha of forest available for wood supply), spread over 36 countries. European forests fulfil a multitude of equally important functions, from preservation of biodiversity to production of raw material for a free market industry. They are a place for leisure for the highly urbanised population of Europe. Despite being under the risk of climate change and increased natural disturbances, these forests have an increasing carbon sequestration potential. In general, we can state that European forests increasingly have to fulfil a wider variety of demands while at the same time meeting the demand for conventional wood products increases as well (Trømborg et al. 2000).

Despite these increasing demands, the current average growing stock is at its highest point since early medieval times. During medieval times European forests went through a long phase of over-grazing and over-cutting, reducing the forest area to less than 10% of the land. Thanks to reduced land needs for agriculture starting in the 19th century and active afforestation schemes, forest area has increased again to 31% (UN-ECE/FAO 2000). Not only has the forest area increased, but due to the fact that current fellings only amount to some 55% (European total, excluding Russian Federation: UN-ECE/FAO 2000) of the net annual increment, growing stocks have rapidly been increasing since the 1960s. The average growing stock overbark now amounts to 143 m^3/ha (UN-ECE/FAO 2000).

General statistics thus indicate that the current status and developments in European forests might look very bright. However, the long-term availability of wood as a raw material in Europe is of concern. This concern is driven by a combination of factors:

- the pulp and paper industry expects structural demand increases in the near future in European countries and thus investments for capacity expansion have to be decided upon;
- even larger increases in consumption (but in the longer term) are expected in Central European countries with economies in transition;

[1] Europe includes in the present study the forests of the thirty-six countries: Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Belarus, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Macedonia, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, and Serbia and Montenegro. It is mentioned if the European part of Russia is meant as well.

- developments in forest management and in competing demand groups indicate that supply to the pulp and paper industry may be restricted in the future. This will notably be because of the following three issues, identified by the Confederation of European Paper Industries (CEPI) as the main impacting factors:
  1. trends towards nature-oriented forest management leading to reduced willingness to harvest;
  2. the EU policies on energy (European Commission 1997) leading to an extra demand for roundwood for bio-energy needs;
  3. the Kyoto Protocol leading to the rewarding of carbon credits for further build-up of growing stock in the forest.

For an industry that relies on a renewable natural resource with long-term characteristics such as the forest, it is important to foresee changes in that resource and its management long before the changes actually occur.

In this study we have tried to foresee the long-term impacts, in terms of wood availability, of the three issues given above. Chapter 3 outlines the data and modelling approach, but also presents the review of current trends in the three issues (§ 3.3). Based on the reviews, the severity of the three issues in the future is estimated and built into the forest resource modelling approach as management changes. Results by country and for European totals are presented in chapters 4 and 5. Chapters 6 and 7 respectively discuss the results and provide conclusions.

2 Aim

The aim of this study is to provide quantitative insight into the actual future supply of wood as a raw material (between 2005 and 2060) from European forests. To do so, the degree to which apparent demand can be met is quantified using a forest resource model (resulting in the actual supply). This actual supply is calculated following two sets of management regimes (‘projection of historical management’ and ‘new management trends’). The scenario ‘new management trends’ incorporates effects of the three issues: nature-oriented management, bio-energy and carbon credits. Emphasis is placed on the implications for the European pulp and paper industry.

The study looks at the problem from a resource and management perspective. The model does not have any endogenous econometric variables. It is assumed that economic effects can be incorporated through changes in forest resource management. The study consists of the projections of forest resources from 36 European countries plus the European part of Russia. Dynamic pricing adjustments for stumpage were assumed not to take place, nor were dynamic pricing adjustments between commodities. This is because the study aims to show if a virtual shortfall would occur in the future because of the three issues mentioned before and to what degree.

The main assumption on incorporated management changes is that the impacts of nature-oriented management, bio-energy and carbon credits can be judged regarding their severity in the future based on literature. The impacts of these issues can be translated into possible changes in management by tree species, country and owner class. These management changes are thus exogenously (i.e. not responding dynamically during simulation) determined and represent forest owner responses to the sum of the three issues. These owner responses again reflect market and pricing mechanisms. These static responses may not be seen as very realistic. However, this assumption was built in to show any possible theoretical shortfall occurring because of the three issues. The supporting notion behind this is that forest owner behaviour is to a large extent determined by the state of his forest resource. The aim was not to quantify the econometric adaptations that may occur to counteract such a shortfall (e.g. less demand, or higher prices offered for stumpage).

The quantification of supply and possible shortage is presented by country, species group and for European totals (the latter both with and without Russia). The supply of coniferous pulplogs is given as well. The latter is based on published information on the current allocation of total national fellings over raw material groups. Based on the ageing of the forest as simulated by the model, these allocation shares were adjusted.

3 Methods and scenario assumptions

3.1 Modelling approach

The projections in this study are made with the European Forest Information Scenario Model (EFISCEN), a forest resource assessment model. EFISCEN is described in more detail in 'Pussinen et al.' (2001) and 'Nabuurs' (2001). In the current study the core modelling approach was used, an area matrix model. The core of the area matrix model is based on 'Sallnäs' (1990) and 'Nilsson et al.' (1992). The area matrix model is suitable for projections of forest resources in large areas under forest management assumptions. It is especially suitable for testing how a certain (roundwood) demand assumption for the future can be met by alternative management regimes.

The projections carried out with this model provide insight into increment, growing stock, age class distribution, and actual fellings for tree species and regions in a country. The EFISCEN model uses time intervals of five years. The input inventory data are structured by forest types, which are defined by country, region, owner, site class, and tree species. Each forest type contains the following variables by age classes:

- area (ha);
- average growing stock (overbark, m^3/ha);
- increment (overbark, m^3/ha.y).

The details of the area matrix model can be found in 'Pussinen et al.' (2001). The state of the forest is depicted as a distribution area over age and volume classes in a volume-age matrix. A separate matrix is set up for each forest type of the inventory data, in this case 5579 forest types for 329 million ha of forest (including the European part of Russia) as stated by the national correspondents. In the tests the area per country was sometimes corrected slightly to represent the exact Forest Area Available for Wood Supply (FAWS).

The projection of increment in the model is based on growth factors that are calibrated based on the inventory data. In the matrices growth is represented as a probability of the area to grow to higher volume levels. The inventory data used for the current study represent the situation in a country in 1994, i.e. the growth factors are linked to the inventory increments. Projections thus assume that the increment has not changed and will not change during the simulation period. Ageing of the forest is incorporated as a factor of time up to the point of clear cutting.

Forest management is controlled at two levels in the model. Firstly, a basic management for each forest type, like thinning and final felling regimes, is incorporated. These regimes are seen as constraints of cutting levels and it is these regimes that are adapted in the current study for the three issues (nature-oriented management, bio-energy and carbon credits). The thinning regimes are incorporated as the range of age classes at which a thinning can be carried out in each forest type. Final felling regimes for each age class and forest type are incorporated as a probability that a final felling can, in principle, be carried out (Appendix 1). Secondly, the required total volume of the harvest was specified for the whole country for conifers, deciduous and coppice species groups for each time period. Thinning is carried out in the matrix of each forest type by preventing part of the area in a cell from moving to a higher volume level, i.e. forest growth is thinned. Thinned forest area receives a 'thinning status' and cannot be thinned while having that status. These thinned areas have a slightly better chance to increase to the next volume level up during the next time interval: a small growth boost.

Natural mortality is described as a percentage of the area in a cell moving one volume level down in the matrix (Schelhaas et al., 2002). In the scenarios it was parameterised at 1% per 5-year time interval of all areas up to 100 years old, increasing by 0.25% for every further 5 years. Furthermore, in the one but the highest volume level of the matrix these probabilities were multiplied by 3, and in the top volume level by 6 to describe increased mortality in dense, highly stocked stands. This parameterisation was tested and it resulted in realistic natural mortality rates of 4–15% of the gross annual increment in a country (Schelhaas et al., 2002, Harmon et al., 1986, Hees and Clerkx, 1999).

3.2 Initialisation inventory data

An enquiry was made in September/October 2001 in collaboration with the European Forest Sector Outlook Studies of the UN-ECE. New data was received from 21 countries and data from the 1996 enquiry was used for 11 other countries (Nabuurs, 2001, Figure 3.1). Table 3.1 gives an example of the type of data received from the country correspondents. For Moldova and Serbia and Montenegro the 'Temperate and Boreal Forest Resource Assessment' (TBFRA) totals were used and disaggregated. (UN-ECE/FAO, 2000). For the European part of Russia the data as presented in 'Pisarenko et al.' (2001) were disaggregated. For the latter, this disaggregation was based on detailed data that were available for the Leningrad and Arkhangelsk region. For Bosnia & Herzegovina and Greece no data was available and a simple balance approach was executed based on TBFRA data. The latter method is a simple forward-looking calculation with increment, fellings and mortality.

Table 3.1. Example of inventory initialisation data as obtained from the country correspondent. In this case for one forest type in Bulgaria (state owned oak coppice on site class 3 in North Lovetch)

Age (mid class) Year	Area Ha	Growing stock m^3/ha of overbark	Current net annual increment m^3/ha/y of overbark
2.5	207	10	1
7.5	397	26	1.8
12.5	425	27	1.4
17.5	342	73	1.9
22.5	312	90	2.1
27.5	391	118	2.2
32.5	574	128	2.1
37.5	1099	124	2.1
42.5	1396	75	1.4
47.5	1494	98	1.7
52.5	577	118	1.8
57.5	540	158	2
62.5	439	146	1.8

Most forest inventories are carried out over 10-year cycles. It is therefore unavoidable that, by the time the results are published, they are at least 5 years old. During the latest enquiry (see above), the underlying data was updated considerably, and the full database now reflects, on average, the state of the forests in 1994. This can be considered as very recent given the time delay in inventories. The database covers 329 million ha of forests available for wood supply. The 5579 forest types are distinguished by country, region, owner, site and tree species (see Tables 3.1 and 3.2). Small deviations between the forest area covered in the present study and the area of Forest Available for Wood Supply (FAWS) (UN-ECE/FAO, 2000, Table 3.2) are due to the fact that country correspondents were not always able to provide the detailed data for the whole FAWS area. These small deviations were corrected during the tests.

Table 3.2. Overview of meta-data of gathered inventory data. For countries in bold a new set of data was received. For the others, data from 'Nabuurs' (2001) was used. For each of the 5579 forest types, the area, growing stock and increment was usually provided for 12 age classes

Country	(UN-ECE 2000) FAWS (1000 ha)	Initialisation inventory data for current study with the EFISCEN model						
		Number of forest types	Year of forest inventory	Number of administra-tive regions	Number of owner classes	Number of site classes (i.e. growth classes)	Number of tree species	Area covered (1000 ha)
Albania	902	16	1991	1	1	1	16	898
Austria	3,352	192	1992-96	8	3	1	8	2,978
Belarus	5,965	300	2001	6	5	1	10	6,567
Belgium	639	44	1997-199	2	2	1	11	725
Bosnia & Herzeg. #	2,276	8	80s	1	2	1	4	733
Bulgaria	3,123	270	2000	9	2	1	15	3,295
Croatia	1,690	8	1980s	1	2	1	4	1,443
Czech Republic	2,559	140	2000	14	1	1	10	2,493
Denmark	440	35	1990	1	1	5	7	442
Estonia	1932	12	1999-2001	1	2	1	6	2074
Finland	20,675	64	1986-1994	2	1	8	4	19,752
France	14,470	660	1988-2000	22	3	1	10	13,729
Germany	10,142	117	1986-1990/1993	13	1	1	9	9,979
Greece #	3,094	52	1961-1987	5	1	1	47	3,252
Hungary	1,702	18	2000	1	1	3	6	1,860
Ireland	580	35	1992-1993	1	1	5	7	329
Italy	6,013	49	1985	1	1	1	19	5,757
Latvia	2,413	140	2000	1	2	7	10	2,804
Lithuania	1,686	506	2000	1	2	23	11	1,960
Luxembourg	85	6	1989	1	1	1	6	71
Macedonia	745	8	1986-1988	1	2	1	4	653
Moldova **	210	1	1997	1	1	1	1	206
Netherlands	314	13	1995-1999	1	1	1	13	307
Norway	6,609	357	1996-2000	17	1	7	3	6,644
Poland	8,300	170	1993	17	1	1	10	6,019
Portugal	1,897	7	1997-1998	1	1	1	7	2,133
Romania	5,617	36	80s	1	1	6	6	6,211
Russia (Eur part) *	174,000	112	90s	56	1	1	2	173,000
Serbia and Montenegro **	2,378	40	1995	2	2	1	10	2,894
Slovak Republic	1,706	16	1994	1	2	1	8	1,909
Slovenia	1,035	6	2000	1	2	1	3	1,152
Spain	10,479	850	1986-1995	50	1	1	17	13,905
Sweden	21,236	180	1996-2000	6	2	3	5	20,967
Switzerland	1,060	100	1994	5	2	2	5	1,140
Turkey	8,635	891	2001	27	3	1	11	8,024
Ukraine	5,999	36	1996-1999	1	2	1	18	3,969
United Kingdom	2,108	84	1995-2000	4	3	1	7	2,202
TOTAL	336,066	5579						329,376

*: source: Pisarenko et al (2001): Forest land under all ownership, **: source: UN-ECE-FAO (2000), #: too few data, therefore simple approach used

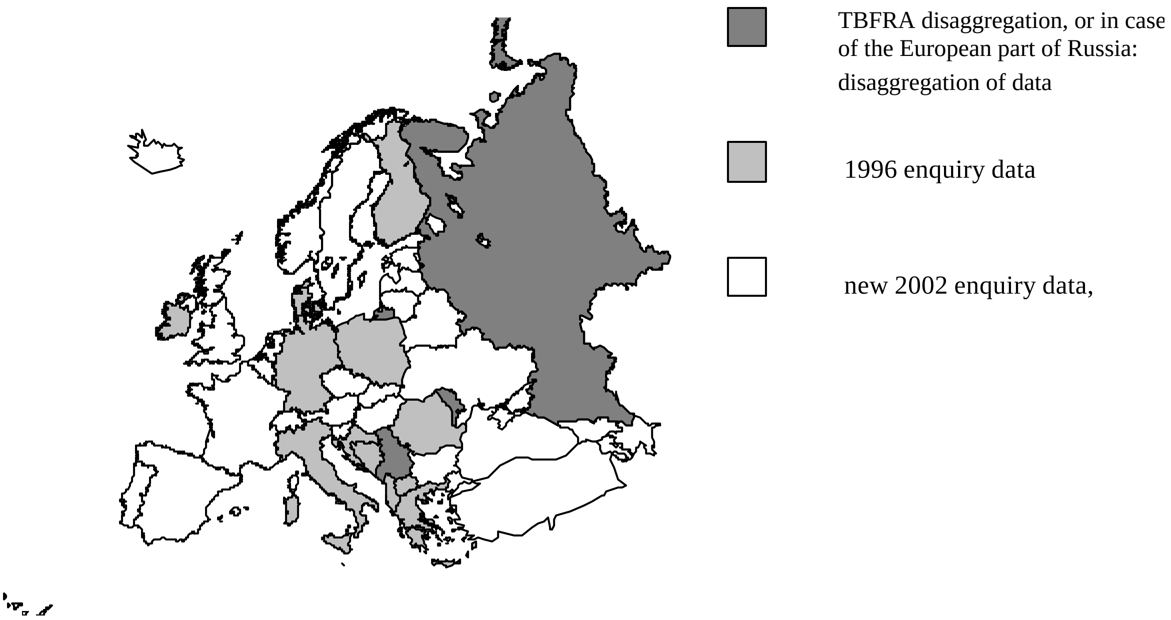


Figure 3.1 Timeliness of the data enquiry results by country

3.3 Scenario assumptions

Studies concerning long-term projections on forest resources and forest management deal with uncertainties. These uncertainties lie in e.g. Gross Domestic Product development, population development, (international) policies, Common Agricultural Policy developments, global change and have impacts on increment and disturbances, forest owner goals, stumpage prices, etc.

Therefore, any supply of raw material can only be quantified for a given set of circumstances. For many of these circumstances assumptions have been made in the present study. E.g. Gross Domestic Product development, population development, and (international) policies are all reflected in the assumption on the demand for wood products. The latter is derived from literature on market models.

However, another set of assumptions deals with specific questions in this study; i.e. the severity of the three issues (NOM, bio-energy and carbon credits) and how they are integrated. The main assumption on these issues is that impacts of nature-oriented management, bio-energy and carbon credits can be examined regarding their future severity based on literature written on this subject. The impacts of these issues can be translated into possible changes in management by tree species, country and owner class in EFISCEN (see Appendix 1). These management changes are thus exogenously (i.e. not responding dynamically during simulation) determined and represent forest owner responses to the sum of the three issues. These owner responses again reflect market and pricing mechanisms. These static responses may not be seen as very realistic. However, it is an assumption that was included in order to show any possible virtual shortage occurring because of the three issues.

Furthermore, it is clear from the related literature that a real shortage of raw material will most likely not occur in the future. The forest-based industries have been concerned about a shortage for decades, but, apart from local shortage in some countries in Europe in the fifties and sixties, this has never occurred. In fact the opposite has occurred: more and more growing stock is building up in the forest. This ample wood stock has developed partly because forest management responded to the local shortages with enhanced drainage and fertilization or by selecting improved provenances, etc., leading to higher increment rates. Another reason for the increasing increment might be that European forests have reached a stage of fast growth now, possibly enhanced by Nitrogen-deposition. The forest industries also responded to threats through improved processing efficiency. This shows the flexibility of response, which is also possible through price mechanisms and enhanced international trade. The fact that growing stocks are building up rapidly may hide that it is increasingly difficult for the forest-based industries to obtain raw material, under stable real prices for stumpage. We can therefore only speak of a '*theoretical shortage*' in the current study: This is a shortage that will never physically occur because it will be compensated by reduced demand for wood through higher costs for producing wood products or because of the forest-based industries more intense search for raw material outside Europe.

3.3.1 Demand development in conventional wood commodities

An analysis of historic consumption and fellings in Europe for the period from 1964 to 2000 shows a 53% increase in consumption in thirty Western and Central European countries (1.2%/y) (Figure 3.2). Fellings in the whole of Europe experienced an increase as well but it was less noticebale than the former area: a 9% increase only on the same time scale. The fact that fellings did not increase as much as consumption has to do with increased processing efficiency and increased recycling that took place over this period of time.

Figure 3.2 shows the strongly increasing trend of net annual increment in European forests. The net annual increment is nowadays assessed at 793 million m^3/y of overbark in Europe excluding CIS (UN-ECE/FAO, 2000). The figure also shows that the increase in fellings clearly stayed behind. Over this course of time, the ratio of fellings to increment declined from 90% in 1950 to currently 55%. This can be seen as a simple indication of the biological potential in the future.

The total demand scenario assumption was based on:

- historic increase in consumption as given in Figure 3.2.
- the notion that consumption in countries in transition is only just starting;
- the notion that consumption in European countries has not reached its maximum yet (given the fact that a maximum is only just showing in the USA (Haynes, 2002);
- a consumption forecast by Trømberg et al.(2000), which show an increase in consumption of wood products in Europe varying per commodity between 0.78% and 2.77% per year between 1994 and 2010;

- a review of nineteen projection studies by Weiner and Victor (2002) that show a global demand increase for industrial roundwood of 1.3% per year during the period of 1995 – 2010;
- an enquiry made by the Confederation of European Paper Industries that shows a 3.4% increase in demand for pulp and paper over the next five years (CEPI, 2002).

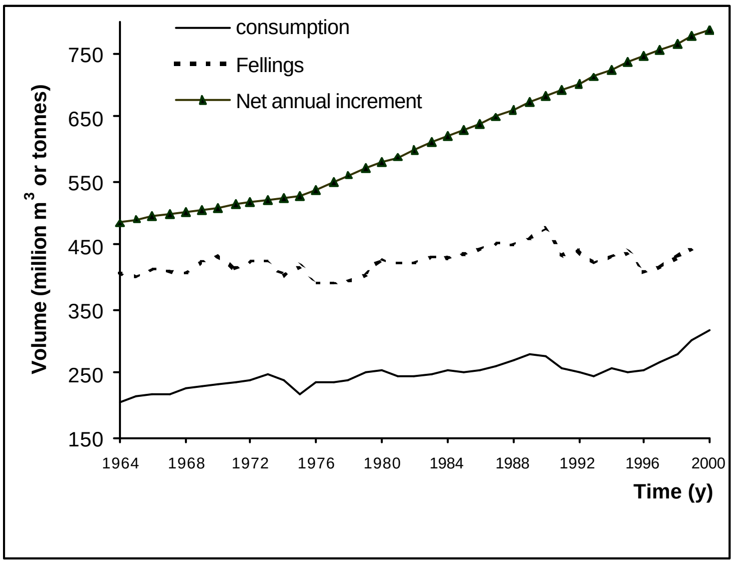


Figure 3.2.Consumption of all commodities (sawnwood, fuelwood, paper and paperboard and panels), fellings (roundwood overbark), and net annual increment (roundwood overbark) in European countries excluding Commonwealth of Independent States (CIS). Sources for fellings and increment are FAO (1948, 1955, 1960, 1976), and UN-ECE/FAO (1985, 1992, 2000). The source for consumption is the UN-ECE database

In the current study, the short-term demand increase was assumed to follow the results of the CEPI enquiry, for the longer term the international literature was followed. The principle demand increase for wood products (assumed to be equal to required fellings!) was assumed to develop according to the scenario: 3.4% per year from 2000-2005, then 1.5% per year until 2020 and then 1% per year until 2060. This is for all 19 CEPI member countries. The total increase was allocated to the countries in relation to their current share in supply. For non-CEPI member countries it was assumed that demand would increase by 1% per year throughout the whole simulated period. For assumptions for Russia see § 3.3.6.

3.3.2 European forest owners' behaviour and availability of wood

According to FAO, European forests are owned by some 9.2 million private owners and some 98,000 public owners (UN-ECE/FAO, 1992 & 2000). Most of the private owners' estates are very small, from 5 to 10 ha each. The group of private owners in particular is a very heterogeneous group and many studies have been made to try to understand their behaviour and responses to changes in stumpage value (Ovaskainen, 1992, Carlén, 1990, Kallio et al., 1987, Brooks et al., 1994, Dennis, 1989, Lönnstedt, 1989, Kuuluvainen et al., 1996, Bolkesjø and Baardsen, 2002, Hyberg and Holthausen, 1989), or optimised owner behaviour (Kangas and Pukkala 1996)(Figure 3.3.). Often, the single group of private owners is initially subdivided in rather homogeneous groups: Small Non-Industrial Private Forest owners (NIPF), large NIPF owners, non-resident NIPF owners, farmer-owned NIPF, and communally-owned NIPF. Still, one should realise that an NIPF owner in the Netherlands will have quite different goals than an NIPF owner in Sweden. The small NIPF owners can be further subdivided according to goals of management: multi-objective owner, recreationists, self-employed owners and investors (Kuuluvainen et al., 1996).

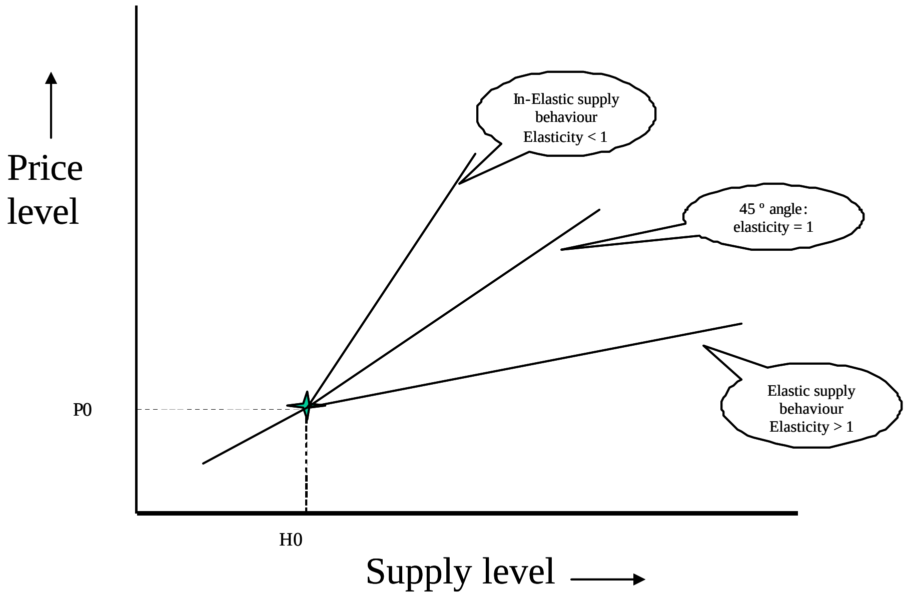


Figure 3.3. General diagram of supply elasticity of forest owners. E.g. if an owner responds according to an elasticity of '1' it means that at a 1% increase of price, he/she will supply 1% more. Note that a low supply elasticity does not mean that these owners are not supplying, they just do not respond to price changes (e.g. State as an owner)

Thus, European forest ownership can be characterised by a huge variety of owners and goals. Trends in their behaviour are, in any case, hard to distinguish because of the inertia in behaviour, the diversity between countries' forest resources and culture of management, and because trends in one group of owners may be counteracted by opposite trends in other groups. Furthermore, the huge variety of ownerships is not reflected in detail in the database used in the current study. In this database, only nineteen countries had distinguished owner groups, and mostly only two categories of ownership were distinguished: state and private. This, of course, limits the possibilities to deal with owner-specific characteristics in large-scale studies such as the present one (Kuuluvainen et al., 1996).

Trømborg and Solberg (1998) analysed structural changes in European roundwood markets and indicated that environmental constraints, certification, unstable roundwood markets, fragmented ownership, and increased costs may hinder the supply of roundwood in the future. Other studies address the general tendency for

NIPF and State owners in Europe to become less price-elastic (Lönnstedt, 1989, Bolkesjø and Baardsen, 2002). However, good studies confirming and showing evidence of a recent decrease in supply willingness were not found. Most studies only address the present undercutting, not being specific whether it is reduced willingness to supply or simply no more demand.

Schwarzbauer (unpublished) analysed data on short-term supply elasticities of roundwood for nine countries from 29 different cases (Figure 3.4). He found an overall supply elasticity of +0.63 (i.e. a price increase of 1% would result in a short-term increase in supply of +0.63%). For the few cases where he could distinguish owner categories, he found the supply elasticity to be +0.65 for private forests, and +0.3 for roundwood from public forests (thus all of them are to the left of the 'inelastic supply line' in Figure 3.3). He also found the supply elasticity to be in the range of +0.8 for pulplogs, and in the range of +0.6 for sawnlogs. He did not report anything about a decrease in supply elasticity over the last decades.

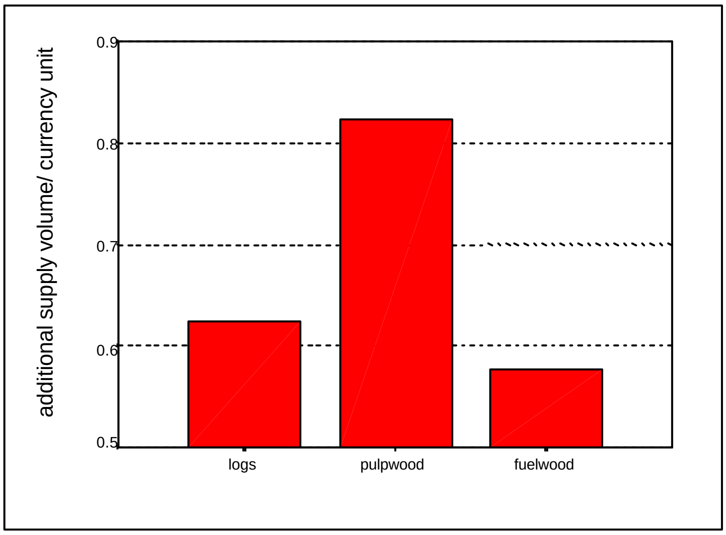


Figure 3.4. Average short-term price elasticity of roundwood supply by assortment (all owners) (number of data points from studies: logs: n=12; pulpwood: n=6; fuelwood; n= 3) (Schwarzbauer unpubl.)

The most apparent occurrence in the replies was that supply is strongly correlated to the state of the forest resource (higher growing stocks in Europe may thus lead to an increase of supply elasticity), i.e. the long term supply elasticity can be very different. It should also be noted that a low supply elasticity (e.g. State) does not mean that those owners are not supplying, they do not really respond to price changes.

Thus, availability of wood is not a fixed quantity. It is very dynamic and can be extended through higher prices for stumpage or through optimised processing. Availability can thus only be quantified for a given set of circumstances and is influenced by many factors (Brooks et al., 1994), for example :

- Owner group characteristics: Small NIPF, large NIPF, non-resident NIPF, farmer NIPF, communal, industry, state, NGO;

- Owner 'willingness' (i.e. supply elasticity) is again determined by social, cultural and historical aspects, beliefs, state of the forest, age of owner, (economic) goals (long and short-term) and presence of heirs.
- Price offered for roundwood (as an expression of demand (also new ones like carbon credits and bio-energy) or competing mills);
- Costs to harvest and transport roundwood (distance and infrastructure related);
- Resources as such (appropriate dimensions, species);
- Regulatory context and society's views: pressures leading to adapted policies, subsidies, taxes, and incentives;
- Trade (and new international trading possibilities).

The lack of information on temporal changes in supply elasticity, and the limited number of owner groups in the current inventory database, did not allow a detailed incorporation of owner behaviour for each forest type in the current scenarios. Nevertheless, to reflect differences between forest owner groups, a fixed rotation prolongation of 10 years compared to past management regimes was applied to those countries that had distinguished a public forest ownership class (see Table 3.2) and where the ownership was dominated (>70%) by public ownership (see Figures 3.5, §3.3.3 and 3.3.7 and Appendix 1). These countries are Bulgaria, Belarus, Croatia, Estonia, Lithuania, Macedonia, Poland, Romania, Turkey, and the Ukraine.

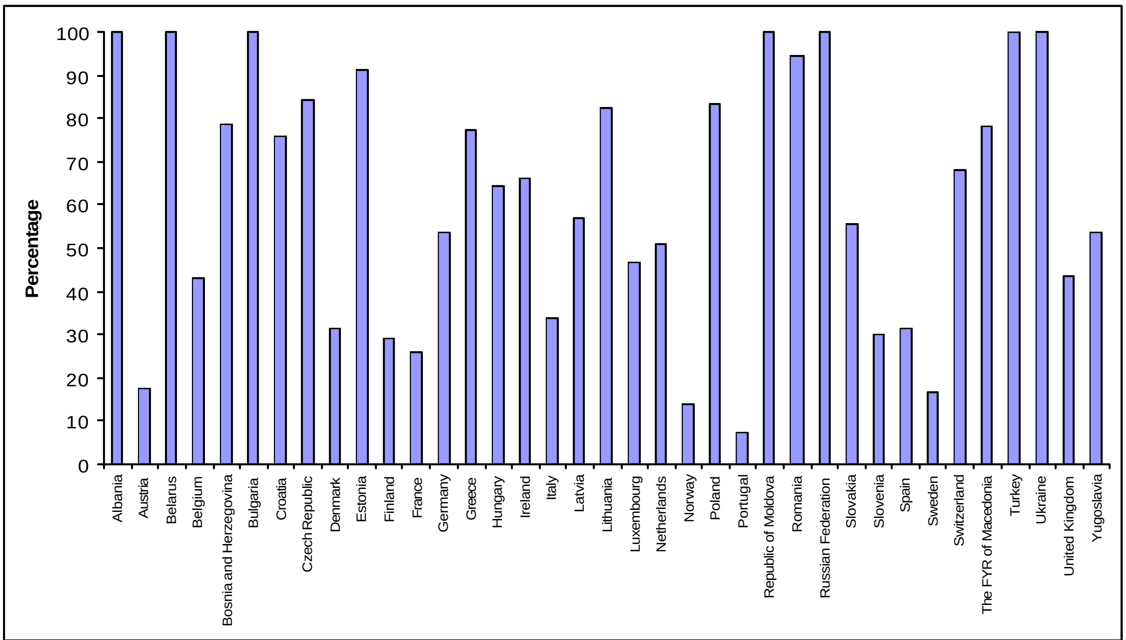


Figure 3.5. Percentage of total forest area in public (i.e. including communal) forest ownership for each European country (UN-ECE/FAO, 2000)

3.3.3 Nature-oriented management

From a case-study point of view, a wide review of related literature shows a Europe-wide change in management style towards nature-oriented management (NOM) (Table 3.3).This style of management encompasses a wide variety of styles of management. NOM generally aims at enhancing nature conservation values in the forest and differs from traditional economic optimisation in forest management in that, it is less directed towards wood production. NOM does not necessarily mean that wood production goes down, but it reflects how nature conservation values receive attention on different levels of intensity. In the simplest case, it may mean just chosing another species of tree and in its most extreme case, the establishment of reserves. Somewhere in between these two variants NOM may mean that some logwood is left in the forest to decay.

NOM reflects a general desire in society for a closer-to-nature situation in European forests. This trend is being promoted both from top (international policies, Ministerial Conference on Protection of Forests in Europe, certification) and bottom levels (forest manager in the field). The change in management style is more predominant in Western than in Central European countries (see Table 3.3).

Table 3.3. Implications of nature-oriented forest management as reported in related literature (adapted according to De Goede, 2000)

REGION	STRATEGY	IMPLICATIONS
Bavaria	Protection of old deciduous trees and harvest of mature high quality trees only.	Conversion to Fagus spp leaves old and dead trees. Annual harvest 2% of stock.
Sweden	Protection of certain habitat types to create desirable ecological structures.	Larger proportion of deciduous species. Larger proportion of older forests
Czech Republic		Rotation length has increased from 93 years in 1920 to 115 years in 1997.
Europe	Transformation of the coniferous monocultures into more stable deciduous ecosystems.	Fagus sylv: 43%, Quercus 29%, Carpinus/Tilia/Acer, 9%,.
Finland	Strategy for average standing volume, area of deciduous spp, dead wood, and clear fellings.	Pinus sylvestris: 41%, Picea abies: 18%, Deciduous, 20%. Volume of dead wood: 33-48 m^3/ha (target values for 2014 in an optimisation study)
Central and Western Europe	Convert Picea abies plantations on sites outside of its natural distribution into Fagus sylvatica, Quercus robur, Acer etc.	Desired species distribution: Fagus, 22%, Quercus, 59%, Acer, 5%, Fraxinus, 1%.
Czech Republic	Tree species change to more stable ecosystems within 110 years.	Species composition in 1990: spruce, 55%, fir, 2%, pine, 18%, larch, 4%, oak, 6%, beech, 6%, other, 8%. To be changed to: spruce, 37%, fir, 5%, pine, 17%, larch, 6%, oak, 9%, beech, 18%, and other, 8%.
Germany	5% of damaged area set aside for biodiversity protection.	More dead wood.
Sweden	Adapted management (no cutting, modified thinning) in edge zones to mires, riparian zones, non-productive hills etc.	11% of productive forests lie within 25 metres of mires, and 3% is located in riparian zones.
Brandenburg	20% of broad-leaved regeneration without protection against game. Regulation of game populations.	Applied to Fagus and Quercus regeneration.
Boreal forests	Exclusion of treatment schedules in 13% of forest area. Buffer zones along water bodies, each 20-40 metres wide. Shelterwood cutting at age 100-300.	Applied to Pinus sylvestris and Picea abies forests. Annual harvest reduced by 10%. Net present value may decrease by 7%.
Northern boreal	Set aside forest areas and develop corridors and restoration zones.	Dead and dying trees are left to enhance biodiversity. Use of exotic species and fertiliser are restricted. Forest fires used as soil-treatment.
Switzerland	Reconstructing original vegetation.	Aim for more Fagus sylvatica and Quercus petraea
Netherlands	Conversion of Pseudotsuga meziesii to mainly Fagus sylvatica and Betula.	Creating gaps and using natural regeneration.
Netherlands		At least 4 dead trees > 30 cm diameter. Volume of dead wood is approximately 30% of volume of living trees. Mortality rate 0.6%-2.0% of stock. Annual input dead wood 1.5-3.5 m^3/ha. Production decrease approximately 15%. Longer rotations to increase diameter of dead trees.

Nabuurs (2001) assessed the total European implications of large-scale moderate adoption of nature-oriented management. Under a modest increase in required fellings, he found that NOM scarcely hindered the total European fellings (on a time scale to 2050), mostly because of present undercutting. However, as it was assumed that NOM would be more intensively adopted in central Europe, demand for roundwood predominantly shifted to Scandinavia. Since Russia was excluded from his study, in principle, it led to overcutting in Scandinavia.

Another study by Eid et al. (2002) looked into local impacts of these management trends in terms of potential production (!) or Net Present Value (NPV). They found the impacts to be severe when all constraints were imposed simultaneously: 30% less fellings and a NPV reduced by 21%[2]. They also found significant efficiency gains when preservation of old forests was decided from a cost-efficient perspective. A comparable study was carried out by Lind (1998). He assessed the total Swedish forest area that may be affected by new management regulations concerning no cutting and modified thinnings in riparian zones, mires etc. He calculated that 11% of Swedish productive forests lie within 25 metres distance of mires, and 3% is located in riparian zones. However, he also noted that the actual national cuttings might not be hindered by this.

In the current study it was assumed that NOM is a long-term trend and that it is going to be very important for European forestry in the future and might reduce the willingness to supply. This reduction in supply willingness is incorporated for the 36 European countries as a combination of:

- longer rotations (20 years for long rotation species, and 10 years for short rotations (<60 years)) for all tree species. This was kept rather simple because of a lack of detailed information on how the management of each tree species may change under NOM (see also the impact of carbon credits in § 3.3.4.);
- from total fellings an additional 10% must originate from thinnings/group fellings;
- thinning can only be carried out in forests with growing stocks over 150 to 300 m^3/ha, depending on the forest type. This is based on the assumption that non-commercial thinnings are not being practised anymore;
- a species change towards the more natural/indigenous species is incorporated as a 30 to 40% chance that species like spruce and pine will be regenerated with species like beech and oak;
- set aside of beech and oak forests older than 150 years (see appendix 1). Initially this usually affects 1 to 1.5% of the total forest area in a country. Due to ageing of the forest during simulation this area may increase to some 6-10% by 2060 depending on management regimes, felling levels, etc.

A detailed representation of these management constraints, as incorporated in the model and compared to the past management, would require the display of some 600 management regimes and cannot be given here (an example is given in Appendix 1).

[2] Note that this study concerned 'potential' felling levels which is very different from studying impacts on presently needed felling levels.

3.3.4 Carbon credits

Although the European Union was not entirely in favour of the terrestrial sink options in the Kyoto Protocol, these are still maintained in the implementation phase. Further steps for implementation of the Kyoto Protocol were made at the Conference of the Parties VII in Marrakech in November 2001 (UNFCCC, 1997, UNFCCC, 2001b). The main outcome of Marrakech conference is that the exact way of how to include these LULUCF measures was agreed upon.
They are as follows: (forest-related only)

- sinks as a result of Afforestation, Reforestation, and Deforestation (ARD) activities can be used fully (although the net results may be debited; Article 3.3);
- sinks due to (ongoing) forest management can be used fully, but only up to a maximum of 8.2 Mt C/y (per country), and only up to the level of debits due to ARD (Article 3.4);
- additional forest management (Art 3.4) can be used to achieve the commitment, however only up to an absolute amount mentioned for each country (e.g. 1.24 Mt C/y for Germany). These amounts are rather small (Table 3.4) and include credits obtained from Joint Implementation projects in other industrialised (Annex I) countries;
- The ongoing ageing effect in many northern countries' forests must be excluded from accounting, as well as indirect effects of e.g. CO_2 fertilisation;
- JI projects can be used to achieve the commitment, but with same restrictions as above and additional baseline restrictions;
- In developing countries (Clean Development Mechanism) only projects falling under Afforestation or Reforestation can be used. These projects in developing countries can only be used up to a maximum of 1% of the 1990 emissions of the industrialised country and have baseline restrictions.

Table 3.4. Maximum amount of credits that can be gained through forest management in Article 3.4. (UNFCCC, 2001b)

Party	Mt C/yr	Party	Mt C/yr
Australia	0.00	Latvia	0.34
Austria	0.63	Liechtenstein	0.01
Belarus		Lithuania	0.28
Belgium	0.03	Luxembourg	0.01
Bulgaria	0.37	Monaco	0.00
Canada	12.00	Netherlands	0.01
Croatia		New Zealand	0.20
Czech Republic	0.32	Norway	0.40
Denmark	0.05	Poland	0.82
Estonia	0.10	Portugal	0.22
Finland	0.16	Romania	1.10
France	0.88	Russian Federation	33.0
Germany	1.24	Slovak Republic	0.50
Greece	0.09	Slovenia	0.36
Hungary	0.29	Spain	0.67
Iceland	0.00	Sweden	0.58
Ireland	0.05	Switzerland	0.50
Italy	0.18	Ukraine	1.11
Japan	13.00	United Kingdom	0.37

One of the subsequent steps was that the Intergovernmental Panel on Climate Change (IPCC) was asked to prepare the Good Practice Guidance report. This report is the final step towards practical implementation, measuring and monitoring and will be adopted late 2003. All countries that have an emission reduction commitment will be obliged to have a full national monitoring and reporting system ready by 2005. The general feeling is that the Kyoto Protocol will be ratified by a sufficient number of countries and that it is close to practical implementation. Furthermore, the general feeling is also that companies are taking the necessary steps for implementation and that a large number of initiatives for carbon trading (partly from forestry projects) are under development.

For the present study two different outcomes of the Kyoto Protocol can have impacts on the scenario assumptions: 1) the amount of new areas being planted due to Kyoto Protocol measures and 2) the likelihood that forest owners will be financially compensated for building up carbon (= growing stock) in existing forests.

Amount of new areas being planted due to Kyoto Protocol measures

Changes in forest areas are already taking place at the moment without any carbon credits being paid. The average annual net changes in the forest area during the period 1983-1993 are shown in Table 3.5 for the CEPI member countries. France and Spain have seen the highest increase of forest area by, respectively, 61.6 and 86 thousand hectares annually. Belgium, Serbia and Montenegro and Albania have seen an overall decrease in forest area. However, these are the net changes between the gross changes in forest available for wood supply and forest not available for wood supply. Figure 3.6 shows these average annual gross changes in forest available for wood supply and forest not available for wood supply in CEPI member countries during the period 1983-1993. For the countries listed in Figure 3.6 there is an overall average annual increase in FNAWS of 262,200 ha and in FAWS of 96,600 ha. Thus, there is a large increase overall in forest area but only part of it is available for wood supply.

Table 3.5. Average annual net change in the forest area of the 19 CEPI member countries during the reporting period 1983 - 1993 [1000 ha] (UN-ECE/FAO, 2000). These are the net values of the gross numbers for FAWS and FNAWS given in Figure 3.6

Country	Average annual net change in the forest area (1000 ha/y)	Country	Average annual net change in the forest area (1000 ha/y)
Austria	7.7	United Kingdom	20
Belgium	-1.3	Poland	11
Switzerland	4.3	Hungary	7.2
Czech Republic	0.5	Ireland	5
Germany	22.0	Italy	29.5
Denmark	0.8	Netherlands	1
Spain	86.0	Portugal	57
Finland	8.0	Sweden	0.6
France	61.6	Norway	31
		Slovak Republic	6.9

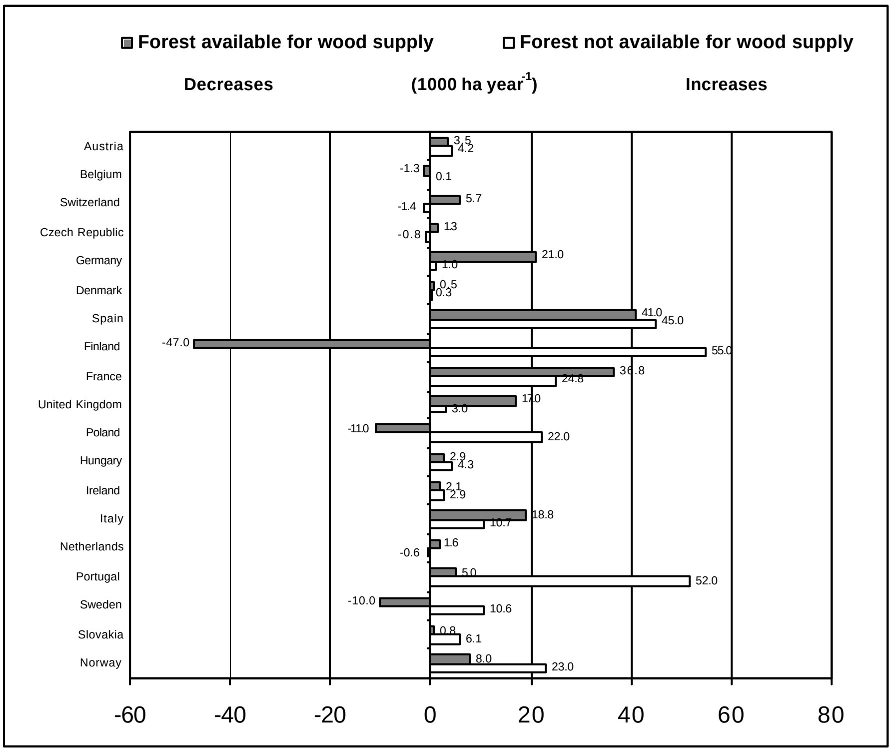


Figure 3.6. Average annual change in forest available for wood supply and forest not available for wood supply in the 19 CEPI member countries in Europe for the period 1983-1993 (UN-ECE/FAO, 2000)

For the 36 European countries in the present study, these figures show an overall annual increase in FNAWS of 590,000 ha and in FAWS of 192,000 ha.

It was assumed that Article 3.3 of the Kyoto Protocol will indeed stimulate the gross FAWS area expansion: from the current +192,000 ha per year (excl. Russia) to 390,000 ha per year (on average over the whole simulation period), i.e. it is expected to double. This scenario assumption will increase the total forest available for wood supply in the 36 European countries from the present 160 million ha (in our database) to 182 million ha. This increase was assumed to take place mainly between 2010 and 2040 and to apply to the present forest area per country with some emphasis on pre-accession countries. In order to deal with the decrease in the net FAWS as given above, a rate of establishment of exempt areas was already incorporated under the NOM assumptions.

Likelihood that forest owners will be financially compensated for building up carbon (growing stock) in the existing forest.

According to the UNFCCC definition, '*Forest management*' is a system of practices for stewardship and use of forestland aimed at fulfilling relevant ecological (including biological diversity), economic and social functions of the forest in a sustainable manner. Each country may decide by 2006 whether they will include forest management in their Green House Gas inventory system. This decision will affect accounting of carbon credits during all following commitment periods. Re-vegetation, forest, cropland and grazing land management activities can provide credits to compensate debit arising from ARD activities in the first commitment period (2008-2012), for an amount not exceeding 5 times 9 MtC for the entire first commitment period.

Additional credits can be gained from forest management up to the maximum amount individually defined for each party in Annex I (available as annex to UNFCCC, 2001b). This ceiling is rather low for the first commitment period and these values include any possible credits obtained from Joint Implementation projects in other industrialised countries. Credits obtained though CDM projects are additional. (UNFCCC, 2001a-b).

Table 3.6. Indicative prices for Verified Emission Reductions (VERs) per commodity type (Natsource, 2001)

Commodity type	Vintage year	Price (€/tonne CO_2 equivalent)
VERs		
Annex B VERs	1991-2007	0.60-1.50
Annex B VERs	2008-2012	1.65-3.00
CDM VERs	2000-2001	
Compliance tools		
Dutch ERUs	2008-2012	4.40-7.99
Danish allowances – Mid market bid – offer	2001-2003	3.78
European ERUs – Indicative Bids	2008-2012	7.00-12.00
Australian Early Action AAUs – Indicative Offers	2008-2012	6.00-12.00
UK permits – Mid-market bid-offer	2003	8.46
BP internal allowances – Pilot phase	1999	10.00-25.00
BP internal allowances – Full-scale internal trading	2000-2001	0.50-25.00

On average, the prices shown in Table 3.6. are in the range of € 4.7 – 11/tonne CO_2 [3], which is roughly equivalent to € 4.25 - 10 per m^3 of stemwood. This is a significant monetary value in comparison to pulplog stumpage of around € 15 - 20/m^3 offered in Scandinavia, and is very high in comparison to pulplog stumpage of € 1 - 5/m^3 offered in Central Europe. The question, however, is whether governments are going to subsidise the ongoing carbon build-up in existing forests because of these kind of prices and are they actually going to pay these prices. Up to now, no government does. The carbon build-up is merely an effect of present undercutting, and is not a deliberate action taken by forest owners to store carbon. It is happening anyway, so why subsidise it? On the other hand, the general notion is that the biospheric sinks in the Kyoto Protocol are settled firmly, and will probably gain attention or importance in consequent commitment periods after 2012.

We can therefore assume that this part of the Kyoto Protocol has had no impact on forest owner behaviour up to now. However, this section of the Kyoto Protocol is in line with the management trend under nature-oriented management, leading to build-up of growing stock. As it is in line with a strong trend in forestry, owners may be interested in it, provided that it is paid for. Taking all this into consideration, as well as taking into account the high uncertainty level in outcomes of future international climate negotiations, we assumed that Article 3.4 may lead to a prolongation of rotation lengths by 10 years (irrespective of country or site).

[3] € 4.7/ tonne CO_2 = 17 € per tonne C. Every cubic meter of stemwood contains 0.25 tonne C. Thus the equivalent value per cubic meter of stemwood is 17/4 = 4.25 €

However, rotation length prolongation was mentioned under owner behaviour, NOM, and now under Kyoto Protocol issues. If forests were subjected to prolongation under these issues, it might have resulted in prolonged rotations of an extra 30 to 40 years. This seemed unrealistic and a total maximum of 20 years prolongation was assumed as a constraint (see Appendix 1).

3.3.5 Bio-energy

In the EU policy on renewables (EC 1997) and its affiliated Action Plan (endorsed in May 1998), the EU aims at doubling the contribution of RES to gross energy consumption from a current 6% to 12% by 2010. The European Commission has designated biomass as an important Renewable Energy Source, with a target of 90 Mtoe (Megatonnes of oil equivalent) of bio-energy, which will be produced from biogas, liquid biofuels, energy crops, conventional wood, wood residues and farming residues. If all of the 90 Mtoe came from woody biomass it would correspond to 483 million m^3 of fresh wood [4], 2.3 times the use in 1990 (Table 3.7). In 1990, about 200 million m^3 of woody biomass from various sources was used for producing renewable energy, mostly for domestic uses and for small scale heating in industrial boilers (Table 3.7).

Table 3.7. The use of wood-based bio-energy in the 15 EU countries in 1990, before the RES policy was implemented (source: ECE/FAO, 1994, in Richardson et al., 2002)

Source of woody biomass	Million m^3 wood equivalent
Conventional fire wood	92 *
Residues from primary wood processing industries	86 **
Residues from secondary industries	17
Recovered wood products	13
Total	208

*: the UN-ECE/FAO reports however a 'wood fuel' consumption in EU + EFTA countries of 40.8 million m^3 in 2000 (see Fig 3.8). This reflects the large uncertainty there is in wood fuel data.
** of which 49 Mm^3 wood equivalents black liquor

A study by Berndes et al. (2003) reviewed 17 projections of future contribution of biomass to global energy supply and showed that, although the potential for bio-energy from biomass is very large (100 to just over 400 EJ/y out of a total primary energy use of around 400 EJ), there were many uncertainties in the projections . The main uncertainties were land availability and yield levels of plantations. For Europe most studies showed that some 4 EJ/y could be produced from existing forests and

[4] Fresh wood with a moisture content of 50% has a energy content of 7.8 GJ/tonne. One tonne of fresh wood is approximately 1 m^3. 1 tonne oil equivalent (Toe) amounting to 41.9 GJ means that 1 Toe = 5.37 m^3 of wood. Or 1 Mtoe is 5.37 million m^3 (as used here). With mixtures of biomass usually consisting of both fresh wood as well as partly dried residues, the conversion factor may often be that ca. 1 Mtoe equals 4.91 million m^3.

new plantations. However, this would require an additional harvesting of more than 600 million m^3/y!

The possibilities for dedicated energy crops on agricultural land are limited in Europe. This is caused by the limited financial support schemes for energy crops and the strong claims on the available EU budgets by traditional agriculture. There is no clear political will yet to support the planting of fast growing tree species on a significant area of arable land, even though the consumption of wood fuel has gradually been increasing since 1978 (Figure 3.7). The harvesting and deployment of forestry biomass as a biofuel might enhance the cash return for forest owners, as well as, stimulate the local economy and the development of 'environmentally-friendly' energy systems. On the other hand, it may affect competition between the traditional forest-based industry and energy producers, which could lead to a distortion of existing wood markets.

Although the White Paper calls for an increased use of solid biofuels, it does not define exact quantities. Dielen et al. (1999) have calculated the relative contribution of agricultural waste, fuel wood (roundwood and forest residues) and industrial wood processing residues using additional information from the TERES II-report, the European Renewable Energy Study. This calculation indicated a target of 27.1 Mtoe of woody biomass for 2010, consisting of 15.3 Mtoe of roundwood and forest residues and 11.8 Mtoe of industrial wood residues. According to Dielen et al., the additional volume of wood required to implement the White Paper target in 2010 will vary between 136 and 190 (average, 163) million m^3, of which 77-107 (average 92) million m^3 should come from roundwood and forest residues.

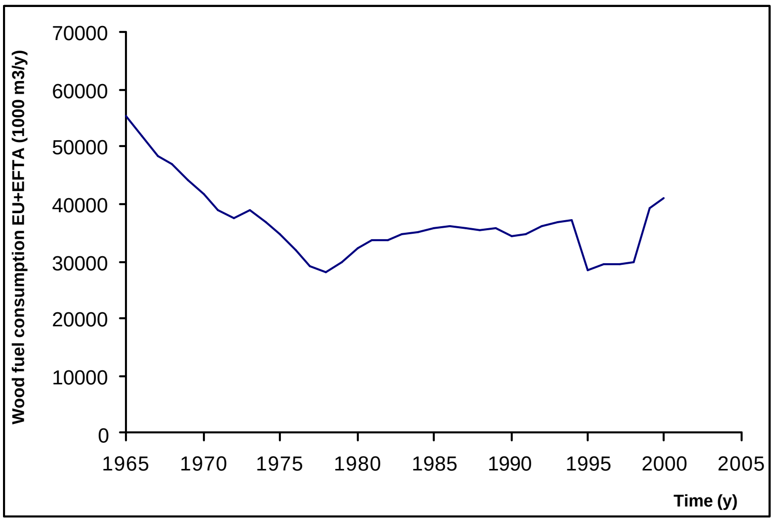


Figure 3.7. Consumption of wood as fuel in the EU + EFTA countries. The decrease until 1978 is due to reduced domestic non-commercial use of fuelwood. The increase since 1978 is partly due to the demand from bio-energy plants. (UN-ECE production database)

The directive on the promotion of electricity from RES proposes that Member States take necessary measures to ensure that the level of renewable generated electricity develops in conformity with the energy and environmental objectives undertaken at national as well as Community level (EBD, 2002). Increase in its use in the EU constitutes an essential measure needed to comply with the Kyoto Protocol. Electricity produced from renewable energy sources will have a specific share of 22.1% of total EU electricity consumption by 2010. This will further enhance the demand for various biomass sources, including woody biomass.

Due to the above mentioned RES policy an increase in demand for wood fibres from forest resources for the production of bio-energy has already been recorded and it can be expected to increase further. This will be enhanced even further by various national grant and tax schemes. The increased demand, based on the EU Whitepaper, has been calculated to amount to approximately 92 million m^3 (Dielen et al., 1999). The EU target for electricity production from RES could easily create this additional demand. Furthermore, several national governments and the oil industries are studying the market opportunities for liquid biofuels, which have the potential to replace fossil fuels to a large extent in the near future, with a strong impact to be expected from 2050 onwards (Shell Global Solutions, pers. communications). This could create a very significant additional demand for woody biomass, the exact amount of which is difficult to predict (and outside the scope of the present study).

In spite of these plans, the present deployment of bio-energy is insignificant with a contribution of 2.3% if we ignore the three exceptions. The exceptions are Finland, Sweden and Austria (see Annex 2). A number of technical and socio-economic barriers are responsible for the slow start. The main barriers are costs, policy and public acceptability. High project and finance risk is considered the most important barrier, even more than high fuel procurement and capital costs. This clearly reflects the early stage of development of the biomass industry in Europe and the risks perceived by the financiers (AFB-Nett, 1995). Also, there is a lack of understanding by the public in general, and the resultant fear of the unknown stands in the way of local acceptance and support. In particular, a lack of understanding by local authorities results in uncertainty about permission for plant operation and construction (AFB-Nett, 1995).

From the current state of implementation of the RES policy in Europe, it can be concluded that it is very unlikely that the RES targets for woody biomass will be met within the intended time span. Adjustment of the time span or of the quantitative targets would seem inevitable (many experts doubt whether the RES targets will be met at all). Given the circumstances mentioned above, a more realistic RES scenario should reflect a mitigated demand and an extended timespan in which the targets are to be met, e.g. with a 15 to 20-year delay. An extra demand of 80 million m^3 of roundwood by 2025-2030, matches this requirement and is incorporated as an assumption in the 'new management trends' scenario. This additional demand for 80 million m^3 of roundwood is distributed over the countries with respect to their current share in total fellings.

3.3.6 Assumptions regarding Russia

The scenarios and assumptions made for the European part of Russia require some additional explanation because of the large impact that this resource may have on the results (Figure 3.8).

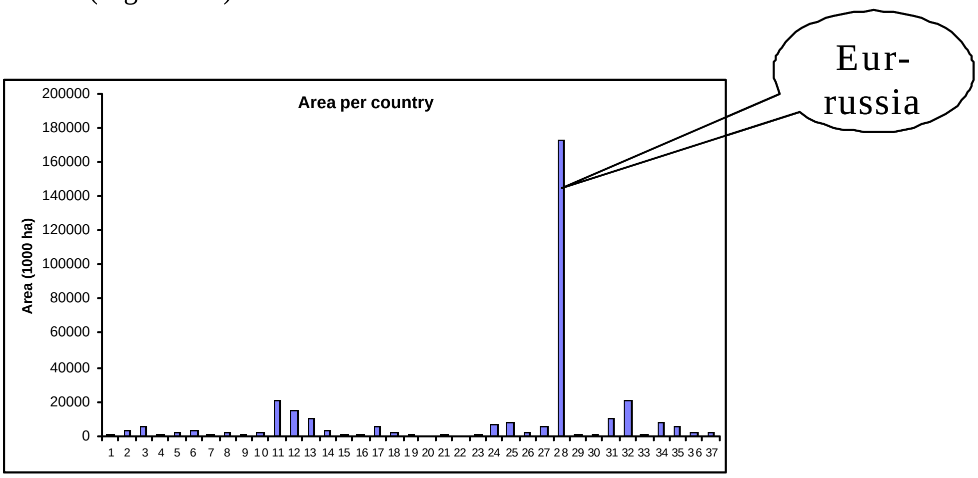


Figure 3.8. Significance of the European Russian forest area in relation to the forest area in all other European countries. Country names are not given, but e.g. Finland can be recognised as country number 11, with roughly 20 million ha of forest (UN-ECE/FAO, 2000)

Generally a very low accessibility was assumed for European–Russia, defined by forest group, and region (distance to Western Europe). For protection classes I (according to the Russian way of classifying forests: highly protected) and II (multi-purpose forests), one tenth of the normal felling opportunities for older forests was set as a constraint. On top of that very small felling opportunities were set for northern regions, starting at forests of around 100 years old. These opportunities were higher for central and most western regions. Thinning opportunities were set to allow thinnings in all volume classes from young to mature age classes but only in class III forests (production forests). Out of the total required fellings only 15% was required to come from thinnings in the ‘projection of historical management’ scenario, and 25% in the ‘new management trends’ scenario. These low proportions are to reflect the lack of interest in thinnings in the past. Furthermore, the basic management regimes were not changed in Russia to reflect NOM or carbon credits impacts. This is because of uncertainty over future Russian forest management and because the aim was to test to what degree Russia could cope with a European shortfall if Russian forest management itself would not change.

As a basic Russian domestic wood products demand scenario a 1% increase per year until 2040 was assumed, and 0.5% afterwards. Furthermore, in the ‘new management trend’ scenario (§ 3.3.7) it was assumed that Russia may act as a net exporter to European countries and thus any shortage arising from the scenarios of European countries was added to the Russian domestic demand scenario as given above.

3.3.7 Scenarios

The simulations were carried out for the Forest Available for Wood Supply area (FAWS) as given by UN-ECE/FAO (2000). If the underlying data for the current study did not fully cover this FAWS (Table 3.2.) then our data were scaled to reach the FAWS in both scenarios. All countries were run individually (ignoring imports and exports within the European continent), thus expressing a possible shortfall in relation to national fellings only (i.e. not in relation to consumption which is the sum of fellings plus import minus export).

Two scenarios were designed:

Projection of historical management: a scenario in which the basic demand development as given in §3.3.1 was run in combination with conventional forest management as may have been carried out until the 1980s according to handbooks, etc. No forest expansion, no species change, no set reserves etc. were assumed

New management trends: this scenario consists of the basic demand development as given in §3.3.1 plus an extra annual total European demand of 80 million m^3 roundwood by 2030 for bio-energy. This total demand scenario is run in combination with the management changes as given in the previous sections due to the three issues (NOM, carbon credits and bio-energy), including the forest area expansion assumptions and loss of FAWS due to reserves. All this is tested under the assumption that real price increases for raw material will not occur.

4 Results for single countries

4.1 Albania

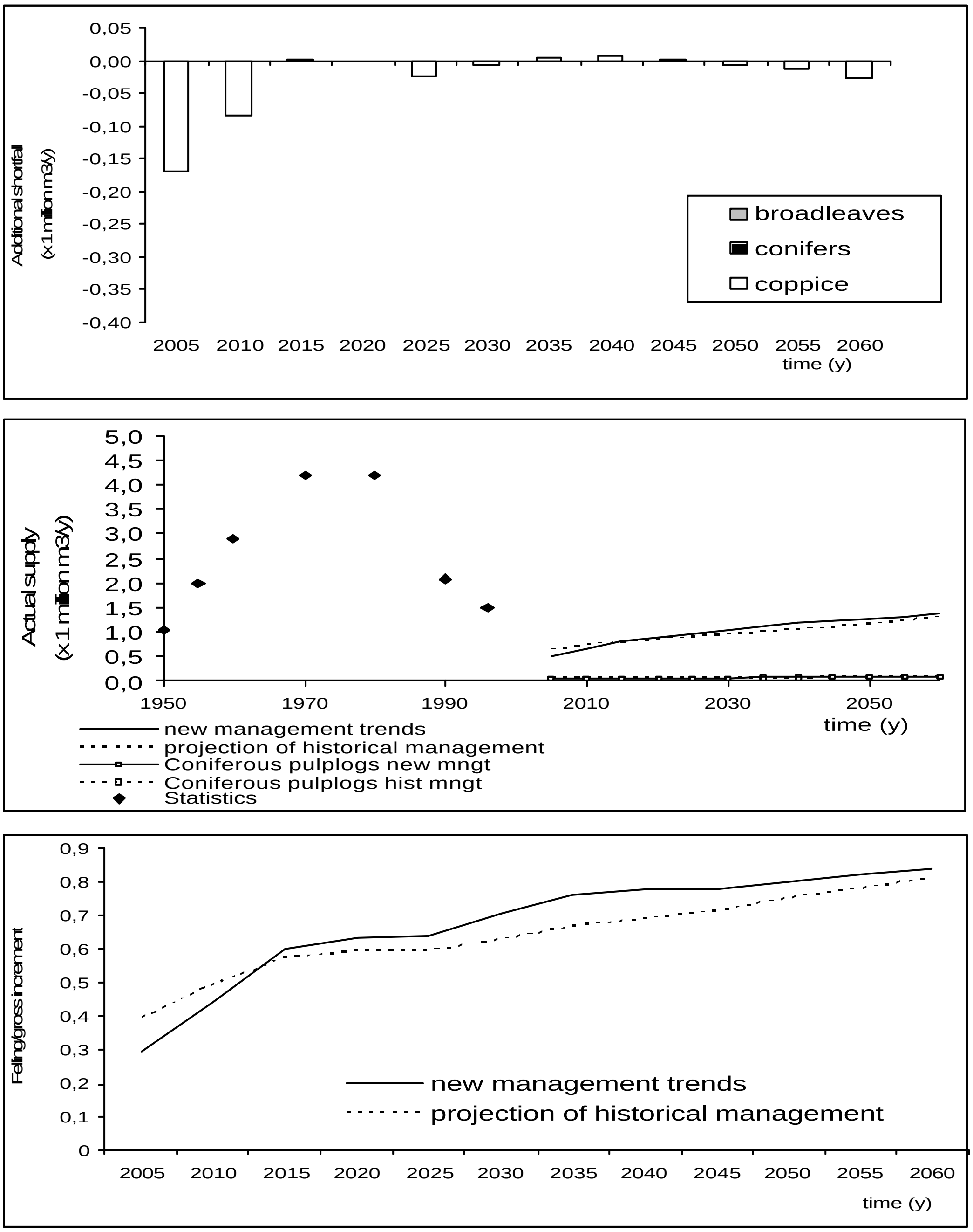


Figure 4.1 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)

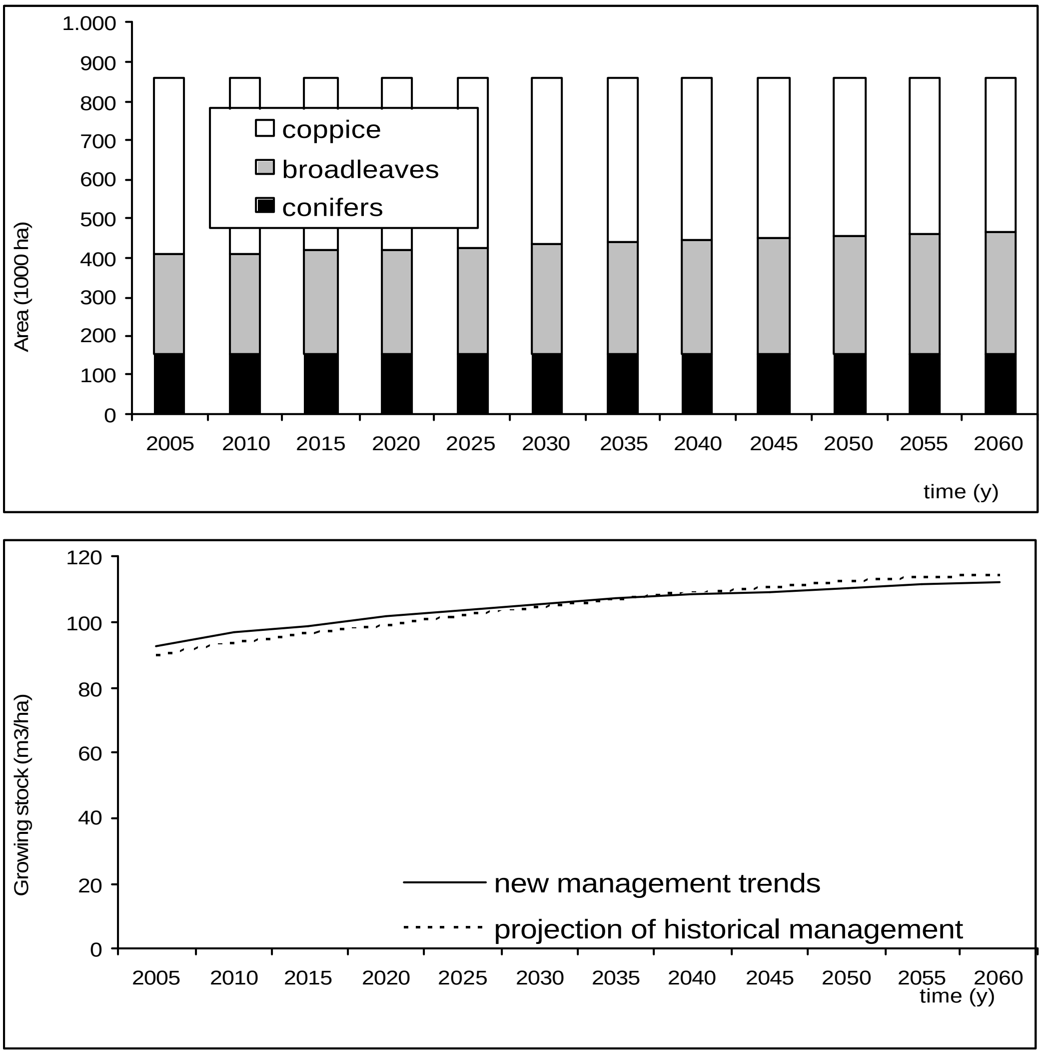


Figure 4.2. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.1. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	857	857	857	857
Gross annual increment (m^3/ha/y o.b.)	1.9	1.8	1.7	1.9
Total additional shortfall (x million m^3/y o.b.)	-0.2	-0.1	0.0	0.0
Growing stock (m^3/ha o.b.)	93	97	106	112
Actual supply by all species (x million m^3/y)	0.5	0.7	1.0	1.4
Actual supply of conifer pulplogs (x million m^3/y)	0.0	0.1	0.1	0.1

4.2 Austria

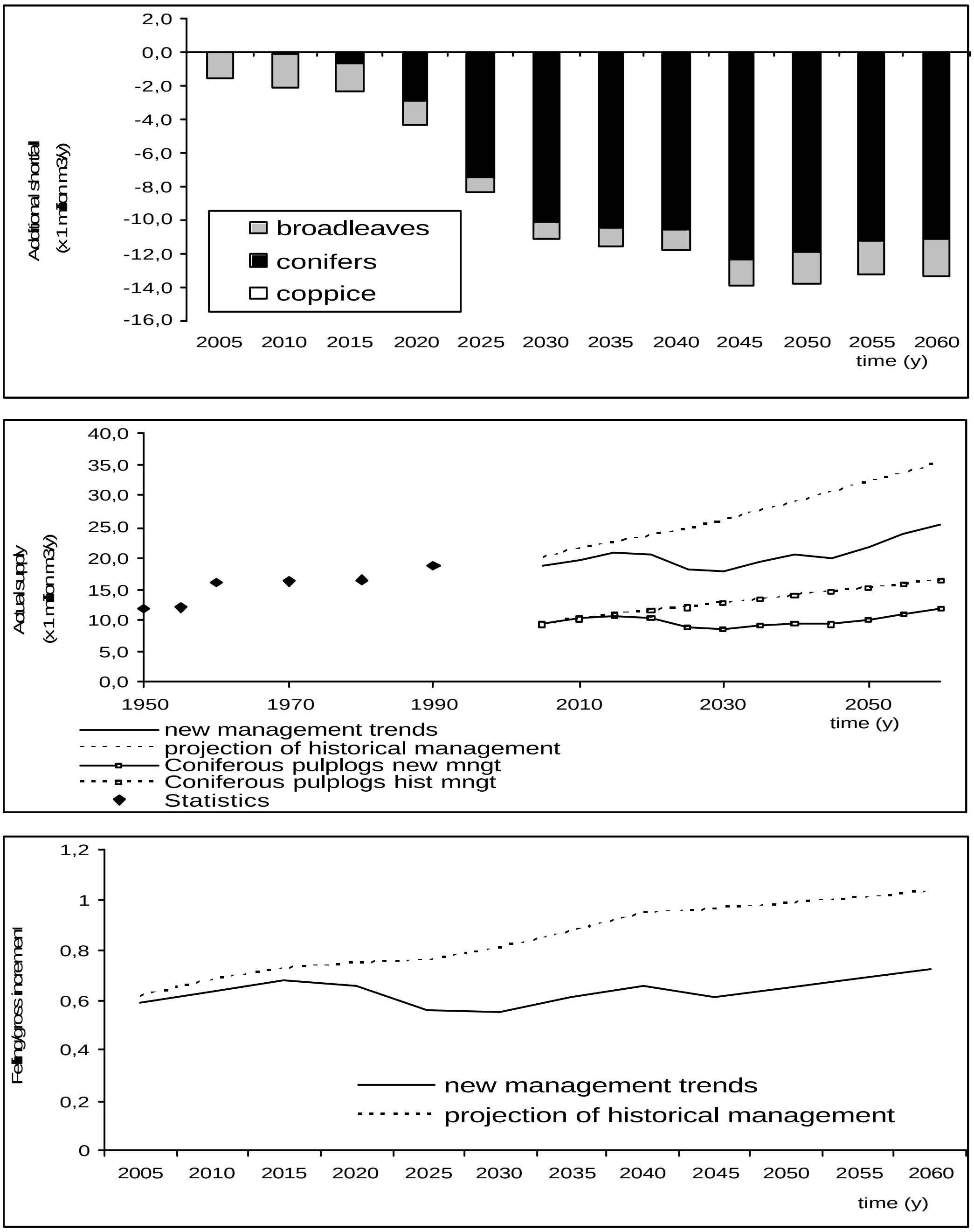
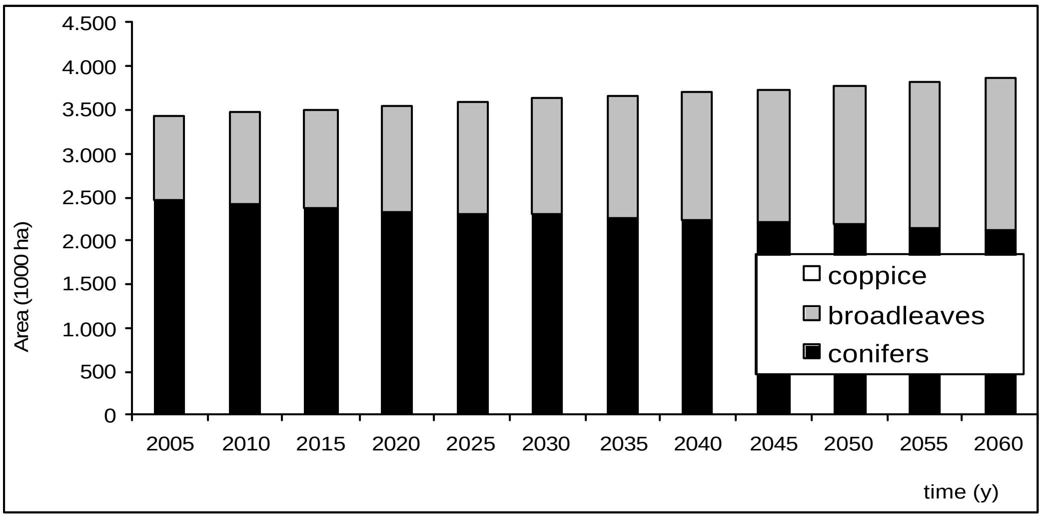


Figure 4.3. Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)



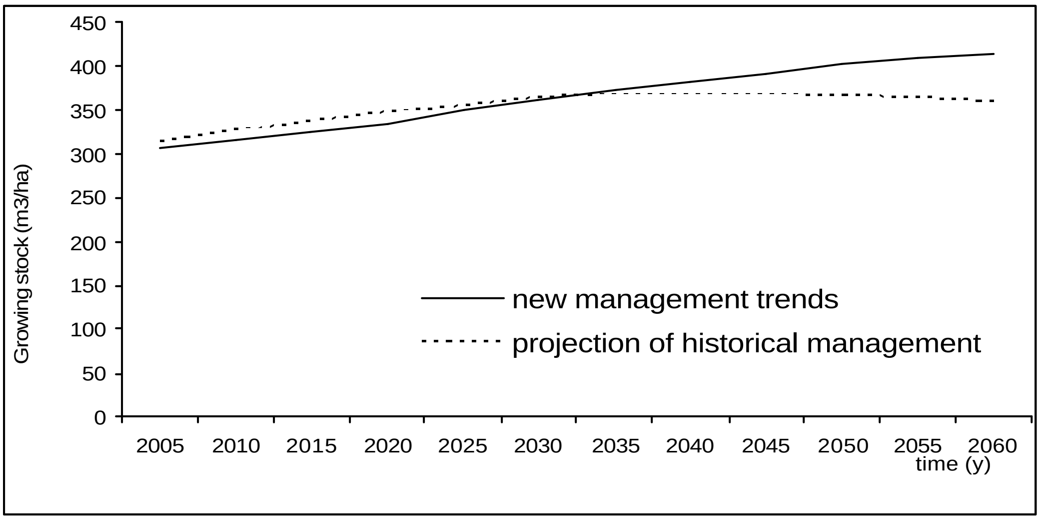


Figure 4.4. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.2. Main output variables under 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	3,431	3,470	3,624	3,855
Gross annual increment (m^3/ha/y o.b.)	9.2	9.0	8.9	9.1
Total additional shortfall (x million m^3/y o.b.)	-1.6	-2.1	-11.1	-13.4
Growing stock (m^3/ha o.b.)	305	316	363	416
Actual supply by all species (x million m^3/y)	18.6	19.8	17.8	25.3
Actual supply of conifer pulplogs (x million m^3/y)	9.4	10.2	8.3	11.7

4.3 Belarus

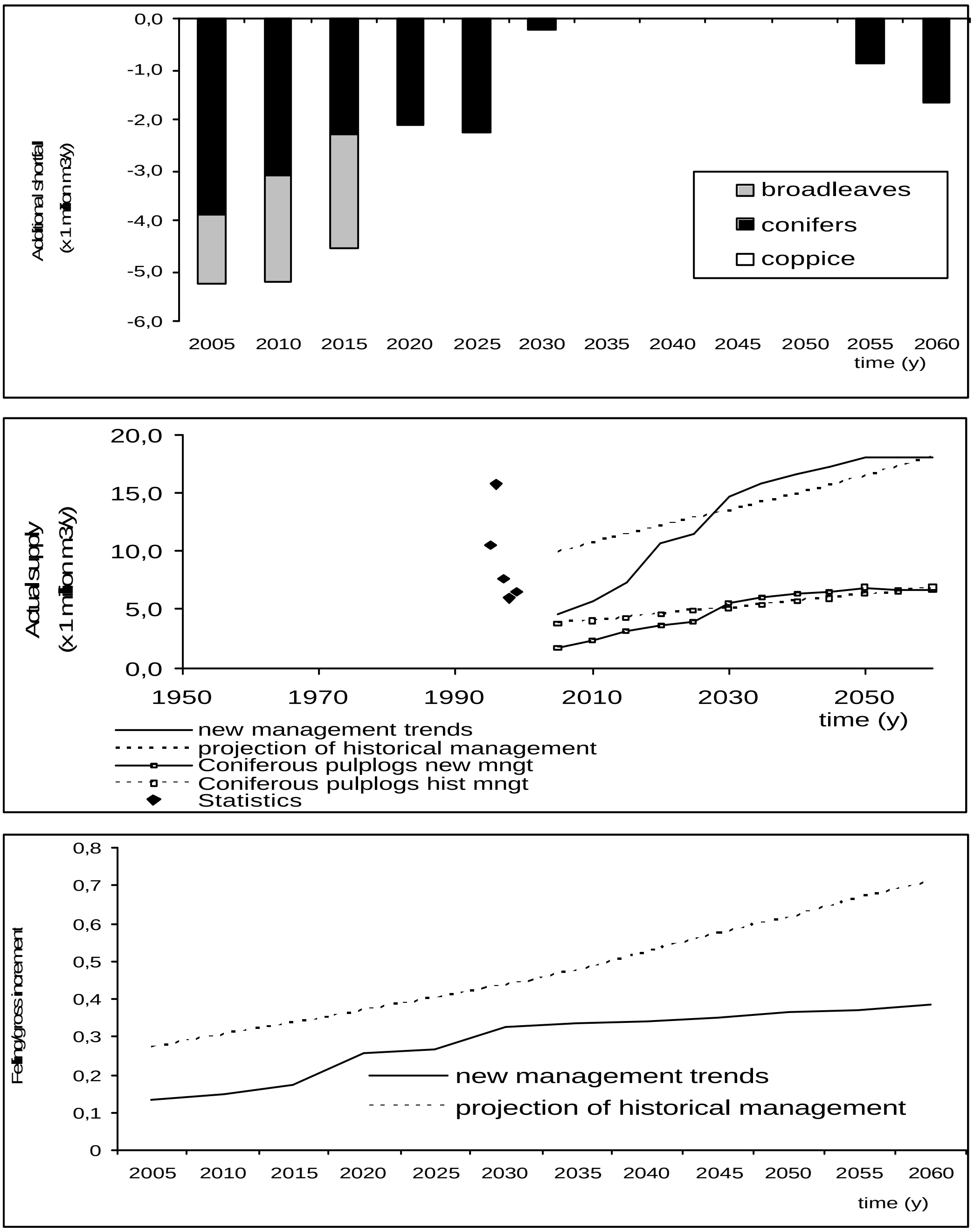
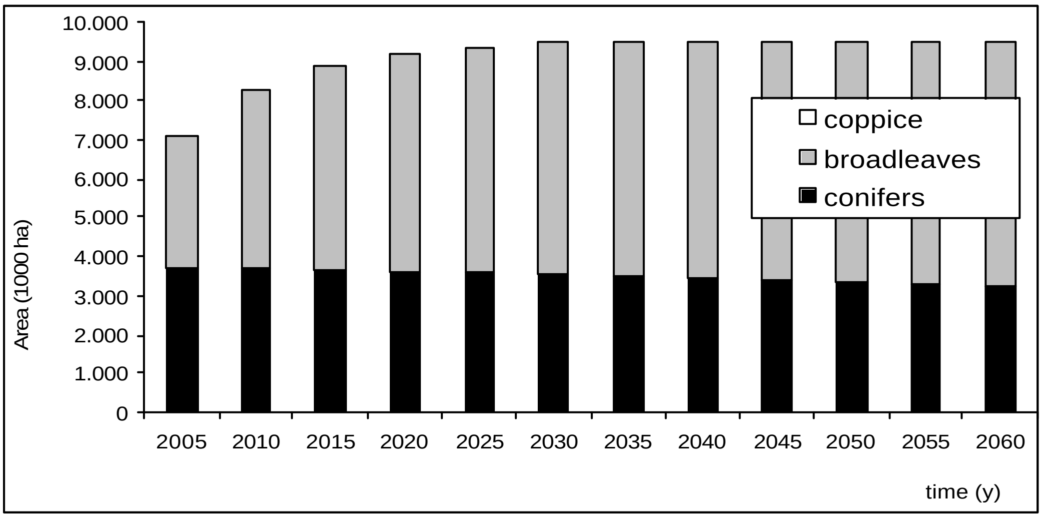


Figure 4.5. Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom).[5]

[5] The supply statistics in the middle graph are given for the 1990's only because they are available only for after the break up of the Soviet Union. These single year data often fluctuate more strongly.



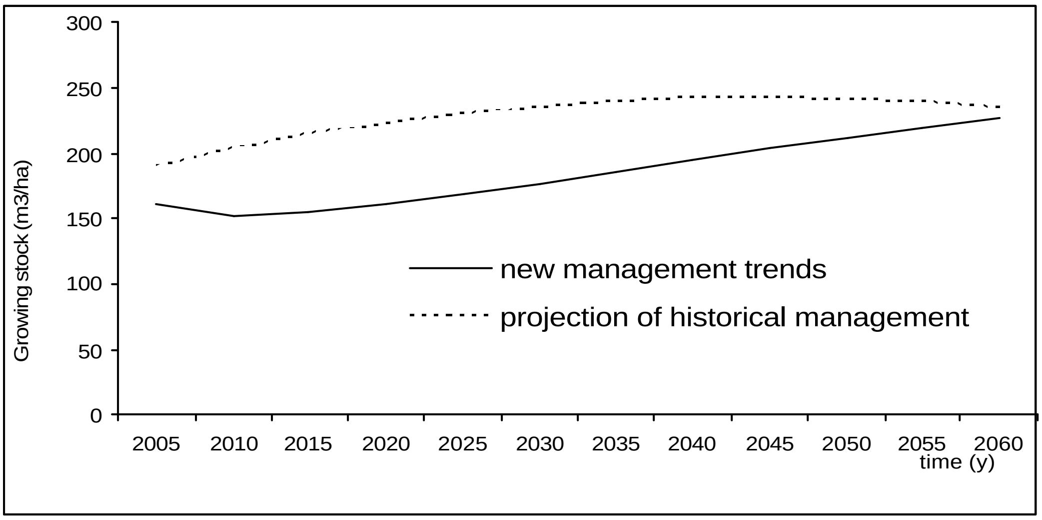


Figure 4.6. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.3. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	7,103	8,302	9,502	9,502
Gross annual increment (m^3/ha/y o.b.)	4.9	4.6	4.7	5.0
Total additional shortfall (x million m^3/y o.b.)	-5.2	-5.2	-0.2	-1.6
Growing stock (m3/ha o.b.)	161	152	176	227
Actual supply by all species (x million m^3/y)	4.7	5.7	14.6	18.1
Actual supply of conifer pulplogs (x million m^3/y)	1.6	2.4	5.5	6.6

4.4 Belgium

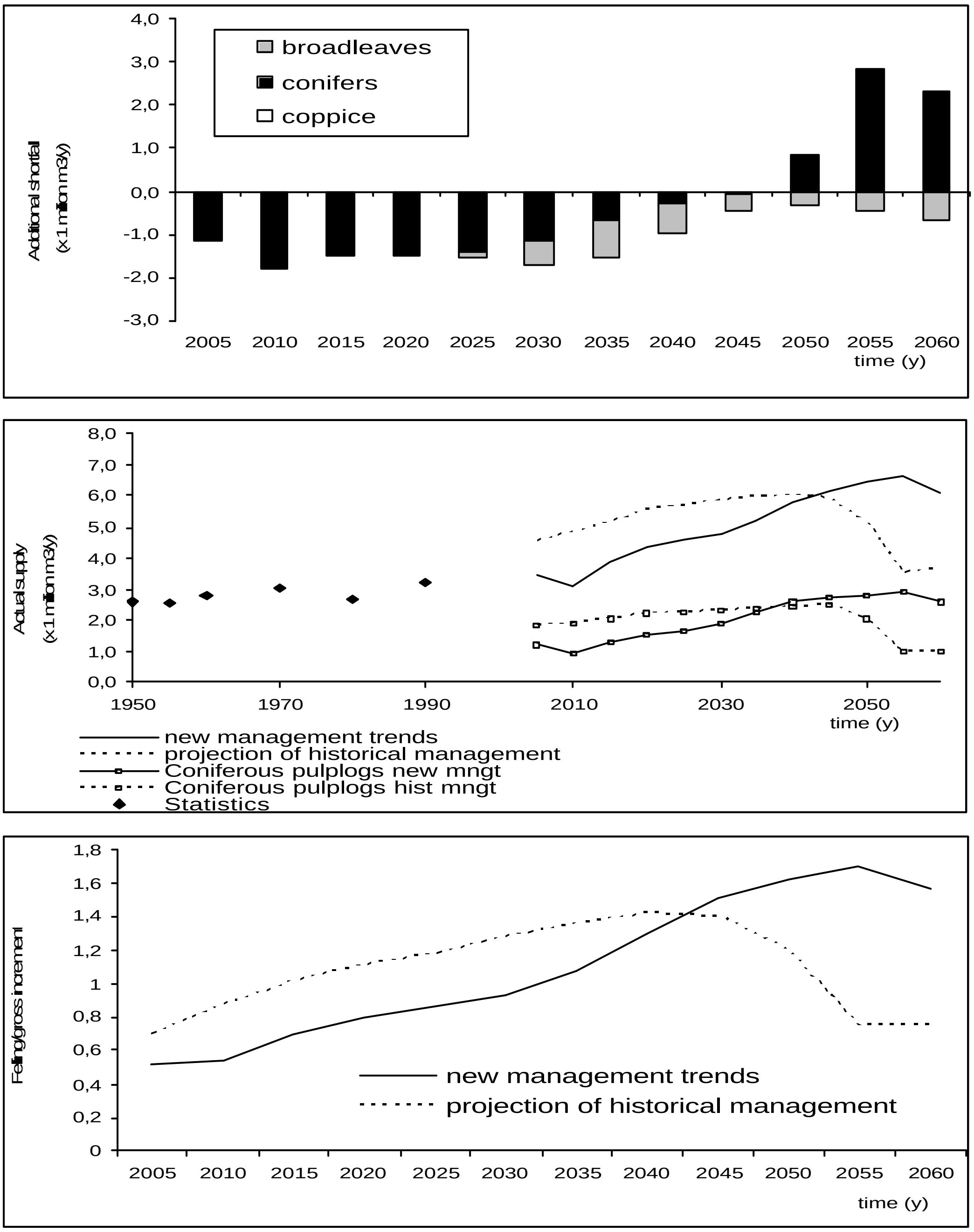
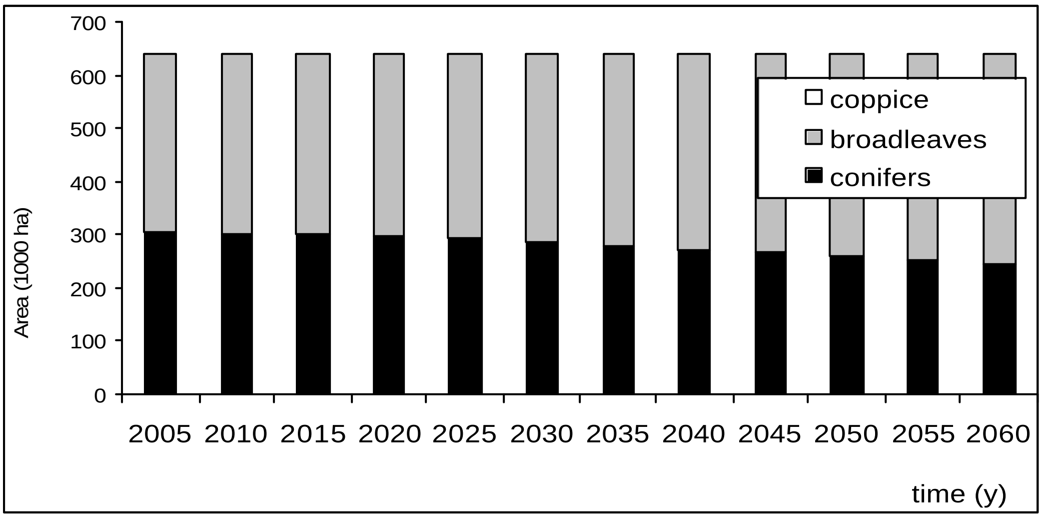


Figure 4.7 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)



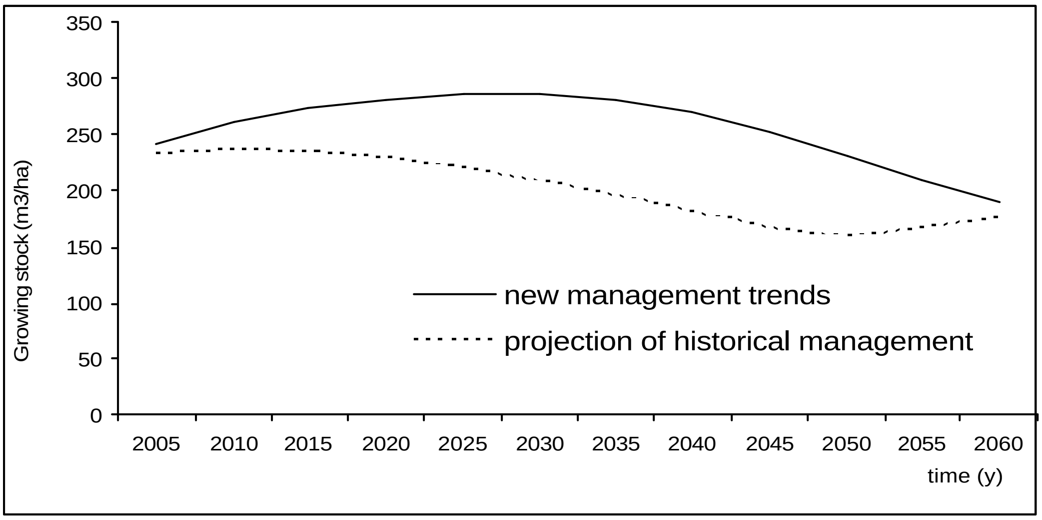
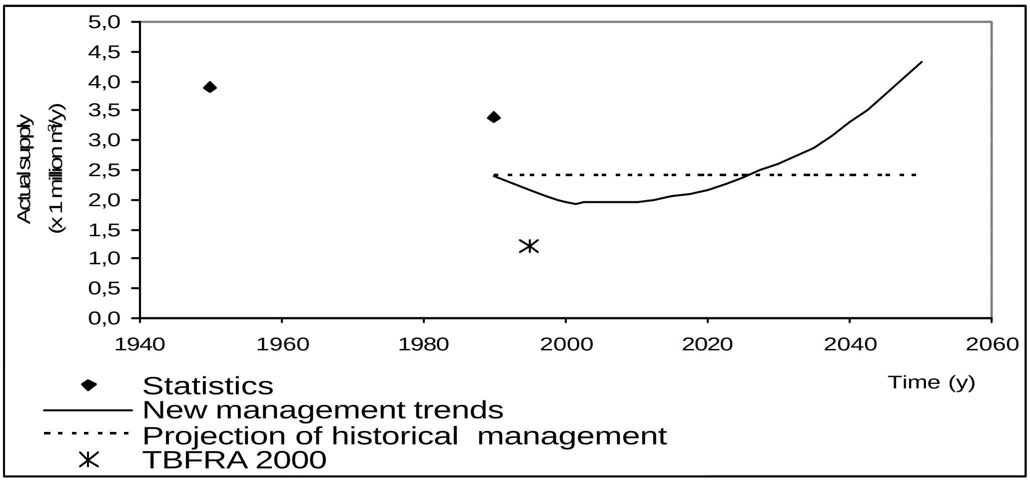


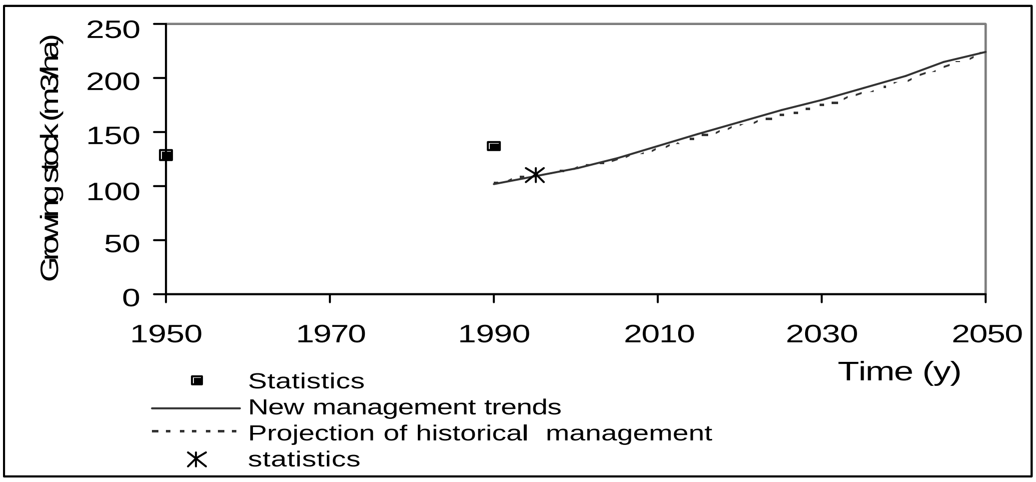
Figure 4.8. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.4. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	644	644	644	644
Gross annual increment (m^3/ha/y o.b.)	10.3	9.1	7.9	6.0
Total additional shortfall (x million m^3/y o.b.)	-1.1	-1.8	-1.7	1.6
Growing stock (m^3/ha o.b.)	243	262	286	190
Actual supply by all species (x million m^3/y)	3.4	3.1	4.8	6.1
Actual supply of conifer pulplogs (x million m^3/y)	1.2	0.9	1.9	2.6

4.5 Bosnia & Herzegovina





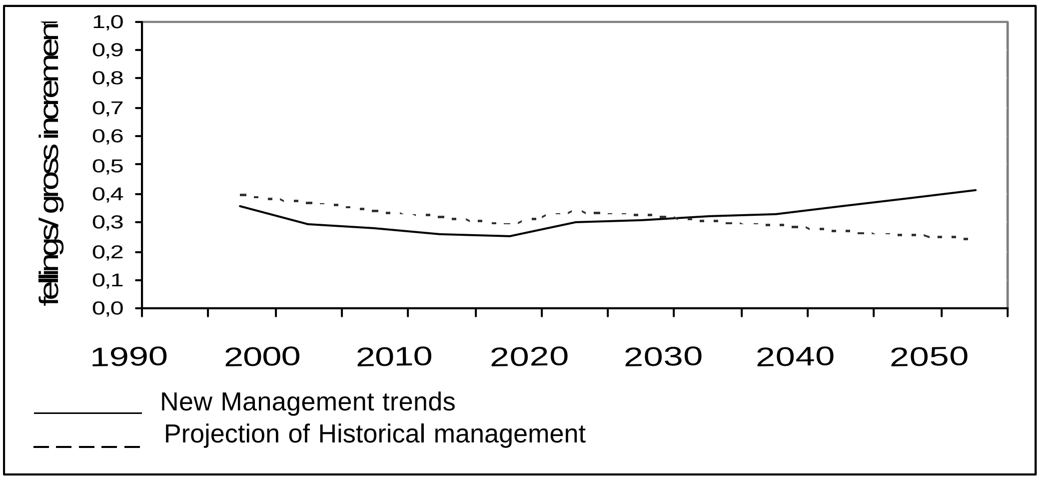


Figure 4.9. Projected supply of roundwood for all commodities for the two scenarios (top), average stemwood growing stock of all the tree species for the two scenarios(middle) , and felling/increment ratio for the two scenarios (bottom)

4.6 Bulgaria

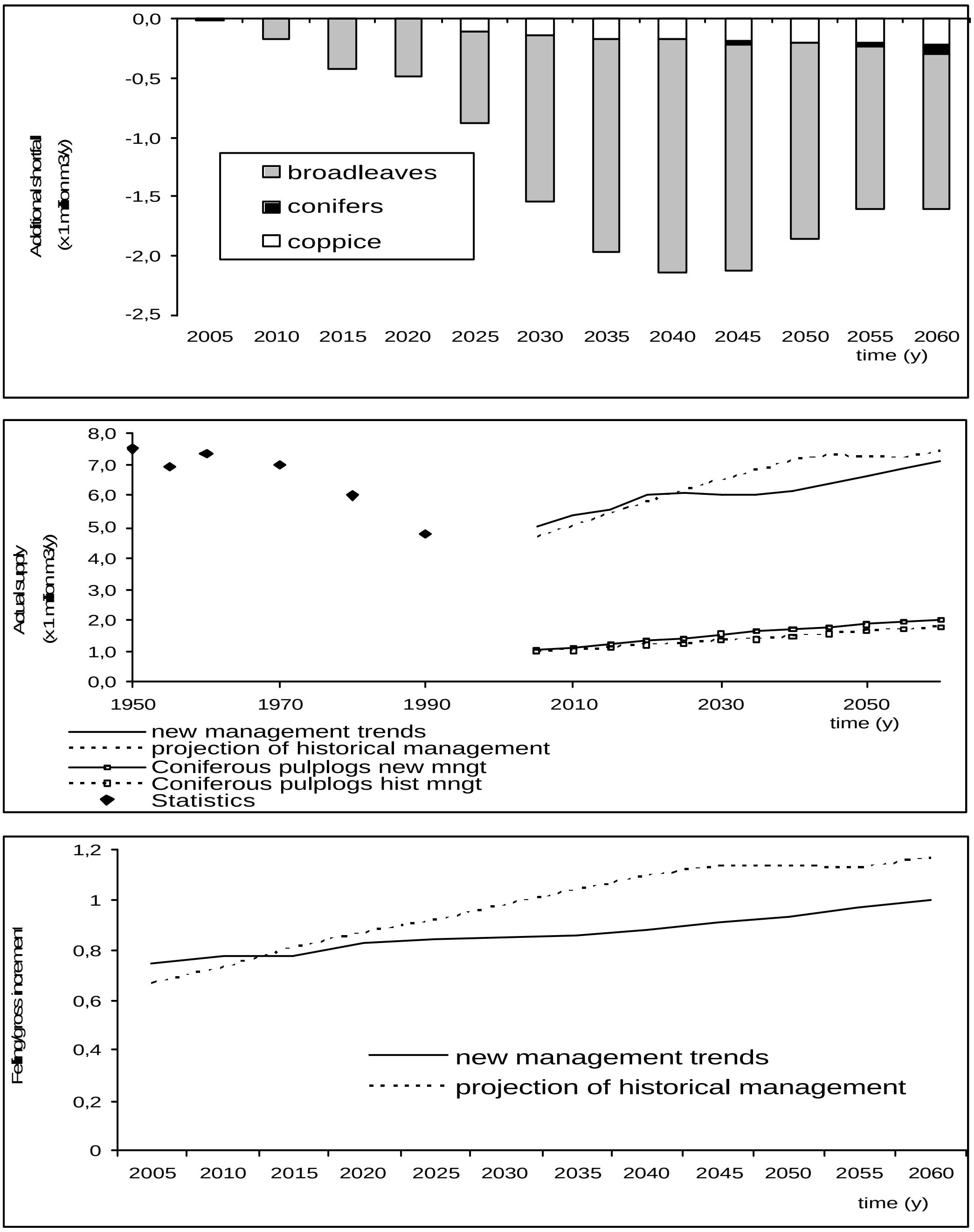


Figure 4.10. Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)

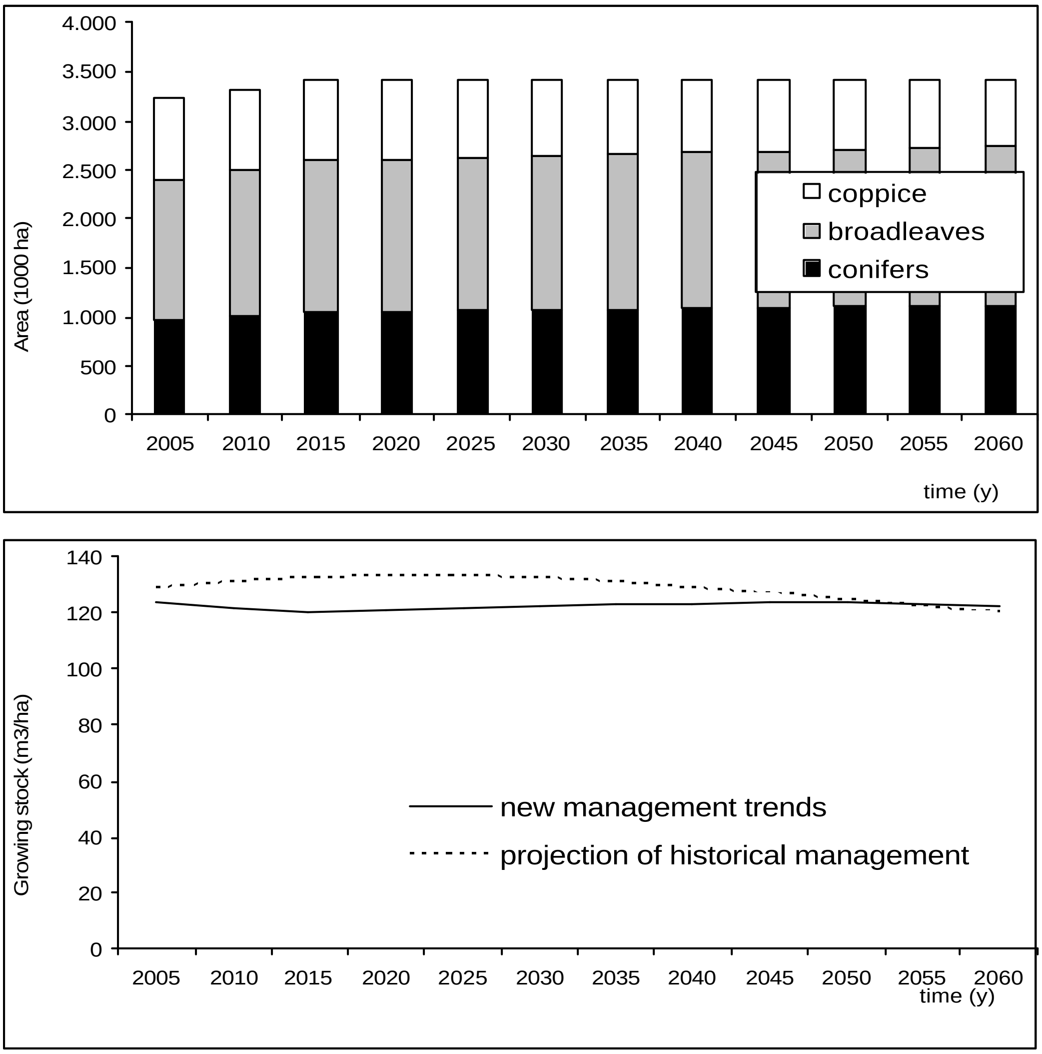


Figure 4.11. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.5. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	3,221	3,321	3,421	3,421
Gross annual increment (m^3/ha/y o.b.)	2.1	2.1	2.1	2.1
Total additional shortfall (x million m^3/y o.b.)	0.0	-0.2	-1.5	-1.6
Growing stock (m^3/ha o.b.)	124	122	123	122
Actual supply by all species (x million m^3/y)	5.0	5.4	6.0	7.1
Actual supply of conifer pulplogs (x million m^3/y)	1.0	1.1	1.5	2.0

4.7 Croatia

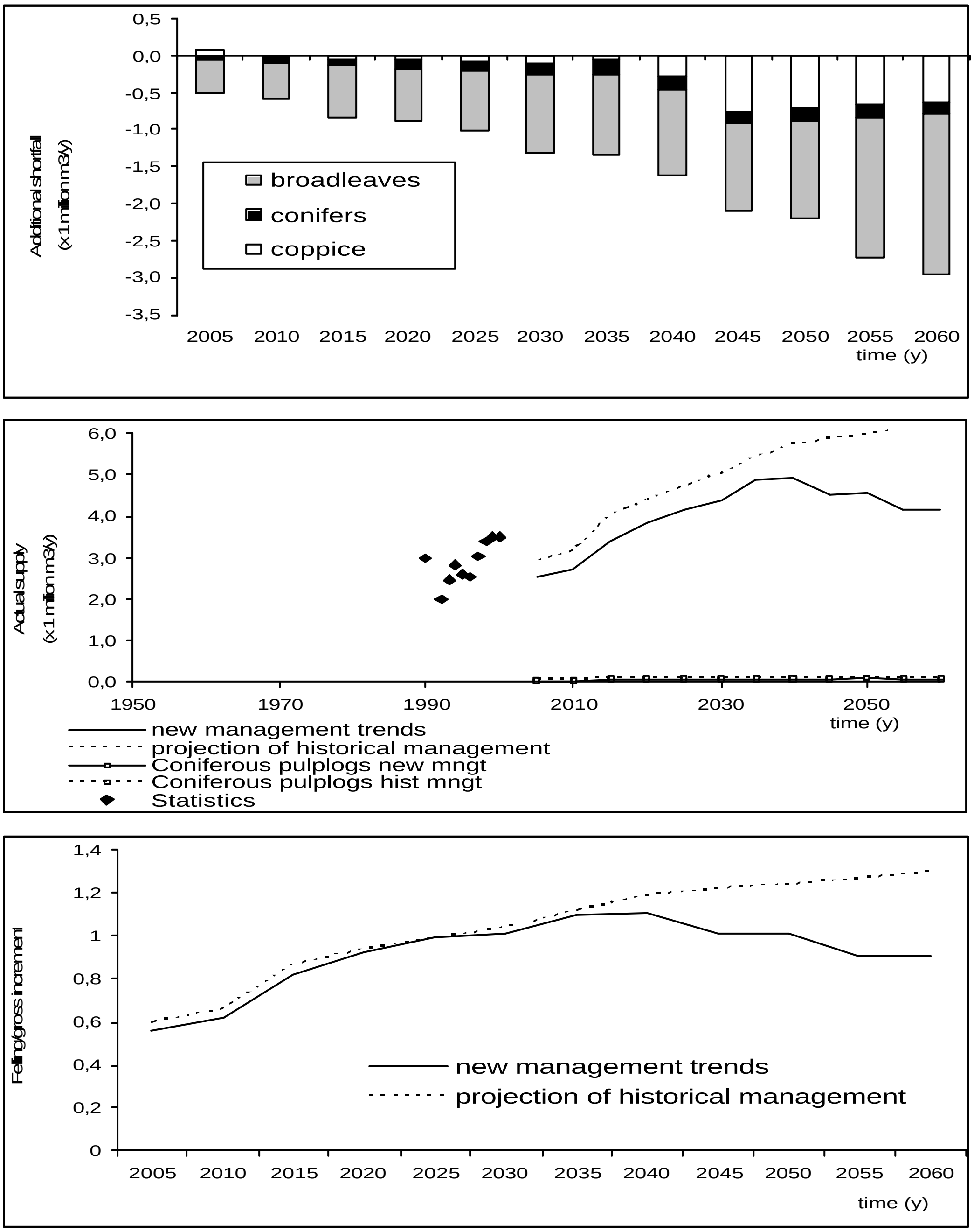
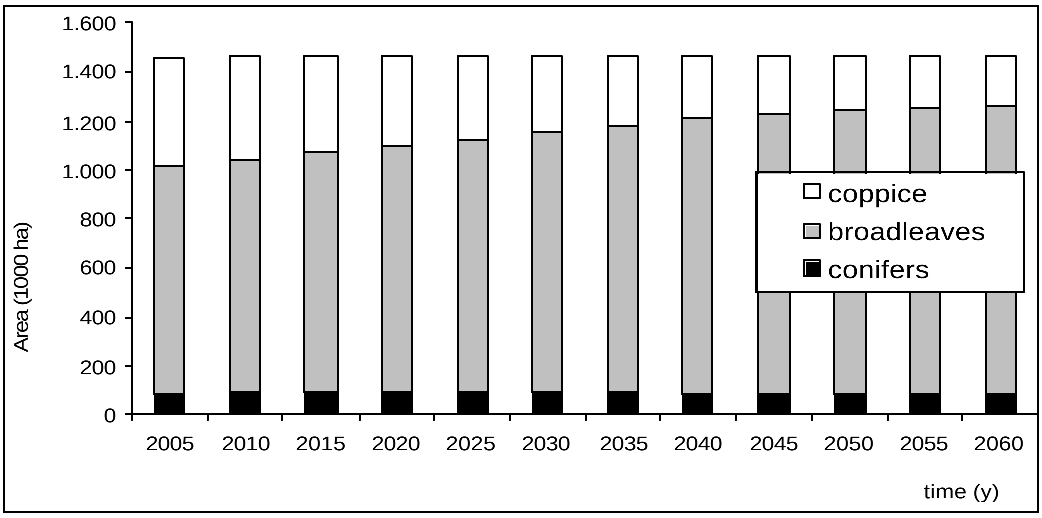


Figure 4.12 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)[6]

[6] 6 The supply statistics in the middle graph are given for the 1990's only because they are available only for after the break up of the former Serbia and Montenegro. These single year data often fluctuate more strongly.



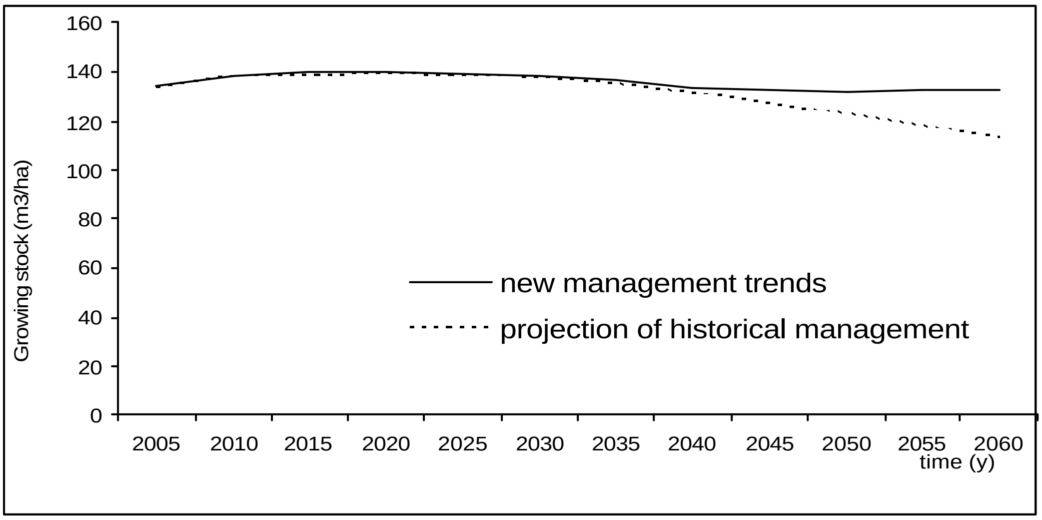


Figure 4.13. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.6. Main output for the 'new management trends' scenario [7]

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	1,458	1,468	1,468	1,468
Gross annual increment (m^3/ha/y o.b.)	3.1	3.0	3.0	3.2
Total additional shortfall (x million m^3/y o.b.)	-0.4	-0.6	-1.3	-3.0
Growing stock (m^3/ha o.b.)	134	138	139	133
Actual supply by all species (x million m^3/y)	2.5	2.7	4.4	4.2
Actual supply of conifer pulplogs (x million m^3/y)	0.0	0.0	0.1	0.1

[7] The initialisation data for Croatia are rather outdated explaining the quite significant differences for growing stock and increment between this study and UN-ECE/FAO (2000).

4.8 Czech Republic

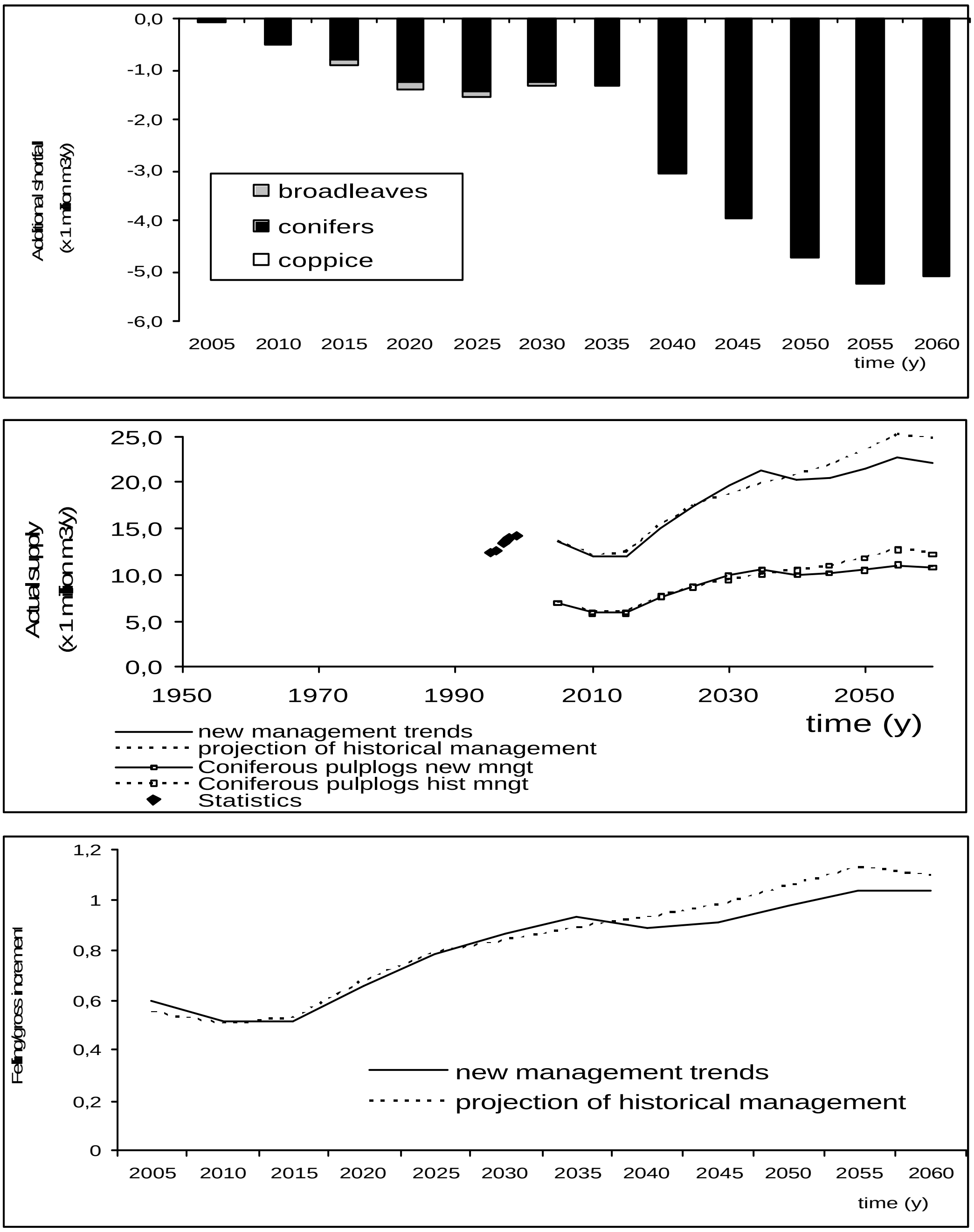
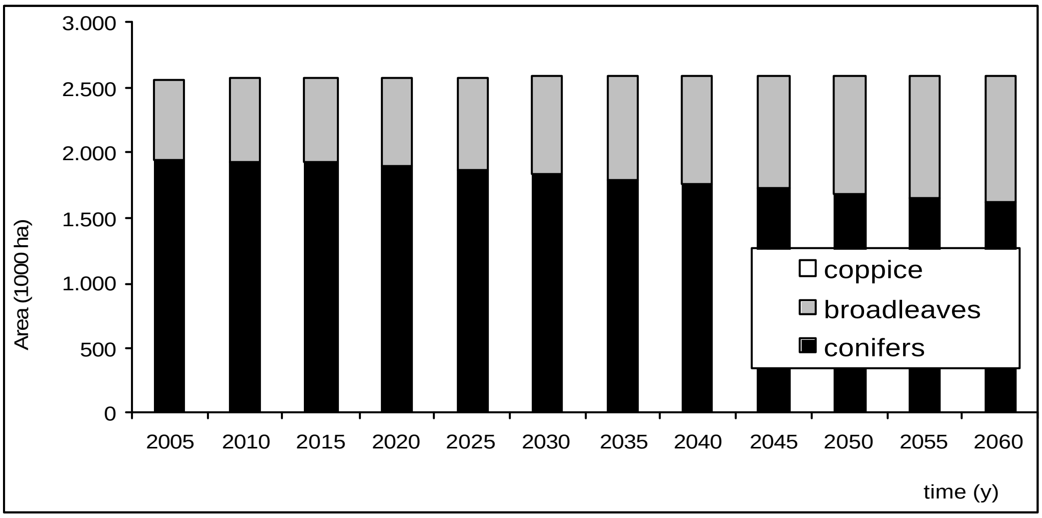


Figure 4.14 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom) [8]

[8] The supply statistics in the middle graph are given for the 1990's only because they are available for the Czech forest area only after the break up of Czechoslovakia. These single year data often fluctuate more strongly.



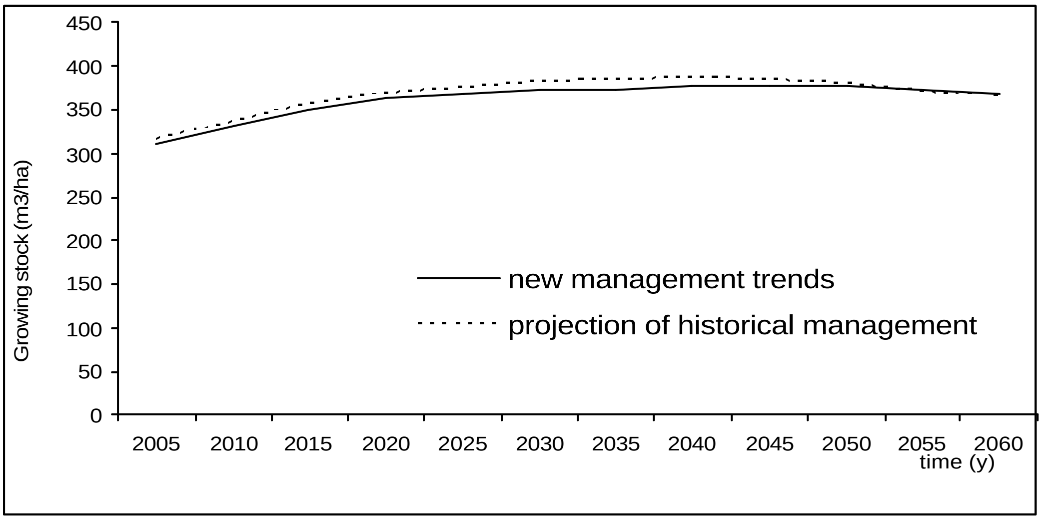


Figure 4.15. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.7. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	2,562	2,566	2,580	2,588
Gross annual increment (m^3/ha/y o.b.)	9.0	9.1	8.8	8.3
Total additional shortfall (x million m^3/y o.b.)	-0.1	-0.5	-1.3	-5.1
Growing stock (m^3/ha o.b.)	312	331	374	370
Actual supply by all species (x million m^3/y)	13.7	12.0	19.6	22.2
Actual supply of conifer pulplogs (x million m^3/y)	6.9	5.9	9.8	10.8

4.9 Denmark

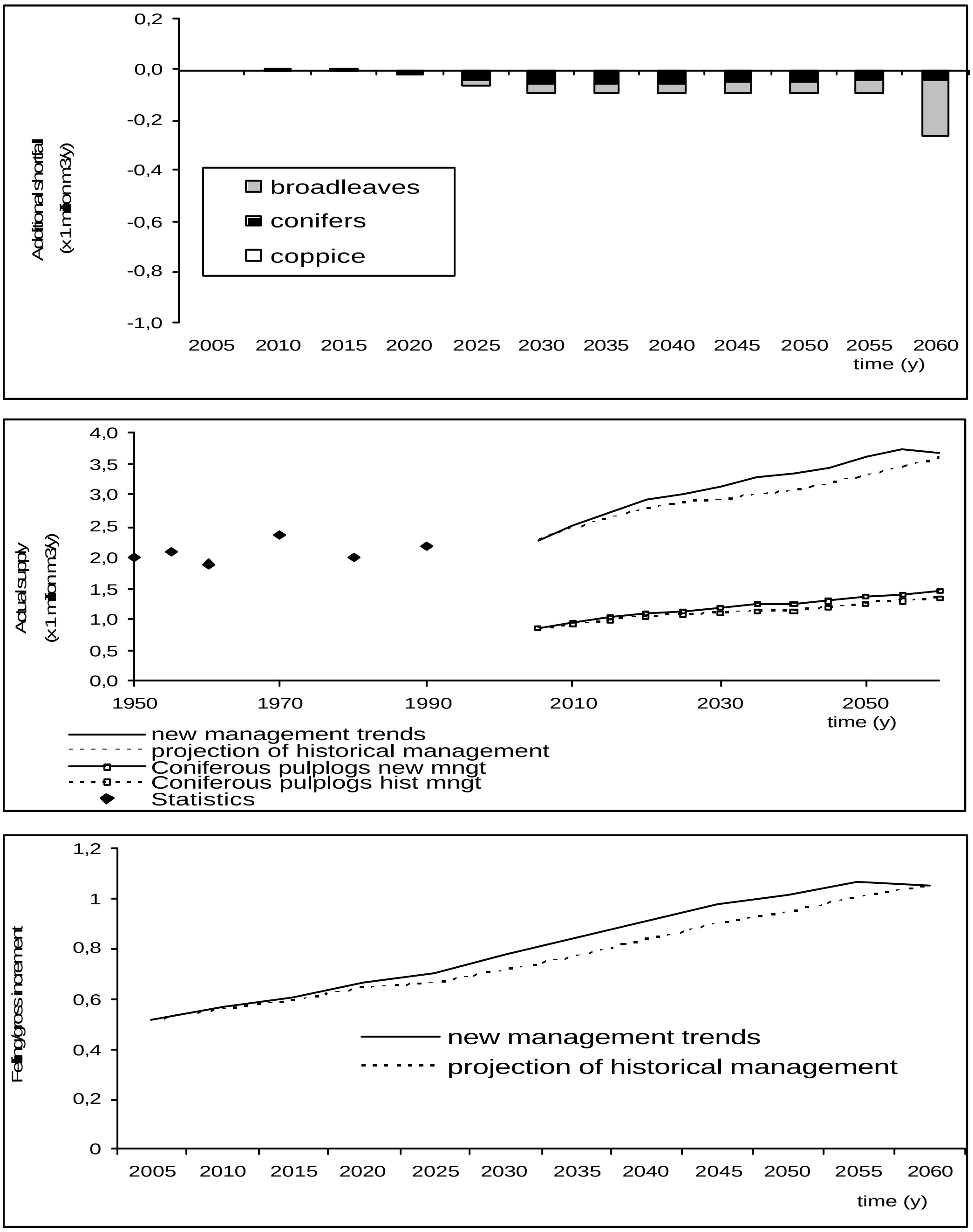
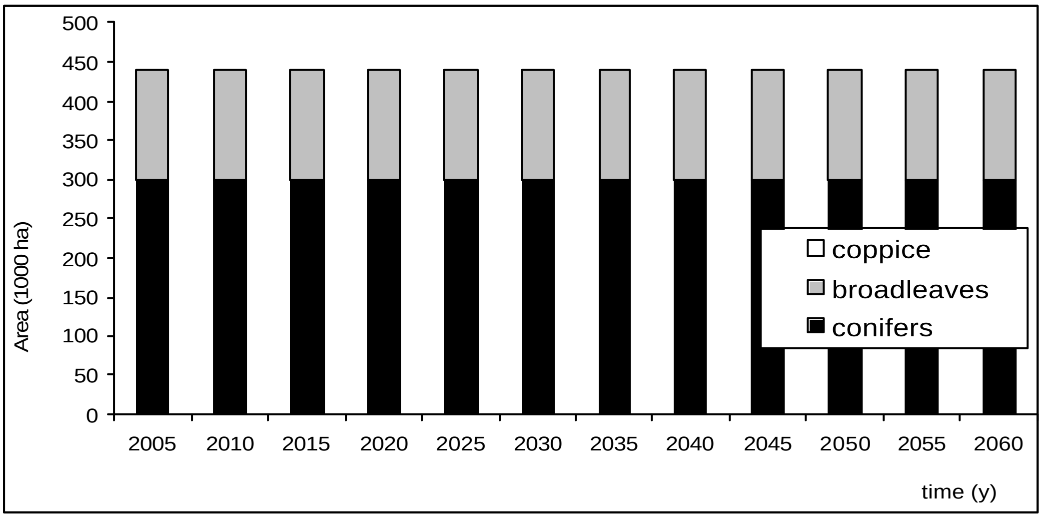


Figure 4.16 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)



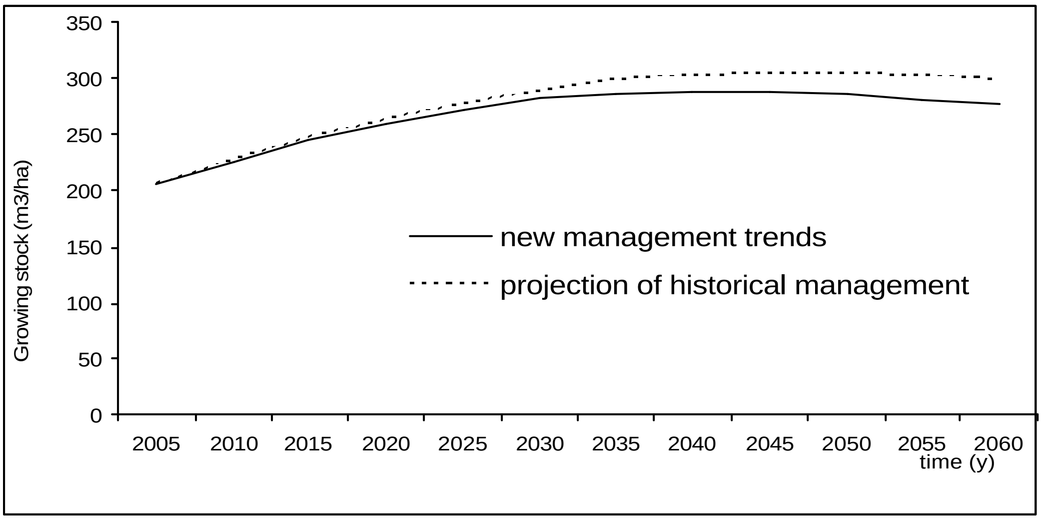


Figure 4.17. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.8. Main output for the 'new management trends' scenario [9]

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	440	440	440	440
Gross annual increment (m^3/ha/y o.b.)	10.0	10.0	9.2	8.0
Total additional shortfall (x million m^3/y o.b.)	0.0	0.0	-0.1	-0.3
Growing stock (m^3/ha o.b.)	206	227	282	277
Actual supply by all species (x million m^3/y)	2.3	2.5	3.1	3.7
Actual supply of conifer pulplogs (x million m^3/y)	0.9	0.9	1.2	1.5

[9] The initialisation data for Denmark displayed a rather high increment explaining the high growing stock in this study already by 2005 .

4.10 Estonia

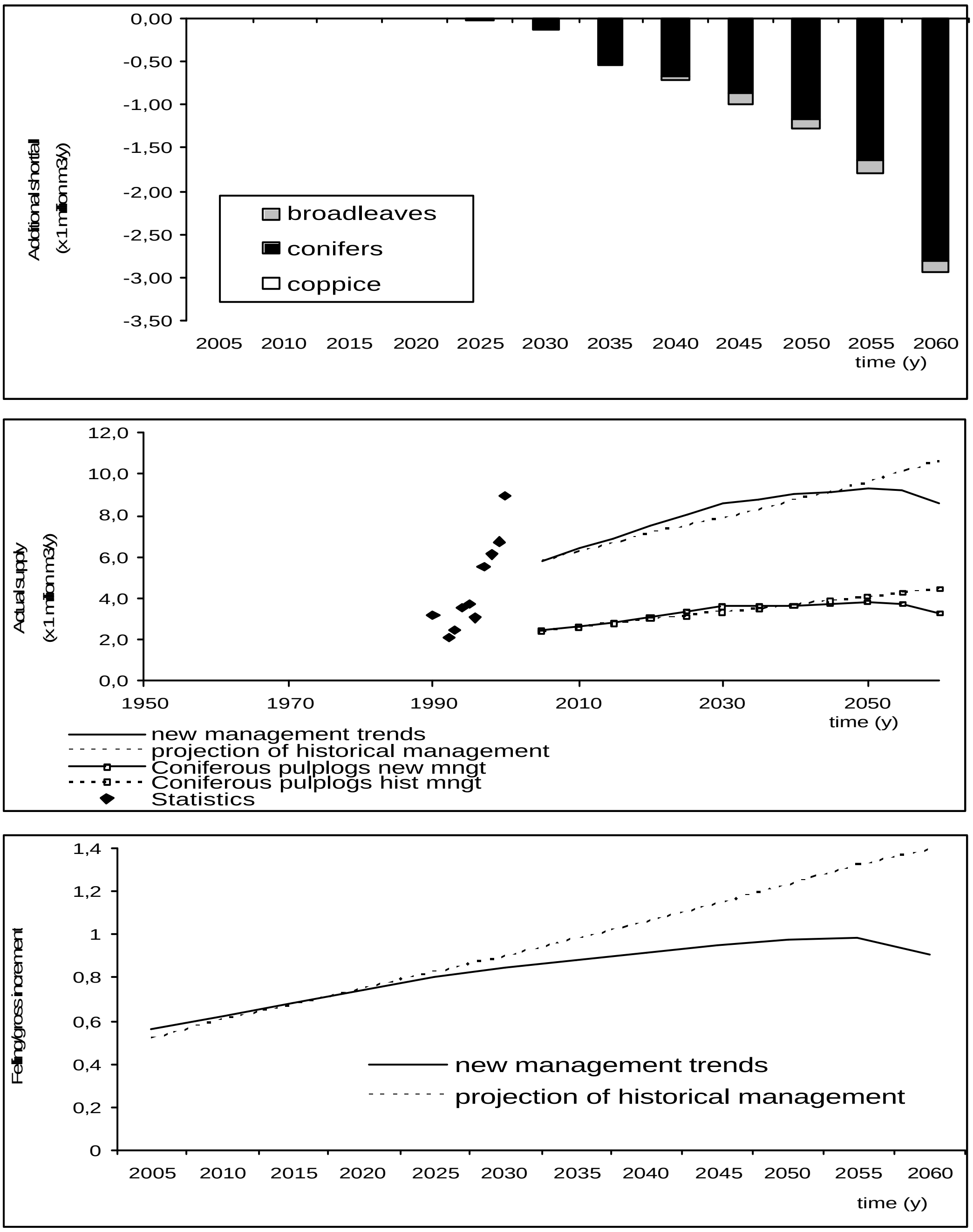


Figure 4.18 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom) [10]

[10] The supply statistics in the middle graph are given for the 1990's only because they are available only for after the break up of the Soviet Union. These single year data often fluctuate more strongly.

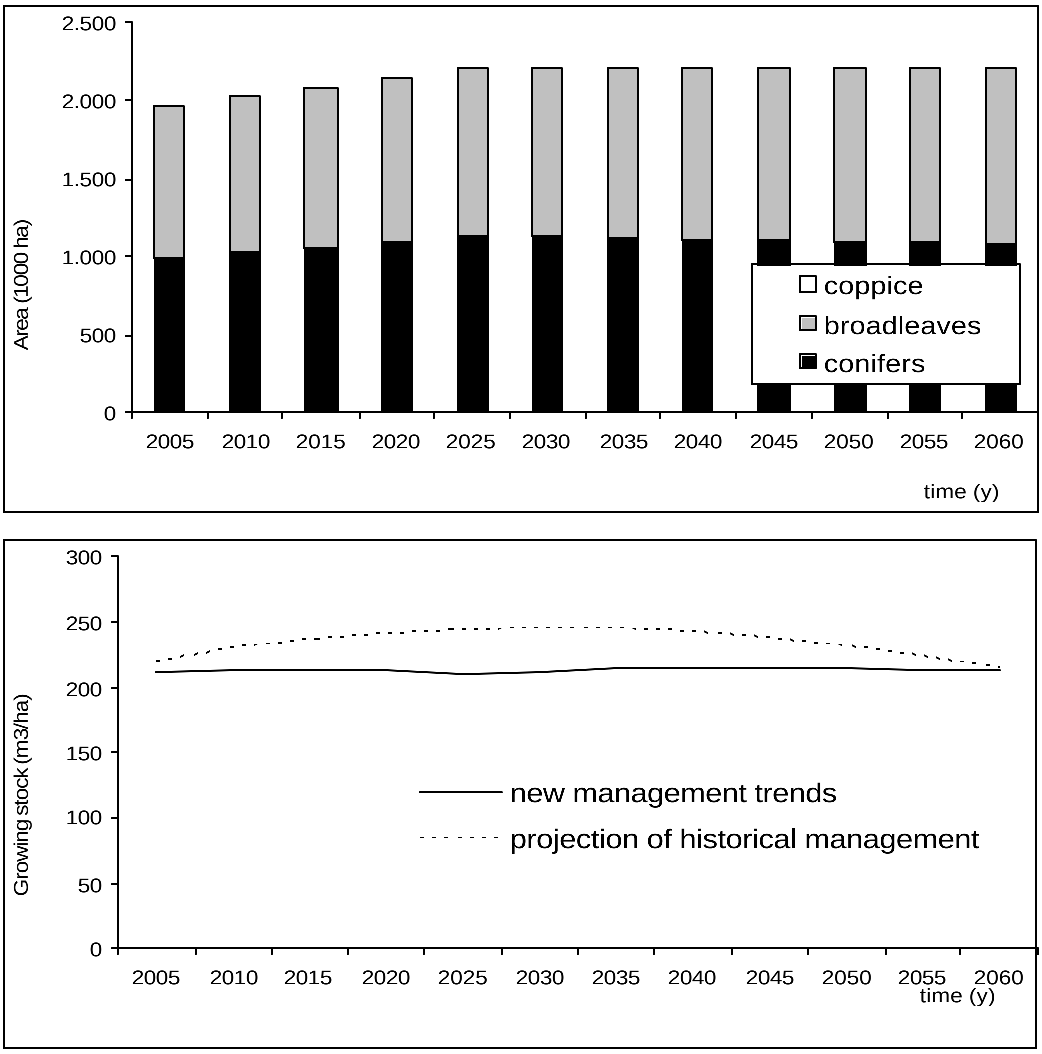


Figure 4.19. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.9. Main output for the 'new management trends' scenario [11]

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	1,967	2,027	2,207	2,207
Gross annual increment (m^3/ha/y o.b.)	5.2	5.0	4.6	4.3
Total additional shortfall (x million m^3/y o.b.)	0.0	0.0	-0.1	-2.9
Growing stock (m^3/ha o.b.)	211	213	213	214
Actual supply by all species (x million m^3/y)	5.8	6.4	8.6	8.6
Actual supply of conifer pulplogs (x million m^3/y)	2.4	2.7	3.6	3.3

[11] The initialisation data for Estonia as received by the country correspondent displayed a rather high increment explaining the high growing stock in this study already by 2005.

4.11 Finland

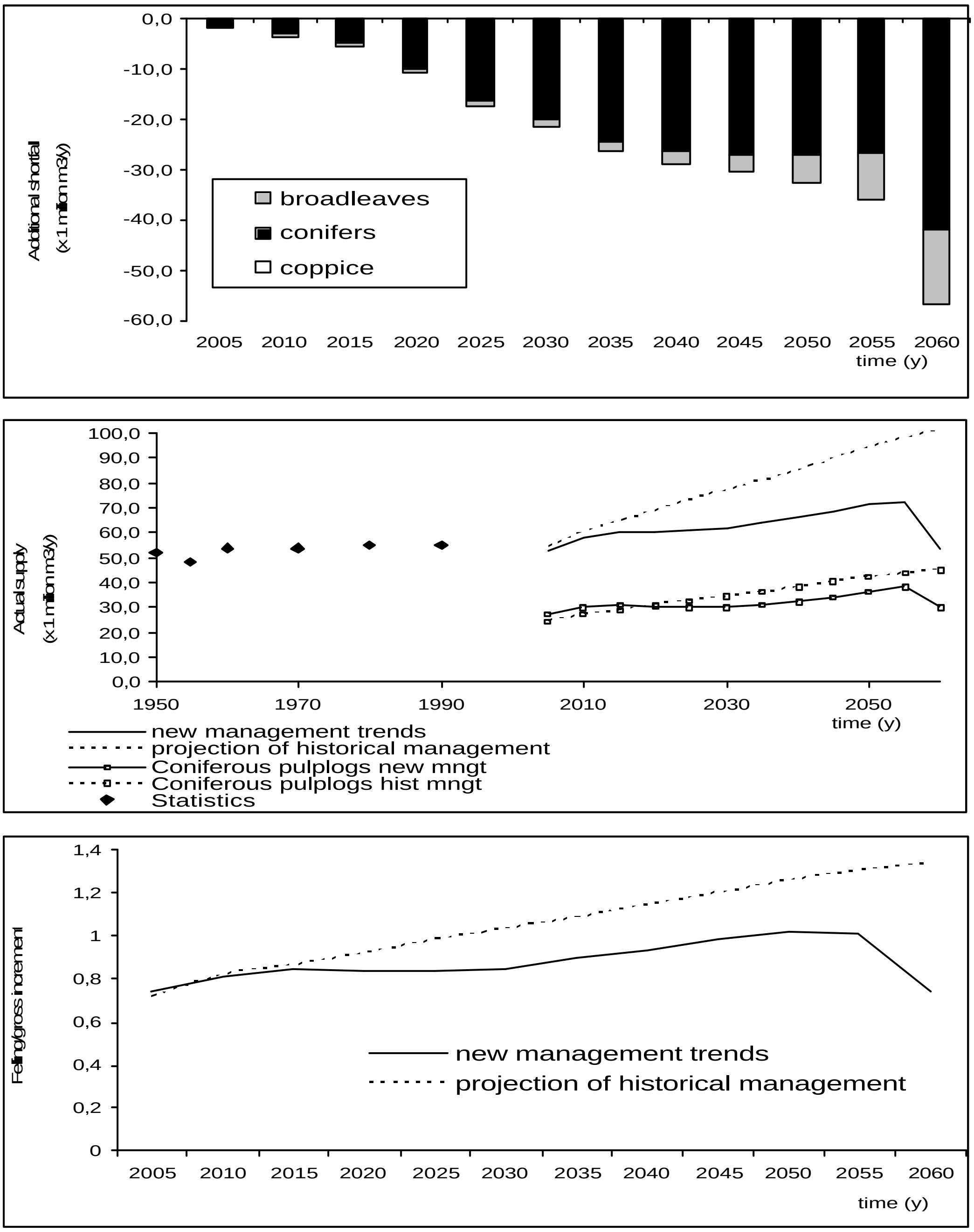
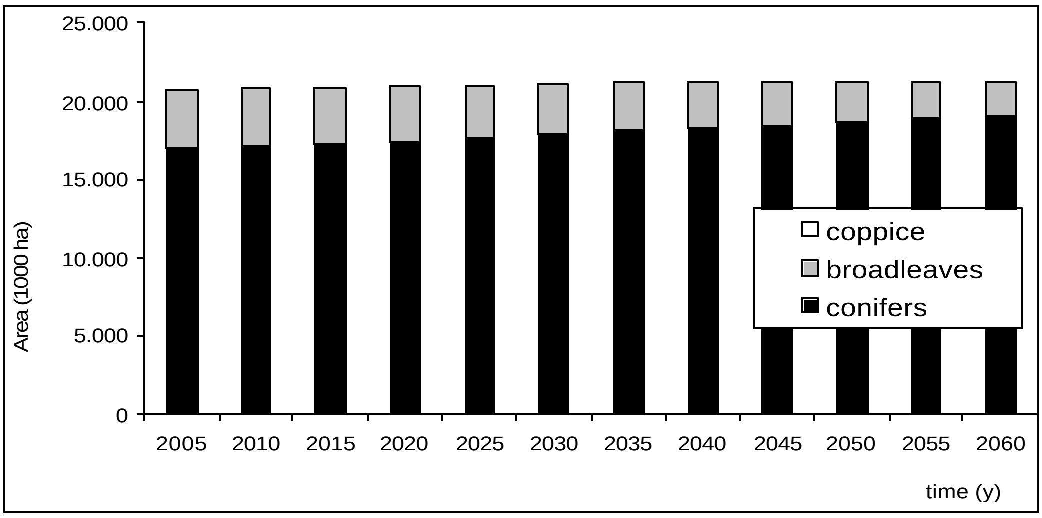


Figure 4.20 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)[12]

[12] The sudden increase in theoretical shortfall from 2055 to 2060 in the new management trend scenario is caused by the fact that 'harvestable forest' has been used up by that time.



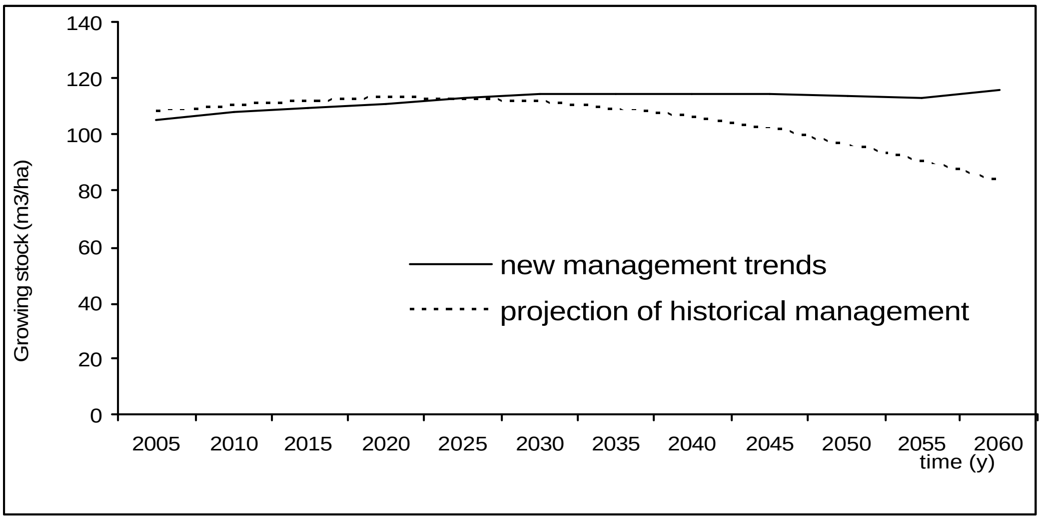


Figure 4.21. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.10. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	20,789	20,829	21,109	21,269
Gross annual increment (m^3/ha/y o.b.)	3.4	3.4	3.4	3.4
Total additional shortfall (x million m^3/y o.b.)	-1.8	-3.7	-21.5	-57.1
Growing stock (m^3/ha o.b.)	105	108	115	117
Actual supply by all species (x million m^3/y)	52.5	57.7	61.6	53.5
Actual supply of conifer pulplogs (x million m^3/y)	27.3	30.0	30.2	29.8

4.12 France

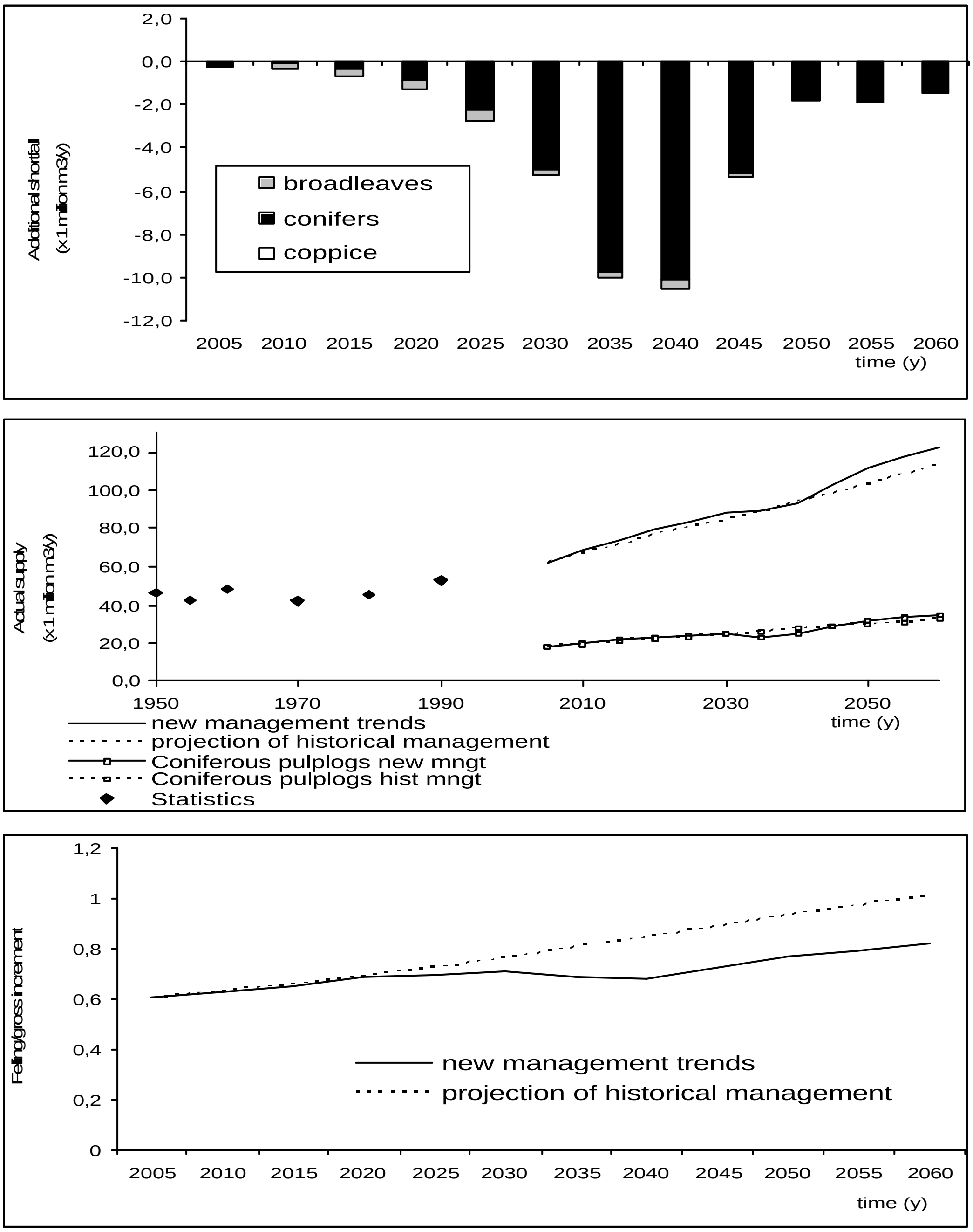
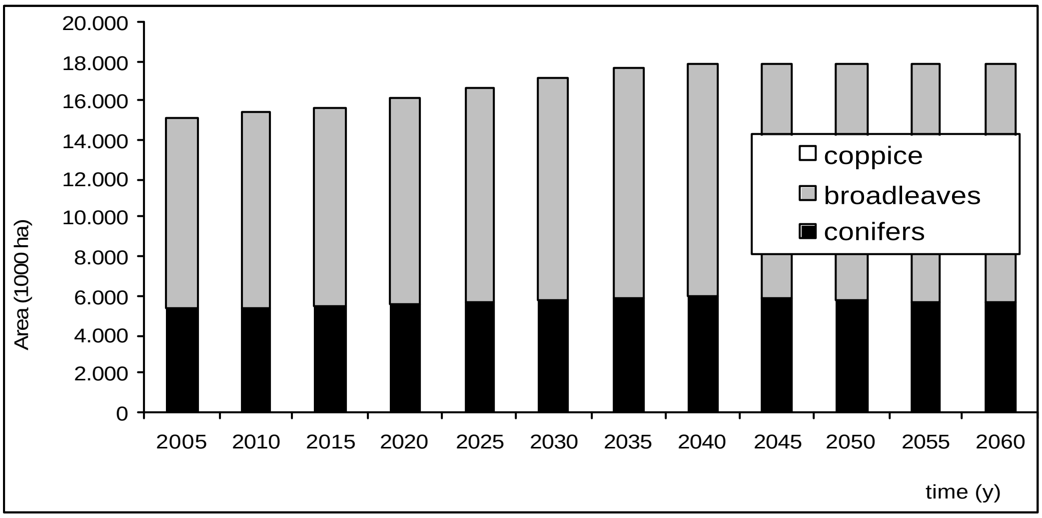


Figure 4.22 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)[13]

[13] The additional shortfall in the top graph shows a peak in additional shortfall because relatively large afforestations take place in the first three decades. These afforestations reduce the additional shortfall later on.



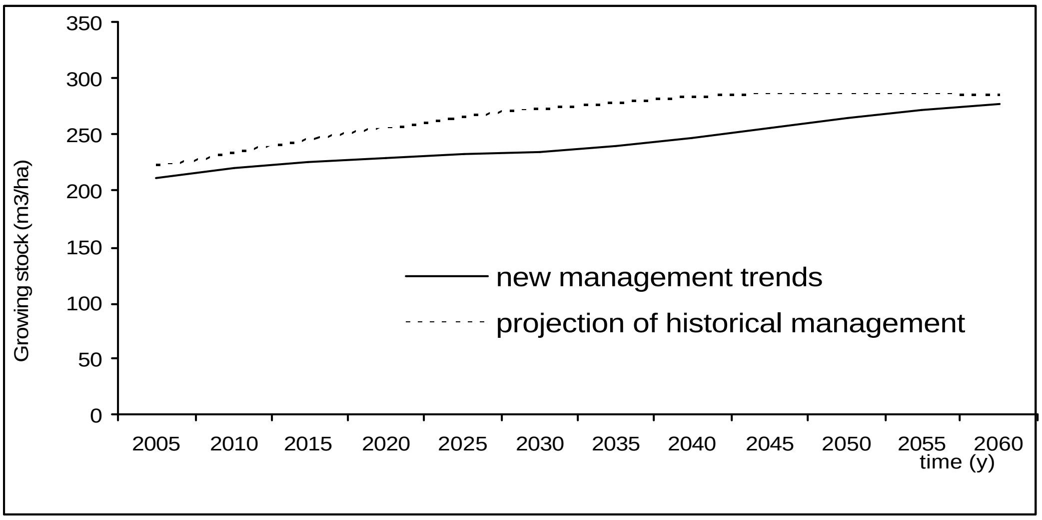


Figure 4.23. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.11. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	15,069	15,369	17,169	17,869
Gross annual increment (m^3/ha/y o.b.)	6.9	7.0	7.3	8.3
Total additional shortfall (x million m^3/y o.b.)	-0.2	-0.3	-5.2	-1.4
Growing stock (m^3/ha o.b.)	212	220	235	278
Actual supply by all species (x million m^3/y)	62.2	68.3	88.3	122.2
Actual supply of conifer pulplogs (x million m^3/y)	18.0	19.9	24.4	34.8

4.13 Germany

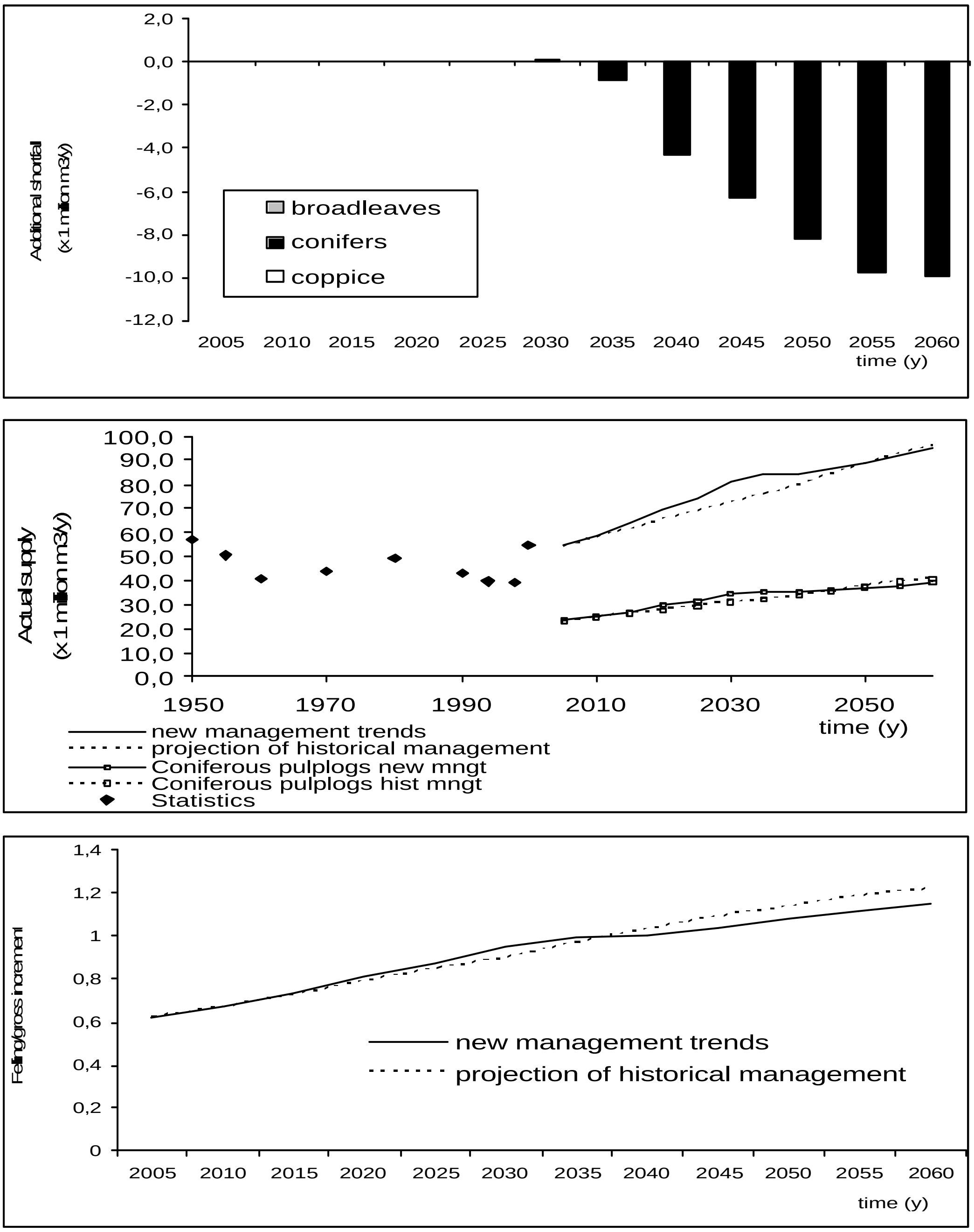
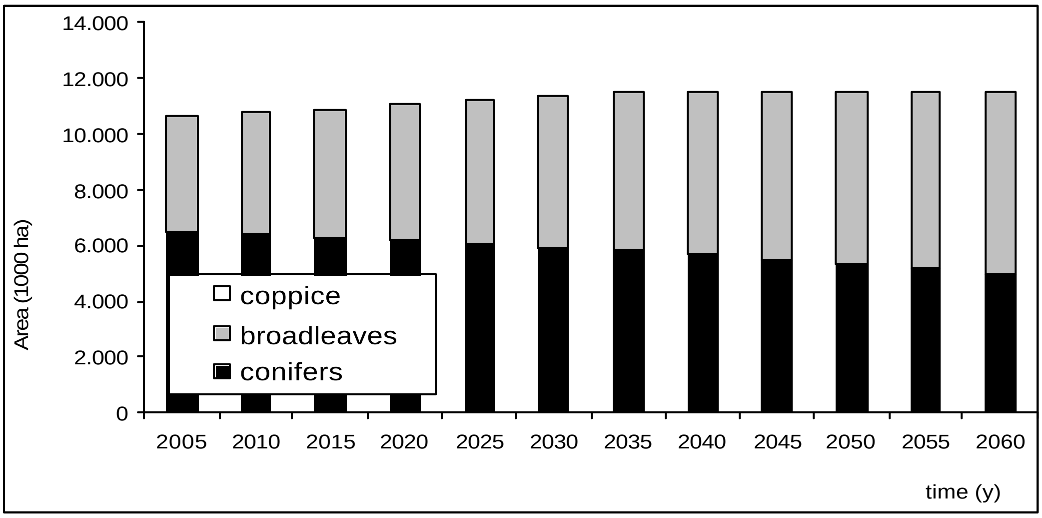


Figure 4.24 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)



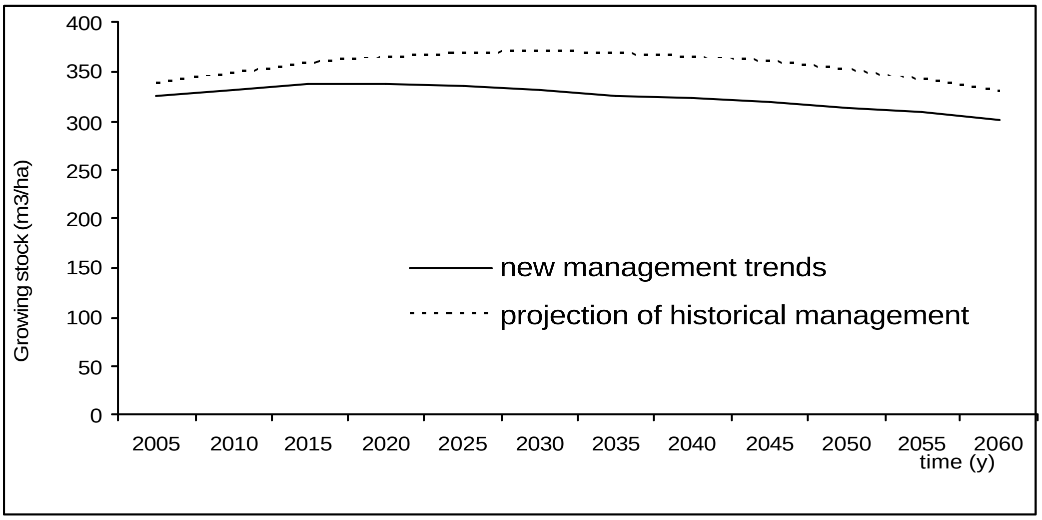
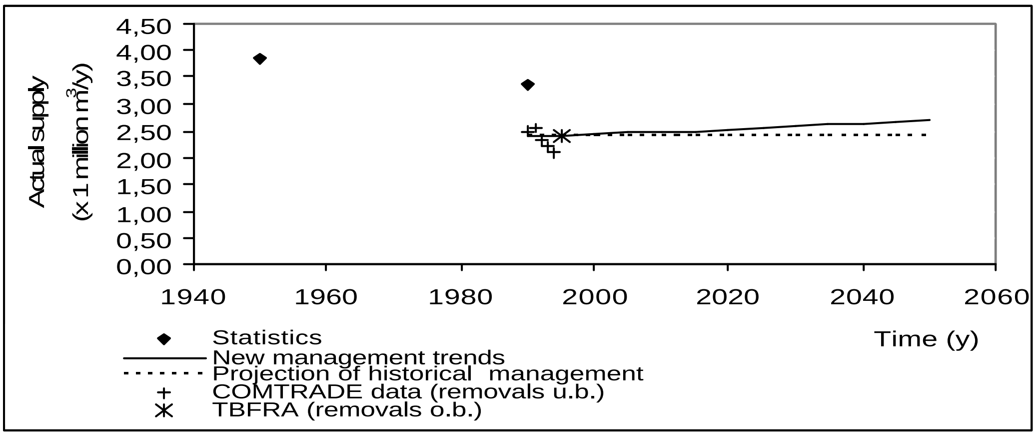


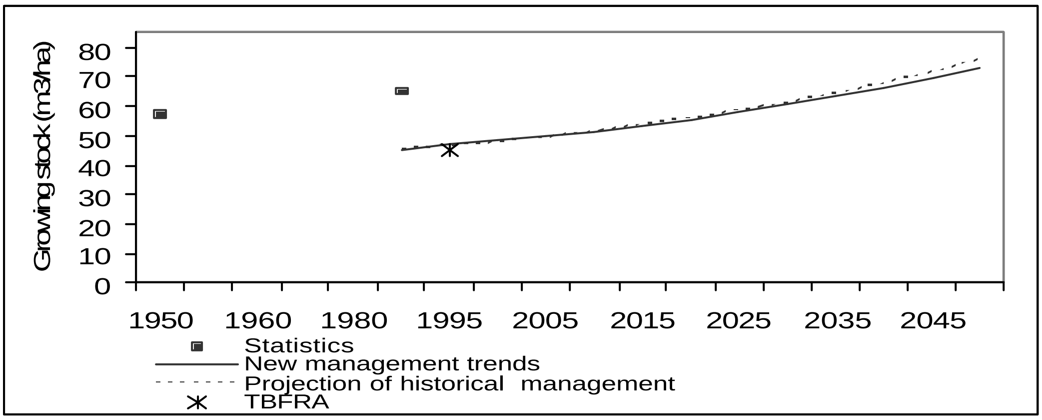
Figure 4.25. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.12. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	10,647	10,747	11,386	11,546
Gross annual increment (m^3/ha/y o.b.)	8.3	8.2	7.5	7.1
Total additional shortfall (x million m^3/y o.b.)	0.0	0.0	0.1	-9.9
Growing stock (m^3/ha o.b.)	324	333	331	301
Actual supply by all species (x million m^3/y)	54.8	58.9	81.0	95.0
Actual supply of conifer pulplogs (x million m^3/y)	23.3	25.1	34.5	38.9

4.14 Greece





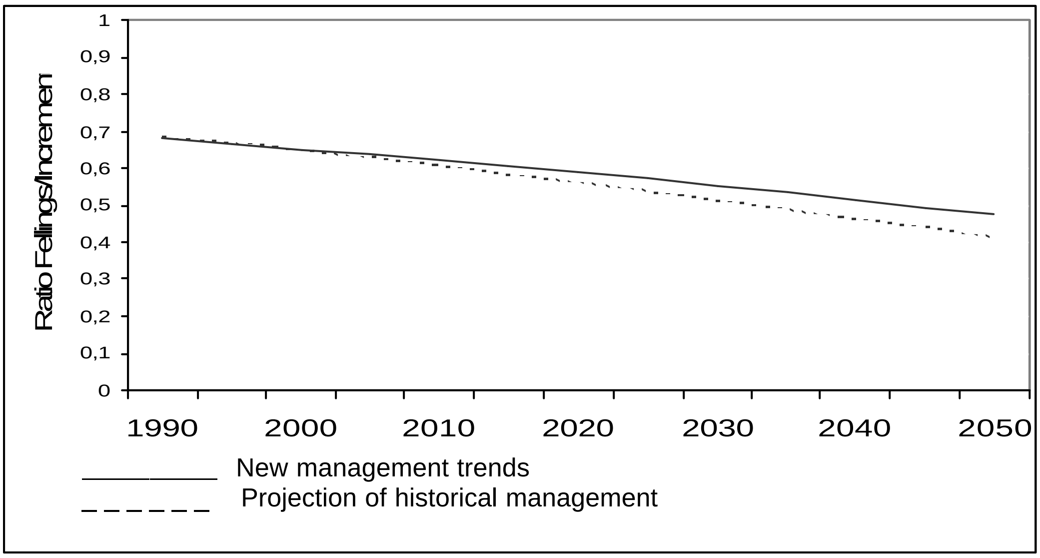


Figure 4.26. Projected supply of roundwood for all commodities for the two scenarios (top), average stemwood growing stock of al the tree species for the two scenarios(middle) , and felling/increment ratio for the two scenarios (bottom)

4.15 Hungary

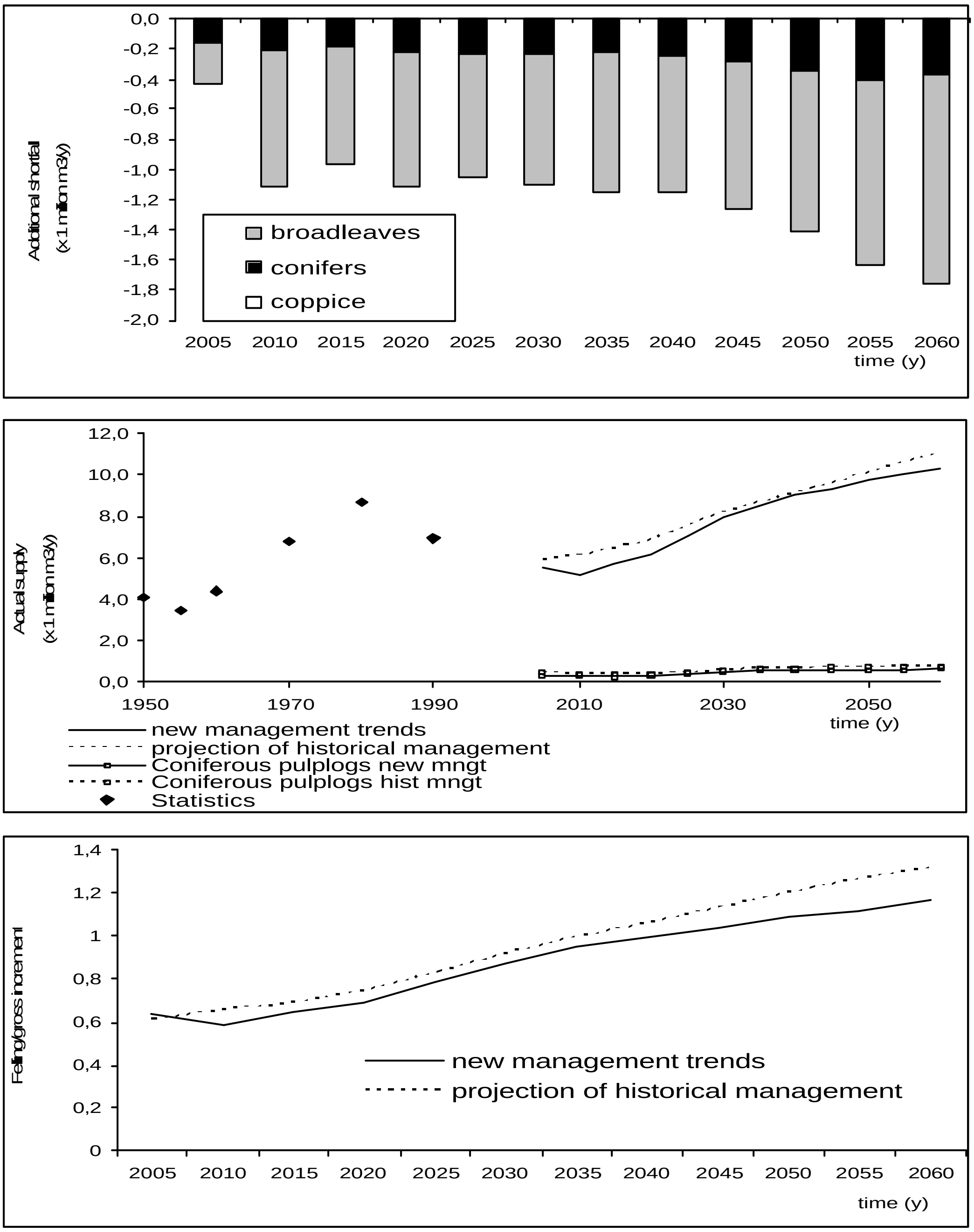
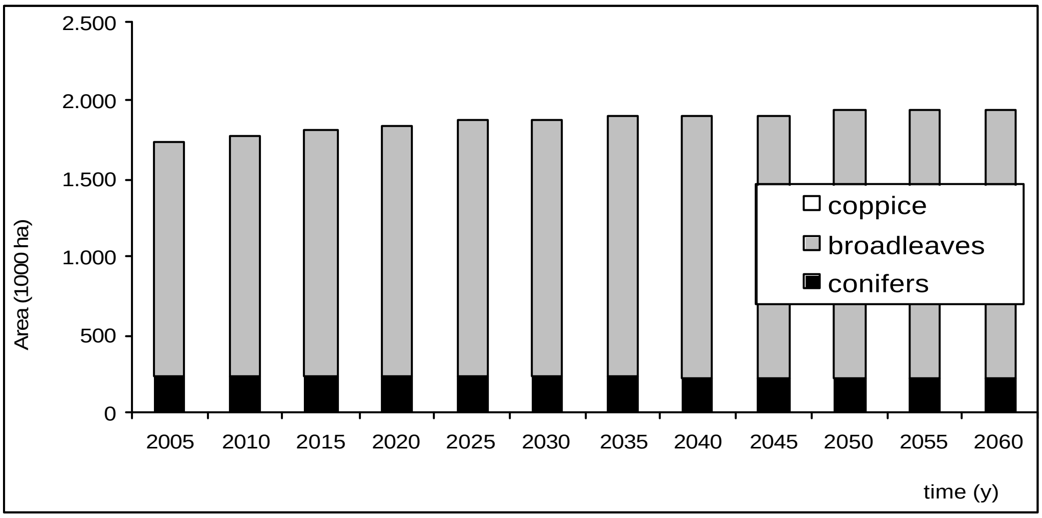


Figure 4.27 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)



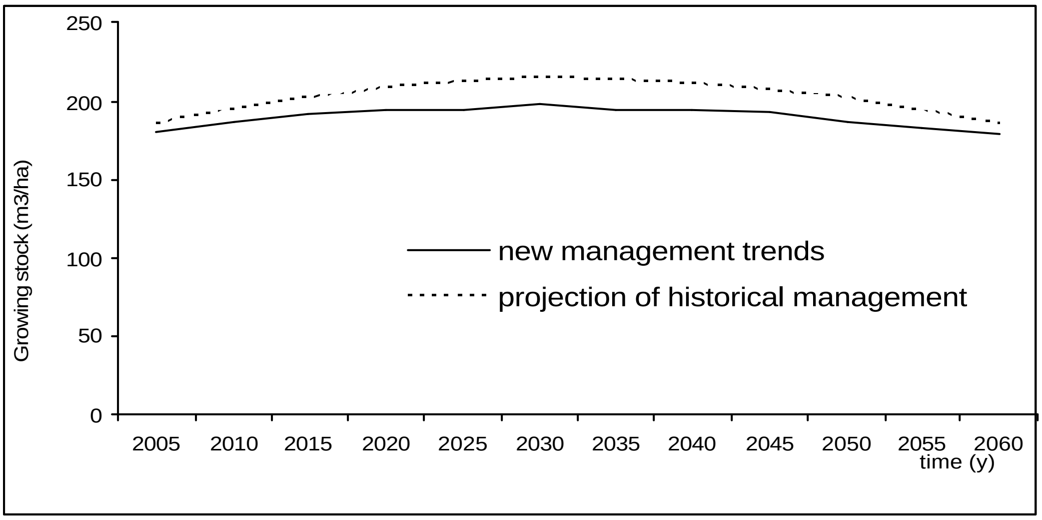


Figure 4.28. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.13. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	1,737	1,771	1,873	1,941
Gross annual increment (m^3/ha/y o.b.)	5.0	5.0	4.9	4.6
Total additional shortfall (x million m^3/y o.b.)	-0.4	-1.1	-1.1	-1.8
Growing stock (m^3/ha o.b.)	180	186	198	179
Actual supply by all species (x million m^3/y)	5.5	5.2	7.9	10.3
Actual supply of conifer pulplogs (x million m^3/y)	0.4	0.3	0.5	0.7

4.16 Ireland

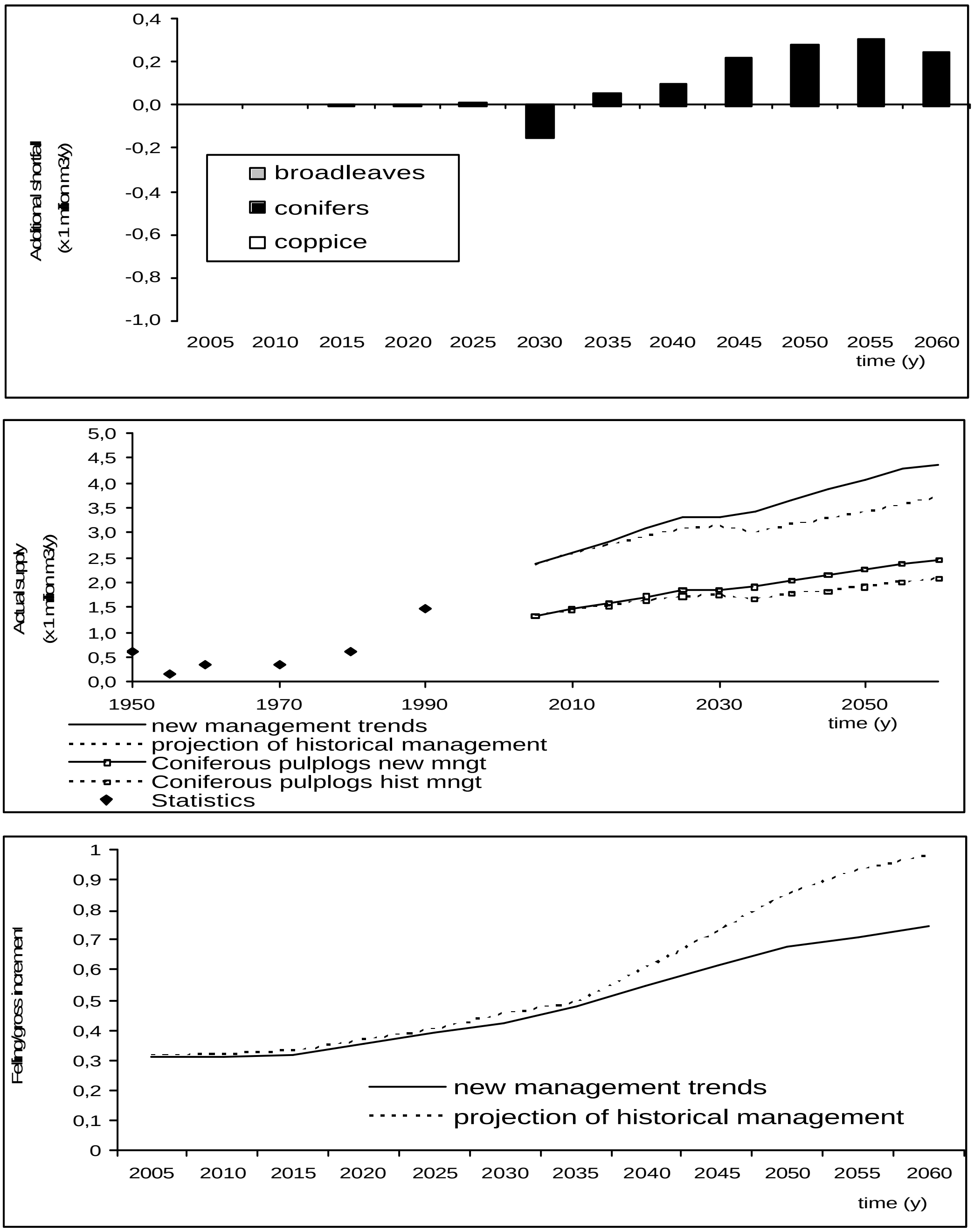
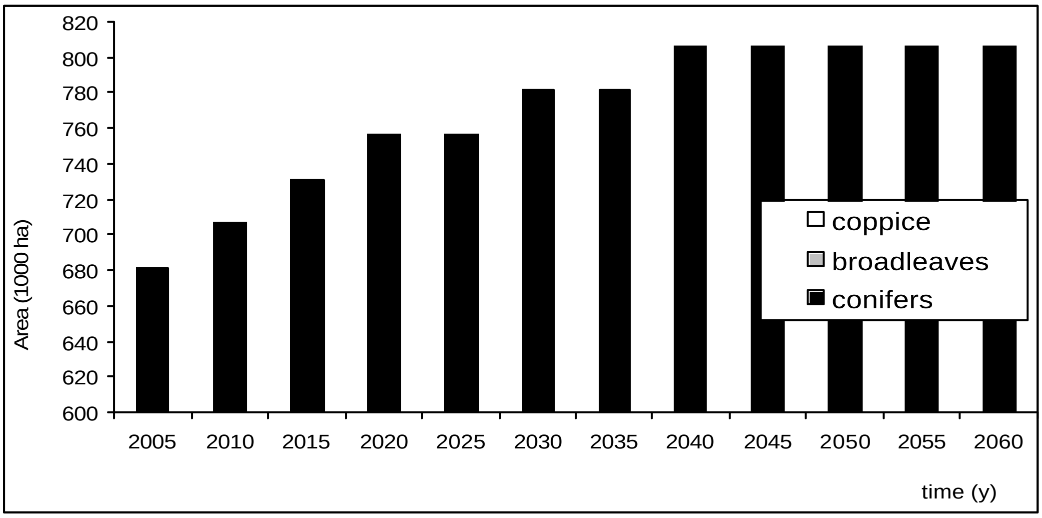


Figure 4.29 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)[14]

[14] The additional shortfall in the top graph shows a positive value because the absolute shortfall in the 'past management' scenario was slightly higher than in the 'new management trends'; this due to afforestations taking place in the latter scenario



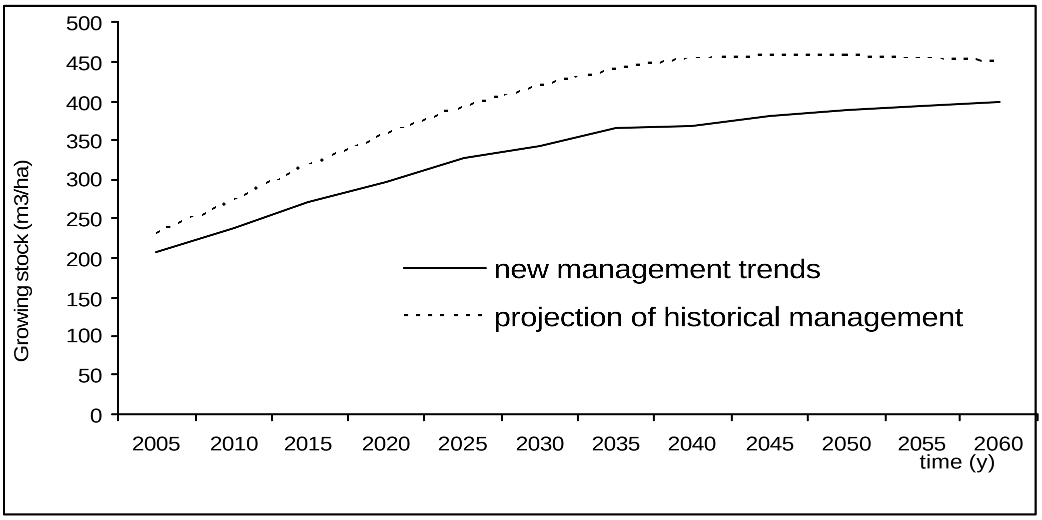


Figure 4.30. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.14. Main output for the 'new management trends' scenario [15]

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	682	707	782	807
Gross annual increment (m^3/ha/y o.b.)	11.1	11.8	10.1	7.2
Total additional shortfall (x million m^3/y o.b.)	0.0	0.0	-0.2	0.2
Growing stock (m^3/ha o.b.)	207	239	344	400
Actual supply by all species (x million m^3/y)	2.4	2.6	3.3	4.4
Actual supply of conifer pulplogs (x million m^3/y)	1.3	1.5	1.9	2.4

[15] The initialisation data for Ireland as received by the country correspondent covered only the coniferous forests, thus explaining the rather high average growing stock in this study by 2005.

4.17 Italy

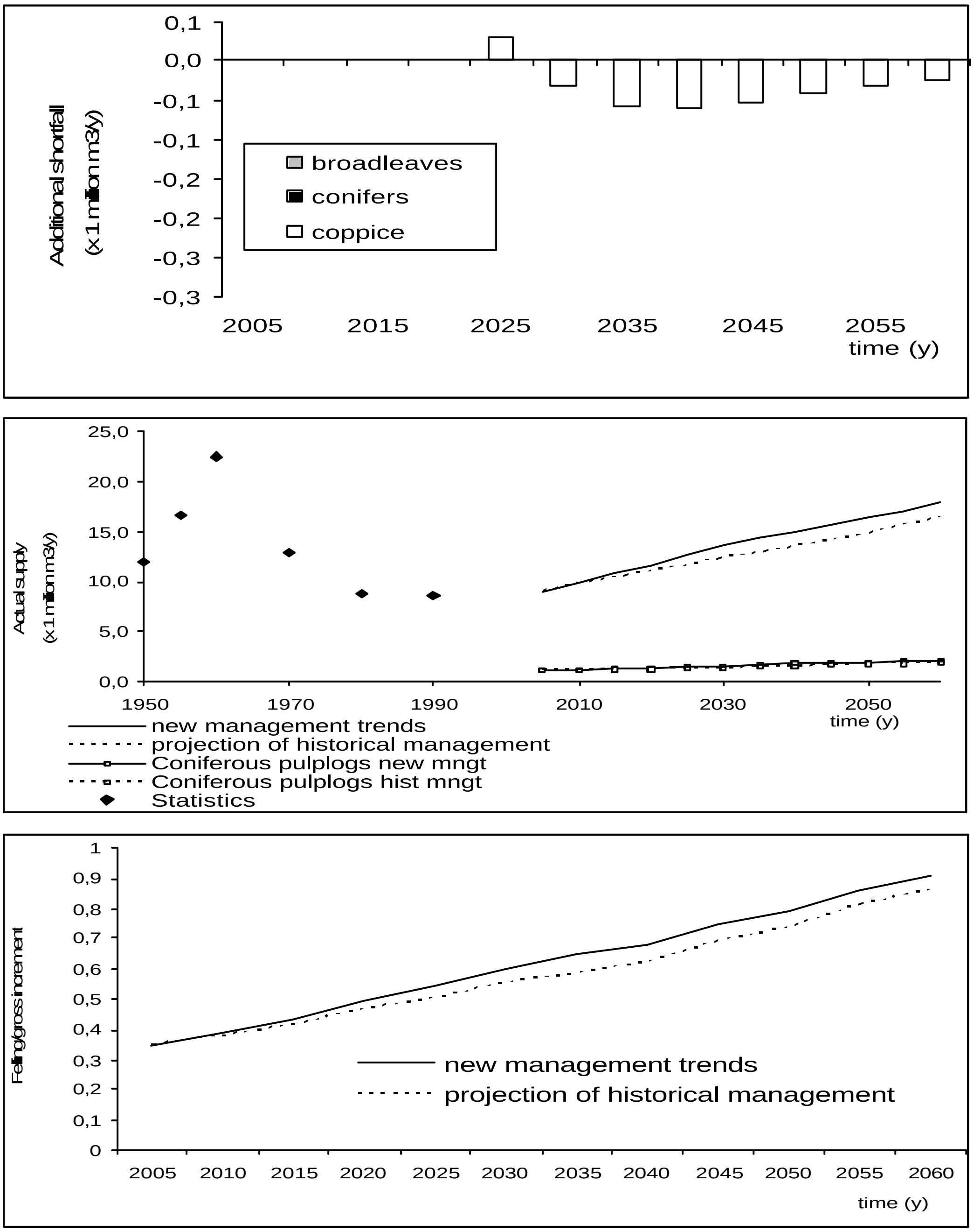
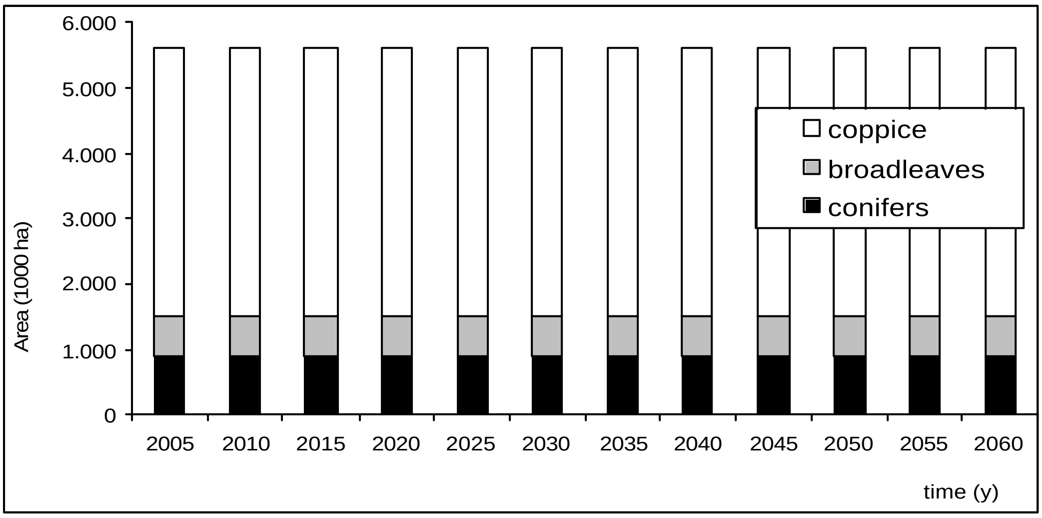


Figure 4.31 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)



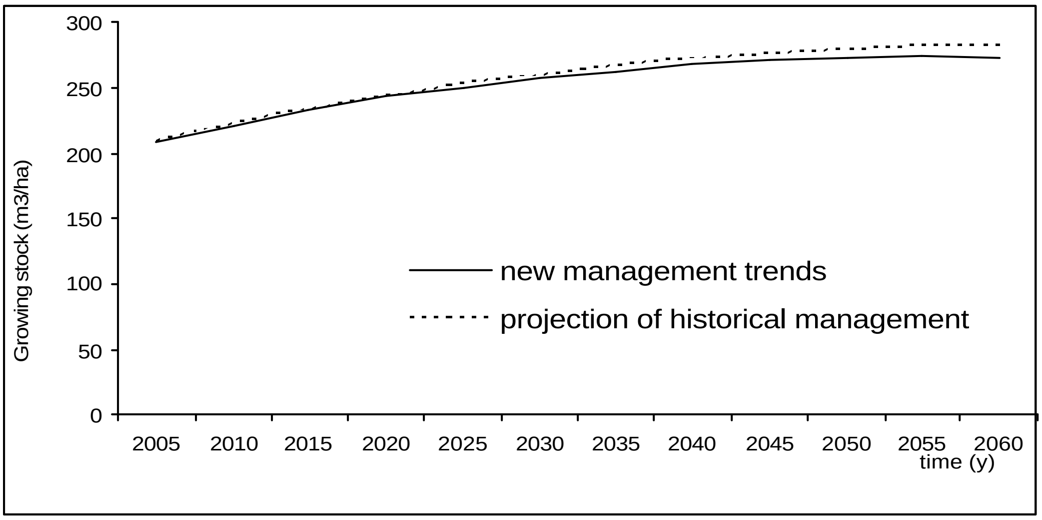


Figure 4.32. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.15. Main output for the 'new management trends' scenario [16]

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	5,604	5,604	5,604	5,604
Gross annual increment (m^3/ha/y o.b.)	4.6	4.6	4.0	3.5
Total additional shortfall (x million m^3/y o.b.)	0.0	0.0	0.0	0.0
Growing stock (m^3/ha o.b.)	209	222	258	275
Actual supply by all species (x million m^3/y)	9.1	10.0	13.6	17.9
Actual supply of conifer pulplogs (x million m^3/y)	1.1	1.2	1.6	2.1

[16] The initialisation data for Italy as received by the country correspondent covered only the more productive forests, thus explaining the rather high average growing stock in this study by 2005.

4.18 Latvia

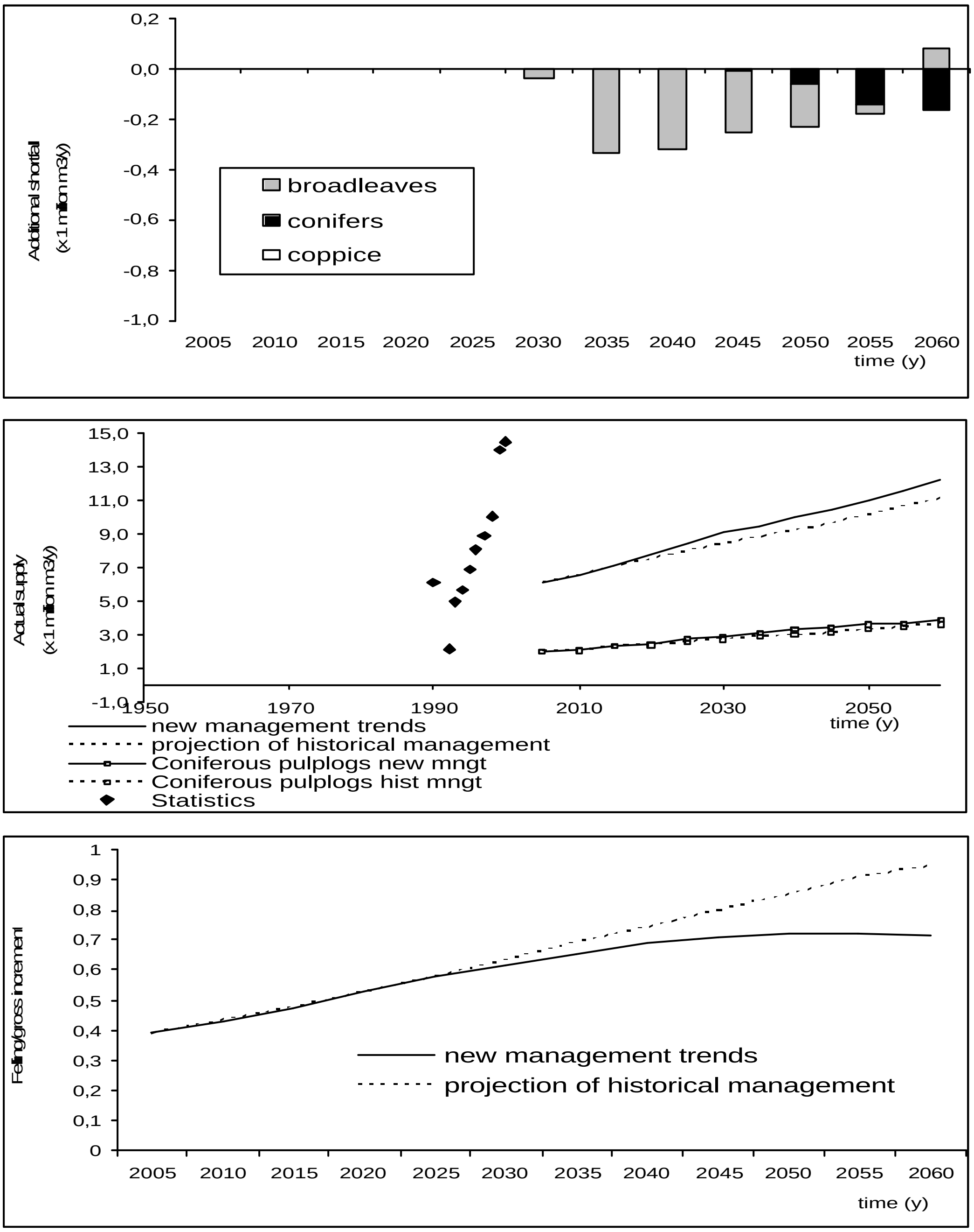
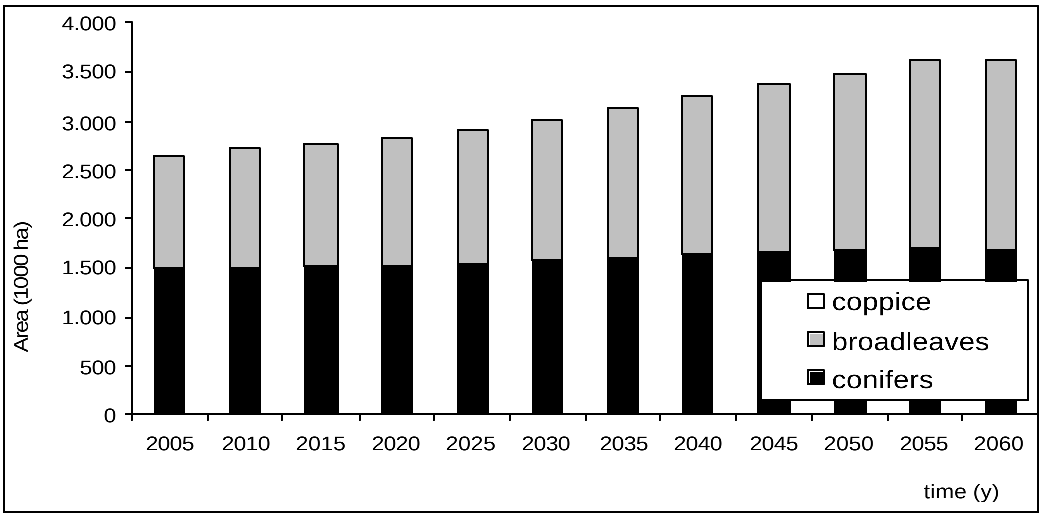


Figure 4.33 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)[17]

[17] The supply statistics in the middle graph are given for the 1990's only because they are available only for after the break up of the Soviet Union. These single year data often fluctuate more strongly explaining the more moderate supply increase we have assumed in the longer term.



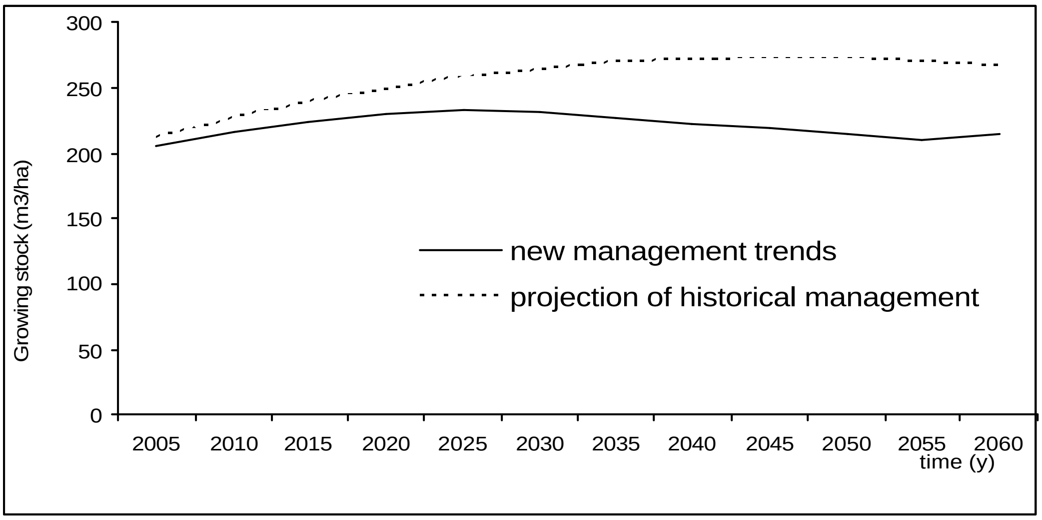


Figure 4.34. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.16. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	2,650	2,710	3,010	3,610
Gross annual increment (m^3/ha/y o.b.)	5.8	5.6	4.8	4.7
Total additional shortfall (x million m^3/y o.b.)	0.0	0.0	0.0	-0.1
Growing stock (m^3/ha o.b.)	207	217	231	214
Actual supply by all species (x million m^3/y)	6.1	6.5	9.0	12.2
Actual supply of conifer pulplogs (x million m^3/y)	1.9	2.1	2.9	3.9

4.19 Lithuania

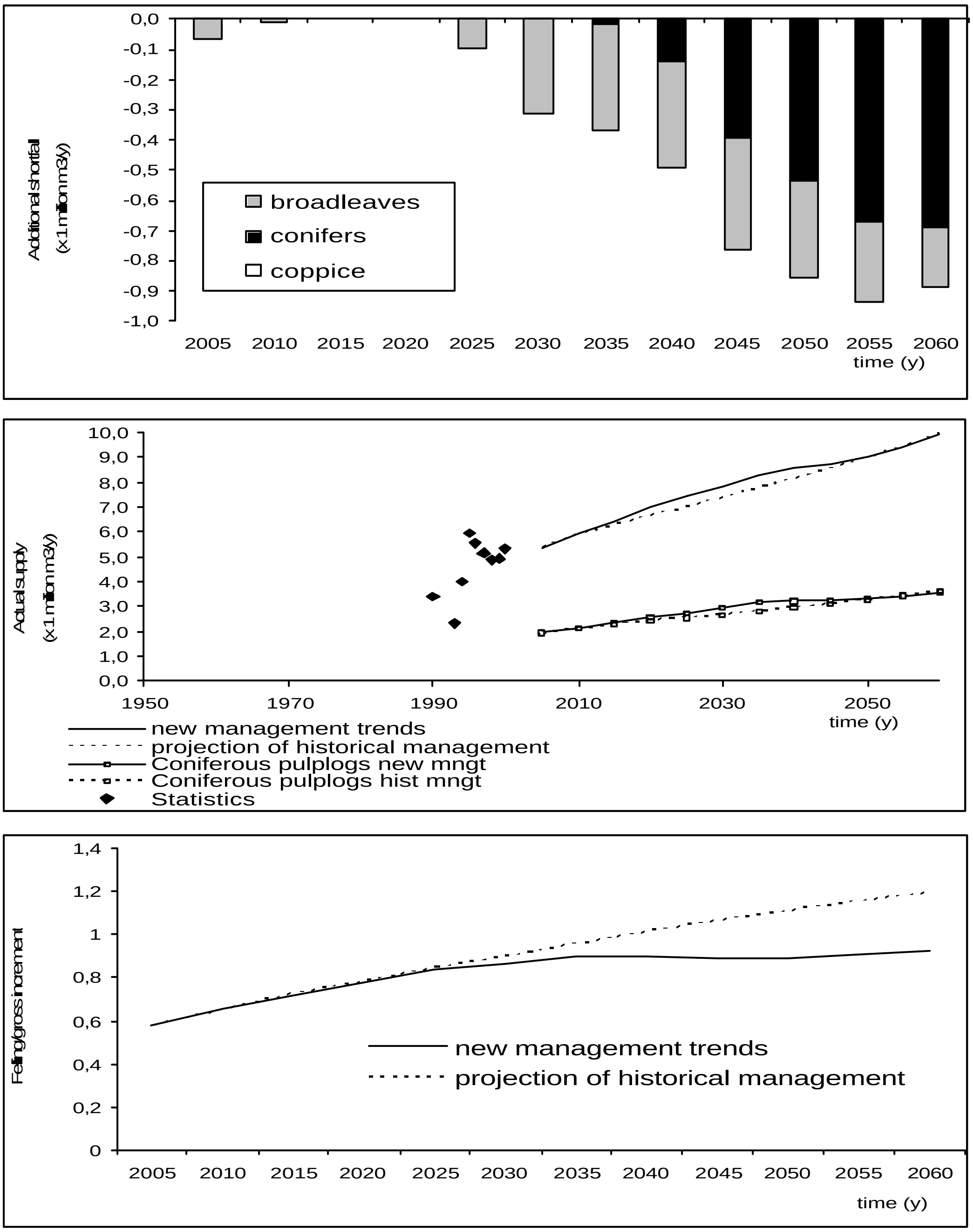
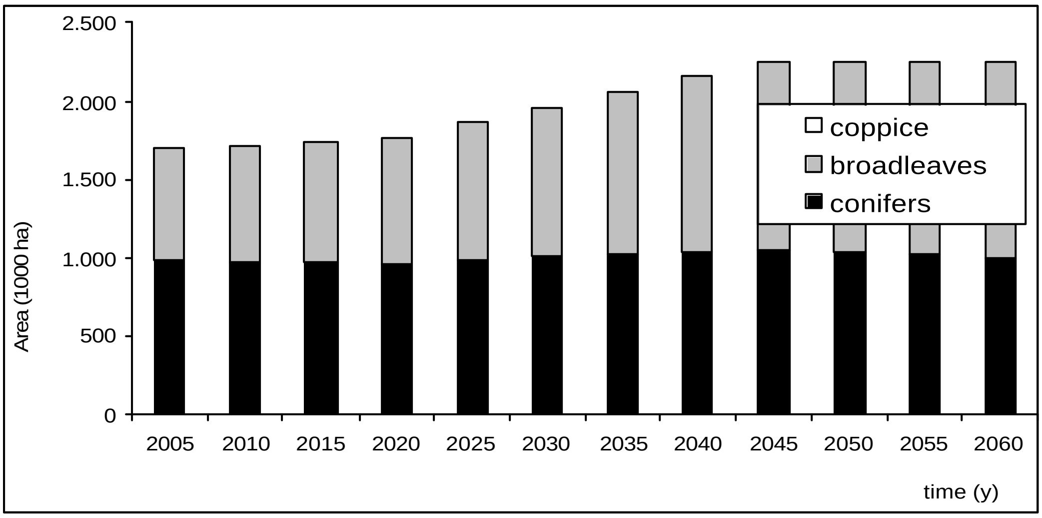


Figure 4.35 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)[18]

[18] The supply statistics in the middle graph are given for the 1990's only because they are available only for after the break up of the Soviet Union. These single year data often fluctuate more strongly.



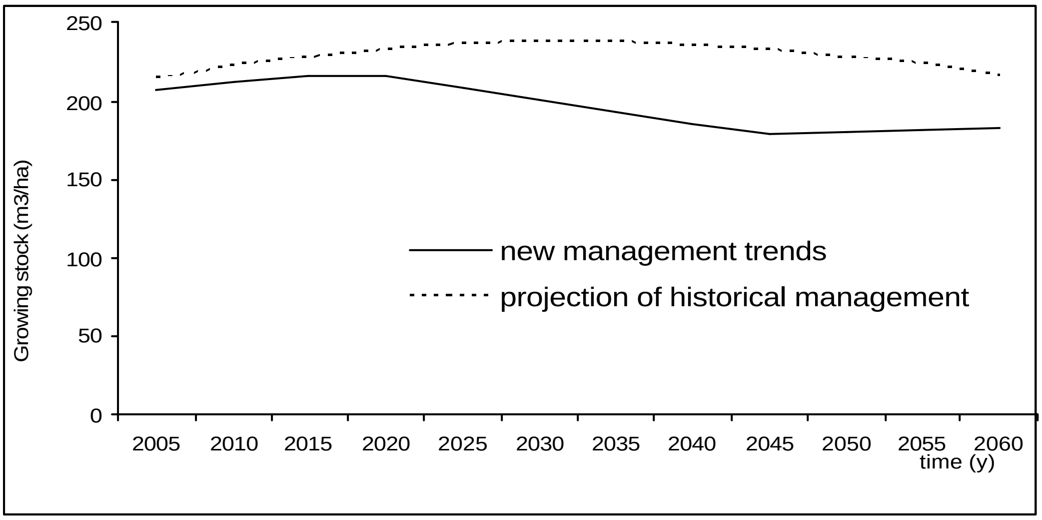


Figure 4.36. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.17. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	1,699	1,723	1,963	2,251
Gross annual increment (m^3/ha/y o.b.)	5.4	5.3	4.6	4.8
Total additional shortfall (x million m^3/y o.b.)	-0.1	0.0	-0.3	-0.9
Growing stock (m^3/ha o.b.)	208	213	201	182
Actual supply by all species (x million m^3/y)	5.4	6.0	7.8	9.9
Actual supply of conifer pulplogs (x million m^3/y)	2.0	2.2	3.0	3.6

4.20 Luxembourg

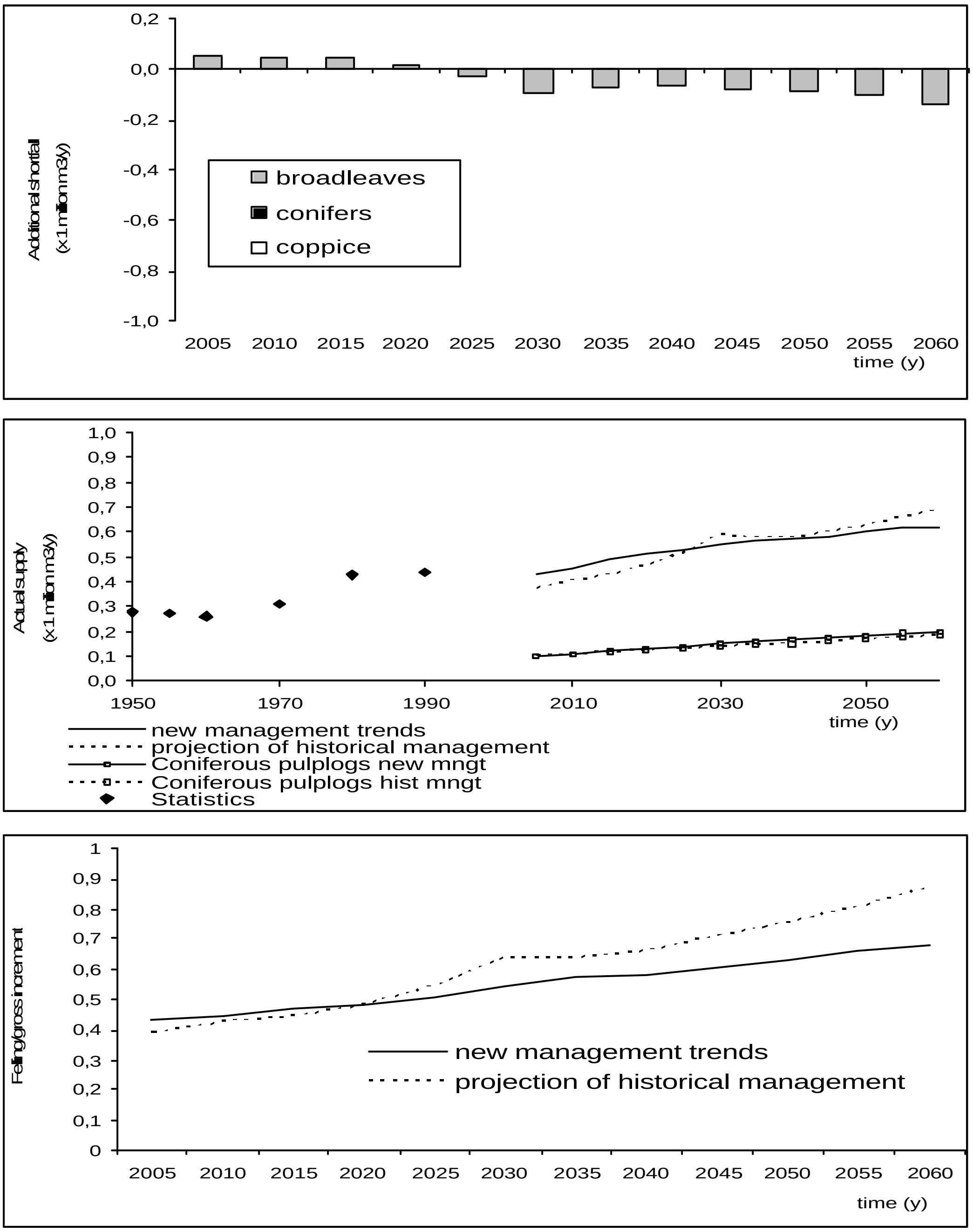
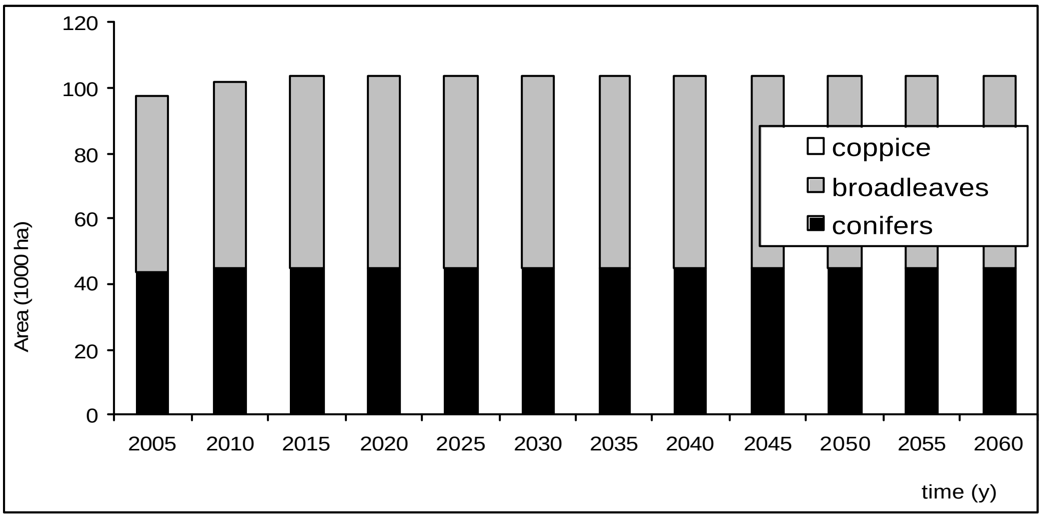


Figure 4.37 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)



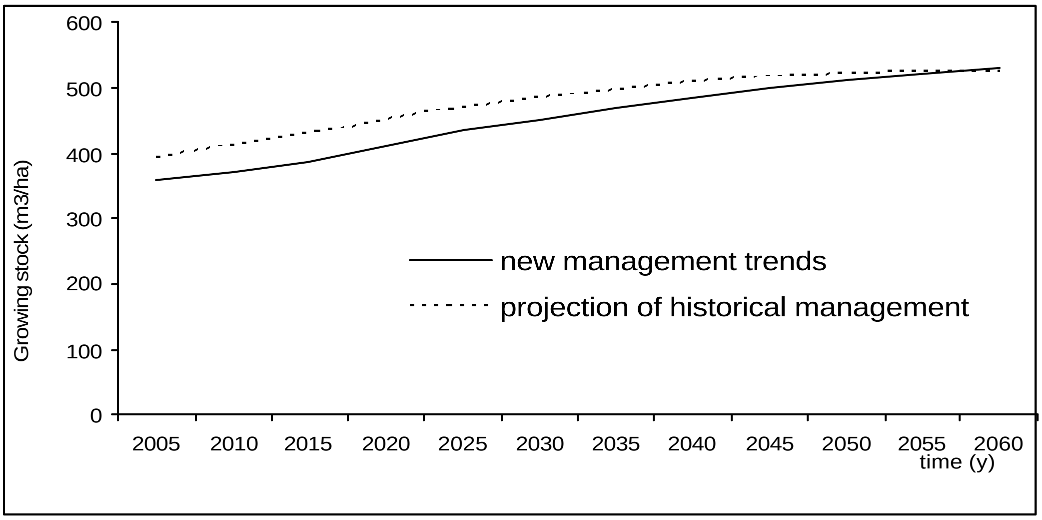


Figure 4.38. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.18. Main output for the 'new management trends' scenario [19]

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	98	102	104	104
Gross annual increment (m^3/ha/y o.b.)	10.2	10.0	9.8	8.8
Total additional shortfall (x million m^3/y o.b.)	0.1	0.0	-0.1	-0.1
Growing stock (m^3/ha o.b.)	360	371	453	532
Actual supply by all species (x million m^3/y)	0.4	0.5	0.6	0.6
Actual supply of conifer pulplogs (x million m^3/y)	0.1	0.1	0.2	0.2

[19] The initialisation data for Luxembourg as received by the country correspondent displayed a rather high increment explaining the high growing stock in this study already by 2005.

4.21 Macedonia

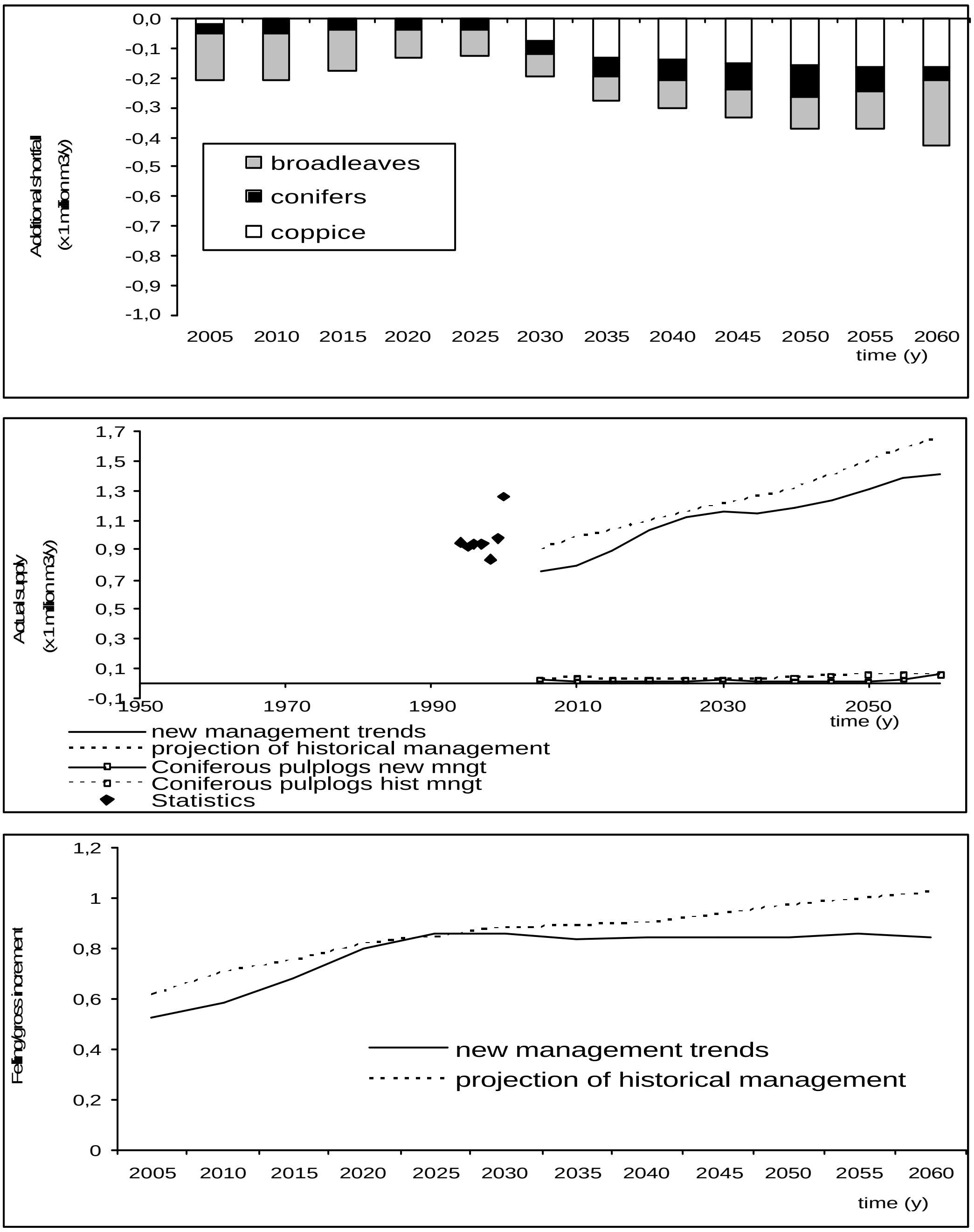
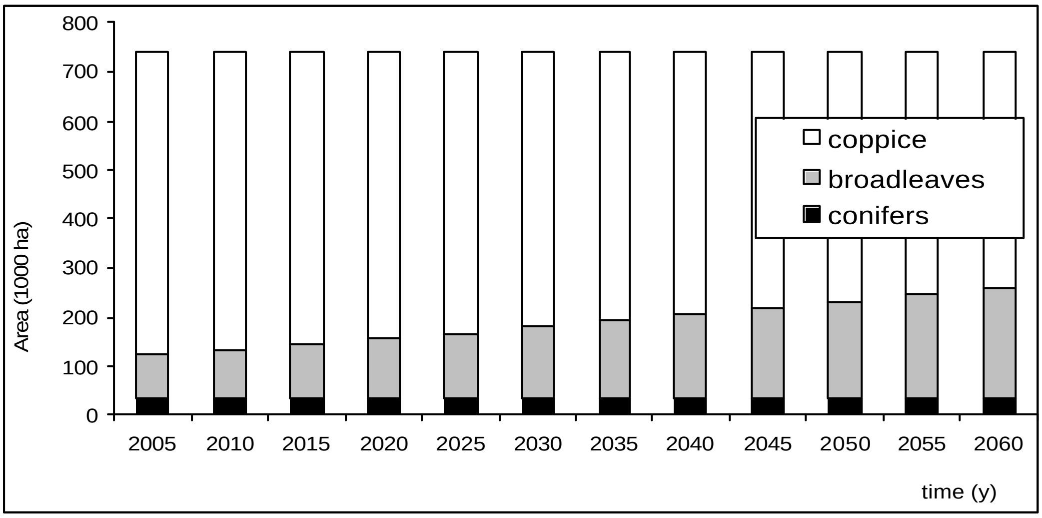


Figure 4.39 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)[20]

[20] The supply statistics in the middle graph are given for the 1990's only because they are available only for after the break up of Yugoslavia. These single year data often fluctuate more strongly



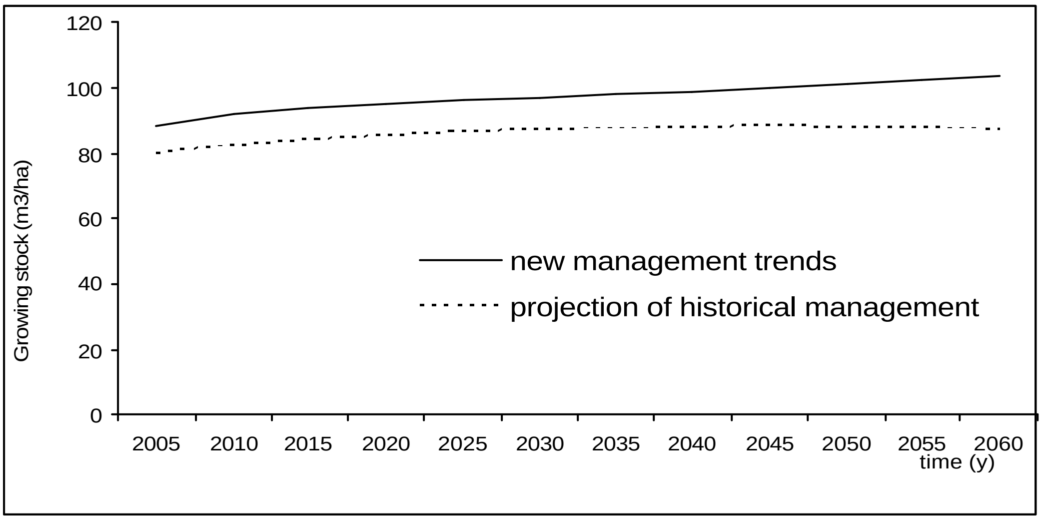


Figure 4.40. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.19. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	743	743	743	743
Gross annual increment (m^3/ha/y o.b.)	1.9	1.8	1.8	2.3
Total additional shortfall (x million m^3/y o.b.)	-0.2	-0.2	-0.2	-0.4
Growing stock (m^3/ha o.b.)	88	92	97	104
Actual supply by all species (x million m^3/y)	0.8	0.8	1.2	1.4
Actual supply of conifer pulplogs (x million m^3/y)	0.0	0.0	0.0	0.1

4.22 Moldova

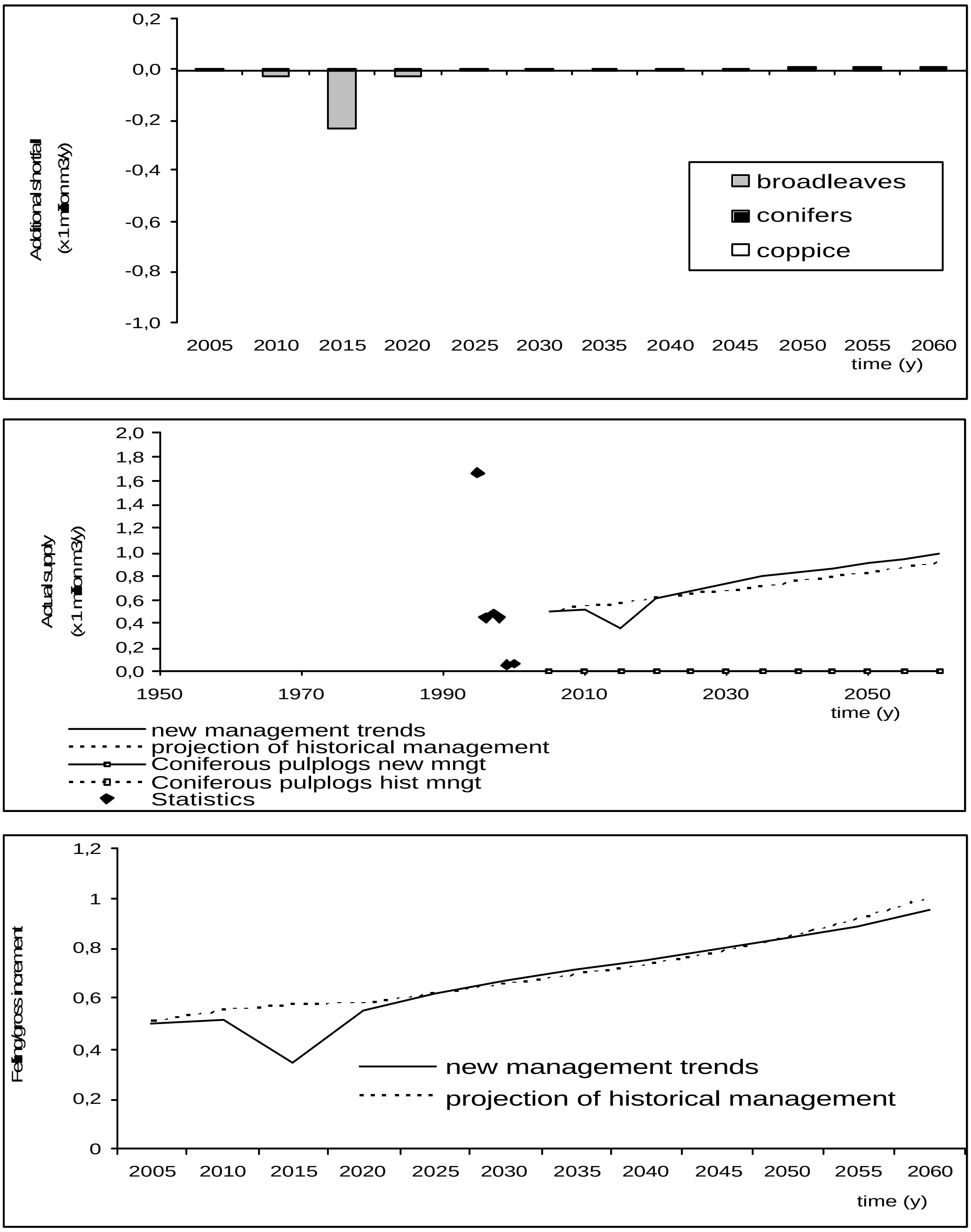
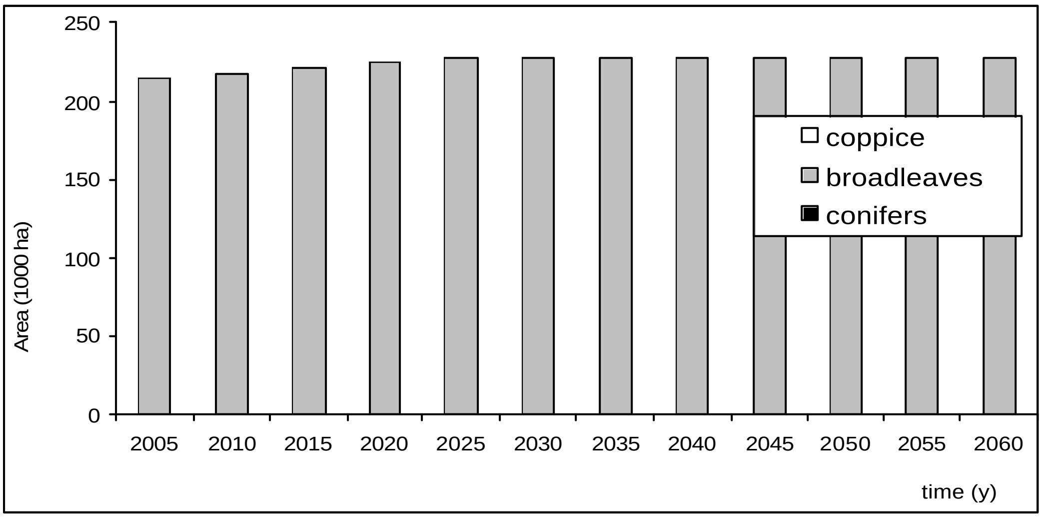


Figure 4.41 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)[21] [22]

[21] A skewed age class distribution can cause a temporary decline in fellings as can be seen here for Moldova in the new management trends scenario in 2015.

[22] The supply statistics in the middle graph are given for the 1990's only because they are available only for after the break up of the Soviet Union. These single year data often fluctuate more strongly.



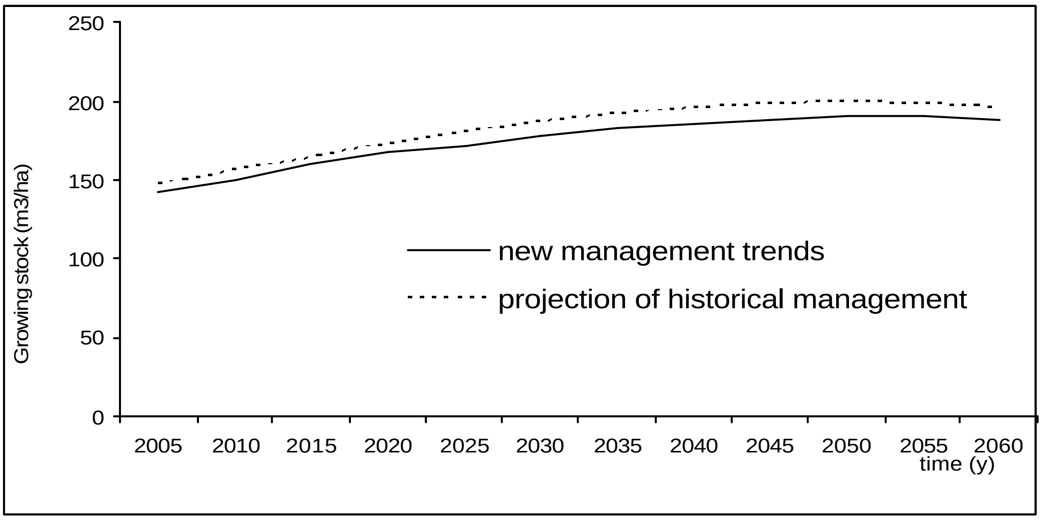


Figure 4.42. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.20. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	214	218	228	228
Gross annual increment (m^3/ha/y o.b.)	4.6	4.6	4.8	4.6
Total additional shortfall (x million m^3/y o.b.)	0.0	0.0	0.0	0.0
Growing stock (m^3/ha o.b.)	143	150	178	189
Actual supply by all species (x million m^3/y)	0.5	0.5	0.7	1.0
Actual supply of conifer pulplogs (x million m^3/y)	0.0	0.0	0.0	0.0

4.23 Netherlands

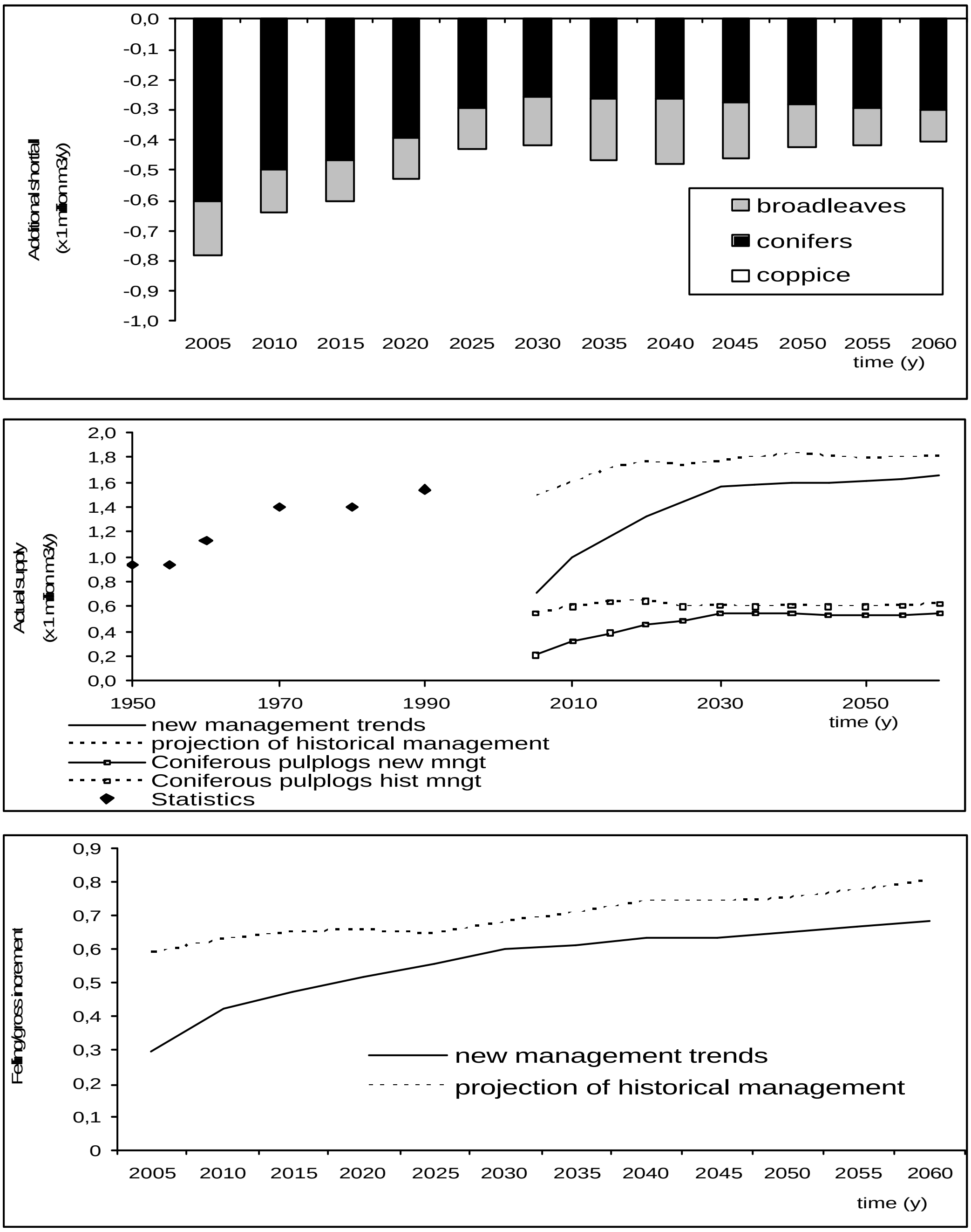


Figure 4.43 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)[23]

[23] A rather stringent set aside policy can cause the immediate decline in fellings as can be seen here for The Netherlands in the new management trends scenario

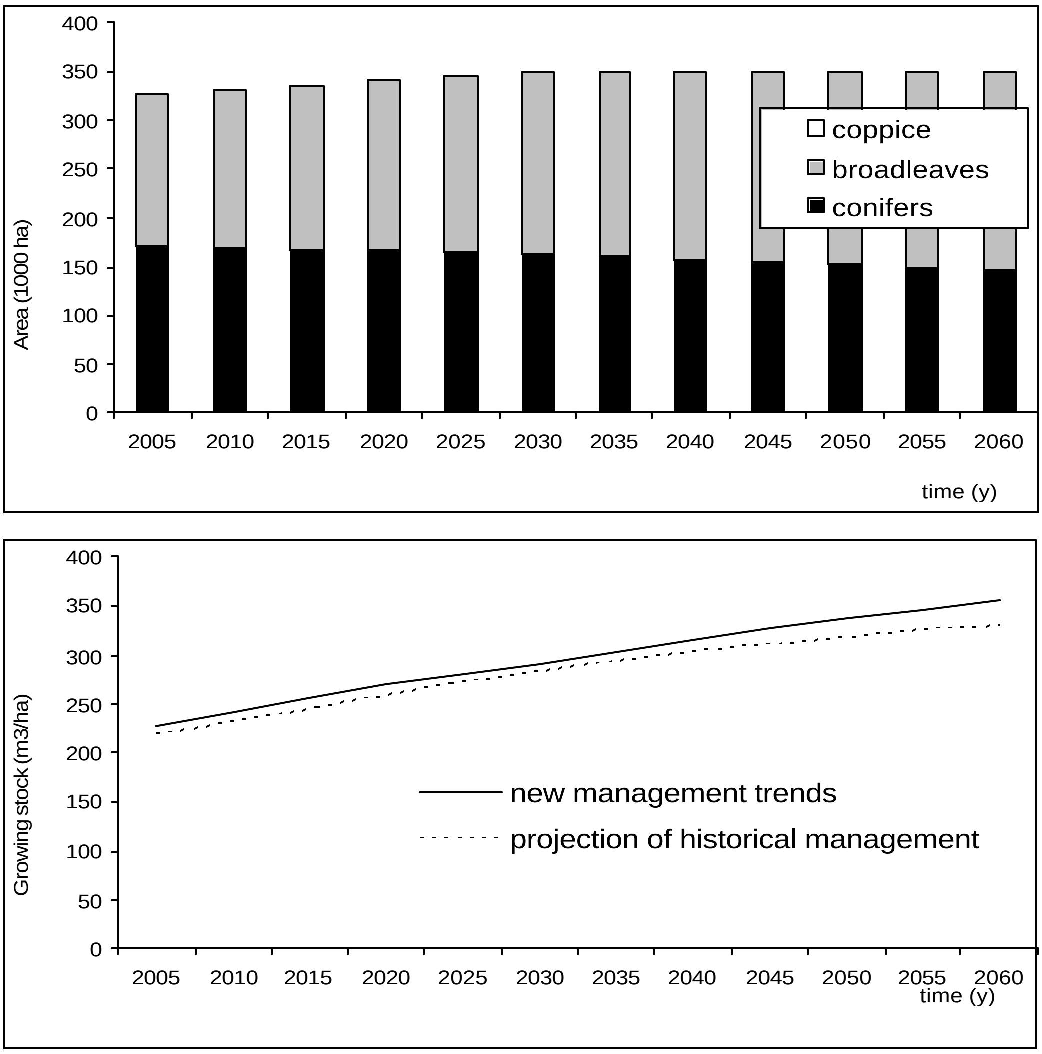


Figure 4.44. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.21. Main output for the 'new management trends' scenario [24]

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	326	331	351	351
Gross annual increment (m^3/ha/y o.b.)	7.3	7.1	7.4	6.9
Total additional shortfall (x million m^3/y o.b.)	-0.8	-0.6	-0.4	-0.4
Growing stock (m^3/ha o.b.)	227	243	290	356
Actual supply by all species (x million m^3/y)	0.7	1.0	1.6	1.7
Actual supply of conifer pulplogs (x million m^3/y)	0.2	0.3	0.5	0.5

[24] The rather high growing stock for the Netherlands for 2005 is in line with most recent inventory reports.

4.24 Norway

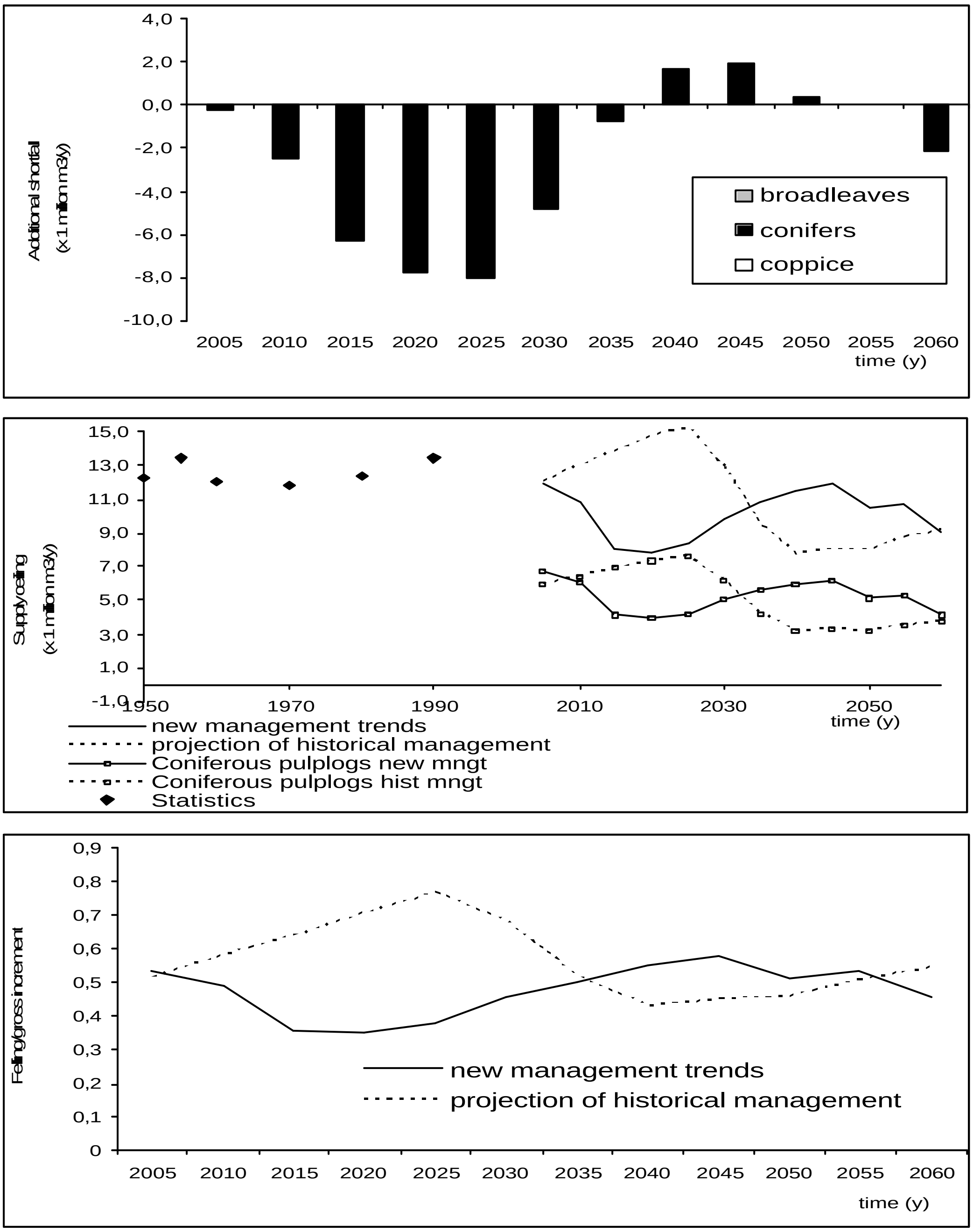


Figure 4.45 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)[25]

[25] The additional shortfall in the top graph shows a peak in shortfall because the absolute shortfall in the 'past management' scenario is large towards the end of the simulation (13 million m^3/y in 2060).

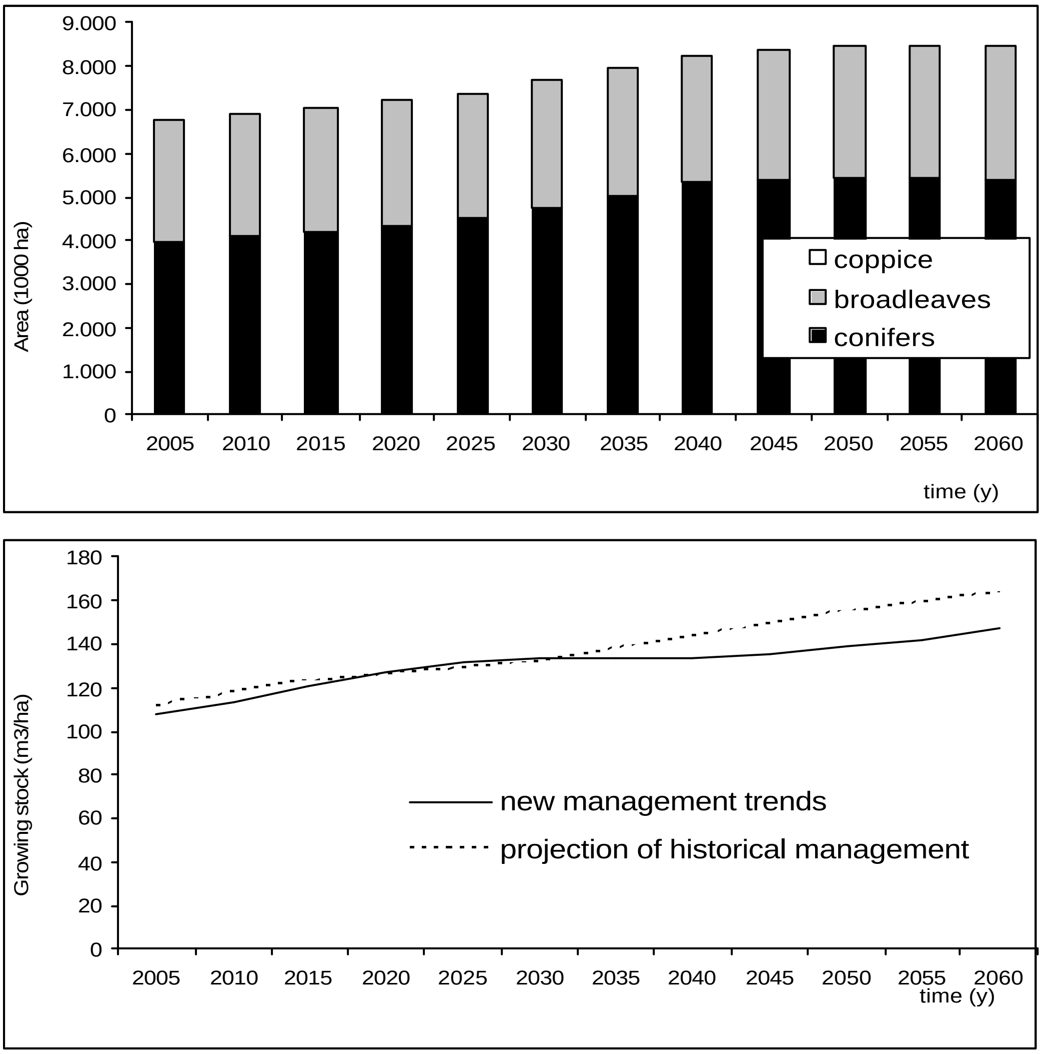


Figure 4.46. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.22. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	6,761	6,911	7,661	8,461
Gross annual increment (m^3 m^3/ha/y o.b.)	3.3	3.2	2.8	2.3
Total additional shortfall (x million m^3/y o.b.)	-0.2	-2.5	-4.8	-2.1
Growing stock (m^3/ha o.b.)	109	114	134	147
Actual supply by all species (x million m^3/y)	11.8	10.8	9.8	9.1
Actual supply of conifer pulplogs (x million m^3/y)	6.8	6.0	5.0	4.1

4.25 Poland

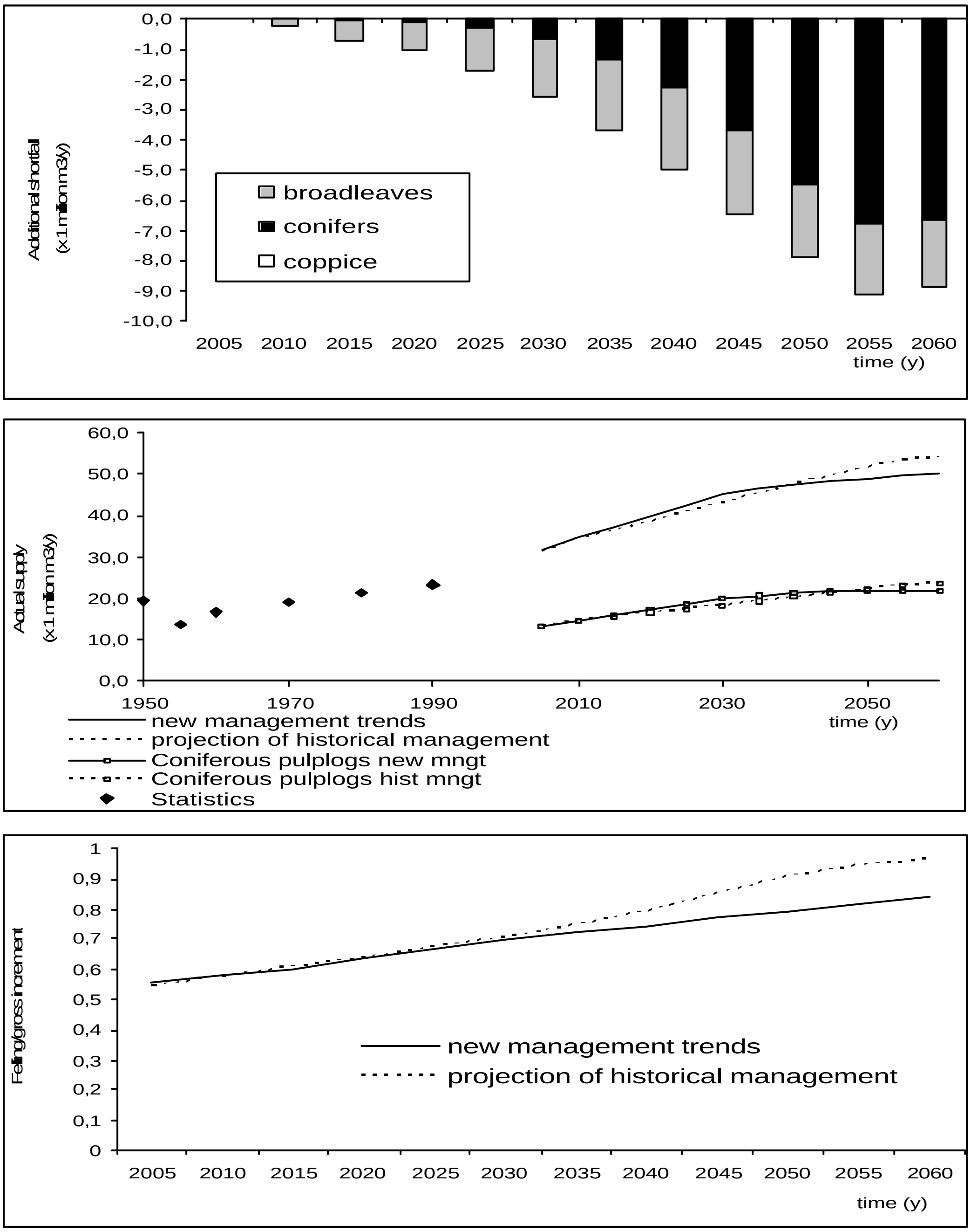
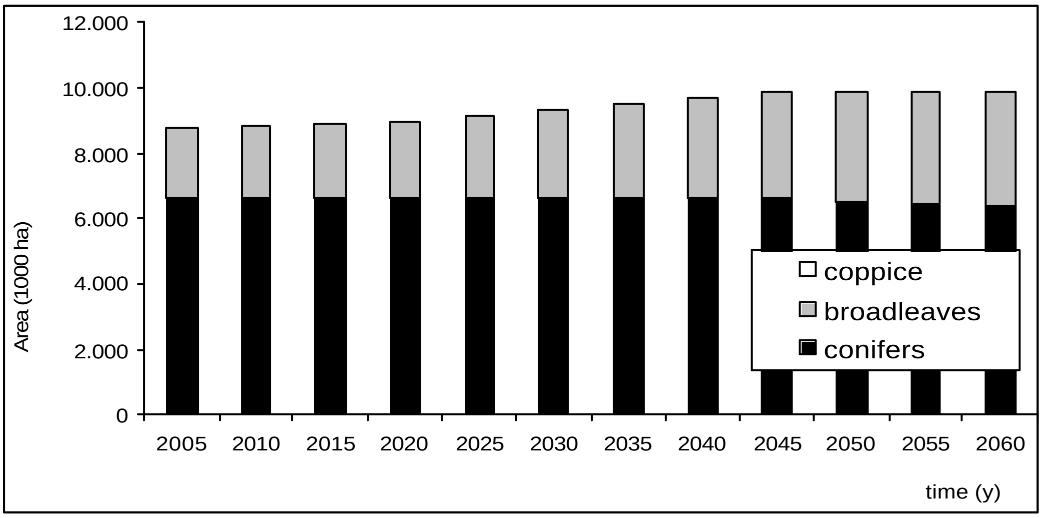


Figure 4.47 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)



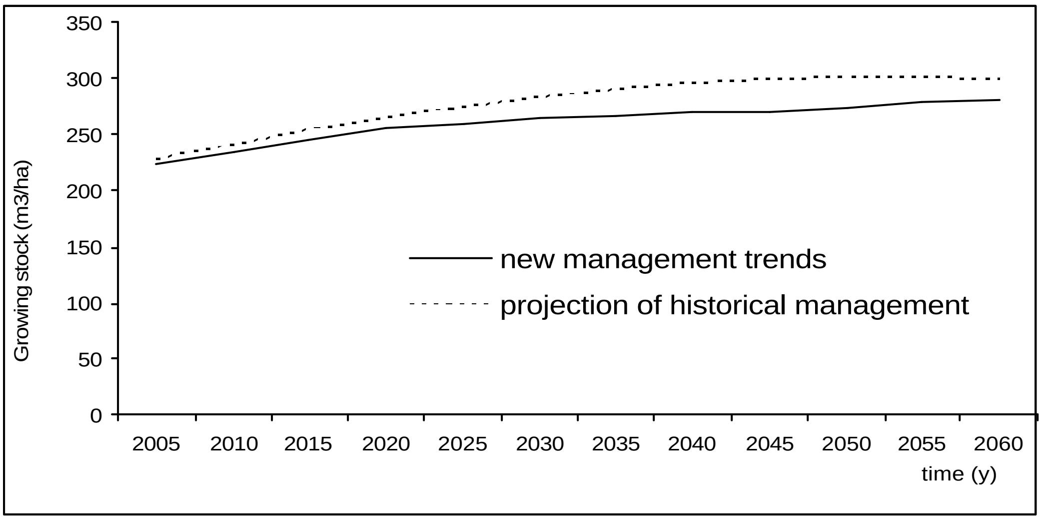


Figure 4.48. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.23. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	8,810	8,865	9,335	9,875
Gross annual increment (m^3/ha/y o.b.)	6.4	6.7	6.9	6.1
Total additional shortfall (x million m^3/y o.b.)	0.0	-0.2	-2.6	-8.8
Growing stock (m^3/ha o.b.)	223	235	264	282
Actual supply by all species (x million m^3/y)	31.7	34.5	44.9	50.5
Actual supply of conifer pulplogs (x million m^3/y)	13.5	14.8	19.9	22.1

4.26 Portugal

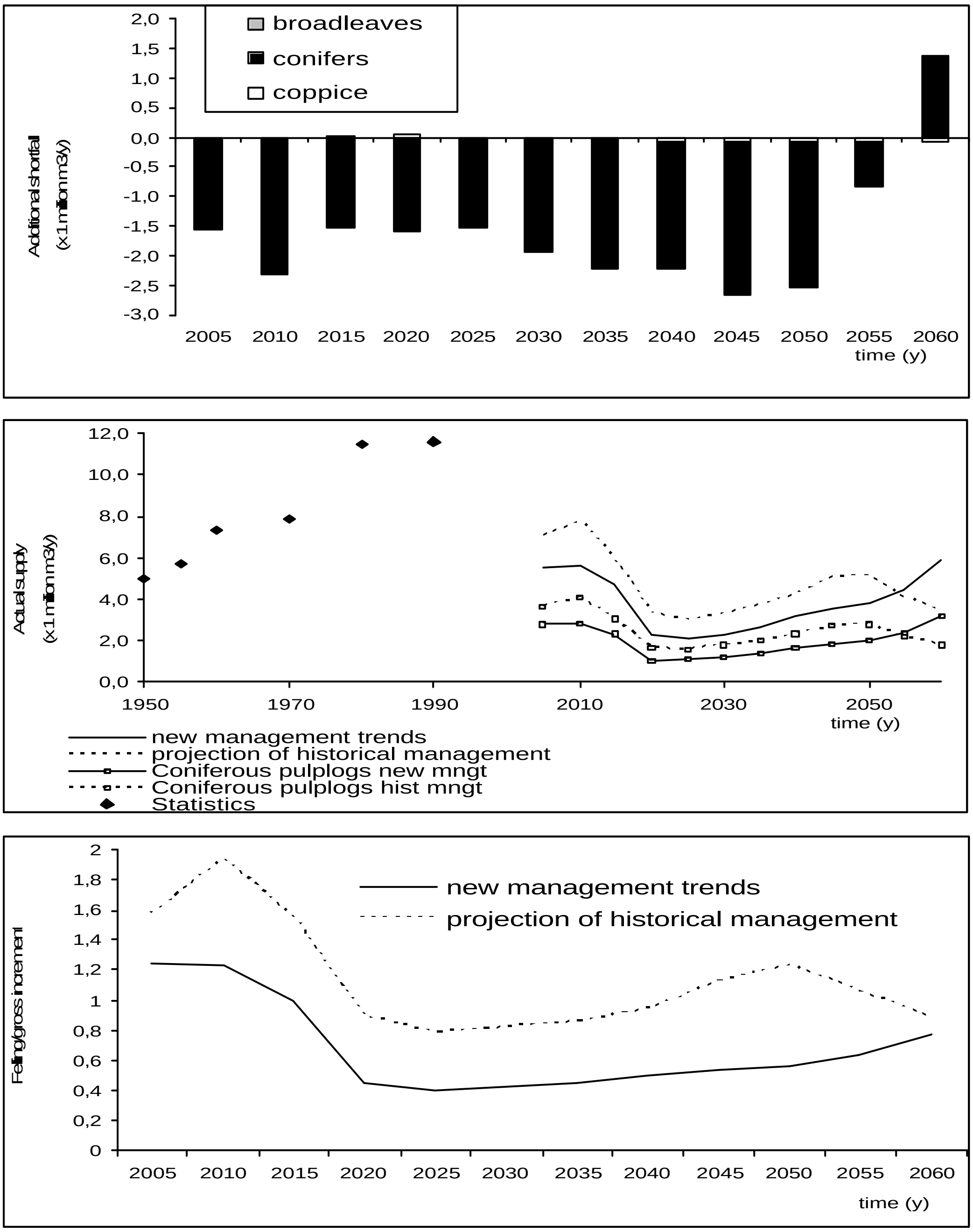


Figure 4.49 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom) [26] [27]

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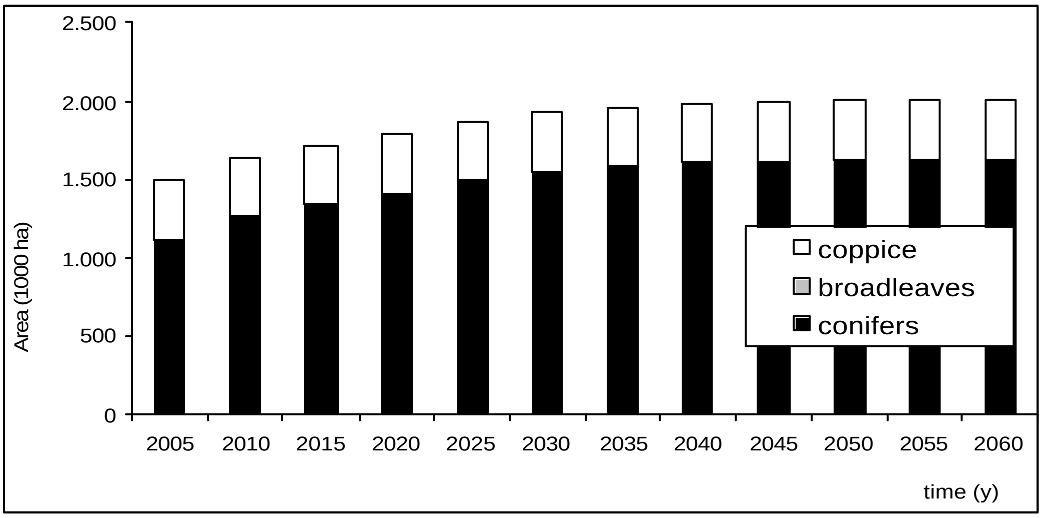
[26] The Portuguese results have to be regarded with care because only initialisation data for conifers and coppice type forests was available; and because the Eucalypts plantations were not included in these simulations.

[27] The additional shortfall in the top graph is rather small because the absolute shortfall in the 'past management' scenario amounted to 7 to 9 million m^3/y in 2050 to 2060 already, and because large afforestations take place in the 'new management trends'



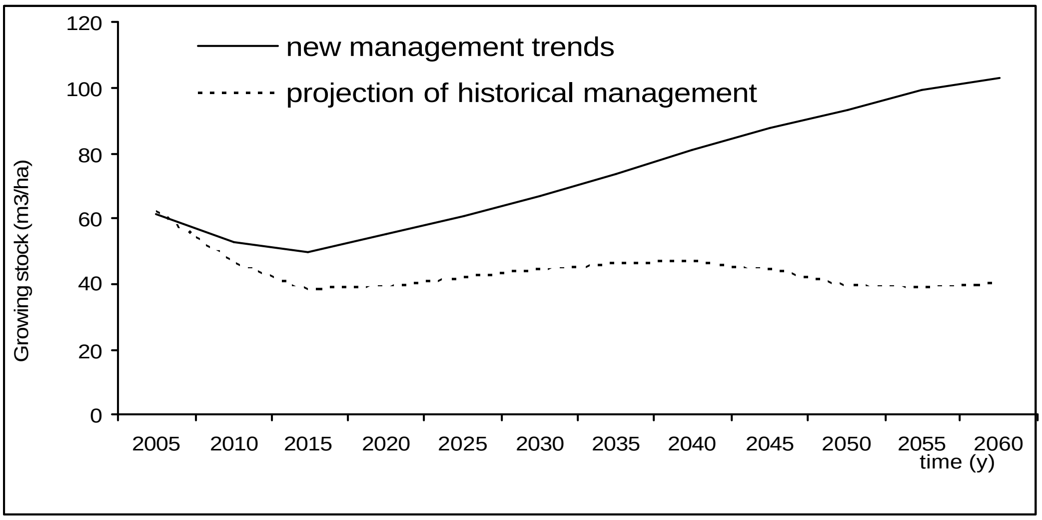


Figure 4.50. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.24. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	1,495	1,635	1,925	2,005
Gross annual increment (m^3/ha/y o.b.)	3.0	2.8	2.9	3.8
Total additional shortfall (x million m^3/y o.b.)	-1.6	-2.3	-1.9	1.3
Growing stock (m^3/ha o.b.)	62	53	67	103
Actual supply by all species (x million m^3/y)	5.5	5.6	2.4	5.9
Actual supply of conifer pulplogs (x million m^3/y)	2.8	2.8	1.2	3.2

4.27 Romania

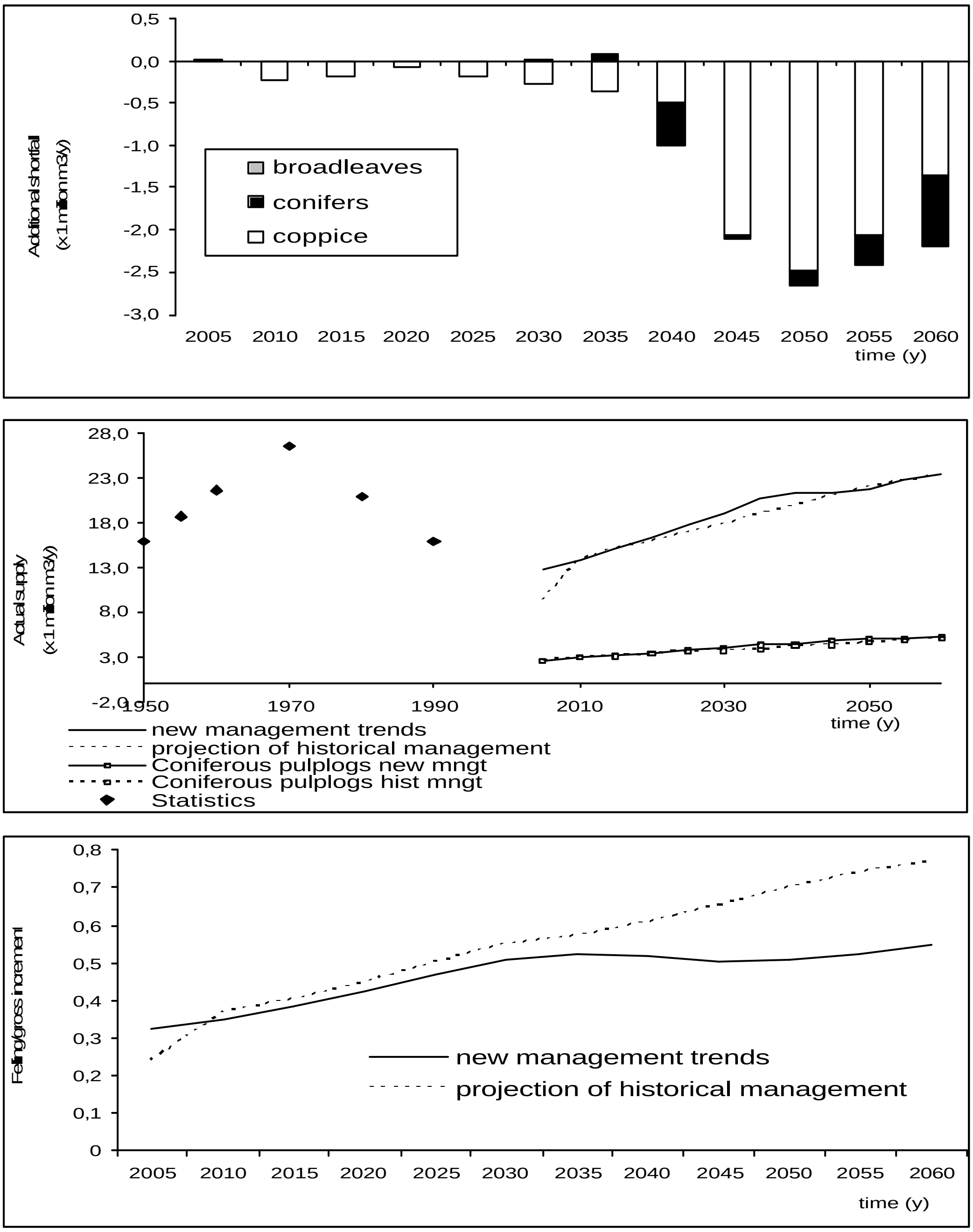
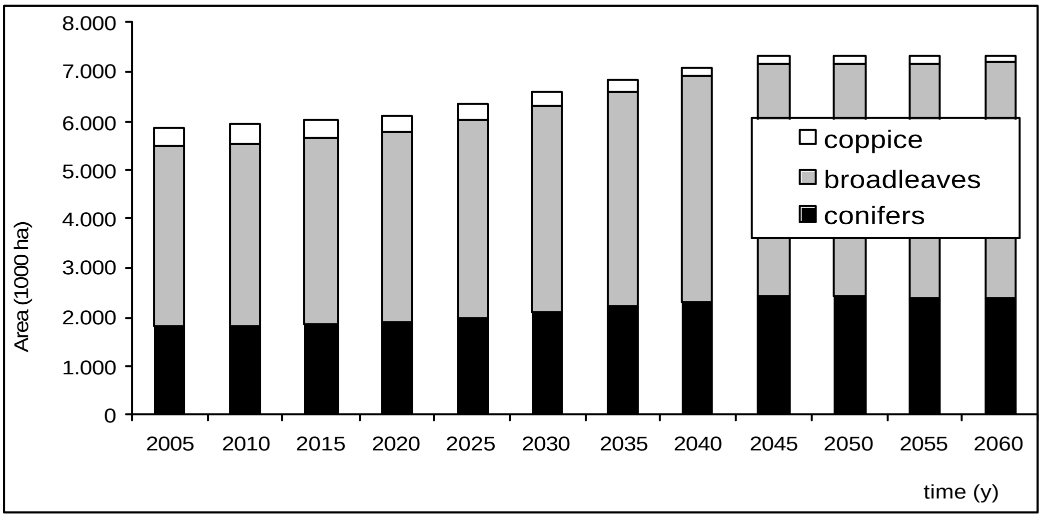


Figure 4.51 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)



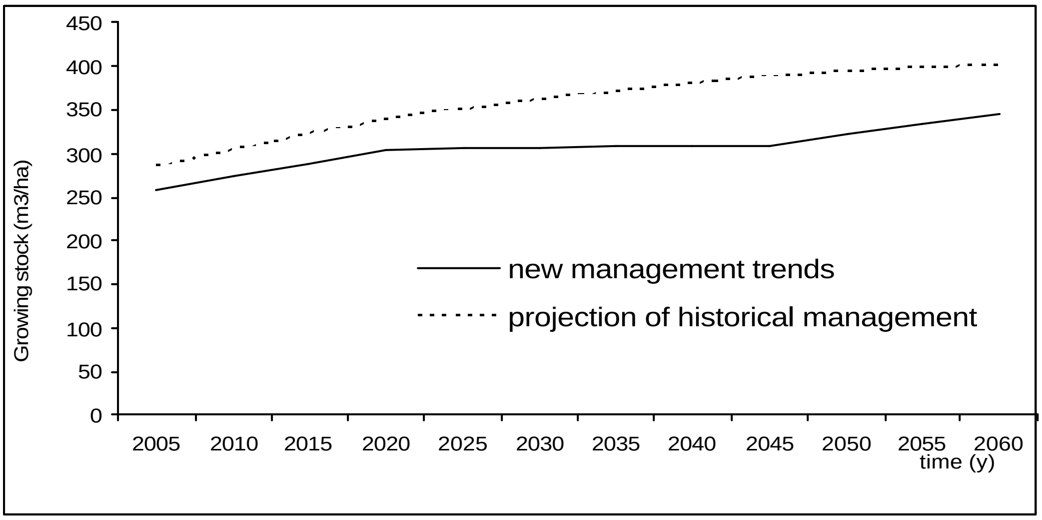


Figure 4.52. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.25. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	5,868	5,943	6,593	7,343
Gross annual increment (m^3/ha/y o.b.)	6.7	6.7	5.7	5.8
Total additional shortfall (x million m^3/y o.b.)	0.0	-0.2	-0.3	-2.2
Growing stock (m^3/ha o.b.)	257	274	306	345
Actual supply by all species (x million m^3 /y)	12.9	13.9	19.1	23.4
Actual supply of conifer pulplogs (x million m^3/y)	2.7	2.9	4.0	5.2

4.28 Russian Federation (European part)

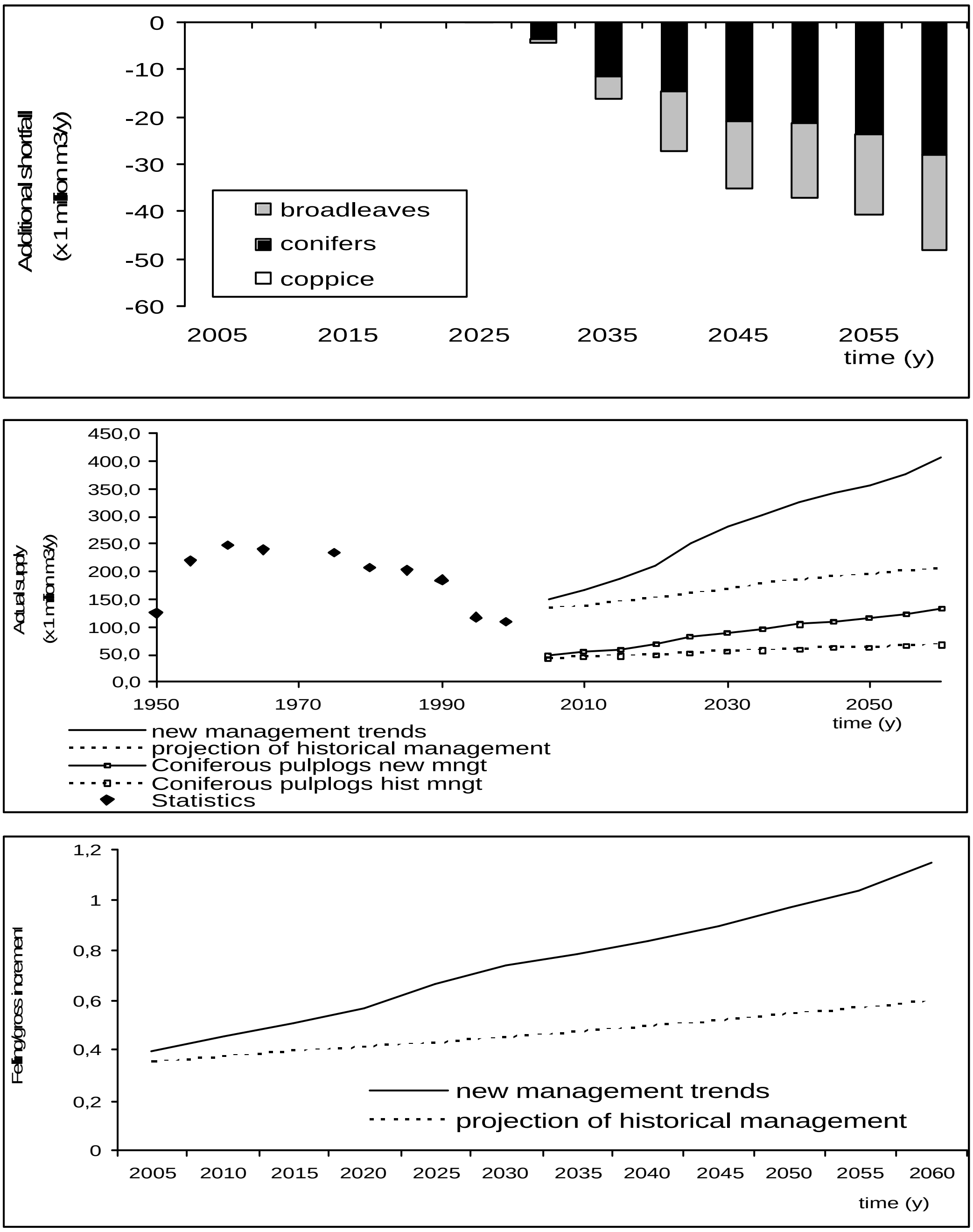
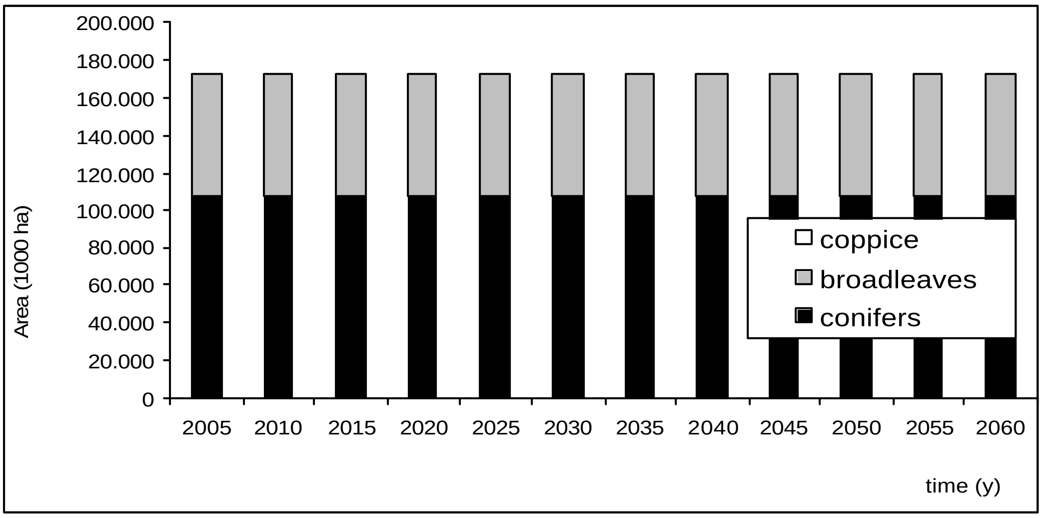


Figure 4.53 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)



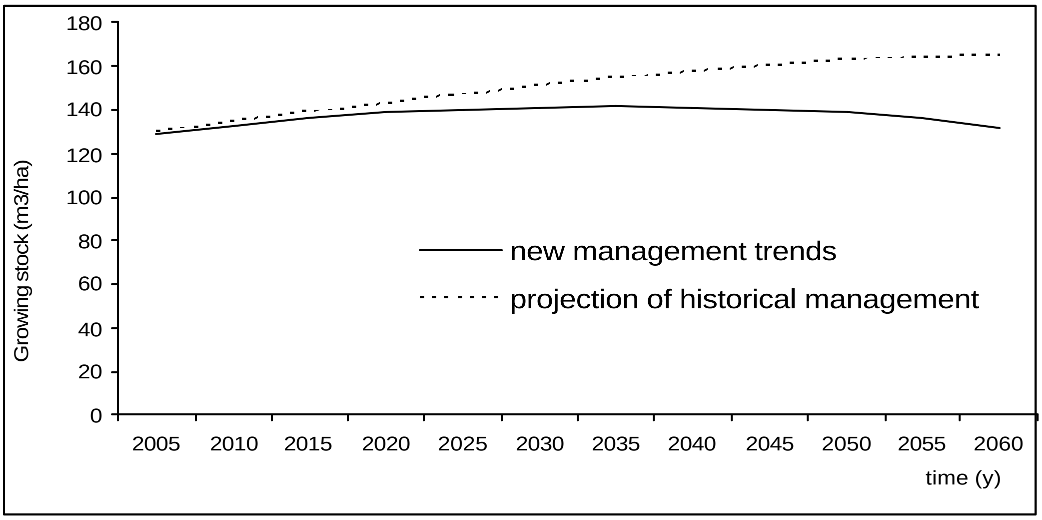


Figure 4.54. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.26. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	173,189	173,188	173,186	173,184
Gross annual increment (m^3/ha/y o.b.)	2.2	2.1	2.2	2.0
Total additional shortfall (x million m^3/y o.b.)	0.0	0.0	-4.3	-48.1
Growing stock (m^3/ha o.b.)	129	133	142	132
Actual supply by all species (x million m^3/y)	148.9	167.6	281.7	407.4
Actual supply of conifer pulplogs (x million m^3/y)	48.3	54.4	90.7	132.2

4.29 Serbia and Montenegro

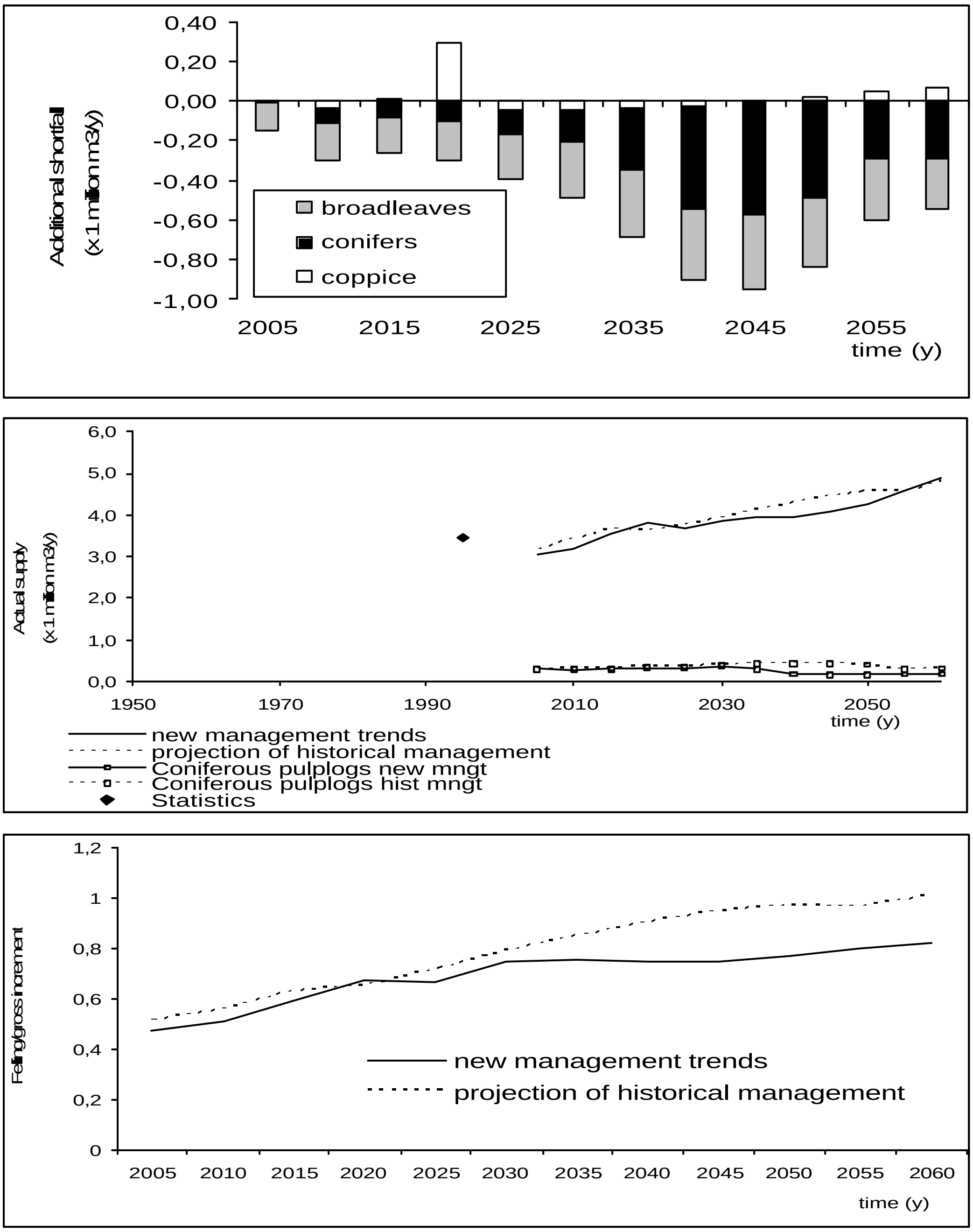


Figure 4.55 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)[28]

[28] The supply data in the middle graph are given for the 1990s only because they are available only for after the break up of Yugoslavia.

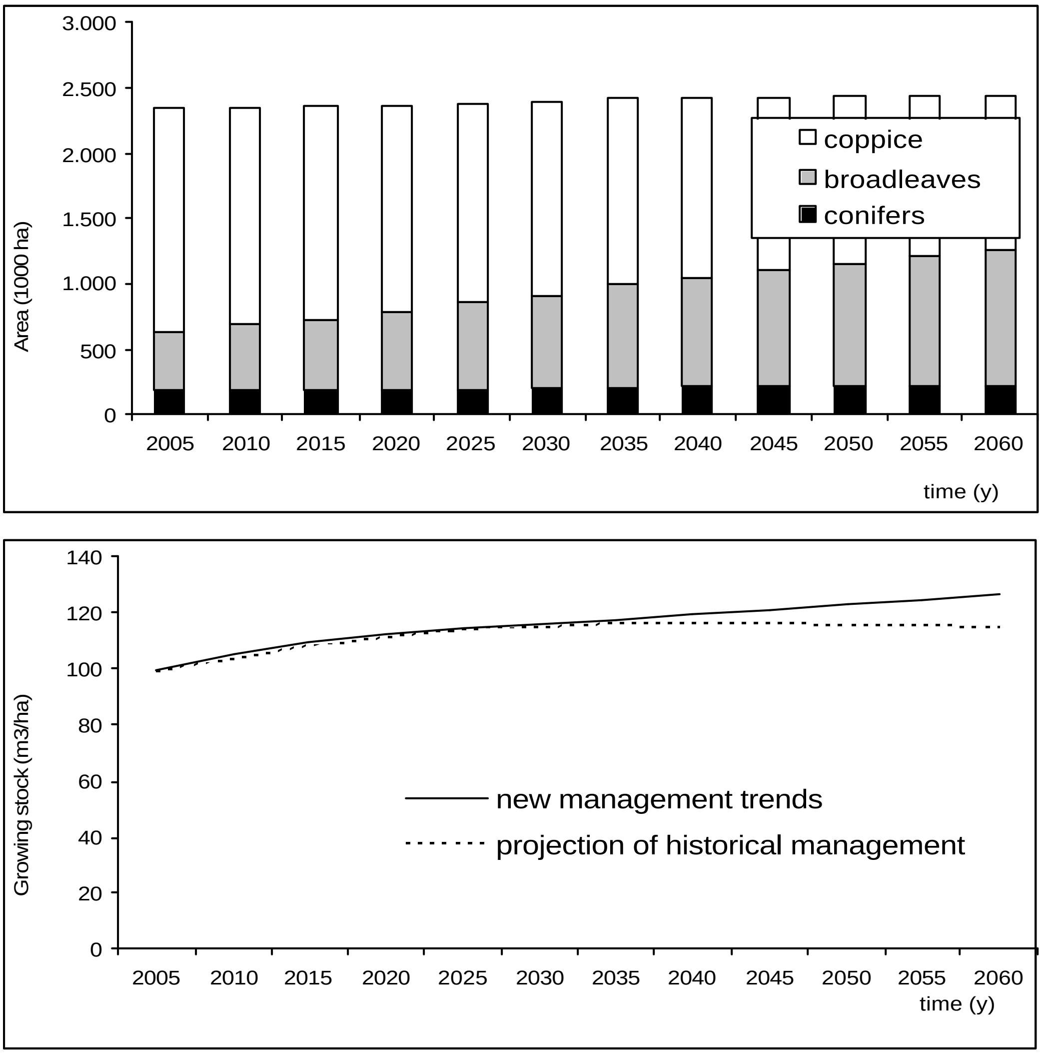


Figure 4.56. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.27. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	2,356	2,358	2,395	2,430
Gross annual increment (m^3/ha/y o.b.)	2.7	2.7	2.2	2.4
Total additional shortfall (x million m^3/y o.b.)	-0.2	-0.3	-0.5	-0.5
Growing stock (m^3/ha o.b.)	99	105	117	126
Actual supply by all species (x million m^3/y)	3.0	3.2	3.9	4.9
Actual supply of conifer pulplogs (x million m^3/y)	0.3	0.3	0.4	0.2

4.30 Slovenia

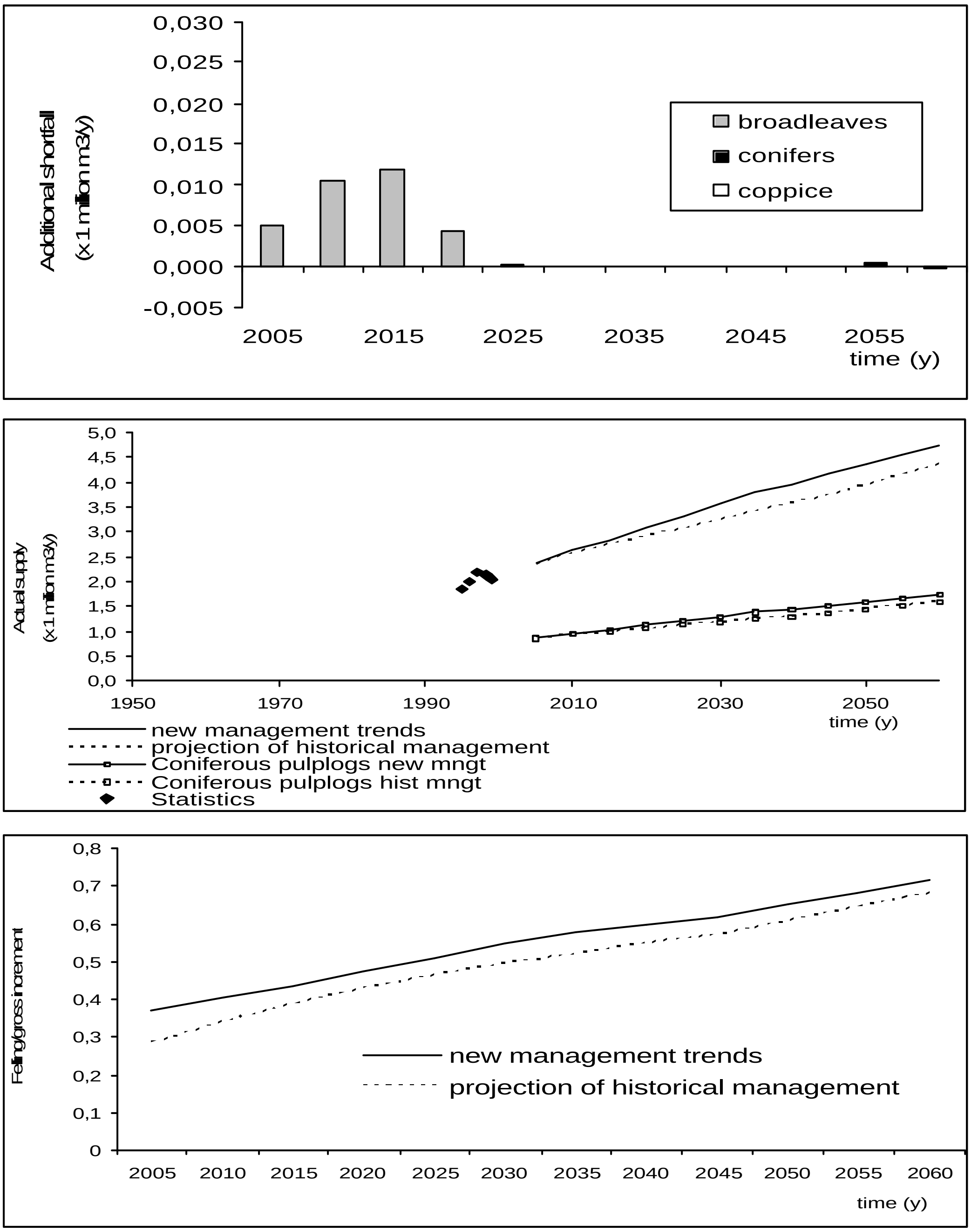
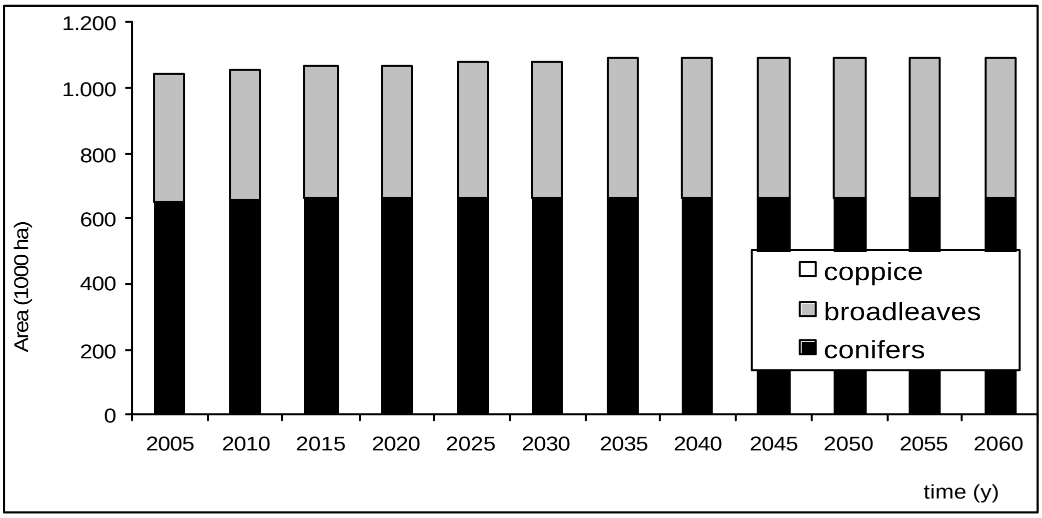


Figure 4.57 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom) [29]

[29] The supply data in the middle graph are given for the 1990s only because they are available only for after the break up of Yugoslavia.



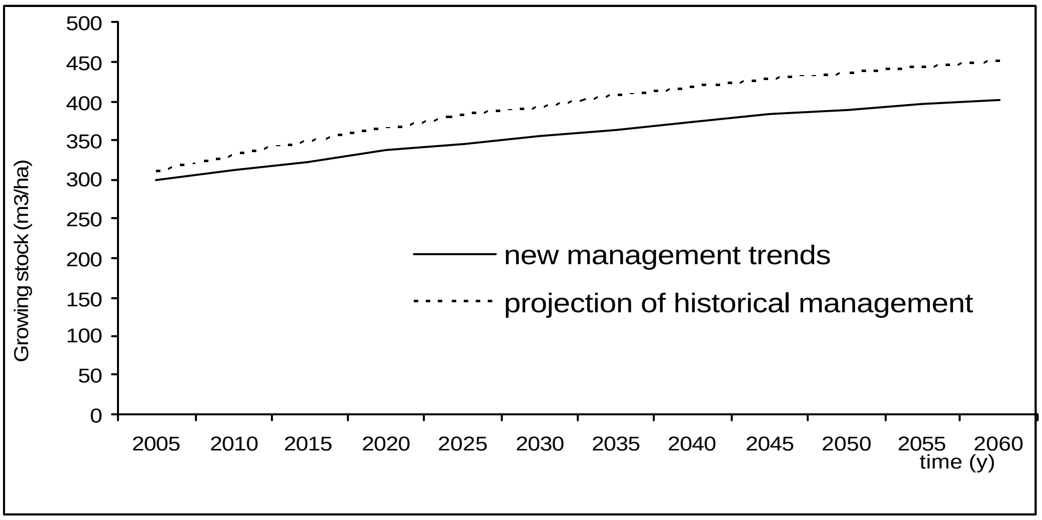


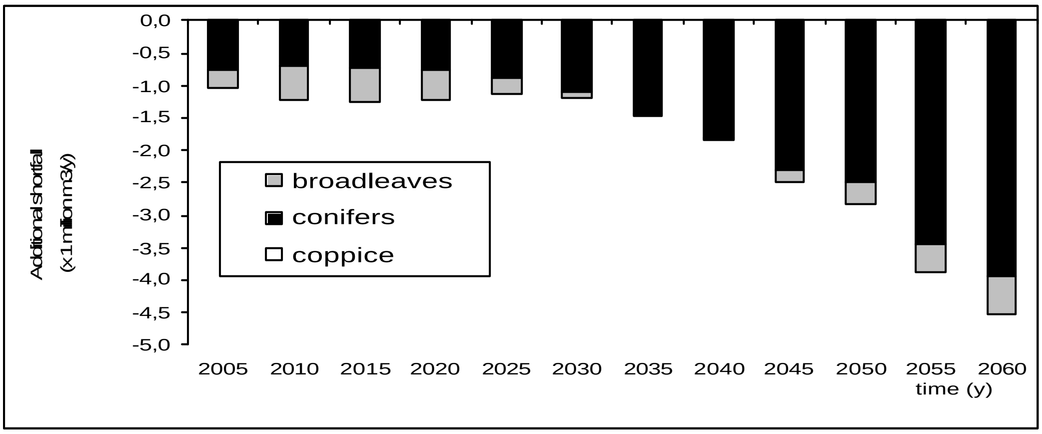
Figure 4.58. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)[30]

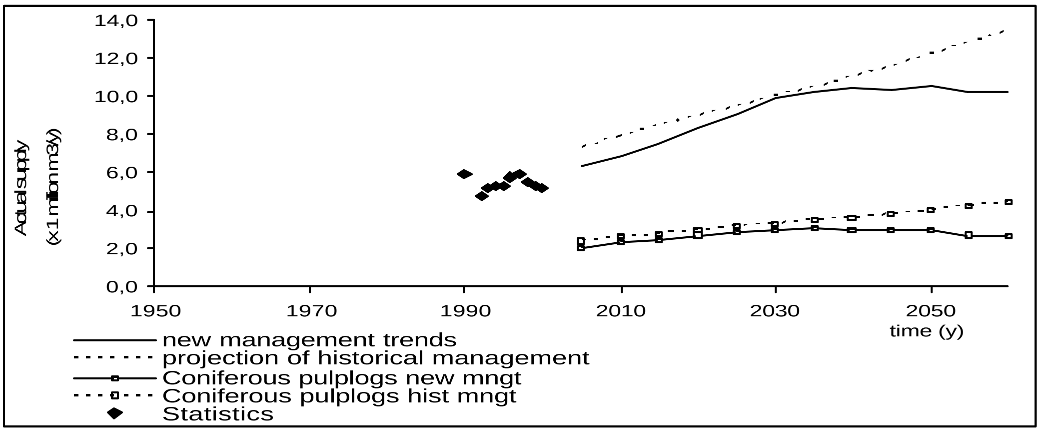
Table 4.28. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	1,046	1,057	1,079	1,090
Gross annual increment (m^3/ha/y o.b.)	6.2	6.1	6.1	6.1
Total additional shortfall (x million m^3/y o.b.)	0.0	0.0	0.0	0.0
Growing stock (m^3/ha o.b.)	299	311	357	402
Actual supply by all species (x million m^3/y)	2.4	2.6	3.6	4.8
Actual supply of conifer pulplogs (x million m^3/y)	0.9	1.0	1.3	1.7

[30] Slovenian input data contained a large proportion of 'mixed forests', these were rather arbitrarily allocated to coniferous forests, explaining the (too) large proportion of the latter tree species group.

4.31 Slovak Republic





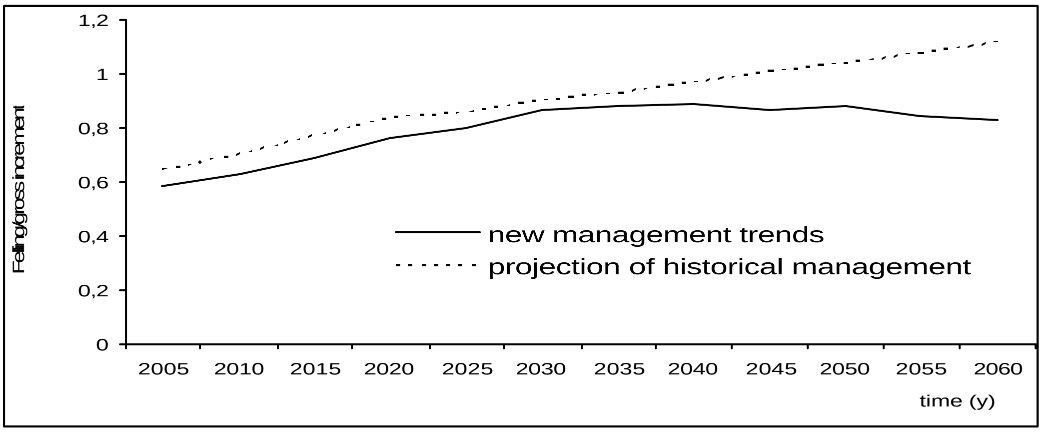
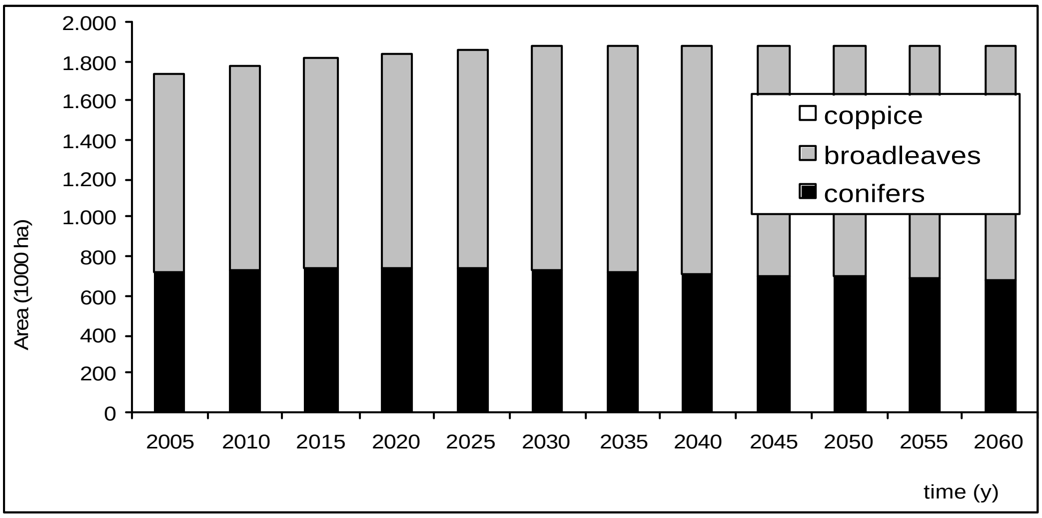


Figure 4.59 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom) [31]

[31] The supply statistics in the middle graph are given for the 1990s only because they are available for the Slovak forest area only after the break up of Czechoslovakia. These single year data often fluctuate more strongly.



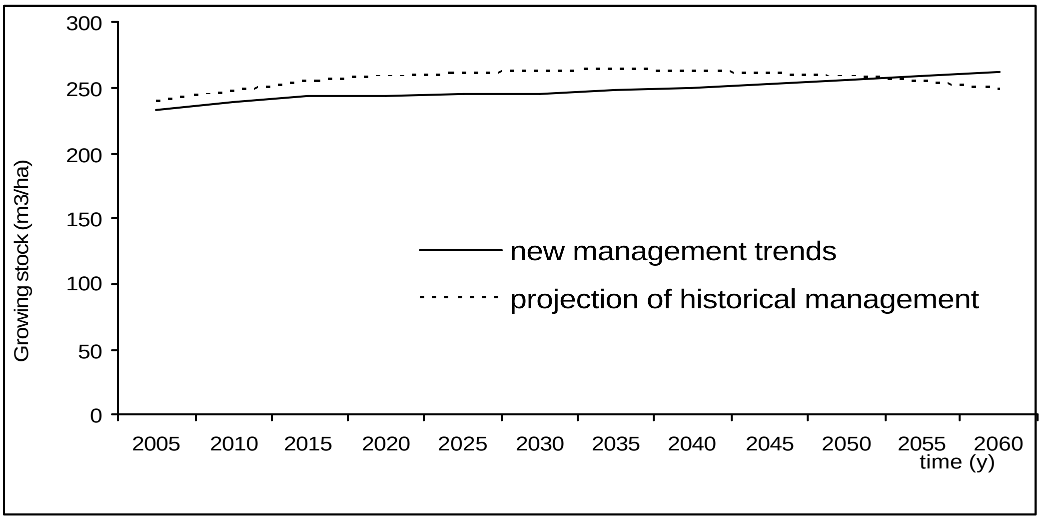


Figure 4.60. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.29. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	1,742	1,777	1,882	1,882
Gross annual increment (m^3/ha/y o.b.)	6.2	6.1	6.0	6.5
Total additional shortfall (x million m^3/y o.b.)	-1.0	-1.2	-1.2	-4.5
Growing stock (m^3/ha o.b.)	234	239	247	263
Actual supply by all species (x million m^3/y)	6.3	6.9	9.8	10.2
Actual supply of conifer pulplogs (x million m^3/y)	2.0	2.3	3.0	2.7

4.32 Spain

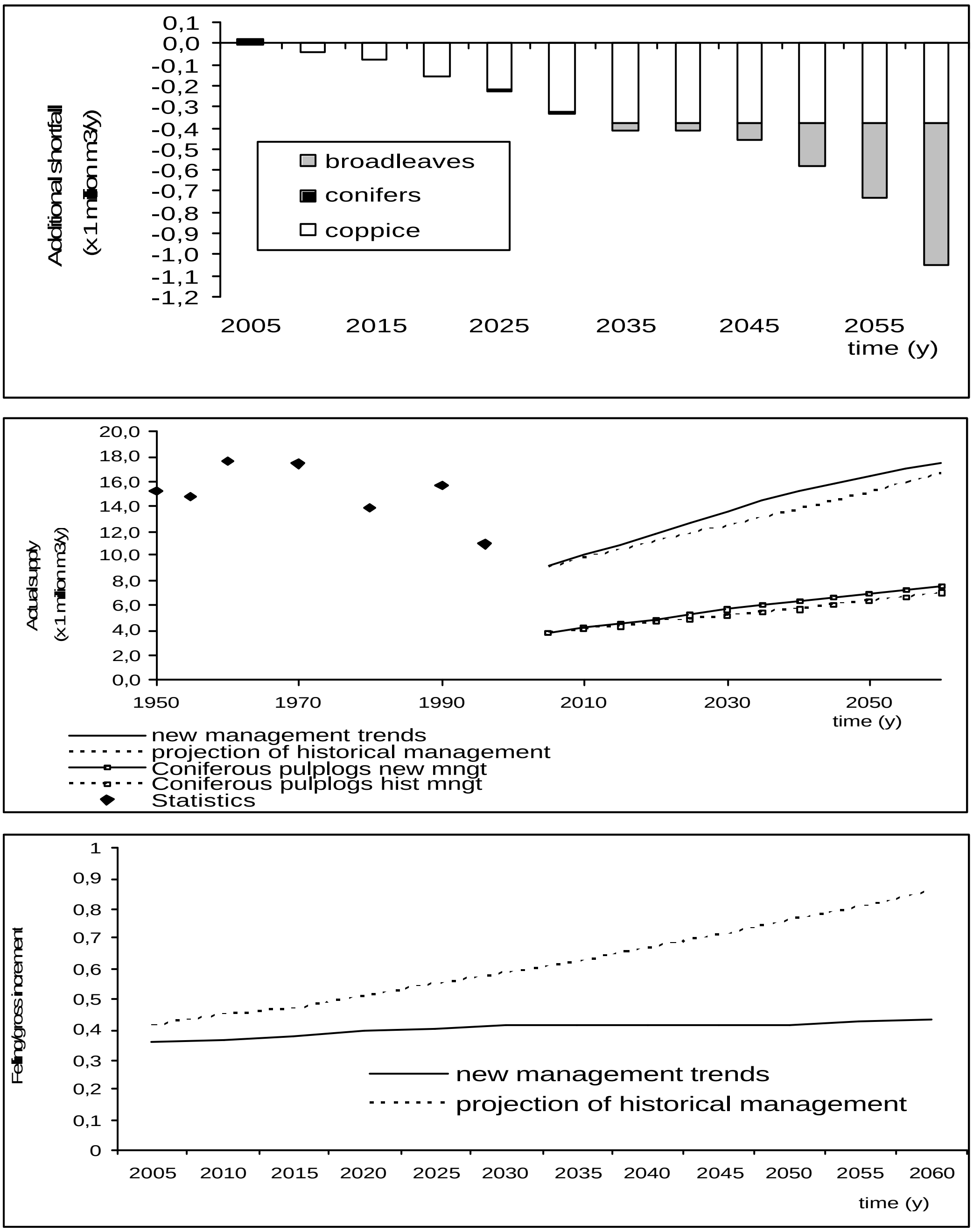
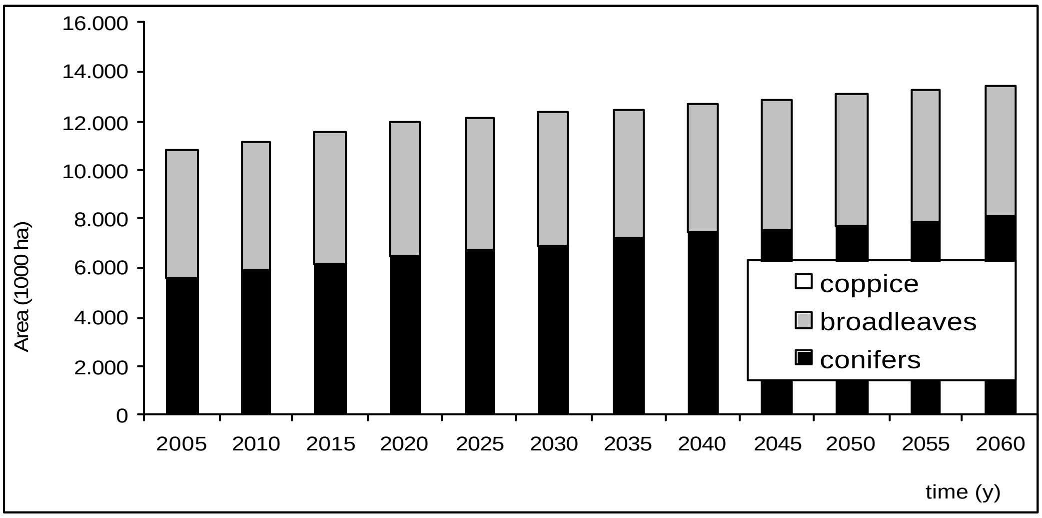


Figure 4.61 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)[32]

[32] The additional shortfall in the top graph is rather small because the absolute shortfall in the 'historical management' scenario amounted to 4.25 million m^3/y in 2060 already and because rather large afforestations take place in the 'new management trends'.



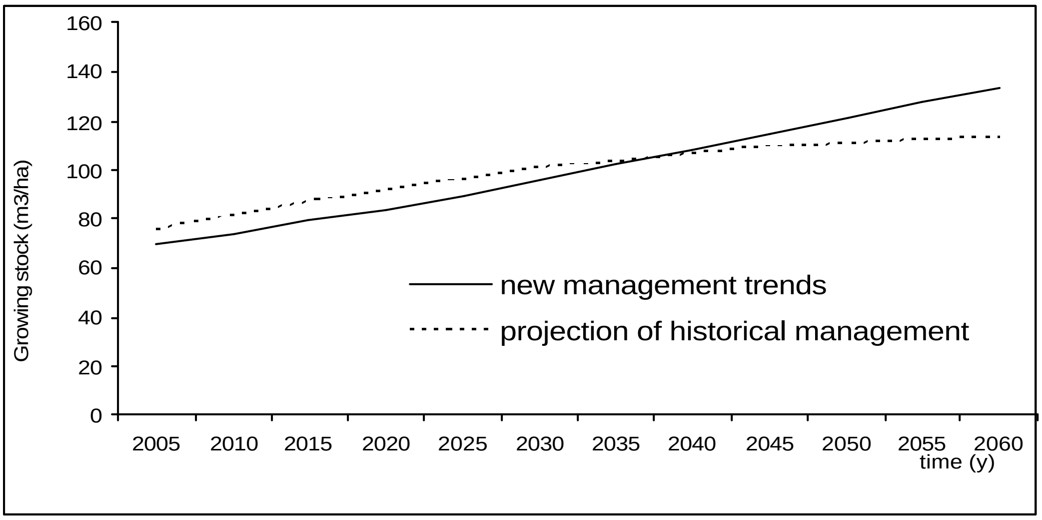


Figure 4.62. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.30. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	10,790	11,170	12,310	13,450
Gross annual increment (m^3/ha/y o.b.)	2.4	2.5	2.7	3.0
Total additional shortfall (x million m^3/y o.b.)	0.0	0.0	-0.3	-1.1
Growing stock (m^3/ha o.b.)	69	74	96	134
Actual supply by all species (x million m^3/y)	9.1	10.0	13.7	17.5
Actual supply of conifer pulplogs (x million m^3/y)	3.8	4.2	5.7	7.6

4.33 Sweden

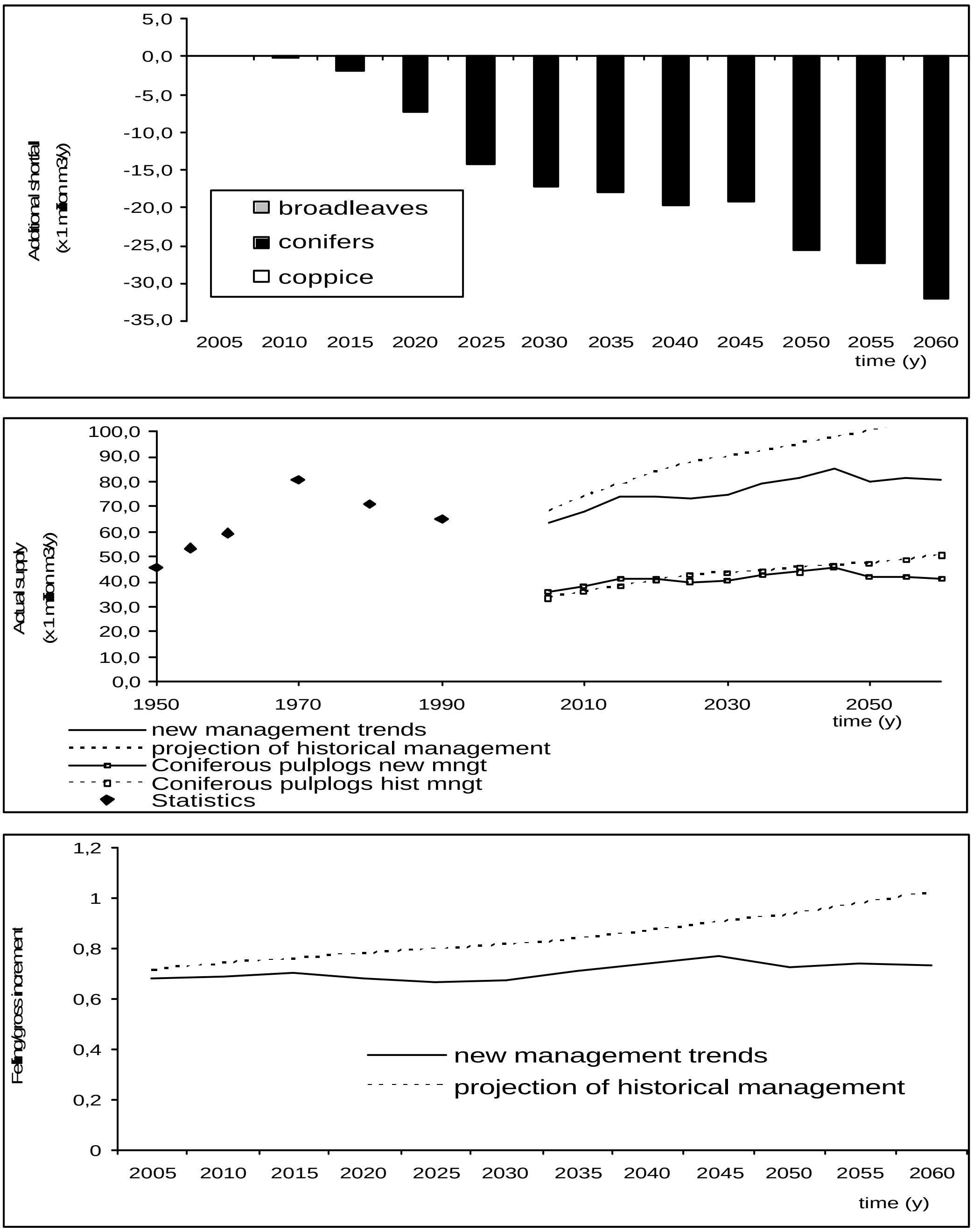


Figure 4.63 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)

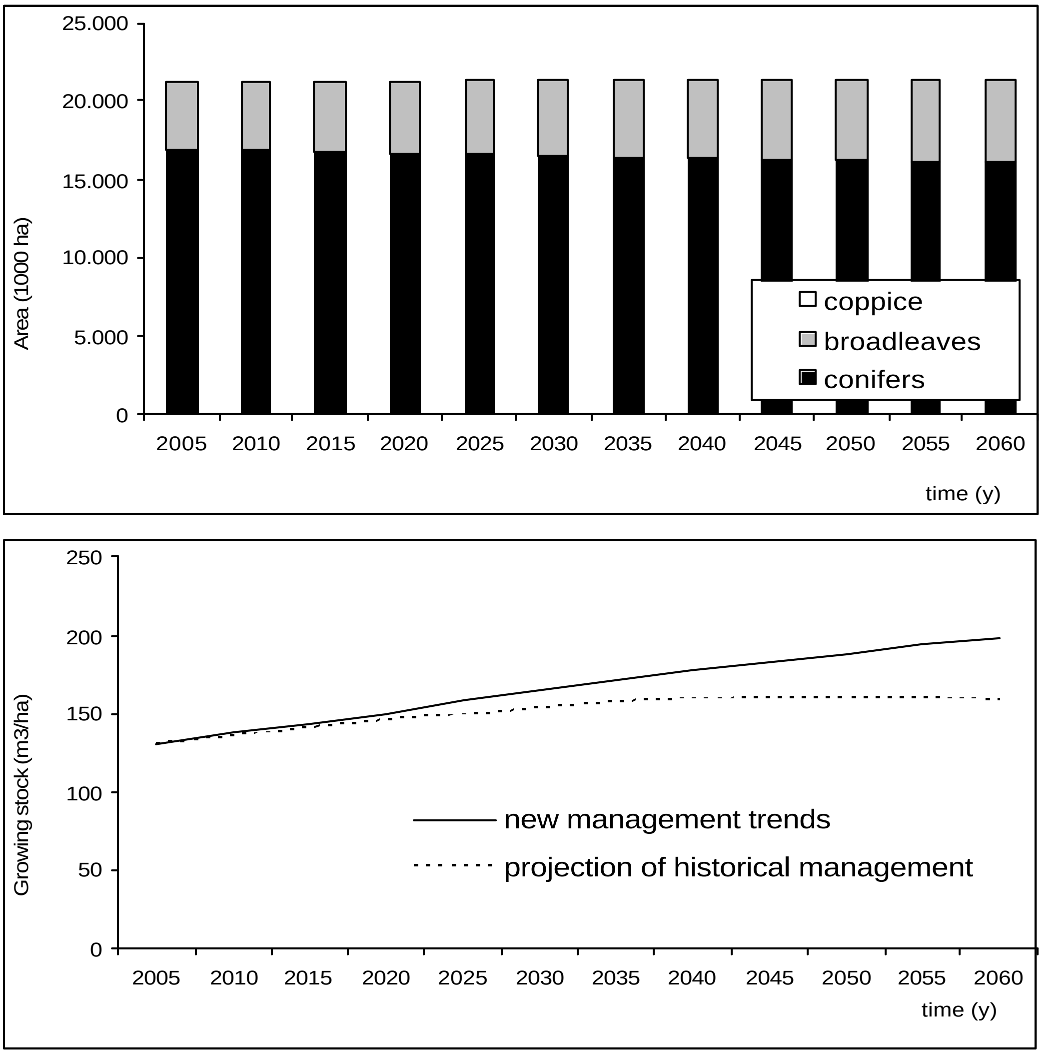


Figure 4.64. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.31. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	21,242	21,245	21,263	21,299
Gross annual increment (m^3/ha/y o.b.)	4.4	4.7	5.2	5.1
Total additional shortfall (x million m^3/y o.b.)	0.0	-0.1	-17.4	-32.1
Growing stock (m^3/ha o.b.)	131	137	166	199
Actual supply by all species (x million m^3 m^3/y)	63.7	68.5	74.7	80.4
Actual supply of conifer pulplogs (x million m^3/y)	35.9	38.6	40.3	40.9

4.34 Switzerland

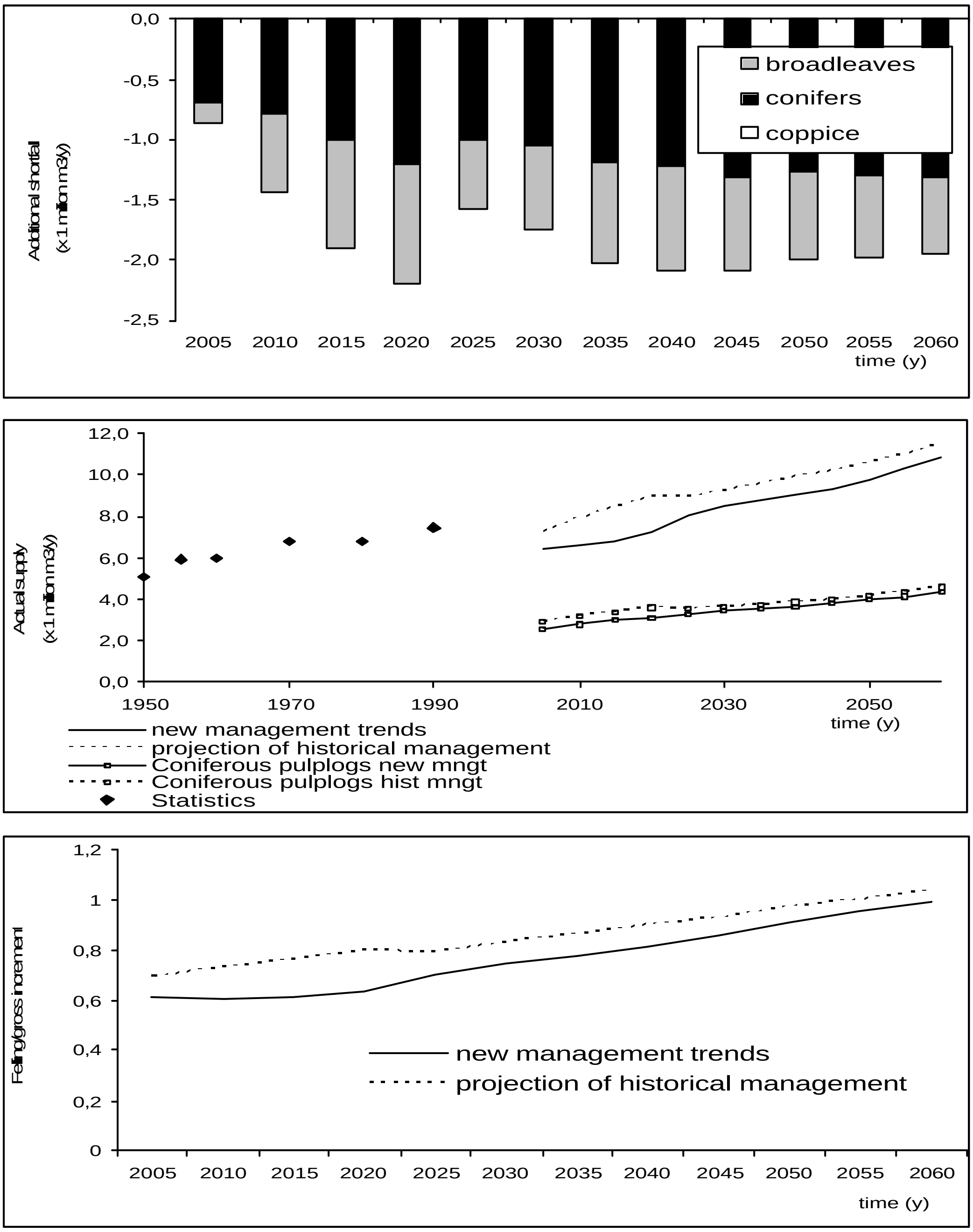
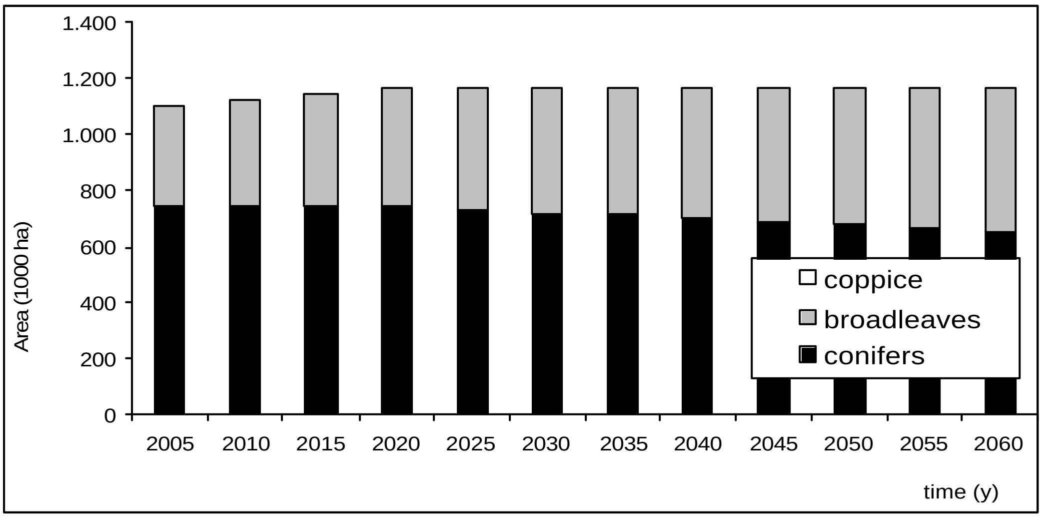


Figure 4.65 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)



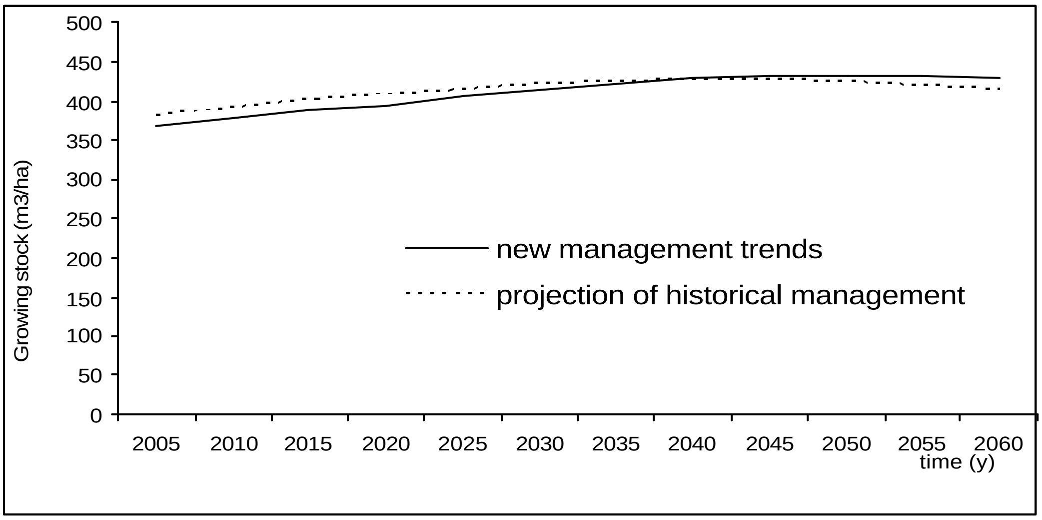


Figure 4.66. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.32. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	1,103	1,124	1,167	1,167
Gross annual increment (m^3/ha/y o.b.)	9.6	9.7	9.8	9.3
Total additional shortfall (x million m^3/y o.b.)	-0.9	-1.4	-1.7	-2.0
Growing stock (m^3/ha o.b.)	369	378	415	429
Actual supply by all species (x million m^3/y)	6.5	6.6	8.5	10.8
Actual supply of conifer pulplogs (x million m^3/y)	2.6	2.8	3.5	4.4

4.35 Turkey

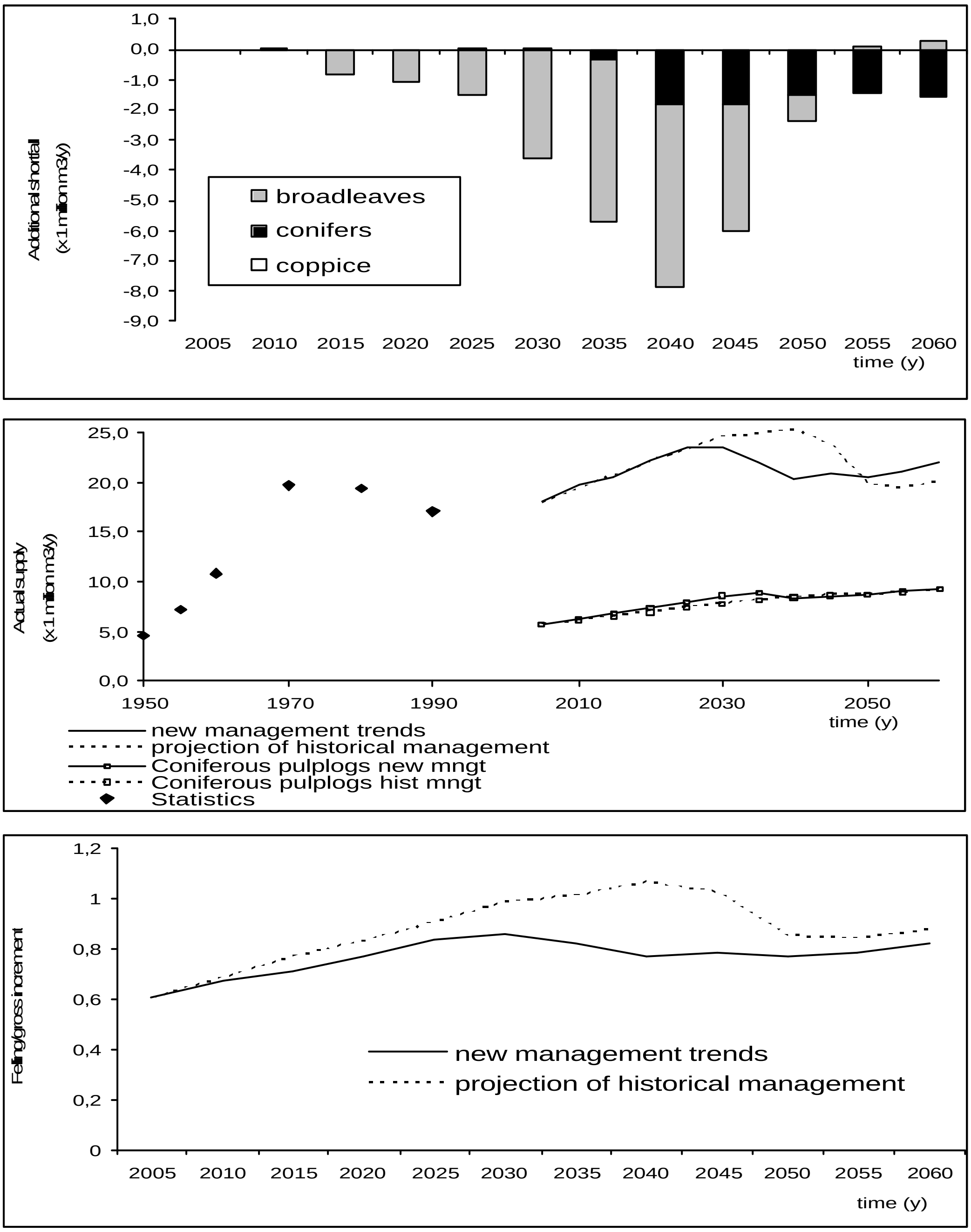
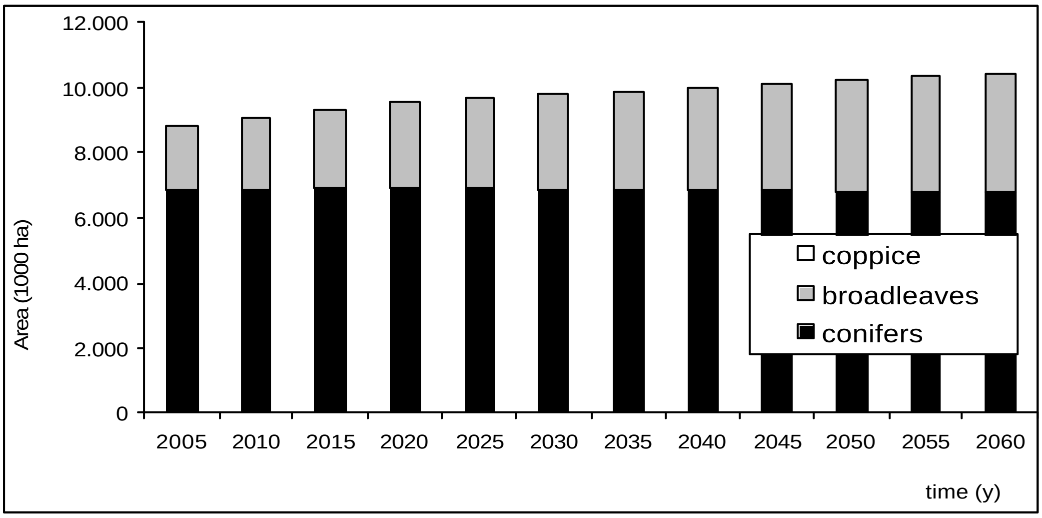


Figure 4.67 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)[33]

[33] The additional shortfall in the top graph shows a peak in shortfall because the absolute shortfall in the 'historical management' scenario is large towards the end of the simulation (13 million m^3/y in 2060).



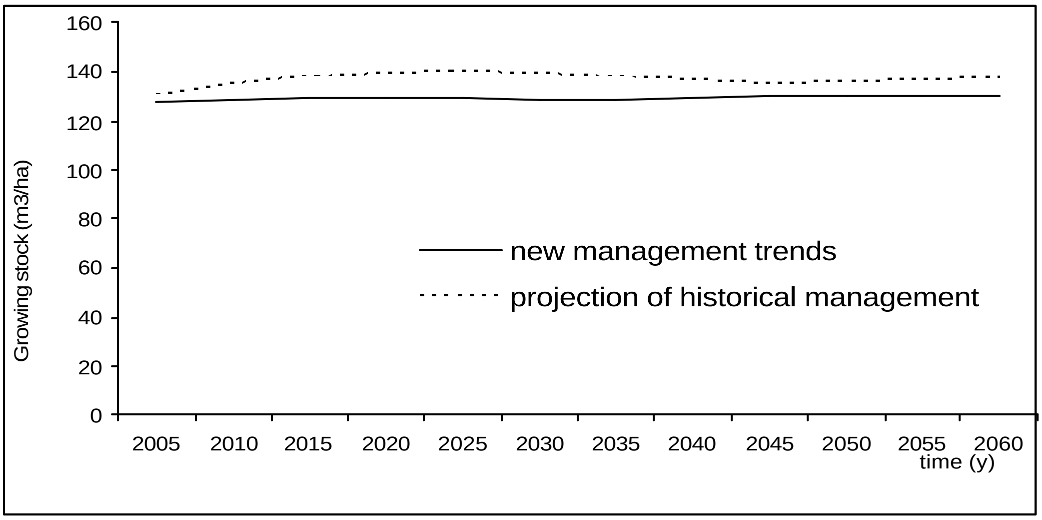


Figure 4.68. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.33. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	8,867	9,097	9,787	10,477
Gross annual increment ($m^3/ha/y$ o.b.)	3.3	3.2	2.8	2.5
Total additional shortfall (x million m^3/y o.b.)	0.0	0.0	-3.5	-1.3
Growing stock (m^3/ha o.b.)	128	129	129	130
Actual supply by all species (x million m^3/y)	18.0	19.8	23.6	21.9
Actual supply of conifer pulplogs (x million m^3/y)	5.7	6.3	8.6	9.4

4.36 United Kingdom

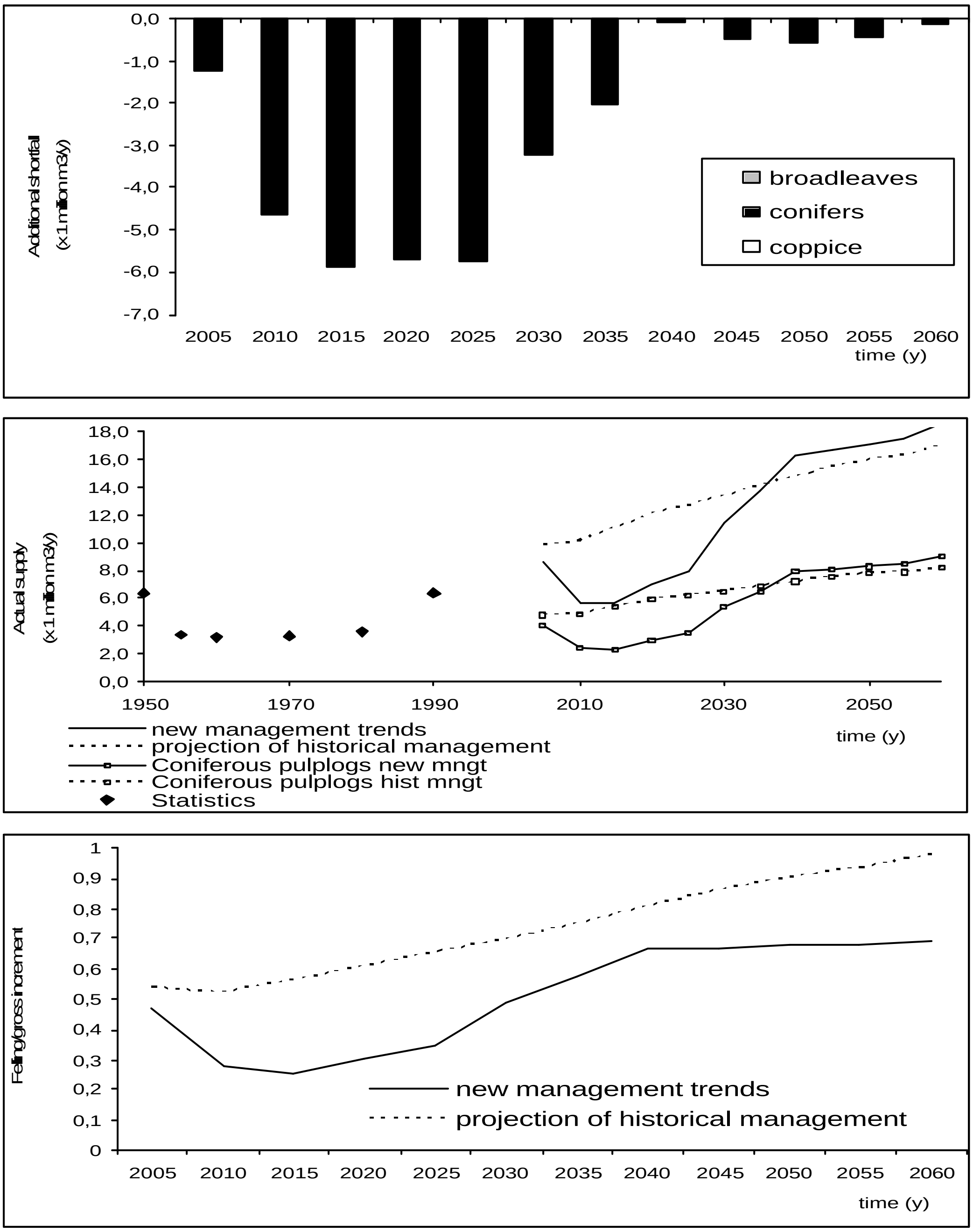
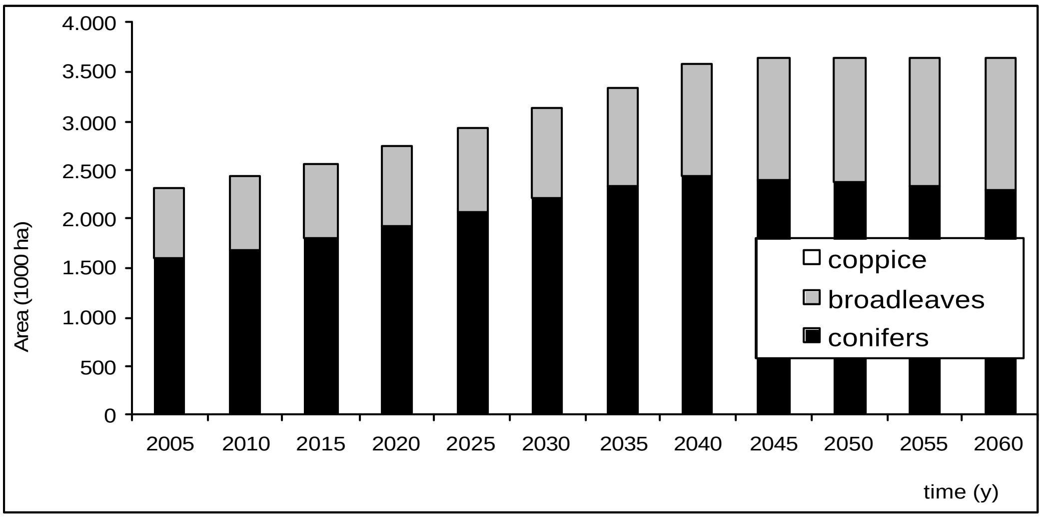


Figure 4.69 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)[34]

[34] A strong decrease in felling in the new management scenario as seen here for the UK is the result of a skewed age class distribution.



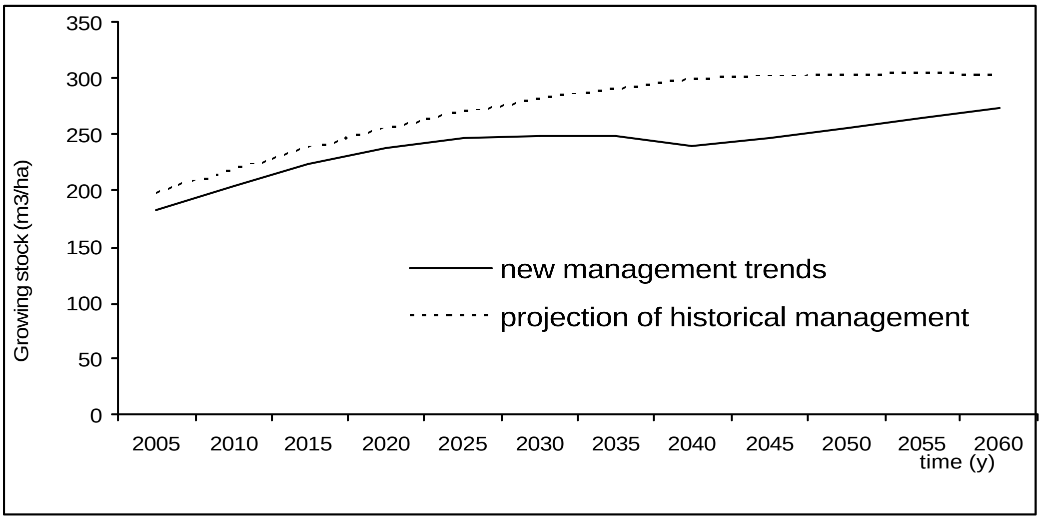


Figure 4.70. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.34. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	2,318	2,433	3,133	3,658
Gross annual increment (m^3/ha/y o.b.)	7.9	8.3	7.5	7.3
Total additional shortfall (x million m^3/y o.b.)	-1.2	-4.6	-3.2	-0.1
Growing stock (m^3/ha o.b.)	184	204	249	274
Actual supply by all species (x million m^3/y)	8.6	5.6	11.5	18.5
Actual supply of conifer pulplogs (x million m^3/y)	4.1	2.4	5.4	9.0

4.37 Ukraine

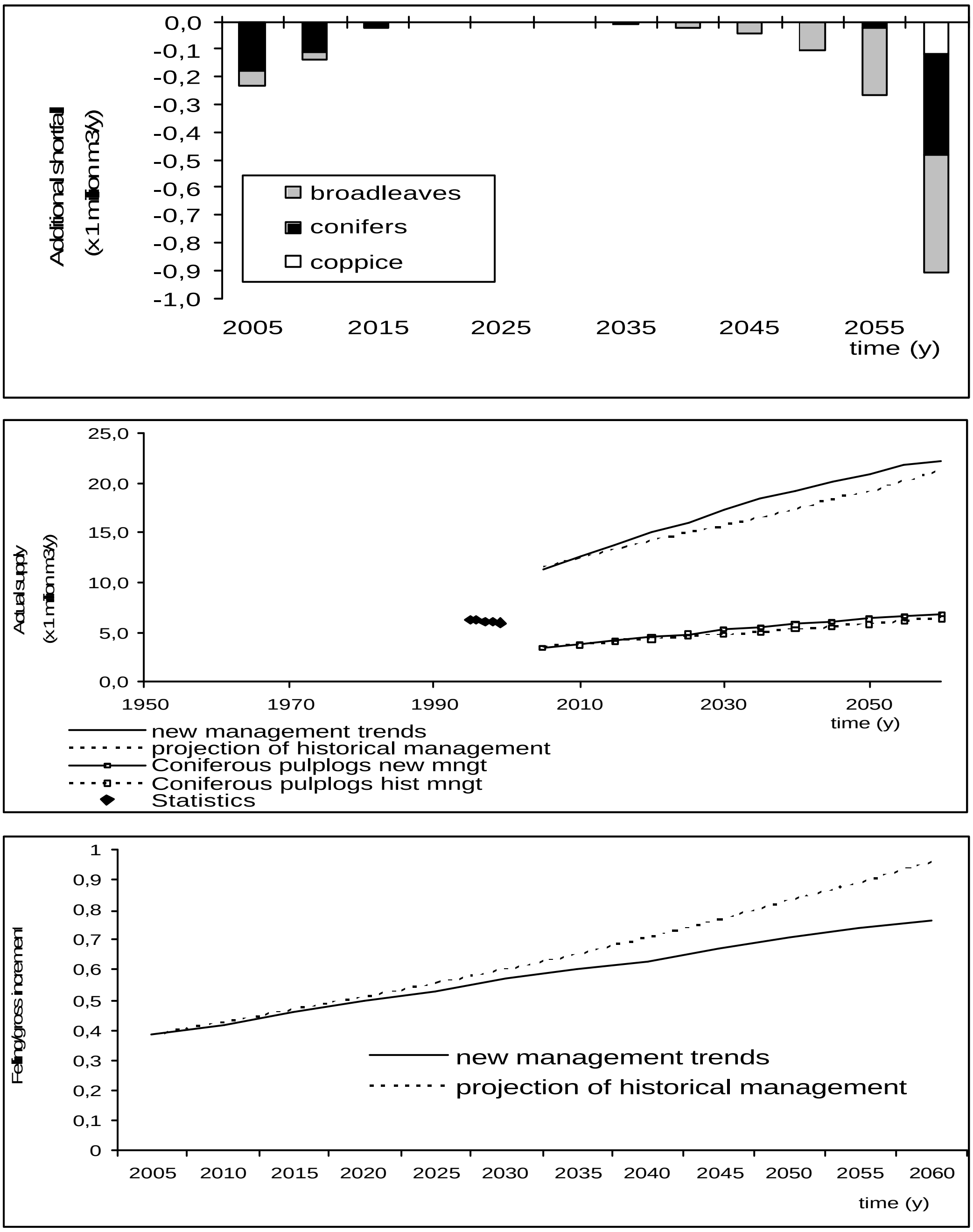
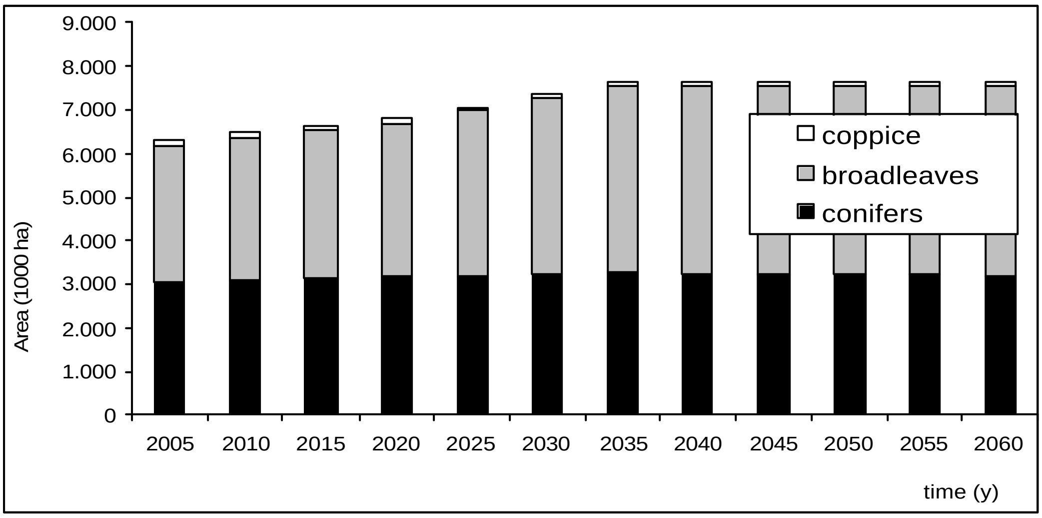


Figure 4.71. Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom) [35]

[35] The supply statistics in the middle graph are given for the 1990s only because they are available only for after the break up of the Soviet Union.



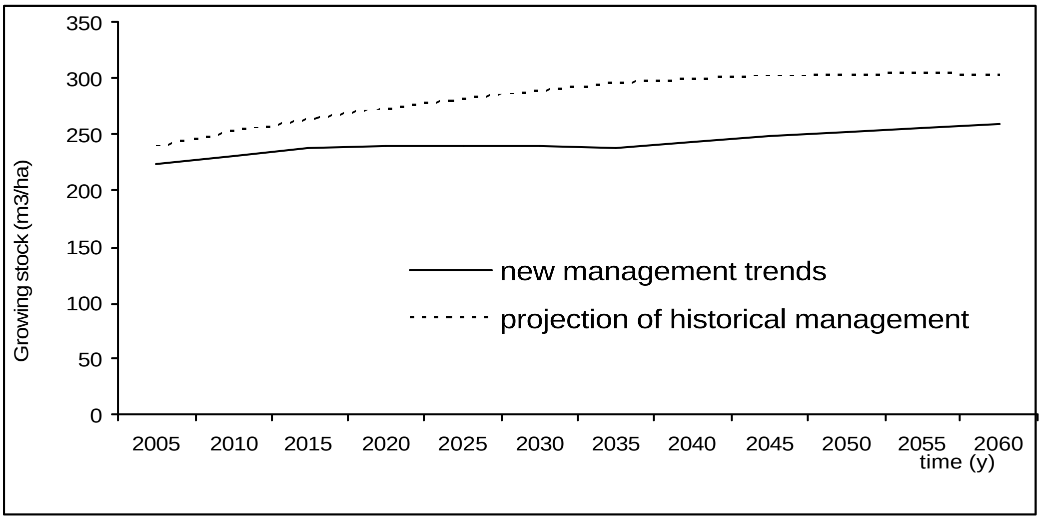


Figure 4.72. Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table 4.35. Main output for the 'new management trends' scenario

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	6,317	6,477	7,357	7,637
Gross annual increment (m^3/ha/y o.b.)	4.7	4.6	4.1	3.8
Total additional shortfall (x million m^3/y o.b.)	-0.2	-0.1	0.0	-0.9
Growing stock (m^3/ha o.b.)	225	232	239	259
Actual supply by all species (x million m^3/y)	11.4	12.6	17.4	22.2
Actual supply of conifer pulplogs (x million m^3/y)	3.4	3.8	5.3	6.8

5 Group totals

5.1 European totals, excluding Russia

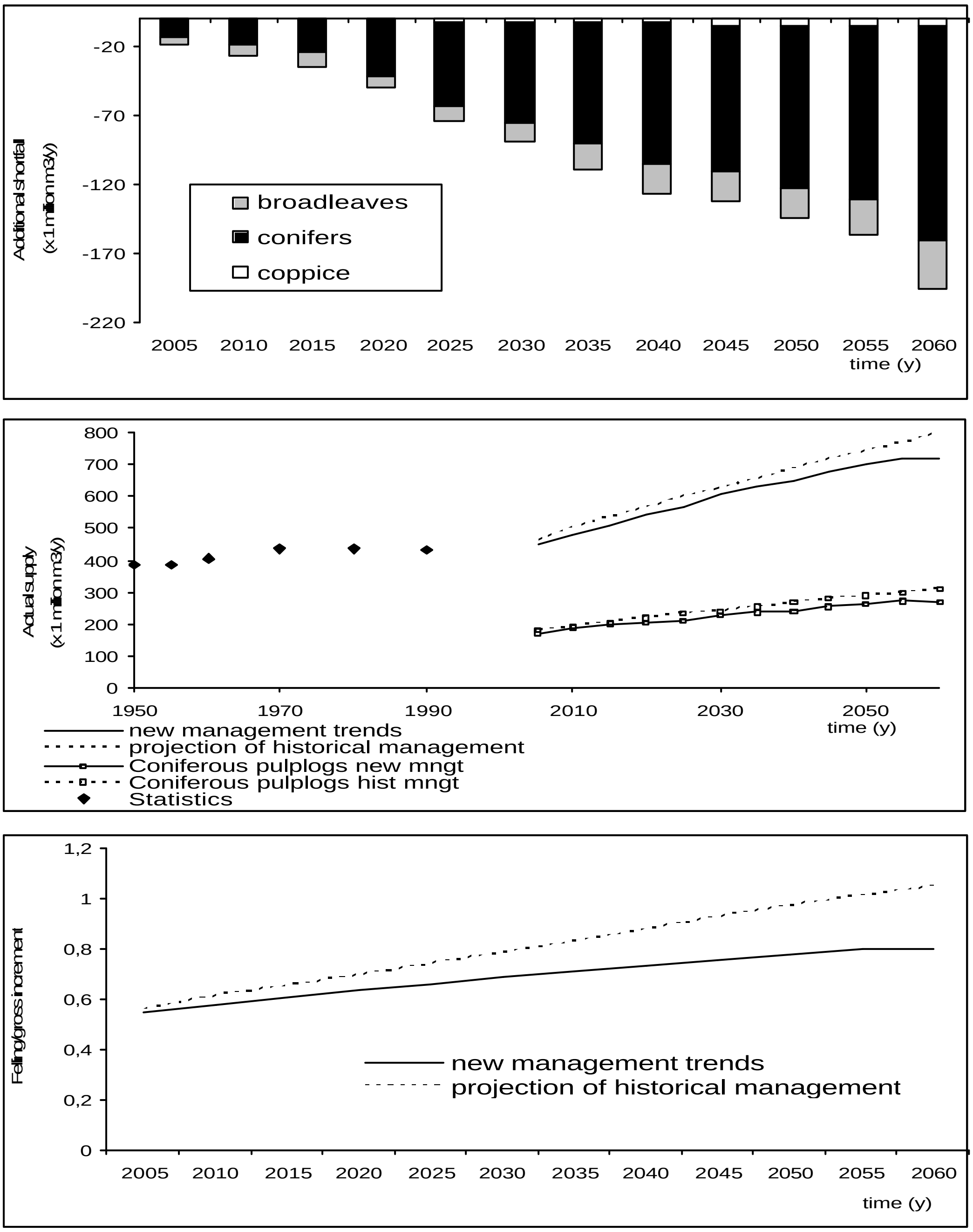
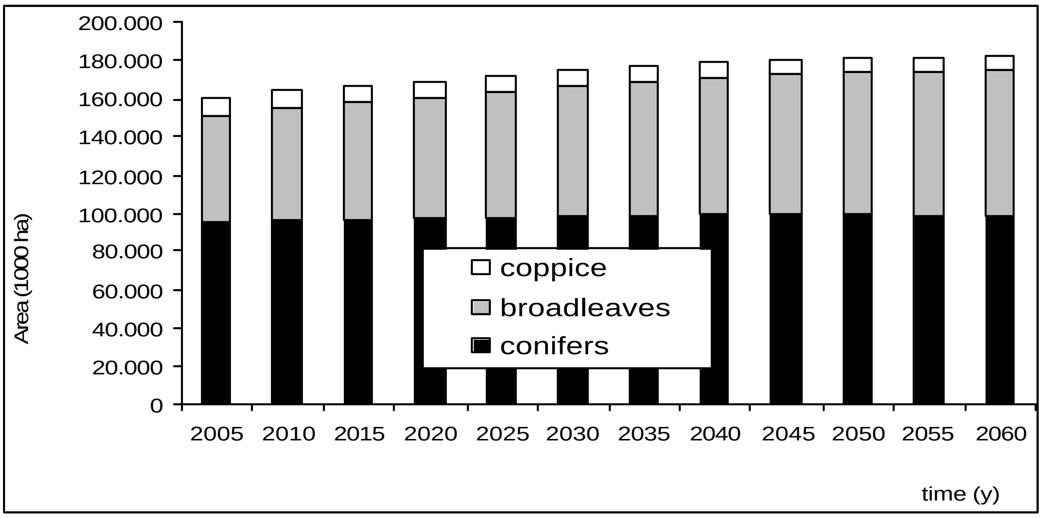


Fig 5.1 Projected additional theoretical shortfall in supply for all commodities under 'new management trends' scenario (top), total supply ceiling and coniferous pulplogs supply ceiling for the two scenarios (middle), and felling:increment ratio for the two scenarios (bottom)



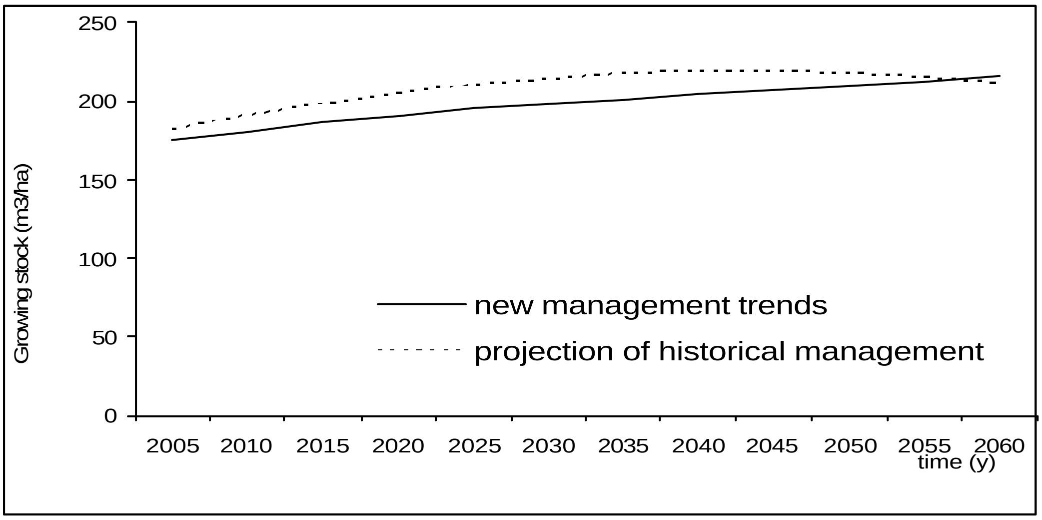


Fig.5.2 Area by main species group under 'new management trends' scenario (top), and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table:5.1. Main output under 'new management trends' scenario for all European countries excluding the European part of Russia

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	160,653	164,037	174,950	182,076
Gross annual increment (m^3/ha/y o.b.)	5.05	5.07	4.98	4.95
Total additional shortfall (x million m^3/y o.b.)	-17.71	-27.32	-89.18	-195.14
Growing stock (m^3/ha o.b.)	174.7	180.6	198.5	215.8
Actual supply by all species (x million m^3/y)	448.04	479.07	603.77	718.52
Actual supply of conifer pulplogs (x million m^3/y)	174.10	186.06	227.24	270.04

5.2 European totals, including Russia

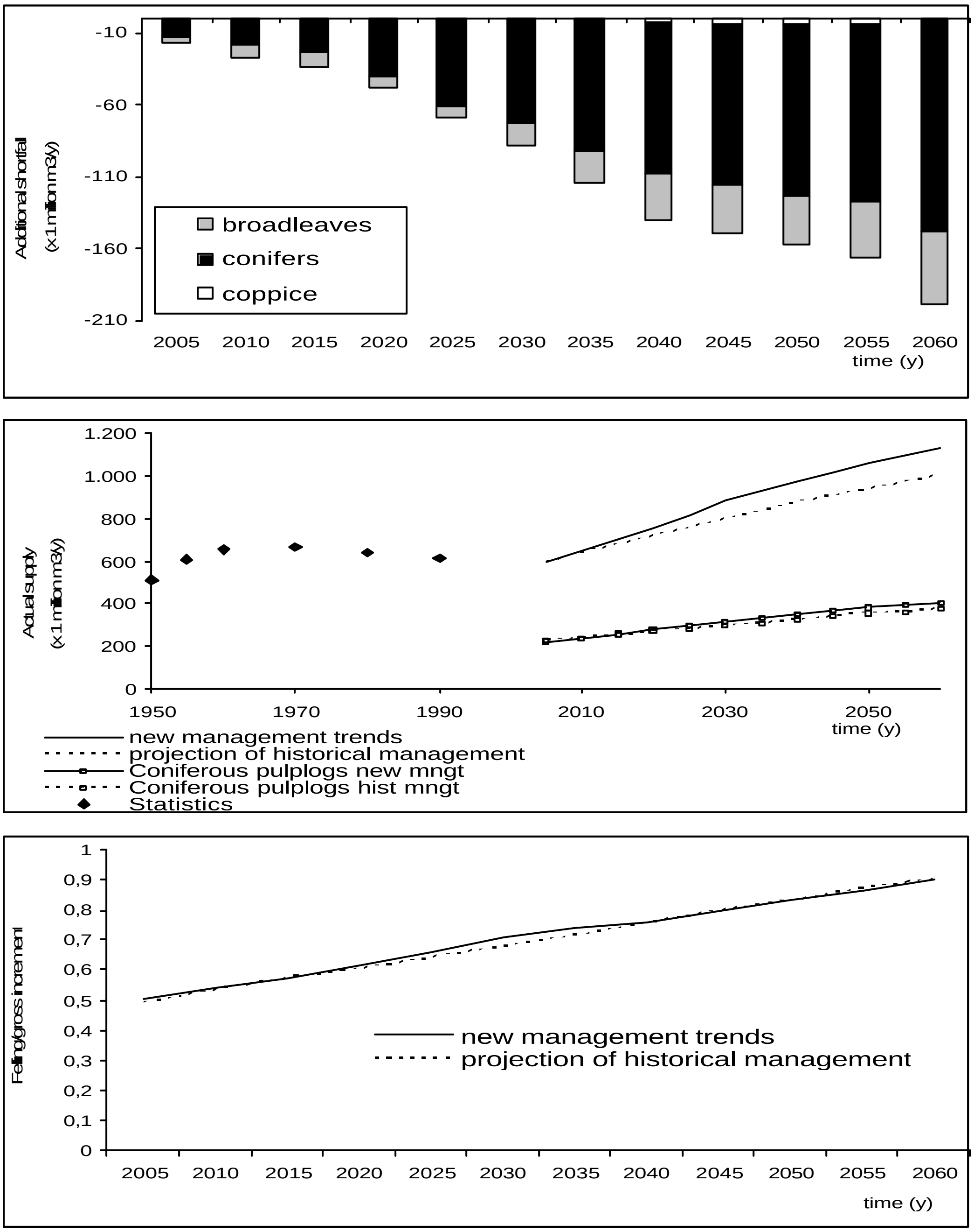
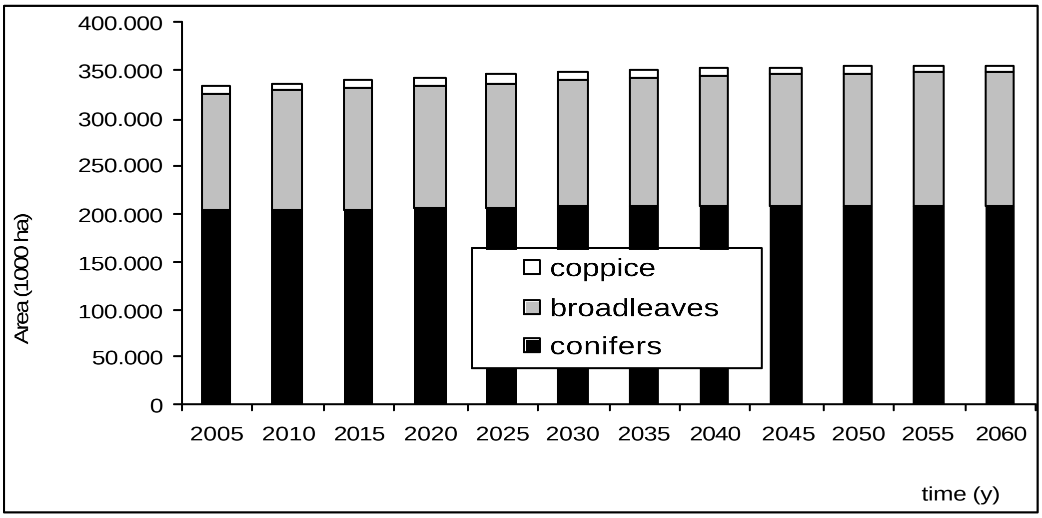


Fig 5.3 Projected additional theoretical shortfall in supply for all commodities under 'new management trends' scenario (top), total supply ceiling and coniferous pulplogs supply ceiling for the two scenarios (middle), felling:increment ratio for the two scenarios (bottom)



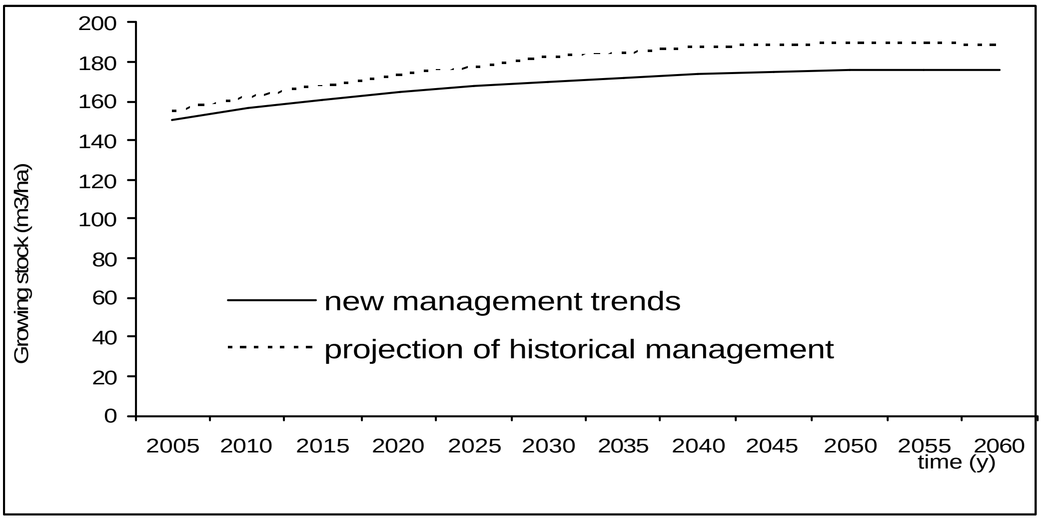


Fig.5.4. Area by main species group under 'new management trends' scenario (top) and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table:5.2. Main output under 'new management trends' scenario for all European countries including the European part of Russia

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	333,842	337,225	348,136	355,260
Gross annual increment (m^3/ha/y o.b.)	3.56	3.56	3.59	3.53
Total additional shortfall (x million m^3/y o.b.)	-17.2	-27.2	-87.5	-201.6
Growing stock (m^3/ha o.b.)	151	156.1	170.1	175.1
Actual supply by all species (x million m^3/y)	596.9	646.6	885.5	1,125.9
Actual supply of conifer pulplogs (x million m^3/y)	222.4	240.5	318.0	402.2

5.3 EU15 plus EFTA[36]

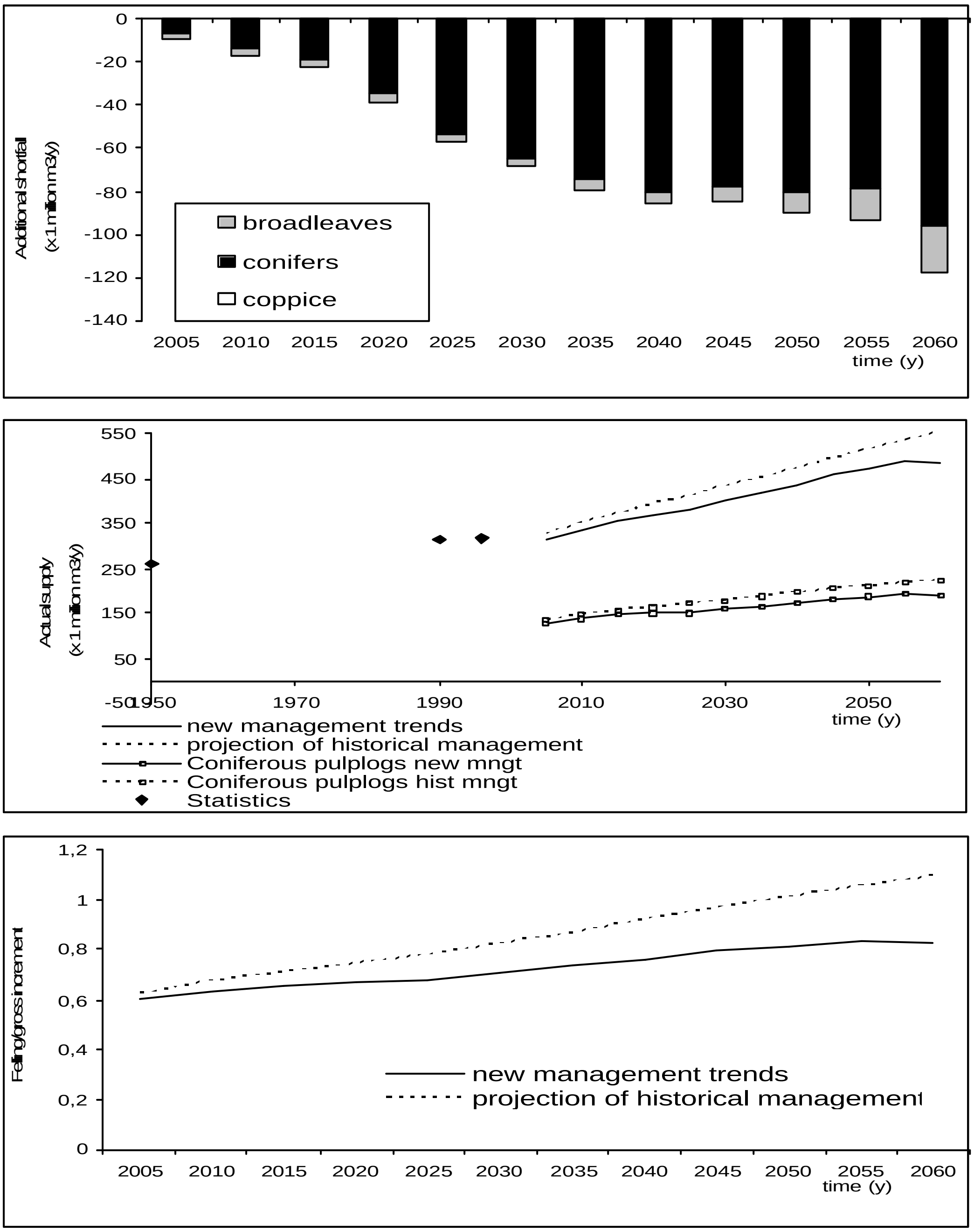


Figure 5.5 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)

[36] European Community and European Free Trade Association States: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and the United Kingdom

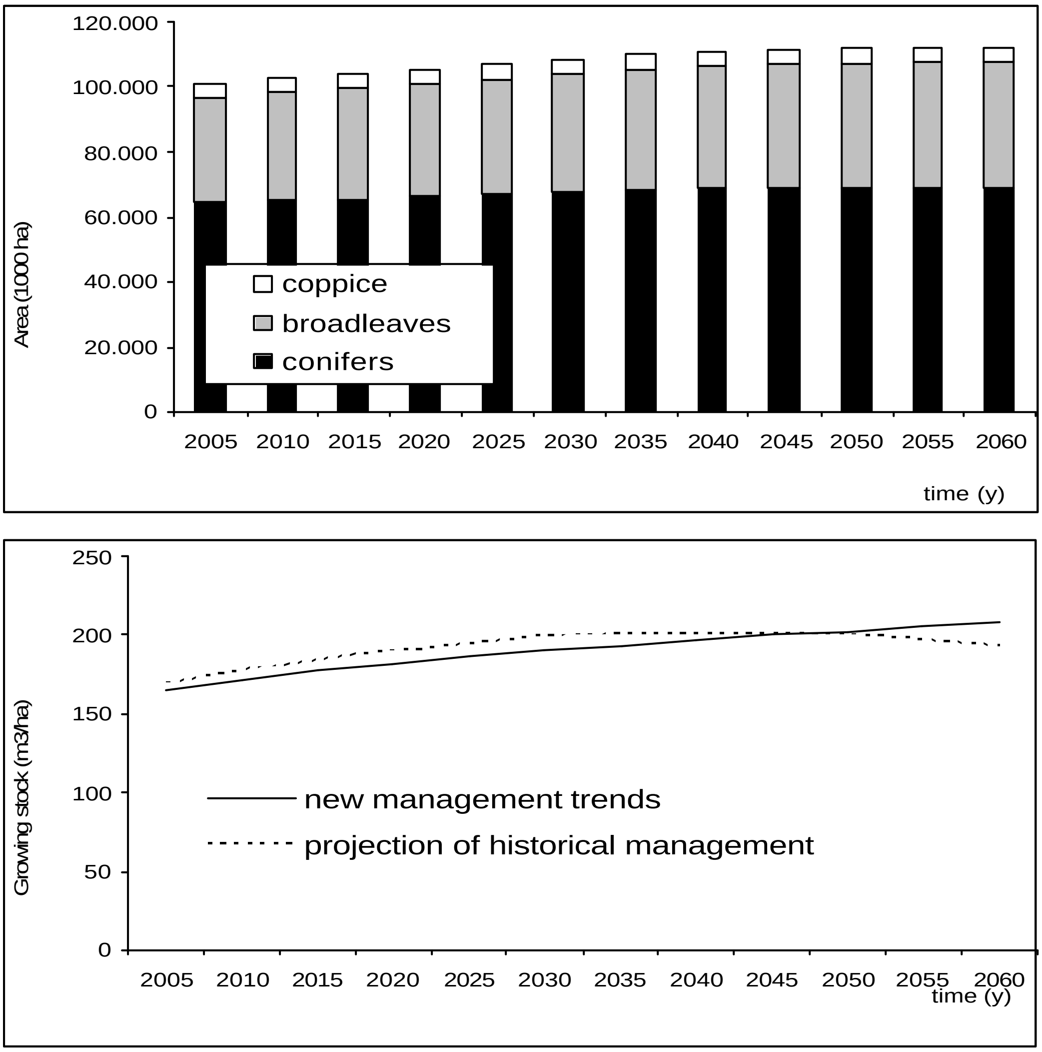


Fig.5.6. Area by main species group under 'new management trends' scenario (top) and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table:5.3. Main output under 'new management trends' scenario for the EU15 plus EFTA countries

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	101,438	102,759	108,670	112,527
Gross annual increment (m^3/ha/y o.b.)	5.09	5.15	5.18	5.23
Total additional shortfall (x million m^3/y o.b.)	-9.2	-17.2	-68.9	-117.8
Growing stock (m^3/ha o.b.)	165	171.4	190.5	208.4
Actual supply by all species (x million m^3/y)	311.9	333.8	400.6	484.3
Actual supply of conifer pulplogs (x million m^3/y)	129.3	137.9	157.8	190.9

5.4 New Accession countries[37]

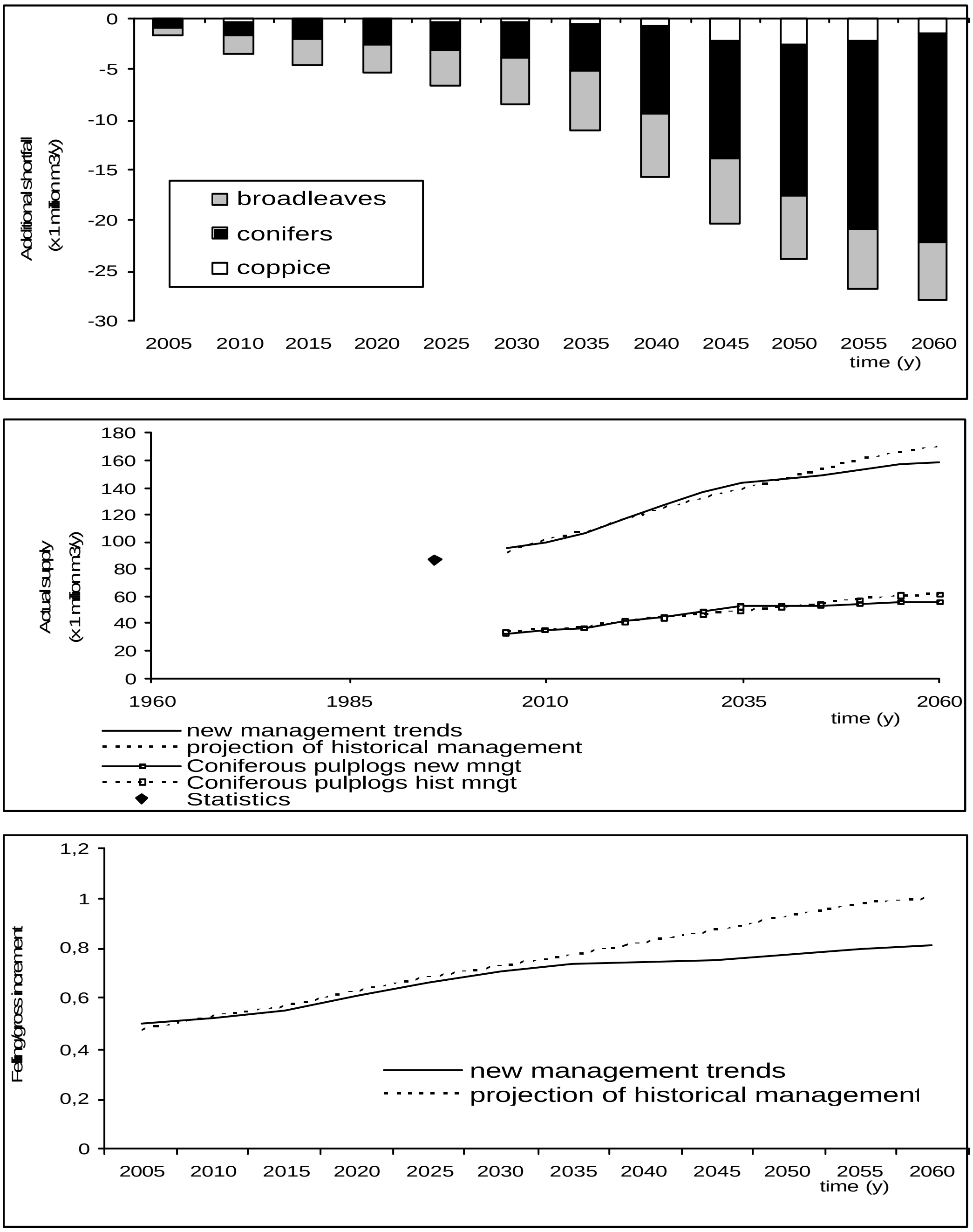


Figure 5.7 Projected additional theoretical shortfall in supply of roundwood for all commodities under 'new management trends' scenario (top), total actual supply and coniferous pulplogs supply for the two scenarios (middle), felling/increment ratio for the two scenarios (bottom)

[37] New-Accession countries: included here are: Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, The Slovak Republic, and Slovenia

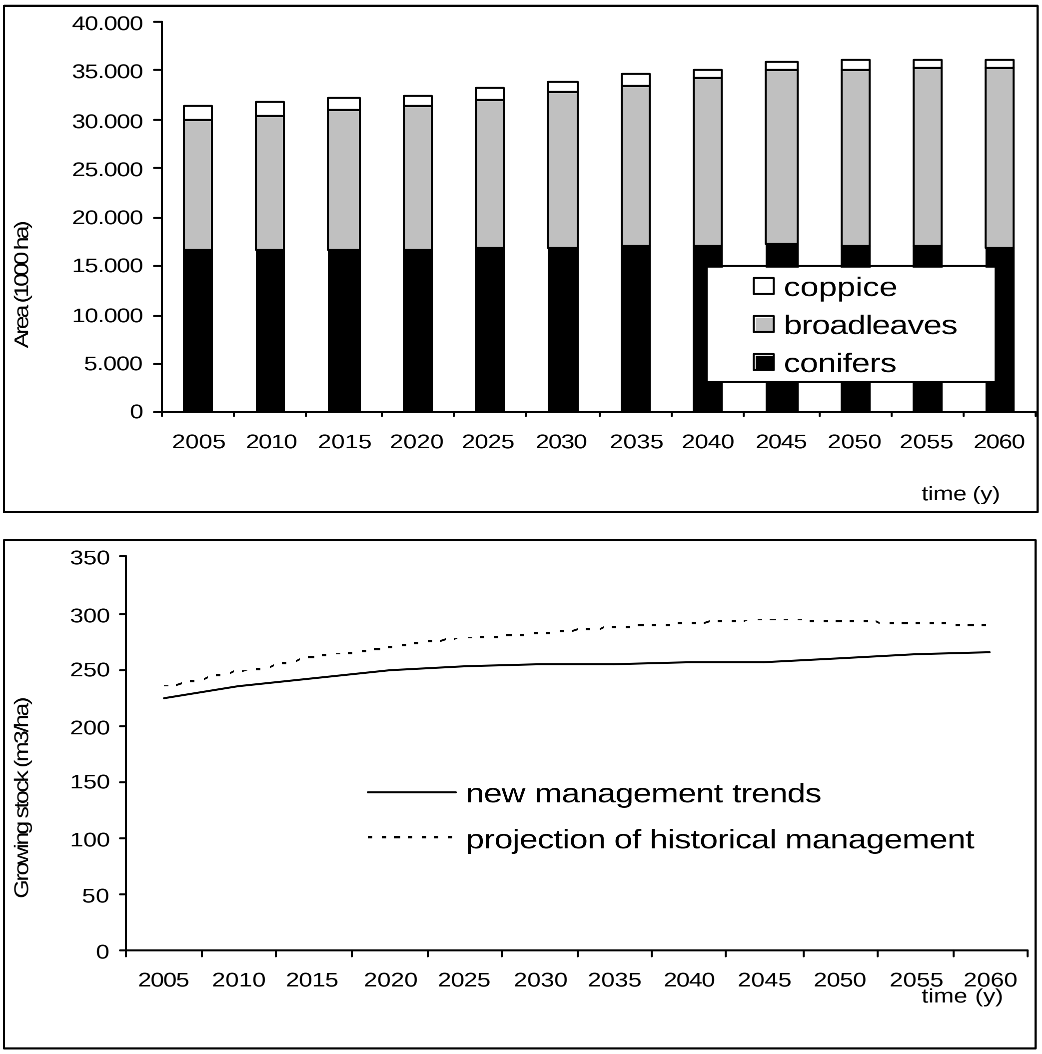


Fig.5.8. Area by main species group under 'new management trends' scenario (top) and average stemwood growing stock of all tree species for the two scenarios (bottom)

Table: 5.4. Main output under 'new management trends' scenario for the new accession countries

	2005	2010	2030	2060
Forest area in simulation (x 1000 ha)	31,301	31,759	33,942	36,206
Gross annual increment (m^3/ha/y o.b.)	6.0	6.0	5.7	5.4
Total additional shortfall (x million m^3/y o.b.)	-1.6	-3.5	-8.5	-27.9
Growing stock (m^3/ha o.b.)	225	234	255	266
Actual supply by all species (x million m^3/y)	94.7	99.3	136.4	159.2
Actual supply of conifer pulplogs (x million m^3/y)	33.7	35.2	49.6	56.0

6 Discussion

6.1 A reflection on the results

In this study it was tested if and how a demand increase for certain wood products can be met by alternative management regimes of European forests. A baseline management regime was assumed to reflect management of forests in Europe in the nineteen-eighties (‘projection of historical management’). The ‘new management trends’ scenario incorporated the influence on forest management of issues such as: 1) nature-oriented management, 2) carbon credits and 3) additional demand for bio-energy.

The assumptions made under the ‘new management trends’ scenario result in an increasing theoretical shortfall in the supply of roundwood in Europe. This additional[38] theoretical shortfall amounts to 195 million m^3 of roundwood per year in 2060 for the whole of Europe excluding Russia. Looking at individual countries the gradual trend can differ considerably. A large shortfall (large in relation to supply and apparent during almost the whole simulated period) was found for the countries: Austria, Belgium, Bulgaria, Belarus, Croatia, the Czech Republic, Finland, France, Germany, Hungary, Macedonia, the Netherlands, Norway, Poland, Portugal, Slovakia, Sweden and Switzerland. Usually the shortfall is minimal at the beginning of the simulated period and then gradually increases. This is caused by the combination of a growth in demand and tightening of constraints through time (e.g. increasing the area of reserves). In countries with a gradual increase of the amplitude of the shortfall the reason may lie in the current existence of a large volume of available stock that is available for utilisation within the next few decades.

Other trends in shortfall occur through time as well (e.g. largest shortfall in the early periods of simulation or a short peak in shortfall). This occurs in Ireland, Italy, Latvia, Moldova, Slovenia, Turkey, the United Kingdom, the Ukraine, and Serbia and Montenegro. This is caused in the former case by a required maturing of the forest before it reaches harvestable ages and in some of the latter cases by a current asymmetrical age class distribution that allows future peaks in actual supply.

The forest area expansion of 22 million ha (half of it assumed to be a requirement of the Kyoto Protocol) as incorporated in the new management trend scenario between 1995 and 2060 did not visibly reduce the additional shortfall within the studied time frame. This is partly caused by the fact that more than half of the afforestations were carried out with species that are managed in a long rotation period. Thus, any significant wood production from these new forest areas can only be expected 60 to 80 years after afforestation. Another reason why these new areas do not show a visible impact, is that they only compensate for the loss of forest available for wood

[38] i.e. additional to any shortfall that may have occurred under the ‘projection of historical management’ scenario

supply which is being set aside for other functions, e.g. protection purposes. Thus, without these new areas the shortfall may have been significantly larger [39].

Russia's inclusion did not compensate for the additional shortfall either. Including Russia in the projections (and thus taking into account Russia's own domestic demand increase) increased the additional shortfall by 6 million m^3 of roundwood per year at the end of the projection period. However, the uncertainty over Russian forest resources concerning, e.g. its future accessibility, the development of Russian domestic demand and the domestic industry, make it difficult to predict with reasonable certainty the trends in supply and shortfalls for this very large forest resource.

The projections also show that a large increase in absolute supply is still possible. Supply may rise to 718 million m^3/y (from the present 448 million m^3/y in the 36 countries subject to this study) for the whole of Europe (excl. Russia). For the EU15 plus EFTA countries it may rise to 484 million m^3/y by 2060 under the 'new management trends' scenario from the present 312 million m^3/y. This highlights the large biological potential of European forests, which is indicated by the growing stock increase which still occurs under this high actual supply. In parallel with this, the total growing stock in European forests (incl. the European part of Russia) increases from 51 billion m^3 in 2005 to 62 billion m^3 in 2060 under the 'new trends' scenario.

For the 'new management trends' the demand was set higher due to bio-energy demands. From the country graphs in chapter 4 it can be seen that the actual supply is often lower under the 'new management trends' than under the historical management. However, for sixteen countries this was not the case. The higher demand could be met (partly), even though the management regimes were tighter under this 'new management trends' scenario. These sixteen countries are Albania, Belarus, Denmark, Estonia, France, Germany, Ireland, Italy, Latvia, Lithuania, Moldova, Romania, Russia (management regimes were not tightened), Slovenia, Spain and the Ukraine.

Can we still refer to a shortfall with this large increase in supply still possible under the new management scenario? Based on the outcome of this study, we can. It is important to note that shortfall does not necessarily refer to shortfall below the present level of domestic roundwood supply. Here shortfall refers to the additional shortfall projected under the given set of assumptions. If demand and management develop as assumed then we can expect such a shortfall, even though it may never physically occur because of market or policy adaptations. The assumed increase in consumption of wood products of 3.4% for the first five years (2001-2005), 1.5% for the next 15 years (2006-2020) and 1% until 2060 may be rather high for the short-term, but is rather modest for the longer term. However, the linear translation of the assumptions on future roundwood consumption into a demand for fellings may be regarded as rather high. The past five decades have not shown this linear relation as a

[39] Note that this was not tested as such.

53% increase in consumption from 1964-2000 (to a small extent based on a net import by Europe) led to a 9% increase in fellings in Europe only. This non-linear relation was possible due to large processing efficiency gains, recycling gains, and increased imports during some periods. As no projections are available on future levels of processing efficiency and recycling, a linear relation between the assumed consumption increase and required fellings was adopted.

Furthermore, the assumptions on increase in wood consumption were adopted as a flat rate for all countries. This can be seen as too simple an assumption, but was adopted partly because of a lack of recent projections of wood products demand and also to avoid a detailed study of the wood market. Instead the flat rate is given and all theoretical shortfall quantification has to take into account these demand assumptions.

One can notice that the 'new management trends' lead to a lower supply (i.e. felling level) than the past management scenario in most countries. One would therefore expect the growing stock to rise higher under the new management scenario in comparison to the historical management scenario. However, the contrary is visible for Belarus, Hungary, the Slovak Republic, Spain and the United Kingdom. Reasons for these developments are linked to a lower net annual increment under the 'new management trends' scenario and/or by large afforestations being carried out under this scenario.

At first glance this study may present a contrasting view to the paradigm emerging over the past two decades, i.e. a view of plentiful resources, increasing increment, and an unprecedented growing stock (Kauppi et al., 1992, Spiecker et al., 1996, UN-ECE/FAO, 2000). This paradigm implicitly gives the impression that ample wood is available for the forest industries as well. Would it then be ridiculous to refer to a shortfall in supply? This might not be the case. The shortfall as presented in this paper is the result of an increase in demand over a long period and restrictions on forest management (e.g. setting aside of nature reserves). In that sense, a shortfall is not illogical as the *available* forest resource does not increase as fast as the demand. The current study confirms the paradigm of more and more resources, but points to and projects one of the reasons for this: a reduced interest in supplying wood to the industry.

Furthermore, it should be noted that in the management constraints the requirement of non-declining growing stock was <u>not</u> set. If this requirement had been set as well, then the shortfall under 'new management trends' scenario would have been even larger for Belgium, Germany, Italy, and Lithuania (countries where there is a significant decline of growing stock throughout most of the simulated period).

The EFISCEN model is not suitable to quantify exactly the impacts of this shortfall on the pulp and paper sector alone. If these shortfalls are going to occur then the different sectors may respond differently and, depending on competitiveness, flexibility and current earning capacity-, they can deal with the shortfall more or less in a successful manner. As said earlier, we only project a theoretical shortfall, being well aware of the flexibility to respond in all woodworking industries. However, we can still hypothesise what the implications on the pulp and paper sector might be. It is clear that the projected shortfall will probably have a relatively strong impact on the pulp and paper industry. An indication for this is the large proportion of coniferous wood (79%) in the total projected shortfall. There are three further reasons to assume that the trends in management are going to impact the pulp and paper industry relatively strongly:

1. European forest resources are ageing and the associated larger diameters will yield less and less pulplog dimensions. The availability of these larger dimension trees is questionable when compared against pulplog prices. However, if the larger availability of large dimension trees is going to lead to increased activity in the sawmilling industry, then this may lead to increased availability of by-products from the sawmill industry for the pulp and paper industry thus reducing the shortfall again.
2. One of the components of NOM is a trend towards increased use of deciduous species. Although it takes a long time before this really shows up in reduced availability in terms of actual supply reduction of coniferous wood, it is a trend that will eventually increase the shortfall for the pulp and paper industry.
3. The reduced interest to supply wood is especially strong for thinnings, the dimension that the pulp and paper industry depends on to a large extent. The interest to carry out forest management in these dimensions is probably only going to get smaller, thus hitting the pulp and paper industry extra hard.

A curbing trend may be the often-reported notion that owner behaviour is to a large extent determined by the state of his forest. With growing stocks building up in Europe, the overall supply willingness may increase in the future. A positive point for the pulp and paper industry is that this sector has shown large flexibility when dealing with problems in the past and still has one of the better earning capacities of the whole sector. This flexibility will make it possible for the sector, under the support of the right policies, to adapt to signs that indicate the occurrence of a possible shortfall.

6.2 Uncertainty

The results presented in this study are projections of ‘what if’ scenarios. Therefore, they should not be seen as predictions of the future, but as an indication of what might happen under certain assumptions about demand for wood products in combination with the three issues: nature oriented management (NOM), carbon credits and additional demand for bio-energy. These large-scale and long-term projections for, in this case, 37 countries bear uncertainties. Specific local or national circumstances can never be taken into account as accurately as when a study was carried out at local level. Therefore, the results as presented here are not meant to replace national level studies. The study aims at providing a multi-national strategic level viewpoint, calculating and presenting results based on a harmonised methodology. Such an approach allows comparison of results between countries.

Simulations of future development of forests always carry some uncertainty. This uncertainty is caused by a combination of uncertainties in input data, modelling approach and scenario assumptions. The latter may be viewed as a relatively large uncertainty. However, it is not the question if these trends in forest management occur, but only to what degree and in which country. The certainty with which the results can be accepted as valid will therefore vary from country to country and the uncertainty most likely increases the further we progress in the simulation.

Concerning the input data, the following can be said: Practically all European countries have a regular forest inventory that is updated in cycles (usually every 10–15 years). Exceptions to this are Albania, Bosnia and Herzegovina, Greece, Macedonia and Serbia and Montenegro. The input data for these five countries are believed to be a rather poor reflection of the current state of the forest and resulted in a simple balance approach being used for Bosnia and Herzegovina and Greece. The five countries mentioned above do not have a large influence on overall uncertainty because these countries account for 6% of the total European forest area. In addition, we believe that, compared to what we could obtain, more recent data may be available for Croatia, Moldova, Romania and the European part of Russia. Furthermore, the new update of initialisation data made for the current study has greatly improved the underlying data. The average base year is now 1994 (was 1988), the level of detail has increased and the level of standardisation is better now.

The aim of the inventories was traditionally to inform government, forest owners, industry and the public about the state and potentials of the forests. In European countries this was done through a sample-based inventory, and in Central and Eastern European countries through a complete stand-based survey. Sampling errors can therefore be derived for sample-based inventories of Western European countries only. Stand-based inventories include error due to assessment method and are exposed to bias.

For the first group, the reported standard errors (s.e.) in sampling are very small, up to 1.5% of the area estimate at the national level for forest area, and up to 5.1% of growing stock at national level. For the few countries that report standard errors in increment at national level (Finland, France, Norway, Sweden and Switzerland), the errors vary between 0.4 – 1.4% (Laitat et al., 2000). Sampling designs are set up to provide accurate information at national level, so when countries report results at a provincial level standard errors can quickly increase to up to 10%. If results are presented in even more detail (by species and age class) standard errors can increase further still. This means that in the present study where detailed results (single age class at sub-national level) of national inventories are used as input data, the uncertainties are rather high. When upscaling to national level, as done in Chapter 4, the standard errors decrease similarly to levels described above.

With respect to model assumptions and validations carried out earlier, we refer to Pussinen et al. (2001) and Nabuurs (2001).

7 Conclusions

The results of the runs of the EFISCEN model have confirmed the impact that the three identified policy developments – namely, NOM, bio-energy and climate change – might have on the availability of wood for the European wood-based industries, in particular the pulp and paper one. Among those, policies in the field of energy appear as the potentially most impacting ones.

According to the assumed demand increase as made in the present study, supply of roundwood in 36 European countries may reach 479 million m^3/y by 2010, 604 million m^3/y by 2030, and 718 million m^3/y by 2060 under the new trends in forest management. Under the 'projection of historic management' this might amount to 798 million m^3/y by 2060.

The new trends in forest management activated by the three identified policy developments, changing supply behaviour and additional demand for wood due to bio-energy, may lead to a theoretical shortfall of 195 million m^3 roundwood per year (of which 155 million m^3/y coniferous) by 2060 for 36 European countries (Figure 7.1). The theoretical shortfall amounts to 27 million m^3 roundwood per year already in 2010, and becomes considerable (more than 50 million m^3/y) by 2020.

Without these policy developments, and without increased felling rate, the wood-based industries would be confronted to a shortfall of 36 million m^3/y by 2060.

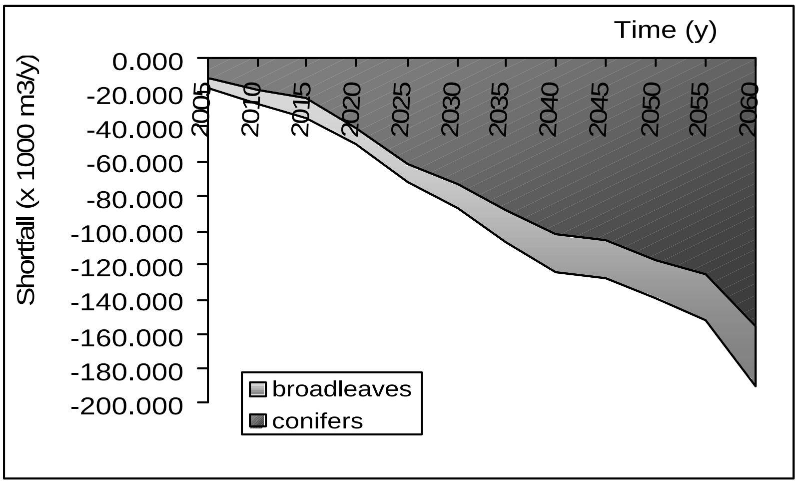


Figure 7.1. Projected additional theoretical shortfall in supply for all commodities under 'new management trends' scenario

Softwood, which represents the main raw material to the pulp and paper industry, would be more severely hit by the policy developments. The high share of theoretical shortfall for coniferous can be explained by a change towards the more natural/indigenous species.

The shortfall is slowly increasing over time but it is already noticeable now.

The European part of Russia (with various constraints incorporated and demand developing in Russia as well) cannot compensate for the shortfall because of its own increasing demand level and rather stringent management restrictions.

The shortfall mentioned above must be seen as a theoretical shortfall that does not reflect any market responses.

In parallel with this projected shortfall, the total growing stock in European forests (incl. Russia) increases from 51 billion m^3 in 2005 to 62 billion m^3 in 2060 under the new management trends scenario with actual supply reaching 1.1 billion m^3/y in 2060. Thus, the study also shows that a huge potential exists in European forest resources for ample wood supply that at the same time takes all the functions of forests into account.

8 The pulp and paper industries’ strategy to mobilise wood

The potential emergence of such a shortfall as indicated by the present study should not be seen as a fate, but as a useful warning to stimulate the wood-based sector and all the stakeholders to work together to mobilise wood while improving sustainability that suits the environmental, social and economical needs.

8.1 Vision

If society wants the European pulp and paper industry to continue to contribute to global welfare in a sustainable and competitive way, the amount of wood that is needed - coming from sustainably managed forests and being “traceable” - should be safeguarded in terms, of quantity, quality and costs.

This might be achieved through the setting up of co-operation networks, exchanges of information and improved business intelligence, adoption of transparent, effective and credible systems to secure the origin and traceability of wood, as well as by promoting a balanced approach of the 3 pillars (economy, social and environment) that constitute sustainability.

8.2 Mission

By involving all stakeholders, CEPI is willing to create a favourable context that permits to make the vision a reality. Dialogues should be established with decision-makers at all levels (EU, national, local). Environmental NGOs and the civil society in general are invited into the partnership building process, as they represent the environmental concerns. At the operational level, action must be taken with the forest cluster (forest owners, forest industries, upstream and downstream activities) in order to secure this favourable context.

On top of all this network-building, stronger co-operation and alliances must be established with strategic partners chosen inside the network.

These networks and alliances should firstly identify concrete reasons that hamper the use of the existing potential of available wood resources: lack of interest or ignorance from some categories of forest owners, increasing environmental pressure that present forestry as a major threat for the environment, constantly decreasing average size of the forest holdings, new silvicultural goals and practices, etc.

Key assets of wood and the wood-based sector should be promoted:

- Sustainable economic management of forests contributes to the development of rural areas;

Forests play different roles (delivery of raw material, nature and environment protection, biological diversity, leisure and recreation, climate change mitigation, as well as peace and spiritual values). One should not emphasise only the environmental one. Sustainability can only be reached via a balanced approach of the three pillars (environmental, social and economical);

- There exist an unused potential in the forests that could be harvested without endangering the overall sustainability;
- Timber harvesting is the basis for the economic incentive to continue growing and maintaining sustainable forests;
- Wood is a renewable carbon neutral raw material;
- Wood-based products are part of a cycle approach. They can be recycled and re-used several times before being burned to produce energy. By doing so, both the carbon cycle and the product value chain are recognised. On top of that, wood-based products play a role in reducing the greenhouse effect by their ability to store carbon. A sustainable, optimal use of the forest and the raw material wood that is coming out of it can only be reached via recognising, respecting and practising the carbon cycle;
- Wood-based products also act as substitutes to other less environment-friendly products made out of non renewable materials and often requiring more energy;
- Wood-based products, as well as forest-based industries are energy-efficient.
- The overall eco-efficiency of the wood-based industries has significantly improved over the last decade.
- Paper and board products fulfil the basic needs of society and hence, contribute to the global welfare

9 The pulp and paper industries' recommendations: developing partnerships

Rather than through manipulating short-term market mechanisms (price, imports), the future availability of wood for the European forest-based industries must be secured by building strong long-term partnerships.

First, the wood-based industries have to be more "cluster" minded and enhance co-operation. Their knowledge and experience are assets that they can share. With the help of recovered paper collectors for example, the European paper industry can further improve its recycling rate, which is already very high today. Technology used is constantly more efficient. Hence, investing in research and development will make it even better.

The forest owners are invited to share the forest "cluster" approach. As suppliers of raw material, they are part of the cycle, which should not be broken. They have to be confident about their major role and this role should be acknowledged and enhanced. They should be made aware that, by providing raw material to the forest-based industry, they contribute to adding value and to rural development, hence participating to the global welfare, as well as to the life and carbon cycle completion. Furthermore, it will secure the further management of their forests and as such their own future.

Policy-makers must be convinced that using wood helps to fulfil international commitments in the field of climate change, sustainable forest management, sustainable use of natural resources, etc. Wood is climate-friendly, not only because forests can sequester carbon, but also because forests are managed and because wood-based products can store carbon and wood is a substitute for other less sustainable non renewable materials. Wood products are one link in a chain. When a wood-based product can no longer be recycled, time has come to use it as a renewable source of energy.

Beyond any polemical approach, the European pulp and paper industries have similar interests than the environmental organisations in sustainable management and use of natural resources in a cycle approach. Forest management is not contradictory with nature and environmental sustainability. Wood is a climate- and eco-friendly raw material. Its promotion should be placed high on the agenda of the environmental NGOs and of the wood-based industries.

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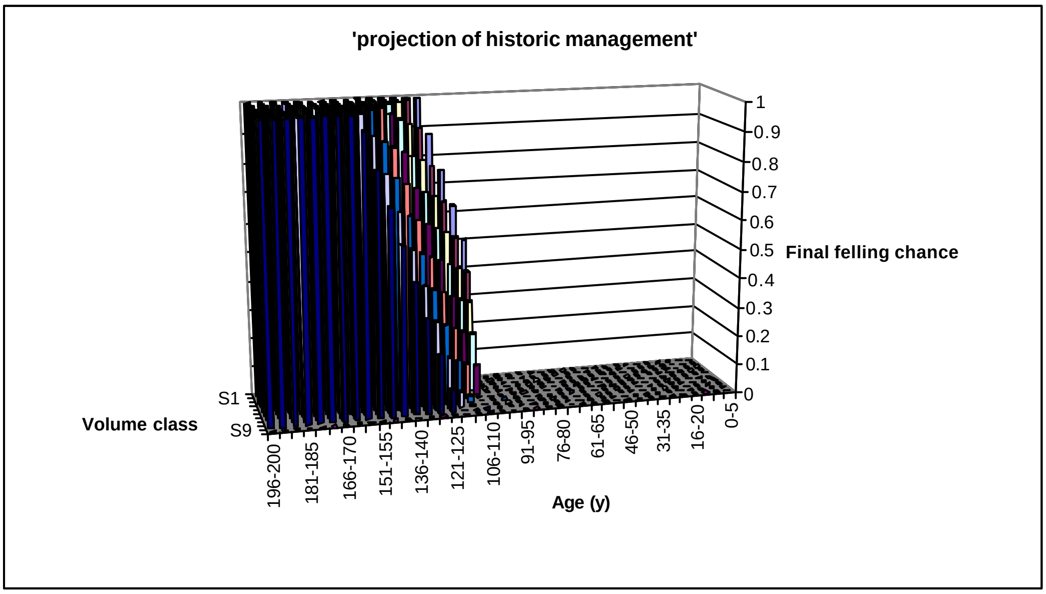
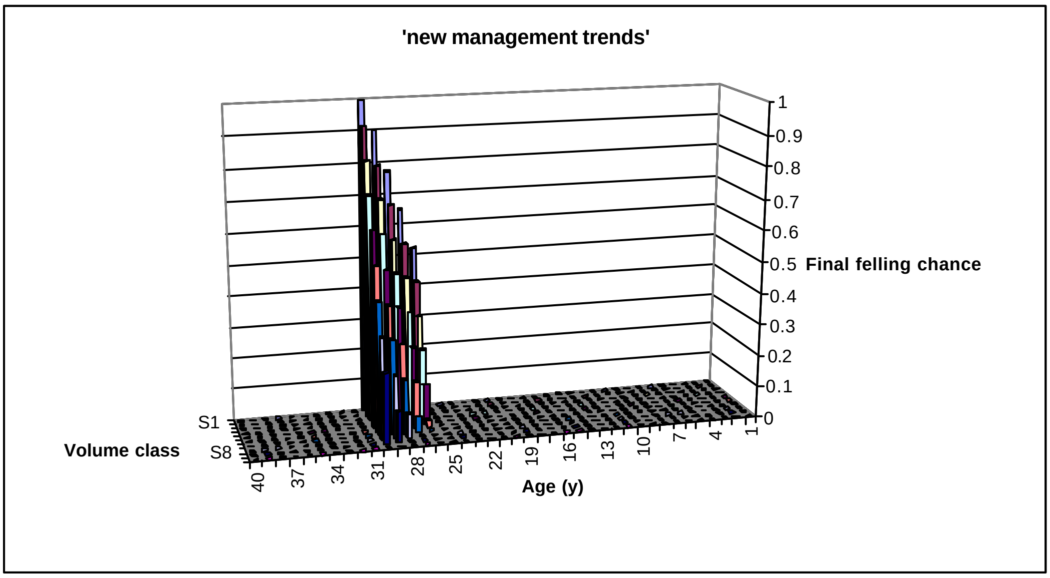
Appendix 1 Example of the incorporation of changes in management regimes due to the issues in question by country and species

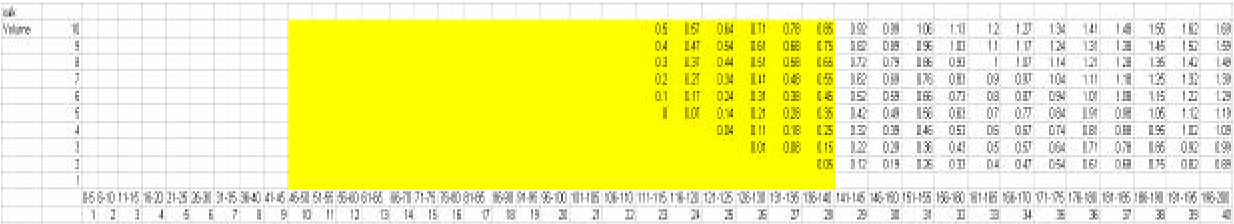




The graphs show the final felling chances for beech in France under the 'projection of historic management' (top) and the 'new management trends' scenario (bottom). If the chance is 1, all forests in that age and volume class can in principle be logged (if the demand is there). So, from the top to the bottom graph, the rotation length is prolonged by 20 years and all forests over 150 years old are set aside for reserves (felling chance is 0). The latter seems very dramatic, but when this policy of setting aside was assumed to be adopted for oak, beech and sweet chestnut in France, it initially affected an area of 20,000 ha (=1.5% of the total French forests).

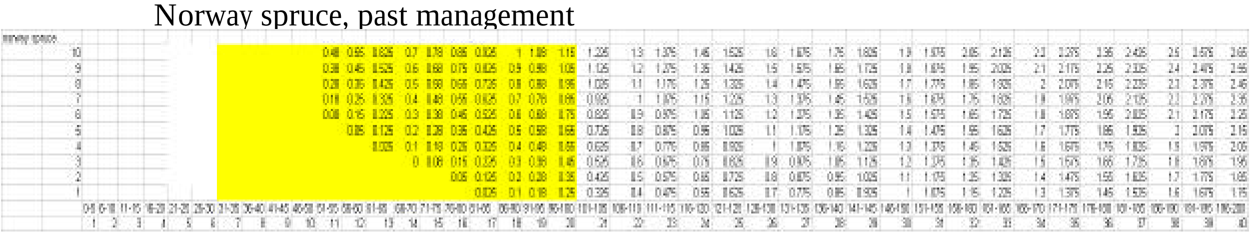
The previous graphs are depicted in numbers below.
E.g. the top graph is for oak where the baseline management regime is given. Volume classes are on the 'y' axis and age classes are on the 'x' axis. The numbers depict the chance that a final felling can be carried out, in principle, for each cell of volume and age, provided the demand is there (i.e. more than 1 equals 1). The grey shaded area is the range of volume and age classes where, in principle, a thinning can be carried out, provided the demand is there. In the graph, 'oak, new management trends' the setting aside of older age classes clearly indicates that final felling chances are 0. In the 'new management trends' scenarios thinnings are only carried out in the higher volume classes.

oak, past management

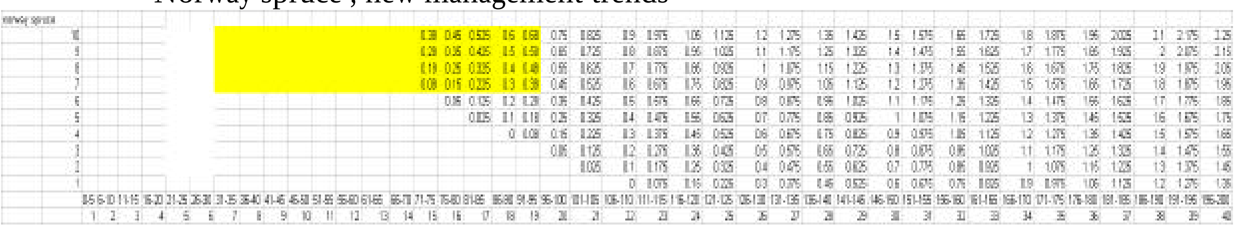


oak, new management trends

Norway spruce, past management



Norway spruce , new management trends



Appendix 2 Country reports on RES policies and the deployment of woody biomass

(1) Austria
Woody biomass (logs and wood chips) and by-products of the wood processing industries (bark, sawdust) make up 90% of the renewable energy sources. In total, the contribution of RES is 141 PJ, of which 63% is traditional fire wood, 13% is black liquor, 7% is chipped wood, 7% is bark, 5% is municipal solid waste and 4% is miscellaneous. (AFB-Nett, 1996).
The only recent available figure in the Austrian Forestry Statistics is fuel wood from forests (without chips from forests, source: Austrian Removal Statistics, Holzeinschlagsmeldung). In 2001 it was 2.91 million m³ of fuel wood (conif 1.64, non-conif 1.26). The average for 1992-2001 was 3.17 Million m³ (conif 1.89, non-conif 1.28). Major sources for woody biomass in Austria are the sawmill industry, other wood processing industries' byproducts, and disposed off products. However, the share used for energy purposes is unknown.

(2) Belgium
The overall aim is that renewable energy should contribute 3% of the total energy consumption by the year 2000 and 5% by 2010. At present (based on 1996 data), the equivalent of 7.4 PJ of firewood is burned by households per annum (176,500 tonnes/y). In the Walloon region the total energy consumption was 520 PJ in 1992 (AFB-Nett, 1996).

(3) Croatia
In 1998 bio-energy contributed 5.1% to the total energy supply in the Republic of Croatia. In the BIOEN programme a 15% contribution of bio-energy derived from biomass and waste is forseen by 2030. The total energy potential of biomass in 1995 was estimated to be 33.8 PJ, the most significant source being wood from conventional forestry (Domac, 1998).

(4) Denmark
Denmark's total energy use in 1999 was 843 PJ. Renewables accounted for 83 PJ, which is 9.8% of the total production. Biomass contributed 68 PJ. This included municipal solid waste (29 PJ), straw (14 PJ), wood 20 PJ) and biogas 3 PJ). (DEA, 1999). Targets for 2005 give a 12-14% contribution of the total energy consumption from renewable energy sources (mostly straw). Denmark's targets for 2000 were to use more than 65% of their straw surplus (1.2 million tonnes) and 0.2 million tonnes of wood chips for bio-energy (Altener, 1995). Bio-energy from wood totaled 21 PJ in 1997, which was 28% of renewable energy produced.

Table App 1. Consumption of wood fuels in Denmark in 1997 (Serup et al., 1999)

Biomass category	Consumption	Proportion
Forest chips	2.7 PJ	13 %
Traditional fuel wood	9.6 PJ	46 %
Ind.wood residues	5.9 PJ	28 %
Wood pellets	2.8 PJ	13 %
Total	21 PJ	100%

Traditional firewood is obtained in Denmark primarily by thinning and clear cutting hardwood stands. It consists of tops, branches and butt ends. Forests produce 420,000 m^3 of fire wood/year, but when prunings from gardens, parks and hedges are included the total is 700,000 m^3 per year. Industrial wood processing residues consist of bark, sawdust, shavings and demolition wood , etc. This is used mostly in the industry's own boiler furnaces. The amount totals 640,000 m^3 per year, part of which is used for the production of wood pellets and briquettes (Serup et al, 1999).

(5) Finland
Finland's total annual energy consumption amounts to 31.5 Mtoe, which corresponds with the 1320 PJ. Woody biomass contributes about 14.7%, which includes industrial wood processing residues, black liquor and traditional firewood (1995 figures, AFB-Nett. 1996). The use of traditional firewood amounts to 5.6 million m^3 per year (42 PJ) (AFB-Nett, 1996).

(6) Germany
The energy policy of the government of the Federal Republic of Germany is focussing intensively on renewable energy sources. Thereby, positive impacts on climate, preservation of conventional energy and the environment are expected. This target can only be achieved if renewable energy becomes economically competitive. Therefore, the government is financially supporting the construction of renewable energy plants with a half billion Euro budget. Furthermore, since 1991 with the "Stromeinspeisungsgesetz" the supplier of electrical power is obliged to include electricity from plants with renewable energy sources at guaranteed minimum prices. Since April 2000 the "Erneuerbare Energien-Gesetz (EEG)" forces the use of renewable energy even more, with relatively high guaranteed prices for electricity produced from renewable sources. This act actually forces the building of many plants. (EBD, 2002)

(7) Ireland
The amount of forest residues potentially available in Ireland amounts to 10 PJ, of which about 3.4 PJ can be extracted from the forests at a cost of 3 euro/GJ. Sawmill residues total about 7 PJ, which are presently used in the panel board industry but could potentially be used for bio-energy as well. Ireland's total primary energy supply was 531 PJ in 1998. The government's Green Paper on sustainable energy aims at an increased contribution of renewable energy from 2% in 2000 to 3.8% in 2005, which corresponds with 25 PJ/y (Broek, 2000). In 1996 less than 1% of the total primary energy demand (4 PJ) came from the use of domestic firewood (Rice et al., 1996).

(8) Italy
At present (based on data from 1994) 4 million tonnes of firewood has been consumed by households and pizzaerias annually, all of which is extracted from forests. Industrial wood residues amount to 3.5 million tonnes. In total the domestic use of woody biomass is estimated at 7.5 million tonnes/year which is equivalent to 94.3 PJ. In addition, agro-industrial firms use wood for heat production equalling 39.6 PJ/year. Co-firing of woody biomass in power plants amount to 2.8 PJ. The

overall total is 136.7 PJ, which is about 2% of the total energy consumption. Its share is expected to rise to 5% by 2005 (AFB-Nett, 1996).

(9) Netherlands

The Dutch government aims to produce 10% of renewable energy by the year 2020, of which bio-energy will constitute 4.4%. At present, less than 1% of the total national energy consumption comes from renewable sources. The Dutch energy sector uses about 550 PJ per annum for heating and electricity, which corresponds to the energy contents of approximately 100 million tonnes of wood. The target of 10% renewables means the conversion of 10 million tons of wood per year for the energy sector, which is quite substantial given the total wood harvest capacity of Dutch forests of 1,5 million tonnes per annum. Most of the harvested wood is dedicated to the traditional wood processing industry in the Netherlands, which relies, to a very large extent, on timber imports. In principle, the leftovers, i.e. the industrial wood residues, can be used for bio-energy. Biomass from conventional forests at present amounts to only 20,000 ODT per annum. (EBD, 2002). The use of traditional firewood and wood residues for small-scale industrial combustion for heating currently (based on data from 1997) amount to 8 PJ/y.

(10) Poland

The strategic objective of Poland is to increase the share renewables in its total primary energy sources to 7.5% in 2010 and to 14% in 2020. The Parliament approved “The Renewable Energy Sector Development Strategy” prepared by the Ministry of Environment on 23 August 2001. In the “Guidelines for Polish Energy Policy by 2020”, approved by the Government in February 2000 it has been assumed that the total energy demand in 2010 in the “reference scenario” will be 4,570 PJ. In order to achieve a 7.5% share of renewable energy in the primary energy balance of the country, 340 PJ of energy will need to be generated from renewable sources by 2010. Compared to 1999 this will require an increase of the operational capacity in the RES sector by an additional 235 PJ. Achieving mentioned capacities will require implementation of many new instruments and measures in different RES sub-sectors and a respective increase of invested capital. The Polish energy law and guidelines mentioned above stipulate the local energy market development and encourage the utilisation of local available renewable energy resources. Biomass is the most promising renewable source for energy at the moment. The technical potential of biomass is estimated at 895 PJ/year. The forest area in Poland is 8,850,000 ha, which is equivalent to 28.3% of the country area. The effectively utilised waste wood and forest residues should play an important role as a renewable energy source (EBD 2002)

(11) Sweden

The total annual energy supply to the Swedish market is 2,200 PJ. The Swedish energy policy (Energy in Sweden, 2000) involves a nuclear power phase out with the aid of increased use of renewable fuels. The policy is meant to induce supporting measures for the use of renewable fuels. This policy is put forward against a background where biofuels already constitute about one fifth of the total energy use in Sweden (440 PJ), of which biofuels provided by forests constitute a dominant part.

Today, solid biofuels are a major energy source for the forest industry and communal heating systems (EBD, 2002).

(12) Switzerland
Harvesting of fuel wood in 2001 covered 1,122,076 m^3 (= 20% of total harvesting). Total fuel wood use in 2001 amounted to 2,500,000 m^3 (fuel wood from forest, industry and wastes). Based on the national policy, the total fuel wood consumption in 2010 would be 5 million m^3.

(13) UK
The UK's renewable energy policy aims to increase the use of renewable energy to meet 10% of UK requirements by 2010. Currently (based on data from 2000), 1% of energy requirements in the UK were provided by renewable energy. The government has introduced a number of support measures and policy objectives that aim to help achieve these targets, including "New Electricity Trading Arrangements" and the "Renewables Obligation", which requires electricity suppliers to provide 10% of electricity from renewable sources by 2010. The government's Policy and Innovation Unit published an "Energy Review" report on 14 February 2002 that gives recommendations for the implementation of a renewable energy policy. Bio-energy is one of the key renewables in the UK, accounting for 82.3% of all renewable energy production at present. (EBD, 2002)

The most recent published statistics (2002) (e.g. in British Timber Statistics and in the Eurostat/UNECE Joint Questionnaire) show an estimate of 250,000 tonnes (air dry) a year of fuel wood produced from forests in UK. This estimate has not been reviewed for more than 10 years and could be much too low. It is scheduled to be reviewed during 2003.
An alternative (partial) source is the Digest of UK Energy Statistics (DUKES). Forward-looking extrapolation from a survey in 1989 estimates that domestic use of wood for fuel in 2000 amounted to around 0.2 million tonnes of oil equivalent (Mtoe), which would be equivalent to about 1 million green tonnes of wood. This is domestic use only, not industrial (or power generation). It is reasonably consistent with a household survey that we commissioned in 1997 to ask about domestic use of firewood. A new survey is being carried out for DUKES, and the results should be available later this year.

Another survey in 1997 estimated UK industrial use of wood as fuel to be around 0.5 Mtoe. I have been told that the figures were updated last year, and the latest "UK Energy in Brief" implies a total of 0.3 Mtoe for industrial use of wood fuel. This source doesn't indicate how much wood was from the forest and how much was from wood processing or post-consumer.
There is little or no wood used for electricity generation in the UK yet. A pilot project (project Arbre) was set up to use forest residues and short rotation coppice, and various other projects using wood have been proposed, but future development is uncertain.

Table app 2. Summary of the use of bio-energy in Europe in 1996 (baseline) plus 2010 targets (indicative figures from the AFB-Network, 1996 and estimates for 2010)

Country	Total Energy Consumption in 1996 (PJ)	Contribution of Bio-energy in 1996	Million m^3 wood eq. 1996	Targets 2010 (PJ)	Targets 2010 M m^3 wood equivalents
Austria	1235	145 PJ (12%)	17.3	150 PJ	18
Belgium	520?	5 PJ (1%)	0.6	25 PJ	3
Croatia	680	34 PJ (5%)	4.1	70 PJ	8
Denmark	528	32 PJ (6%)	3.8	50 PJ	6
Finland	1320	194 PJ (19%)	23.0	250 PJ	30
France	8750	350 PJ (4%)	41.6	450 PJ	54
Germany	9046	97 PJ (1%)	11.5	485 PJ	58
Ireland	530	4 PJ (0.7%)	0.5	25 PJ	3
Italy	8300	135 PJ (1.5%)	16.0	340 PJ	41
Netherlands	550?	5 PJ (1%)	0.6	50 PJ	6
Poland	4500	105 PJ (2.3%)	12.6	340 PJ	41
Spain	257	6 PJ (2.3%)	0.7	15 PJ	2
Sweden	1660	144 PJ (9%)	17.1	150 PJ	18
Switzerland	?	21 PJ ?	2.5	42 PJ	5
UK	9862	42 PJ (0.5%)	5.0	800 PJ	96
Total		1185 PJ	146.9	2895 PJ	389 million m^3

1 Mtoe (million tonnes of oil equivalent) = 41.9 PJ = approximately 5 million m^3 fresh wood
1 PJ corresponds with 0.12 million m^3 of fresh wood

Conclusion

From Table App 2 it can be derived that the additional demand compared with the 1996 baseline is 389 - 147 = 242 million m^3, i.e. if all the policy plans will indeed be implemented.

Appendix 3 Glossary

Actual supply: the volume of wood (overbark) actually felled under assumptions for apparent demand and assumptions for the forest management regimes as specified.

Additional shortfall (AS): difference between the apparent demand (Dn) for wood products (in terms of fellings of overbark) and the actual supply from the forest (fellings of overbark) (Fn) in the new management trend scenario minus the difference between the apparent demand (Dh) for wood products (in terms of fellings of overbark) and the actual supply from the forest (fellings of overbark) (Fh) in the past management scenario. Simply : AS = (Dn - Fn) – (Dh – Fh)

ARD: Afforestation, Reforestation and Deforestation; a part of the Kyoto Protocol

CDM: Clean Development Mechanism; part of the Kyoto Protocol

CEPI-member-countries: all EU15 countries minus Greece and Luxembourg, plus Czech Republic, Hungary, Poland, Norway, Slovak Republic and Switzerland.

CIS: Community of Independent States

Consumption: equals actual production minus exports plus imports. In the current study assumptions on future apparent consumption (treated as apparent demand) were translated into total required fellings on the European forest (because Europe is approximately self sufficient, UN-ECE/FAO 1996). The volume of wood which is felled from the forest (overbark) under the three issues under study is regarded the 'actual supply'.

Demand: apparent demand for wood products is determined by population, GDP, etc. Whether this demand results in actual consumption depends on prices and wood supply.

DUKES: Digest United Kingdom Energy Statistics http://www.dti.gov.uk/energy/inform/dukes/index.shtml

EBD: European Biomass databank

EFISCEN: European Forest Information Scenario Model, see http://www.efi.fi/projects/forsce

EJ= ExaJoule (Exa = 10^{18})

EU+EFTA: European Community and European Free Trade Association States: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, and United Kingdom

Europe: Europe includes in the present study the forests of the thirty-six countries: Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Belarus, Croatia, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Macedonia, Moldova, The Netherlands, Norway, Poland, Portugal, Romania, The Slovak Republic, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom, and Serbia and Montenegro. It is mentioned if the European part of Russia is meant as well

FAO Food and Agriculture Organization of the United Nations

FAWS: Forest Available for Wood Supply: forest where any legal, economic, or specific environmental restrictions do not have a significant impact on the supply of wood. In theory this makes some 25 billion m^3 of growing stock in principle available (biological availability) in Western Europe. Including the European part of the CIS, adds another 20 billion m^3.

FBI: Forest Based Industries, the conventional forest industries producing commodities like pulp, paper, poles, sawnwood, panels, etc.

Fellings see actual supply

FNAWS: Forest not available for wood supply

GJ: GigaJoule (Giga = 10^9)

Increment:

- gross annual increment (GAI) during the period n is the difference between growing stock at two points in time, including the volume of that part of initial growing stock that has been felled or has died during the period.
- net annual increment (NAI) is the difference between gross increment (GAI) and natural losses.

IPCC: Intergovernmental Panel on Climate Change

JI: Joint implementation; part of the Kyoto Protocol

Kyoto Protocol: Industrialised countries agreed in 1997 in Kyoto to reduce their anthropogenic greenhouse gas emissions with on average 5.2% compared to 1990

LULUCF: Land use, land use change and Forestry; a sector identified within a total nation's greenhouse gas reporting system.

MCPFE: Ministerial Con the Protection of Forests in Europe; a series of ministerial conferences. http://www.minconf-forests.net/

MtC: Megatonne carbon (Mega = 10^6)

New-Accession countries: included here are: Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, The Slovak Republic, and Slovenia.

NGO: Non Governmental Organization

NIPF: Non industrial private forest owner

NOM: Nature oriented forest management

NPV: Net Present Value: discounting back all future costs and revenues of the lot of land provides the net present value

ODT: Oven dry tonnes

Over bark: a (stem) volume designation for the whole stem including any bark

PJ: PetaJoule (Peta = 10^{15})

RES : Renewable Energy Sources

TBFRA: Temperate and Boreal Forest Resource assessment

TERES II: The European Renewable Energy study II

Theoretical shortfall: the shortfall presented here would never physically occur. Markets will dynamically adapt. This is represented by the term theoretical shortfall.

Under bark: a (stem) volume designation for the whole stem excluding any bark

UN-ECE: United nations Economic Committee for Europe

UNFCCC: united Nations Framework Convention on Climate Change

Volume: all volumes in this report (unless specified differently) are given in m^3 overbark. Fellings are usually reported in roundwood. Consumption volumes are specified in actual cubic metres or tonnes of commodities.