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European forests — ecosystem conditions and sustainable use

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Executive summary

Despite political commitment, Europe is struggling to halt the loss of biodiversity by 2010. Forests, as the hosts of much of the biological diversity in Europe, are vital to this debate. Any initiative designed to halt the biodiversity loss in Europe must take forests into account.

Forests and biodiversity: are we doing better?

Forests today cover 33 % of the land area of the countries of the EEA region corresponding to 185 million hectares (ha). Around 25 % of this total is excluded from wood harvesting, mainly because of their special importance for biodiversity. The EEA member and associated countries have reported an almost 40 % increase in the protected forest areas from 2000 to 2005.

Over the past decades, both the total forest area and the standing volumes have increased. More forests are now allowed to grow into older development stages, which have positive effects on forest biological diversity. Afforestation programmes as well as decreasing grazing pressure lead to large-scale conversion of mainly former agricultural land. Nevertheless, afforestation may also threaten existing biodiversity values in some localities, such as peatland when it is combined with draining.

Animals and trees are both under threat

So far, Europe's efforts in halting biodiversity loss in forests has had mixed results. According to IUCN, 11 mammal species depending on forest in some stage of their life cycle should be considered as threatened, including the 'critically endangered' Bavarian vole, *Microtus bavaricus* and Iberian lynx, *Lynx pardinus*. In the case of forest birds, common populations show a decline in north and south Europe, while they are largely stable in the West and East.

Managed forests in Europe are increasingly becoming more diverse, often with a mixture of coniferous and broadleaved tree species. On the other hand, concerns are raised over the genetic diversity of the commercially important trees, especially in connection with the widespread transfer of tree genetic material between countries and regions.

The rate of introduction in recent decades of really problematic alien species known as 'worst invasives' has been less dramatic in forest ecosystems than in other ecosystems. Although European forestry is largely based on native tree species, deliberately introduced tree species are important in some countries. Countries classify only a minor part of the area covered by introduced forest tree species as occupied by invasive trees. One of the countries reporting substantial areas occupied by invasive tree species is Italy.

Climate change will affect biological diversity

Climate change will add to increased abiotic and biotic disturbances, including drought, salinification, increased spring and autumn frost risk, and insect and pathogen damage. The changes will also effect the biology, phenology, growth and distribution of species and the species composition of forests in Europe. Changes in the frequency and degree of extreme climatic events (such as droughts and floods) may have a greater effect on forest ecosystems than the changes in the projected average climate. The effects of climate change have to be approached through adaptation measures such as ensuring connectivity to facilitate migration of species.

Larger areas of forests must be connected for viable populations

Forest fragmentation impacts biological diversity on all spatial scales, depending on species' habitat needs, population dynamics, dispersal ability and interactions with the biological community. In regions with low forest density, where the forests are small and occur in scattered patches throughout the landscape, fragmented forest habitats must be linked into habitat networks to improve protection of forest biological diversity. This is a key discussion in connection with the Natura 2000 process to ensure the long-term effectiveness of the established network of designated areas, especially in connection with prospective impact of climate change.

Public awareness and participation

Maintaining and increasing public awareness of the Europeans on forests, its biological diversity and cultural values is a general challenge which also is an inherent part of national forest programmes. The increased multifunctional values of the forest ecosystems will reinforce the need of participation of a wide range of stakeholders in the forest management.

Forest management: what are we doing and does it work?

Sound principles and legislation are already in place

Around 87 % of forests in the EEA member and collaborating countries are subject to some degree of human intervention. These so-called 'semi-natural' forests in Europe are run in accordance with sustainable forest management principles, as defined and developed by the Ministerial Conference on the Protection of Forests in Europe (MCPFE), which are in most cases complemented by national or regional forest programmes. In general, such forest management programmes focus on the ecosystem approach, reduction of threats, protection and recovery measures, promoting sustainable use as well as management of genetic resources.

Europe needs more research and data exchange

In many respects, forests still remain a mystery. Despite a number of ongoing initiatives, a systematic and harmonised Europe-wide monitoring and assessment of forests is not yet available. This is in particular the case for forest biological diversity and ecosystem functioning. Although they are given increasing attention in the EU research framework programmes, there is still much research to be done before we can fully understand what is happening.

The cooperation between the European Environment Agency and its member countries within the European information and observation network (Eionet) together with EU Data centres for biological diversity (EEA) and for forests (DG JRC) will considerably further improve data accessibility and data exchange at both the national and European levels.

Tips for better management of forests

The biological diversity values of forests are in particular negatively influenced by intensification measures like drainage of peatlands and wet forest, fertilization and forest-tree genetic 'improvement', including application of biotechnology, and the suppression of natural disturbances like fires.

The biological diversity potential of a forest stand depends to a considerable extent on the way in which the trees are harvested, including their age, size of the cut area and volume of wood extracted by felling. Retention of large and old trees, and reducing the area of clear-cutting promotes biological diversity. The amount of wood harvested must not, in the long run, be greater than the increment in forest biomass.

For EEA countries as a whole, the average annual fellings only accounted to around 59 % of the net annual increment of the growing stock in the year 2005. This ratio is, however, expected to increase to 70–80 % by 2010 due to increased demand for wood in Europe.

Forest management also determines how the trees making up the new stand will establish. Natural regeneration is often associated with a diverse tree species composition, and builds on the gene-pool of the previous tree population. Although industrial forestry often prefers planting because forest establishment is achieved quicker and allows to determine the composition of the future stand, the tendency towards natural regeneration is on the rise in Europe.

Deadwood is both an important substrate for a large number of forest species such as insects and other invertebrates and a refuge and nesting place for several mammals and birds. Intense forest exploitation, widespread burning of small wood pieces and concerns about pest risks have strongly decreased the quantities of deadwood in European forests. However, many European countries have taken initiatives to increase the amount of deadwood in forests. Although it is still low, available data show a slight increase. Unfortunately, this may change as demand for woody biomass for bioenergy is increasing.

Improved fire fighting techniques reduce damage to forests

The most drastic damage to forests in Europe is caused by forest fires (such as in Portugal in 2003 and in Greece in 2007) and wind storms (such as in Carpathian mountains in 2005). More than half a million hectares of forests burn every year. Although the number of fires has increased in the last decade, the area burnt has not increased significantly due to the improvement of forest fire fighting means. The damage caused by wind storms also added impetus to changes in silvicultural practices. For instance, changes from coniferous to broadleaved species, and from uniform to irregular stands continue to take place, especially in France, Germany as well as in the United Kingdom.

Forests can stock carbon but carbon release must be minimised

In an effort to curb atmospheric CO_2, the Kyoto Protocol allows forests to be used as carbon sinks. But forest ecosystems are naturally dynamic and subject to disturbances and successions. These disturbances should be maintained to allow survival of species adapted to the different succession stages while the potential carbon release is minimized. Another opportunity to favourably combine carbon and biological diversity policies is to increase the amount of deadwood.

Challenges ahead

Although preliminary assessments show that the 2010 target of halting the loss of biodiversity will not be met entirely in the forests, Europe has the institutional, legal, financial and information framework in place to make a real difference. If Europe succeeds in developing sound forest policies and management programmes, there is reason to be optimistic.

What to take into consideration when formulating future policy?

Demands on forests will become stronger and spatially more diversified. Production of wood and other traditional forest resources will have to be balanced against other kinds of goods and services from the forest ecosystems. Europe must develop frameworks capable of addressing all these demands to create optimal forest landscapes in the future while preserving biodiversity.

Demands on forests as a resource for bioenergy will grow. Any use of forests for bioenergy should not damage biological diversity and ecosystem conditions. Harvesting and systems for recycling ash must be designed to minimise the negative effects on forest biological diversity.

Genetically modified trees may offer benefits as well as risks to biological diversity and humans. In accordance with the Convention on Biological Diversity, Europe must follow a precautionary approach to genetically modified trees.

Ongoing changes in European society — urbanisation, immigration, technological development, change of life-style, etc. — will modify the cultural role of forests and will impact the awareness of nature, including forests. Education, information and interest groups for nature, history and etnographics are essential for long-term conservation of biodiversity.

Decision-makers and stakeholders must be provided with the necessary information on forests and forest biological diversity. Existing knowledge should be made accessible through efficient information systems. New and better information, in particular European-level information on biological diversity composition (species, communities), is also needed. Such information will help set solid and relevant targets and continually improve sustainable management schemes for the forest ecosystems.

1 Safeguarding the biological diversity of Europe's forests

Europeans have long understood that forests serve society with a multitude of ecological, social and economic functions and benefits. Forest ecosystems contain much of Europe's biological diversity. Forests also provide wood for building, paper and fuel, as well as providing a variety of non-wood products ranging from cork to game, berries, nuts and mushrooms. In addition to this, they regulate water flow and provide protection from soil erosion and avalanches, support people in their livelihoods and offer a place for recreation, and in many places they have a special cultural–historical value. All these aspects are relevant when assessing the biological diversity of Europe's forests.

How Europeans use and manage their forests today will determine the future state of forest biological diversity in Europe. Understanding and managing slow-evolving ecosystems like forests requires a long-term time perspective. History has defined the current state of forest biodiversity and ecosystems, and reveals societies' successful actions and failures to address threats to forests and their biodiversity. Compared with many parts of the world, Europe is now relatively advanced in securing sustainable use of forest ecosystems and their related biodiversity values. However, maintaining the economic viability of forest production remains a challenge for many European forest owners and to cope with this, forestry is expected to develop new and more intensive methods (EC, 2002). Forests in Europe are also greatly affected by developments outside the forests sector — high population densities, land ownership, habitat fragmentation, fires, pollution and climate change — are all potential drivers of future biodiversity loss. New threats and challenges, as well as opportunities, will therefore need to be addressed in the management of Europe's forest resources.

The European Environment Agency (EEA) was set up by the European Union (EU) to support sustainable development and the improvement of Europe's environment through the provision of relevant information to policy-making agents and the public. To this end the EEA and its member countries (Map 1.1) cooperate in the European Environment Information and Observation Network (Eionet) set up by the EEA founding regulations in 1994. A review of the UN Convention on Biological Diversity's (CBD) Expanded programme of work (EPOW) on forest biological diversity will be a major issue at the 9th Conference of the Parties (CBD COP-9) in Bonn, Germany in 2008. This background report presenting European experiences in forest management and its impact on forest ecosystems and biodiversity is a contribution to the issue from the EEA. This report also supports the EEA's activities towards a 'European Ecosystem Assessment' (Eureca), being developed for 2012.

The current EPOW on forest biological diversity was adopted in 2002 at the CBD COP-6 and was confirmed in 2006 at the CBD COP-8. This decision was taken on the basis of a programme developed by an ad-hoc expert group on forest biological diversity established at the CBD COP-5 in 2000. The expert group recognised the national sovereignty of parties and determined the CBD's role as providing guidance to monitor progress in implementation. The EPOW on forest biological diversity contains 129 actions organised under three programme elements and 12 goals. These cover a wide range of related aspects. Parties choose which goals to address from this 'menu' according to their own priorities.

The main programme elements and goals of the EPOW on forest biological diversity are:

- Conservation, sustainable use and benefits sharing:
    - apply the ecosystem approach to the management of all types of forest;
    - reduce threats and mitigate impacts of damaging process on forest biological diversity;
    - protect, recover and restore forest biological diversity;

- promote the sustainable use of forest biological diversity;
- access and benefit-sharing of forest genetic resources.

- Institutional and socioeconomic enabling environment;
  - enhance the institutional enabling environment;
  - address socio-economic failures and distortions that lead to decisions resulting in the loss of forest biological diversity;
  - increase public education, participation, and awareness.
- Knowledge, assessment and monitoring:
  - characterise and analyse forest ecosystems at a global scale and develop a classification system at various scales to improve the assessment of status and trends of forest biological diversity;
  - improve knowledge on and methods for the assessment of status and trends of forest biological diversity, based on available information;
  - improve understanding of the role of forest biodiversity in ecosystem functioning;
  - improve infrastructure for data and information management to enable accurate assessment and monitoring of global forest biological diversity.

Furthermore in 2002, at the COP-6, parties to the CBD committed themselves to achieve a significant reduction in the current rate of biodiversity loss by 2010. Subsequently, in the same year this target was given high-level status at the World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa, and was incorporated within the Millennium Development Goals (CBD, 2007). Prior to this, in 2001, the EU's Member States went further and agreed an even more ambitious target to *halt* biodiversity loss by 2010 (EC, 2006a). The environment ministers of the 51 UNECE and EU Member States participating in the pan-European 'Environment for Europe' process, reinforced the aim to halt the loss of biodiversity at all levels by 2010 in the Kiev Resolution on biodiversity (UNECE, 2003). In the following meeting in Belgrade in 2007, the environment ministers, in response to the assessment of Europe's environment presented by the EEA (EEA, 2007a), expressed 'particular concern' that 'biodiversity decline and the loss of ecosystem services continues' (UNECE, 2007).

This report (1) supports the objectives outlined above by: presenting a preliminary assessment of the progress towards the 2010 target of halting biodiversity loss in European forests; indicating the major actions needed to stabilise forest biodiversity in Europe; presenting examples of European efforts to meet the goals associated with of the EPOW on forest biological diversity; and highlighting some of the major challenges ahead (Chapter 2).

The assessment within this report presents an analysis of:

- the state of biological diversity within European forests, and the contribution of forests to total European biodiversity (Chapter 3);
- the historical and current use of forest resources, followed by: an analysis of the effects on biodiversity and forest ecosystems of production of roundwood and bio-energy; threats from forest fires and other causes of damage; invasive alien species; air pollution; and climate change (Chapter 4);
- actions to sustainably manage forest resources, conserve forest biodiversity and mitigate the threats through, for example, legal measures, multi-functional forestry, education, research and monitoring (Chapter 5).

The region 'Europe' can be defined in different ways. In this report statements about 'Europe' generally refer to the EEA's 32 member countries (2) and seven cooperating countries (3) (Map 1.1).

The EU is a strong political, legal and economic actor in a number of policy areas important for European forests. The EU is party to a number of international conventions and processes, including the CBD and the Ministerial Conference for the Protection of

(1) Although this report is published by the European Environment Agency — a European Union body — it is not a formal report from the European Community as a party to the CBD.
(2) The 'overseas territories' of some EEA member countries are not considered in this report.
(3) Monaco and the western Balkan countries: Albania, Bosnia and Herzegovina, Croatia, Montenegro, Serbia, and the Former Yugoslav Republic of Macedonia.

Forests in Europe (MCPFE). Depending on the year that the information relates to, the term EU refers to:

- EU-15 (up until 2004): Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Sweden, Spain and the United Kingdom;
- EU-25 (2004–2006): EU-15 plus Cyprus, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia;
- EU-27 (from 2007): EU-25 plus Bulgaria and Romania.

European forests are extremely variable with regard to: their ecological conditions; socio-economic and technical characteristics; and major threats. A classification of forest types reflecting this variation is needed to facilitate assessments of European forests. To serve this purpose a European Forest Type scheme consisting of 14 main categories of European forests has recently been presented by the EEA (Section 3.3).

Map 1.1 Forest map in the area of member and cooperating countries of the European Environment Agency

EEA member and cooperating countries

EEA member country | EEA cooperating country | Outside EEA region | EU-27 (Switzerland and Liechtenstein not included)

Note: No forest data coverage for Turkey, cf. Map 3.2.

Source: EEA, 2007b; and EFI, 2002.

A major source of data used in this report is the reports provided by countries to the Ministerial Conference on the Protection of Forests in Europe in 2007 (MCPFE, 2007). All EEA member and cooperating countries, as well as other EU Member States, participate in the MCPFE process, which comprises a total of 46 countries ([4]). This EEA report is a stand-alone assessment focussing on biodiversity and ecosystem aspects, and utilises information available from a number of other sources in addition to the MCPFE 'State of Europe's forests 2007' report ([5]).

([4]) It should be noted that this report does not cover the Russian Federation, which is party to the MCPFE. The Russian Federation has the largest area of forest and also makes up a major part of the 'European region' in global forest assessments such as the FAO Global Forest Resource Assessments (FAO, 2007).

([5]) Many of the concepts and terms related to forests and forest biological diversity still need to be more precisely defined and, perhaps more importantly, widely understood in a similar way. In the context of reporting, FAO, UNECE and MCPFE have made commendable efforts. Annex 3 presents brief definitions of some of the terms used in this report.

2 Managing European forests — main findings and challenges

2.1 Main findings and preliminary assessment of European forest biological diversity

Globally, European forest biodiversity and forest ecosystems are unique in the sense that the area covered by forest is stable and even increasing slightly, especially given the long history of forestry and use of forest resources. The importance of forestry, and the many objectives it can fulfil, is reflected by the dominance of semi-natural forests (Section 2.2).

Present-day European biodiversity has been, to a large extent, shaped by the re-colonisation of species some 13 000 years ago, after the last glaciation period, when the climate began to become warmer. Human influence through farming and other resource use even occurred during the most recent ice-age in areas not covered by ice, such as the Mediterranean region. Traditional farming and other uses of natural resources — on the whole sustainable systems — have created much of the present European landscape and habitats, and have significantly influenced species' distribution. The current concerns about biodiversity loss, including within forests, are closely connected to the transformation of the traditional landscape into a more industrial one.

Linked to the historical development of forests, is the structure of forest ownership in Europe. This clearly influences the management of the forests and thus forest biodiversity and ecosystem conditions. Within Europe the structure of forest ownership varies considerably from areas dominated by a handful of large industrial enterprises and state managed forests supported by ecological and biodiversity expertise, to areas made up of millions of small- and medium-sized family holdings. The latter is often managed according to a multitude of objectives, levels of ambition, knowledge, and receptiveness to forest management advice (Section 5.1). However, forest management in all countries is guided by national forest policies and instruments to implement these policies.

A European forest biodiversity strategy must also take the landscape level into consideration from a future perspective. The European forest map (Map 3.2) reveals large variation in forest cover: forests are clearly fragmented in the west and south, while forest cover is more continuous in the north and east. However, while there are significant forest areas in all major European mountain regions, within these seemingly continuous forest areas, human activities may have resulted in the fragmentation of specific forest characteristics including particular habitats. As a result, landscape issues are highly relevant for European forest biodiversity today (Section 3.4).

The high-level biodiversity target of halting biodiversity loss in Europe by 2010 (Chapter 1) was found not to be achievable 'without additional efforts' in a recent assessment report to environment ministers of 53 countries in the pan-European region, including the EEA member and cooperating countries (EEA, 2007a). However, for forests, an earlier EEA assessment analysing the biodiversity of major European ecosystems stated that: 'There are clear signs of progress in reducing the threats to and enhancing the biological diversity of Europe's forests' (EEA, 2006a).

The present assessment allows a preliminary analysis of forest biodiversity in Europe with respect to progress made towards the 2010 target. This is in line with the indicator framework outlined within the CBD (CBD, 2006a) and the headline biodiversity indicators identified in Europe (Chapter 1). The assessment is summarised in Table 2.1.

Although the preliminary assessment illustrated in Table 2.1 is positive in important aspects, it also suggests that the 2010 target of halting the loss of biodiversity will not be met for all aspects of European forest biodiversity. This, and the variation across the forest area, is discussed in more detail in the following chapters of this report. In Europe there is a well-developed institutional, legal, financial and information framework for forest protection (Chapter 4) and it is difficult to identify the additional efforts required to make it possible

Table 2.1 A preliminary assessment of European forest biodiversity with respect to the 2010 biodiversity target and headline biodiversity indicators

EU 2010 headline biodiversity indicator	Preliminary assessment	Comment
1. Trends in the abundance and distribution of selected species		Forest birds show a variety of population trends. Some large mammal predators are expanding in range but the most threatened cat species (the Iberian lynx) is found in Europe (Section 3.7).
2. Change in status of threatened and/or protected species		A number of forest species are threatened (Section 3.7).
3. Trends in extent of selected biomes, ecosystems and habitats		The European forest area is slightly increasing (Section 3.2). The use of forest land for building infrastructure is occurring but is limited (Section 3.4).
4. Trends in genetic diversity of domesticated animals, cultivated plants, and fish species of major socio-economic importance		There are considerable differences between countries in the efforts to conserve forest tree genetic diversity and concerns remain about maintaining genetic variation. However, the European Forest Genetic Resources Programme (EUFORGEN) has been established to promote a European forest genetic conservation strategy (Sections 3.8 and 5.4).
5. Coverage of protected areas		Forest areas are increasingly being protected (Section 5.2).
6. Nitrogen deposition		Nitrogen deposition of long-range air pollution is increasing in large areas of Europe. There is growing evidence of negative effects on biodiversity (Section 4.6).
7. Trends in invasive alien species		Although few alien tree species used in forest plantations are considered invasive, there are many other alien species threatening European forest biodiversity (Section 4.5).
8. Impact of climate change on biodiversity	?	Adapting to climate change is a major future challenge (Section 4.7).
9. Marine Trophic Index		Not considered in this report.
10. Connectivity/fragmentation of ecosystems	?	The overall forest area is stable or slightly increasing. However, landscape structure (measured by satellite) shows that forest pattern is dynamic. Changes are occurring in development stages 'within-forest' and the effects of this remain to be assessed (Section 3.4).
11. Water quality in aquatic ecosystems		Not considered in this report.
12. Area of forest, agricultural, fishery and aquaculture ecosystems under sustainable management		In European forests, felling is significantly lower than the increment. Deadwood, an important aspect of forest quality, is low but increasing (Sections 3.6 and 4.2). The MCFPE has established a framework for sustainable forest management which is well-reflected in national forest policies (Section 5.1).
13. Ecological footprint of European countries		Not considered in this report (but see reference to FLEGT in Section 5.3).
14. Percentage of European patent applications for inventions based on genetic resources		Not considered in this report.
15. Funding to biodiversity		Funding to protect and manage forest biodiversity, as well as to monitor forests, is being increasingly made available through the EU Life programme(Sections 3.7, 5.2 and 5.4). EU research funding related to forest biodiversity is also increasing (Section 5.4).
16. Public awareness and participation	?	Maintaining and enhancing public awareness of forests, their biodiversity and cultural values is identified as a major future challenge (Section 2.2).

Notes: Key:  Positive trend;  Stable or no clear trend;  Negative trend; ? No information.

This assessment followed the structural framework of the headline biodiversity indicators identified in Europe in line with the CBD.

Source: Indicator framework from CBD, 2006a, EEA, 2007c.

to halt the loss of biodiversity by 2010. However, if commitments are given towards the period '2010 and beyond'—in line with the EC Communication 'Halting the loss of biodiversity by 2010 and beyond' (EC, 2006a) — there is reason to be more optimistic. Nevertheless there are serious challenges ahead (Section 2.2).

Deposition of nitrogen — one of the EU headline biodiversity indicators — stands out as having a clearly unsatisfactory outcome. This is occurring at a large scale on forest land, mainly caused by long-range air pollution, and information is emerging about its effects on forest biological diversity (Section 3.6). Invasive alien species also pose a significant problem. However, in forest ecosystems in recent decades, it should be noted that the rate of introduction of alien species which turn out to be particularly problematic ('worst invasives') is less than in other ecosystems (Section 3.4). Several factors show mixed trends and/or the information basis for the assessment is insufficient. Perhaps the most positive signal is the fact that European forest area is increasing, while fellings are less than the increment (Section 4.2). Another positive aspect is the existence of an overarching policy framework for sustainable forest management (Section 5.1). However, it must also be noted that climate change (Section 4.7) needs to be addressed and certain adaptation measures may conflict with biodiversity protection. Of a different nature, but also important, is the need to ensure public awareness and interest in forests. These latter issues are identified as major challenges for the future (Section 2.2).

The 'Streamlining European 2010 Biodiversity Indicators' (SEBI 2010) process is developing operational indicators in line with the CBD and the EU headline biodiversity indicator framework. Among the initially proposed 26 SEBI 2010 indicators (EEA, 2007c), two address the EU headline indicator on sustainable development and refer to forest areas (No 12 in Table 2.1). One of these — the SEBI 2010 indicator 'Forest: growing stock, increment and fellings' — thus builds on identical data to the corresponding analysis in this report, and the conclusions on this are also expected to be positive (Section 4.1). The second SEBI 2010 indicator adds 'quality' concerns by considering 'Forest: deadwood', but the outcome of this analysis is less obvious (Section 3.6). The SEBI 2010 process will, in the near future, present a comprehensive indicator-based assessment of progress towards the 2010 biodiversity target, for all ecosystems in the pan-European area. Until this process has been completed, it is not possible to foresee the final conclusions for forest biological diversity.

In addition to assessing progress towards halting forest biodiversity loss, i.e. the 2010 biodiversity target, it is also important to assess the current state of European forest biological diversity and ecosystem conditions *per se*. Table 2.1 presents both positive and worrying information about the development of European forest biodiversity. However, for the time being, due to a lack of quantitative targets and baselines, a comprehensive European-level analysis about the state of European forest biodiversity and ecosystem conditions is not possible.

The EU Habitats and Bird Directives explicitly mention species and habitats that should be preserved in 'favourable conservation status'. In line with the Habitats Directive Article 17, EU Member States are required to report on this (Sections 3.7 and 5.2). In principle, this should enable a European assessment of defined biodiversity targets covered by these Directives in the near future.

More generally, this report highlights several aspects of biodiversity and ecosystem conditions of European forests which need improvement. The formulation of the MCPFE sustainable forest management criterion 4 'Maintenance, Conservation and Appropriate Enhancement of Biological Diversity in Forest Ecosystems' (MCPFE, 2007) as well as other MCPFE decisions (Figure 5.2) indicates a political awareness that forest biodiversity needs additional support. Based on the issues covered in this report, Table 2.2 presents some examples of management measures to enhance forest biodiversity in Europe related to the main European Forest Type categories.

Some examples of European activities which meet the main goals of the EPOW on forest biological diversity are presented in Table 2.3.

In 2006 the CBD COP identified targets related to the programmes of work, including the EPOW on forest biological diversity. Most of these targets are qualitative and similar to what has been discussed above in relation to the EU target of halting biodiversity loss. However, as regards forest protection, Goal 3 within Programme Element 1 (Table 2.3) provides a quantitative target that 'at least 10 % of each of the world's forest types are effectively conserved' (CBD, 2006a). Presently it is not possible to indisputably assess to what extent this target has been met in Europe. Reporting by EEA member and collaborating countries to MCPFE indicates that protection of forests for biodiversity is the main management objective for 5.8 % of forest and other wooded land area (Figure 5.3, Section 5.2).

Table 2.2 Examples of management measures to improve biodiversity conditions in European forests

European Forest Type category (see Annex 1)	Potential management measures to improve biodiversity conditions
1. Boreal forest	Restore fire regimes and fire-succession habitats (Section 4.4, see also Annex 1) Increase amount of deadwood, large trees and late succession stages (Section 3.6) Increase proportion of deciduous tree species (Section 3.7) Promote management practices that maintain or increase continuous tree cover (Section 5.1)
2. Hemiboreal forest and nemoral coniferous and mixed broadleaved-coniferous forest	Increase amount of deadwood, large trees and late succession stages (Section 3.6) Preserve veteran trees (Section 3.6) Decrease nitrogen deposition (Section 4.6) Promote management practices that maintain or increase continuous tree cover (Section 5.1) Increase protected forest area (with no or minimal intervention, Section 5.2)
3. Alpine coniferous forest	Decrease nitrogen deposition (Section 4.6)
4. Acidophylous oakwood and oak-birch forest	Increase amount of deadwood and late succession stages (Section 3.6) Preserve veteran trees (Section 3.6) Decrease nitrogen deposition (Section 4.6) Increase structural diversity and 'close-to-nature' management (Section 5.1) Increase protected forest area (with no or minimal intervention, Section 5.2)
5. Mesophytic deciduous forest	Increase oak and ash-oak forest area and forest connectivity in the western European region (Sections 3.1 and 3.4) Preserve veteran trees (Section 3.6) Increase structural diversity and 'close-to-nature' management schemes (Section 5.1), especially for short rotation coppices Decrease nitrogen deposition (Section 4.6) Increase protected forest area (with no or minimal intervention, Section 5.2)
6. Beech forest	Reduce fragmentation (Section 3.4) Increase amount of deadwood and late succession stages (Section 3.6) Increase structural diversity and 'close-to-nature' management (Section 5.1) Decrease nitrogen deposition (Section 4.6) Increase protected forest area (with no or minimal intervention, Section 5.2)
7. Mountainous beech forest	Increase amount of deadwood and late succession stages (Section 3.6) Decrease nitrogen deposition (Section 4.6) Increase structural diversity and 'close-to-nature' management (Section 5.1) Increase protected forest area (with no or minimal intervention, Section 5.2)
8. Thermophilous deciduous forest	Preserve veteran trees (Section 3.6) Control forest fires (Section 4.4)
9. Broadleaved evergreen forest	Preserve veteran trees (Section 3.6) Promote/conserve silvo-pastoral systems (Section 4.1) Control forest fires (Section 4.4)
10. Coniferous forest of the Mediterranean, Anatolian and Macronesian regions	Control forest fires (Section 4.4)
11. Mire and swamp forests	Increase protected forest area (with no or minimal intervention, Section 5.2) Where possible restore natural water balance

Table 2.2 Examples of management measures to improve biodiversity conditions in European forests (contd)

12.	Floodplain forest	Increase floodplain forest area (Section 3.1) Where possible restore natural water regime and seasonal flooding
13.	Non-riverine alder, birch or aspen forest	Maintain a readiness to protect types which are of minor interest to forestry at present
14.	Plantations and self-sown exotic forest	Control forest fires and avoid fire-prone species in the Mediterranean region (Section 4.4) Control invasive alien species (e.g. Rhododendron in the United Kingdom and Ireland) (Section 4.5) Increase tree species and structural diversity (Section 5.1) Select sites for afforestation optimising biodiversity on a landscape level (Section 5.1)

Table 2.3 CBD Expanded programme of work on forest biological diversity: examples of policy responses in Europe

EPOW programme elements and goals	Summary of policy responses in Europe
Programme element 1: Conservation, sustainable use and benefits sharing	
Goal 1; To apply the ecosystem approach to the management of all types of forests	Several resolutions of the MCPFE, to be followed up by criteria and indicators for reporting, define Sustainable Forest Management fully in line with the CBD ecosystem approach. Most European countries have either national or regional forest programmes or equivalent processes in place. Aiming towards sustainable management, conservation and sustainable development of forests, national forest programmes should also contain an integrative ecosystem approach. The second resolution of the MCPFE Warsaw Conference in 2007 goes beyond forest ecosystems, by emphasising the role of forests and forest management for biodiversity of water ecosystems and vice versa. Forests will be one of the components of the fully-fledged European Ecosystem Assessment (Eureca) by the EEA for 2012. See further information in: Sections 2.2, 4.1 and 5.1.
Goal 2; To reduce the threats and mitigate the impacts of threatening processes on forest biological diversity	Forest fragmentation and the effects of land-use change on forest ecosystems are the object of several European monitoring and research activities. Within these activities forest spatial patterns are being analysed and links made with ecological trends. Increasingly, action is being taken to control and manage invasive alien species within forests. Most European countries are in the process of developing National Strategies for Invasive Alien Species, in response to CBD Guiding Principles and the Bern Convention. European countries have monitoring systems to assess atmospheric pollution and its impact on forests (in response to Convention on Long-range Transboundary Air Pollution (CLRTAP) and future EU funding through the Life+ Regulation) and natural disturbances and forest fires (in support of EU and national policies to reduce these threats and their impacts). All European countries have ratified the Kyoto Protocol and many countries have set up programmes to develop climate change adaptation measures in forestry. See further information in: Sections 3.4, 4.5, 4.6, 4.7 and 5.3.
Goal 3; To protect, recover and restore forest biological diversity	Many countries have programmes, for relevant forest categories, to support the conversion of single-aged single-species stands into more structurally diverse or mixed forests. Networks of protected forest areas have been established nationally and through European initiatives, such as the Natura 2000 process. Discussions are on-going on what a well-balanced proportion between different protection regimes and managed forests should be, and how different concepts can be integrated holistically. See further information in: Sections 5.1 and 5.2.

Table 2.3 CBD Expanded programme of work on forest biological diversity: examples of policy responses in Europe (contd)

Goal 4; To promote the sustainable use of forest biological diversity	European countries' annual timber harvest is consistently far below annual forest volume growth at the national level and also mostly at the regional level. Illegal timber harvesting is not recognised to be a significant problem in most countries. European countries have committed themselves to fulfilling MCPFE resolutions for the conservation of European forest biodiversity. See further information in: Sections 4.2 and 5.1.
Goal 5; Access and benefit-sharing of forest genetic resources	The European Forest Genetic Resources Programme (EUFORGEN) is a collaborative mechanism among European countries to promote conservation and sustainable use of forest genetic resources. See further information in: Section 3.8.
Programme element 2: Institutional and socio-economic enabling environment	
Goal 1; Enhance the institutional enabling environment	Most European countries have updated their legislation to address the various commitments to forest and environmental processes and conventions. These include the CBD, the United Nations Forum on Forests, the MCPFE, the Environment for Europe Process, the CLRTAP and the Convention to Combat Desertification. Most countries have forest monitoring and planning systems in place, but these sometimes cover only state-owned forests. In addition, monitoring methodologies and related definitions that are used across Europe are not harmonised. The EU promotes forest law enforcement and trade through the Forest Law Enforcement, Governance and Trade (FLEGT) programme and action plan. The EU also takes a leading role in the development of methodologies to reduce emissions from deforestation and degradation (REDD) in the context of the Kyoto Protocol. See further information in: Chapter 5.
Goal 2; Address socio-economic failures and distortions that lead to decisions that result in loss of forest biological diversity	The need to improve coordination of policies to halt the loss of forest biological diversity has been discussed within the MCPFE and the Environment for Europe process. See further information in: Sections 5.1 and 5.3.
Goal 3; Increase public education, participation and awareness.	The MCPFE approach to national forest programmes calls for participation, partnership-building and awareness-raising. Due to the development of the European society, maintaining public awareness of forests and their values will be a major future challenge. See further information in: Sections 2.2 and 5.1.
Programme element 3: Knowledge, assessment and monitoring	
Goal 1; To characterise and to analyse from forest ecosystem to global scale and develop general classification of forests on various scales in order to improve the assessment of status and trends of forest biological diversity	A new European forest type classification system has been developed by the EEA in support of biodiversity-related assessments, through consulting a wide range of European experts. Although most European countries monitor forests, there is not yet a systematic and harmonised Europe-wide monitoring of forests in place. However, several ongoing activities are expected to contribute to this. See further information in: Table 2.2, Sections 3.3 and 5.4.
Goal 2; Improve knowledge on and methods for the assessment of the status and trends of forest biological diversity, based on available information	Over the past few decades, national forest inventories and connected analyses have been developed, from surveys to ensure sustainable wood supply, to integrated sustainable forest management assessment tools, with components for monitoring wood resources, carbon, biological diversity, socio-economic and other parameters (Also relevant to Goal 1). See further information in: Section 5.4.
Goal 3; Improve understanding of the role of forest biodiversity and ecosystem functioning	Biodiversity and forests issues are given increasing attention in the EU framework programmes on research and technological development. See further information in: Section 5.4.
Goal 4; Improve the infrastructure for data and information management for accurate assessment and monitoring of global forest biological diversity	The European information and observation network together with EU data centres for biodiversity and for forests should improve data accessibility and data exchange at both national and European levels. See further information in: Chapter 1, Section 5.4.

Source: CBD, 2002.

One might assumed that much of these areas are protected by national law and/or designated under the EU Birds and Habitats Directives (Section 5.2). As discussed in Section 5.2, as much as 13 % of the forest area of the 27 EU Member States is designated as 'Special Protection Areas' under the EU Habitats Directive. However such designations do not exclude normal forestry or other intervention, as long as a 'favourable conservation status' of the listed habitat types is maintained.

A more in-depth analysis of the conservation status of the forest habitats listed by the EU Habitats Directive will be possible in the near future (Section 5.2). The CBD target also states that the protection should cover 'each of the world's forest types'. In Europe the collection of data and analysis of how representative protected forests areas are with respect to world and European Forest Types (Section 3.3) is yet to be undertaken.

2.2 Main challenges for future management and use of European forests

While today, most political attention on the role of forests focuses on issues such as climate change and energy, any strategy for sustainable forest management must also address the conditions of the forest ecosystems and forest biological diversity. Managing European forests to 'maintain, conserve and as appropriate enhance the biological diversity of forest ecosystems' (MCPFE, 2002) thus faces a number of new challenges in the coming years:

1. The role of European forests can be expected to develop further towards **multi-functionality** (Chapter 5). Production of wood and other traditional forest resources will have to be balanced against all kinds of other goods and services from the forest ecosystems. Other 'societal requests' on forests, including the protection of biodiversity, will become stronger and more diverse in different areas. There is a need to develop frameworks capable of addressing all these demands to ensure optimal future forest landscapes. In line with this, the EEA is developing a European Ecosystem Assessment (Eureca) as a follow-up to the Millennium Ecosystem Assessment. This will also be in line with the strategic goals as formulated by the UN Environment Programme to: improve the knowledge base regarding ecosystem functioning and services; develop and apply tools for political decision-making at the European level; and outreach to stakeholders.

2. Climate change is currently high on the political agenda, and forest management must include **adaptation to future changes in climate** as well as making a contribution to the **carbon sink** (Section 4.7). It is important that measures such as afforestation and more intensive forest utilisation to increase carbon sequestration do not conflict with biodiversity objectives. Connectivity between forest areas must be secured and in some cases corridors must be created to ensure migration of populations. Protected forest areas will also need special attention in this context. In a future climate many of the current threats to European forests can be expected to increase, including forest fires, droughts, storms, invasive alien species and insect damage.

3. There will be increased demands on forests as a resource for **bio-energy** (Sections 4.1 and 4.3). The legitimate need to contribute to Europe's energy supply does not necessarily conflict with biodiversity and ecosystem conditions. However, recent EU policy developments that reinforce the need for renewable energy (EC, 2008) may lead to several Member States further promoting biomass from forestry — including measures to increase forest production and/or more intensive use of forests — which potentially conflict with biodiversity protection. For instance, non-native tree species and highly productive 'improved' genetic breeds and clones can be used, but this needs to take into account the risks of invasions to other areas, including gene pool impacts.

4. **Genetically modified trees** may offer benefits such as increased growth and favourable composition of wood and resistance to pests. However, as is currently being debated in Europe and elsewhere, this biotechnology may also bring risks to biodiversity and humans that are not yet fully understood. In line with this the CBD recommends Parties take a precautionary approach to the use of genetically modified trees. There are presently no plantations with genetically modified trees for commercial use in Europe, but experimental plantations can be found in Belgium (indoors only), Finland, France, Germany, Italy, the Netherlands, Poland and Sweden (CBD, 2006b). Research and future field testing of genetically modified trees must include comprehensive, transparent and publicly-accessible studies of the potential risks. They must also include an assessment of impacts to the gene pools of other populations, as a basis

for a risk assessment and to assist decisions on practical use.

5. Recently European forests have experienced severe damage by **forest fires,** which have been largely induced by man and need to be brought under control. Albeit mainly in the Mediterranean region, few problems in the affected countries currently surpass that of forest fires (Section 4.4). In these areas, it is important to avoid restoration methods that have a negative effect on biodiversity as well as securing appropriate fire regimes for biological communities that are dependent on fire succession (the latter being relevant also in northern Europe (Table 2.2)).

6. The present changes in European society — including urbanisation, immigration, technological development and changes in lifestyle — will change the **cultural role of forests** and impact future societies' awareness of nature and forests. There has been, and will continue to be, a steady and inexorable decline in the proportion of the European population living close to and having a cultural relation to a local forest. Urbanisation and the increased mobility of the populations — voluntarily or as result of conflict — are the main drivers for this development. On the other hand, increased standards of living, travel and information flows open up new opportunities. It is most likely that education, information availability, interest groups for nature and the use of traditional knowledge, history and folklore will be a prerequisite for long-term biodiversity conservation.

7. Finally, to manage European forests and biodiversity values, there is a need to provide decision-makers and stakeholders with the necessary **information on forest ecosystems and forest biodiversity.** In particular, European-level information availability on biodiversity composition (i.e. species and communities) needs to be strengthened (Section 3.7). To capture the variation in European forests, data should be collected according to the European Forest Types and relate to the relevant headline biodiversity indicators (Table 2.1) (Section 3.3).

3 Development of forests and forest biological diversity in Europe

3.1 Europe's forest area is increasing

Much of Europe's land area would have been covered by forest in the absence of man, human settlements and agriculture. Recent reporting to the MCPFE shows that forests today cover 33 % of the land area of the 39 countries in the EEA region (MCPFE, 2007). This corresponds to appoximately 185 million ha of forest area.

Currently there is no major deforestation in Europe, and on the contrary, the forest area slightly increased in most countries between 1990 and 2005. The annual increase in forest area in the EEA region amounts to approximately 800 000 ha per year or around 0.4 % annually (MCPFE, 2007).

Forest cover and the recent increase in forest area is not uniform across Europe. For instance in Ireland, where forest covers slightly less than 10 % of the land area, forestry is being considered a viable future land use, with forested areas expected to deliver important ecosystem services. Accordingly, afforestation has been actively promoted over the past twenty years. Ireland's forest policy, as reflected in the 1996 national policy objective, is to achieve a 2.5-fold increase in forested area over a 30 year period (Department of Agriculture, Food and Forestry, 1996). Three Mediterranean countries (Portugal, Spain and Italy) report relatively large forest area increases (1–2 % per year). In these countries, as well as in some other regions, a large-scale conversion of mainly agricultural land to forest is taking place. This is either being actively promoted by afforestation programmes or is a result of decreasing grazing pressure allowing re-growth of forests through natural succession processes (MCPFE, 2007).

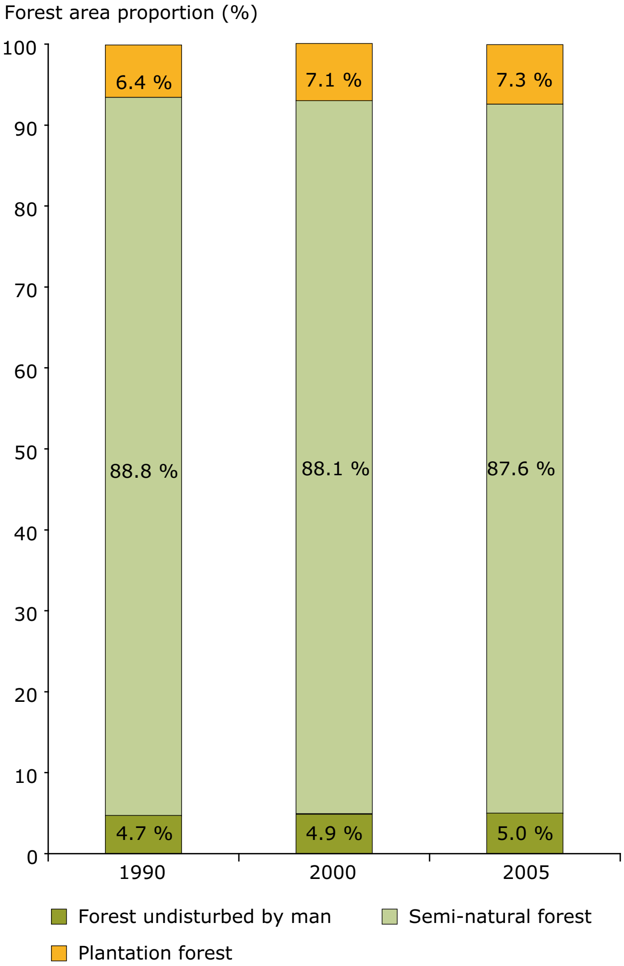
From a biodiversity point of view, the overall positive picture of increasing forest area is complicated by the potential loss of high-biodiversity non-forest land being converted to forest (High Nature Value farmland, EEA, 2004). This concern is strengthened because much of the increase in forest area is made up by plantations, which create less natural ecosystem conditions (Section 3.2).

In Europe, the harvest of wood is prohibited in substantial areas of forest because of their special importance for biodiversity, protective functions and recreation. Only 75 % of the total forest area (around 139 million hectares) is considered to be available for wood supply in the 39 countries of the EEA region. This share is reported to have decreased between 1990 and 2005 due to an increasing focus of national policies towards other uses of forest land (e.g. protection) in e.g. Finland, Bulgaria, Latvia, Poland, Romania, Sweden and Turkey (MCPFE, 2007).

Not only is the forest area stable and slightly increasing in Europe, but the standing volume of forest (the growing stock) has increased during past decades. This increase has been both in terms of absolute numbers (total growing stock) and in relative terms (growing stock per hectare) (MCPFE, 2007).

The reasons for this are multiple: fellings have been lower than increment; management practices have improved; atmospheric deposition of nitrogen has increased site fertility; and there has been an increasing concentration of atmospheric carbon dioxide (Karjalainen *et al.*, 1999). This expansion of the growing stock is forecast to continue during the coming decades, despite an expected higher market demand for timber. As a consequence, there are more veteran and large trees and more forests are being allowed to grow into older development stages. These factors have a positive effect on forest biological diversity.

Figure 3.1 Forest naturalness in EEA member and cooperating countries



Source: MCPFE, 2007.

3.2 Semi-natural forests dominate in Europe

Semi-natural forests include a broad range of ecosystems with an ecological dynamics influenced by human interventions ([6]). To a certain extent they maintain their natural characteristics, including biodiversity. Around 87 % of forests in the 39 EEA member and cooperating countries (77 % in the EU-27 Member States) are classified as 'semi-natural' (Figure 3.1). In the Czech Republic, Latvia, the Netherlands, Poland, Slovakia and Switzerland, semi-natural forests are reported to make up 100 % of the total forest area (MCPFE, 2007).

Forests undisturbed by man may host populations of otherwise threatened species and, if large enough, provide ecosystems comparable to a natural state of biodiversity. Such forests are therefore valuable for understanding ecological processes and serve as references for forest policy and planning. However, it is extremely rare to find any forest in Europe totally devoid of anthropogenic influences, and the interpretation of the definition of the areas to be 'undisturbed by man' differs considerably between countries. In all, about 9 million hectares of forest in the EEA region (around 5 % of the total forest area) (Figure 3.1) is considered undisturbed by man. More than half of this area was reported by Sweden, and most of the remaining areas are found in Bulgaria, Finland, Norway, Spain and Turkey. In the other countries the share of forests undisturbed by man is more limited (MCPFE, 2007), cf. however Box 3.1.

The area of plantation forest in the EEA region has increased over the last 15 years from 10.9 to 13.3 million hectares (almost 8 % of the total forest area) (MCPFE, 2007). Plantations are not evenly distributed, for example Malta reports all its forests as plantations. Plantations also dominate in Denmark, Iceland, Ireland and the United Kingdom. In Belgium, Luxembourg, Portugal and Turkey, a quarter or more of the forest area is made up of plantations. However, a narrow interpretation of the definition of plantation forest which focuses on introduced species, may explain why several countries report the area of plantations rather restrictively. In areas prone to desertification, such as the Mediterranean, forest plantations have been promoted to combat land degradation (Vallejo *et al.*, 2003) (Box 3.2). However, plantation forests are controversial from a biodiversity point of view (Sections 4.2 and 5.1).

([6]) Definitions of 'semi-natural forest', 'forest undisturbed by man' and 'plantation forest' are presented in Annex 3.

Box 3.1 The Białowieza forest

Photo 3.1: © T-B. Larsson

One of the largest European forest areas in (almost) natural conditions outside the boreal region is the Białowieza Forest, mainly comprised of the 'Mesophytic deciduous' forest category (Annex 1). The forest is located in the border region of Poland and Belarus. The total area of continuous forest, including areas subject to wood harvest and related forestry measures, is estimated at 150 000 ha. Of this Poland's 10 500 ha Białowieza National Park and Belarus's 15 700 ha of protected park create strictly protected core areas.

The history of protection of the Białowieza Forest dates back to the 1500's as a royal hunting reserve, mainly to safeguard the hunting of the wisent, *Bison bonasus.* The protection regime lasted up to the Russian Revolution and the overthrow of the Tsar in 1917. World War I ended the four hundred years of protection and in 1919 the last wisent was killed. The species was returned to the forest from zoos and game parks in 1929. It was bred in enclosures for twenty years and released back to nature in 1952. Today, the Białowieza Forest hosts the largest free-ranging population, estimated at some 3 000 individuals (another subspecies is found in the Caucasus).

The core area of the Białowieza Forest has developed a near-to-natural stand structure, with trees of all ages and the small-scale patch dynamics associated with this forest type. The late succession stages are dominated by a mixture of large broadleaved trees such as oaks (*Quecus robur*), lime (*Tilia cordata*), hornbeam (*Carpinus betulus*) and aspen (*Populus tremula*) as well as coniferous trees such as spruce (*Picea abies*) and on dryer sites, pine (*Pinus sylvestris*). Regeneration predominantly takes place in small gaps created by fallen trees. Wind is the main gap-creating agent, but spruce is also significantly affected by fungi and subsequent bark beetle attacks. The gaps, which typically range in size from a single tree to several dozen fallen trees, are first invaded by pioneers like aspen (*Populus tremula*), birch (*Betula pendula*), rowan (*Sorbus aucuparia*) and alder (*Alnus glutinosa*). These are followed by the 'gap-fillers' — lime (*Tilia cordata*) and hornbeam (*Carpinus betulus*), the latter species also being able to regenerate in closed stands.

Source: Bobiec, 2007, and http://www.bpn.com.pl.

Photo 3.2: © A. Bobiec

Box 3.2 Forest plantation establishment in Portugal and Spain

Catalonian forest landscape

Photo 3.3: © T-B. Larsson

Spain and Portugal have seen an important increase in the area of forest plantations (plantation forests) during recent decades, established mainly on formerly extensively grazed land. This is an ongoing development and over the past 15 years plantation area increased from 1.1 to 1.5 million ha in Spain and from 0.6 to 1.2 million ha in Portugal. In both countries forest plantations have been established with protective as well as productive (wood and pulp supply) objectives in mind and combined protective-productive purposes.

In Spain, the main species used have been native tree species such as *Pinus sylvestris, P. nigra, P. pinea, P. halepensis* and *P. canariensis.* Short-rotation is also introduced and non-native species have been used with productive objectives in mind, mainly in the northwest and southwest of the Iberian Peninsula, e.g. *Eucalyptus* spp., *Populus* spp., *Pinus radiata and P. pinaster* (MMA, 2005).

In Portugal, the main species used are non-native *Eucalyptus* spp. (mainly *E. globulus*), conifers like *Pinus pinaster* (with wide distribution) and *Pinus pinea* (found mainly in the south and in coastal areas) as well as native broadleaved species such as *Quercus suber,* in the southern part of the country. In recent decades, the plantation of native species has increased for protection and biodiversity purposes.

Parts of these plantations were partially co-funded through the reformed EU common agricultural policy, which offered incentives to promote the use of native and particularly broadleaved species (MMA, 2005). This was not least because of the concern that monocultures — especially those of introduced species — are more vulnerable to pest outbreaks, and may therefore have detrimental impacts on local hydrology and nutrient balance. Plantations in Portugal and Spain have suffered considerably in recent years from extensive, largely human-induced, forest fires (Section 4.4).

Source: MCPFE, 2007; MMA, 1999, 2005; Aguiar *et al.*, 2007; Dias *et al.*, 2007.

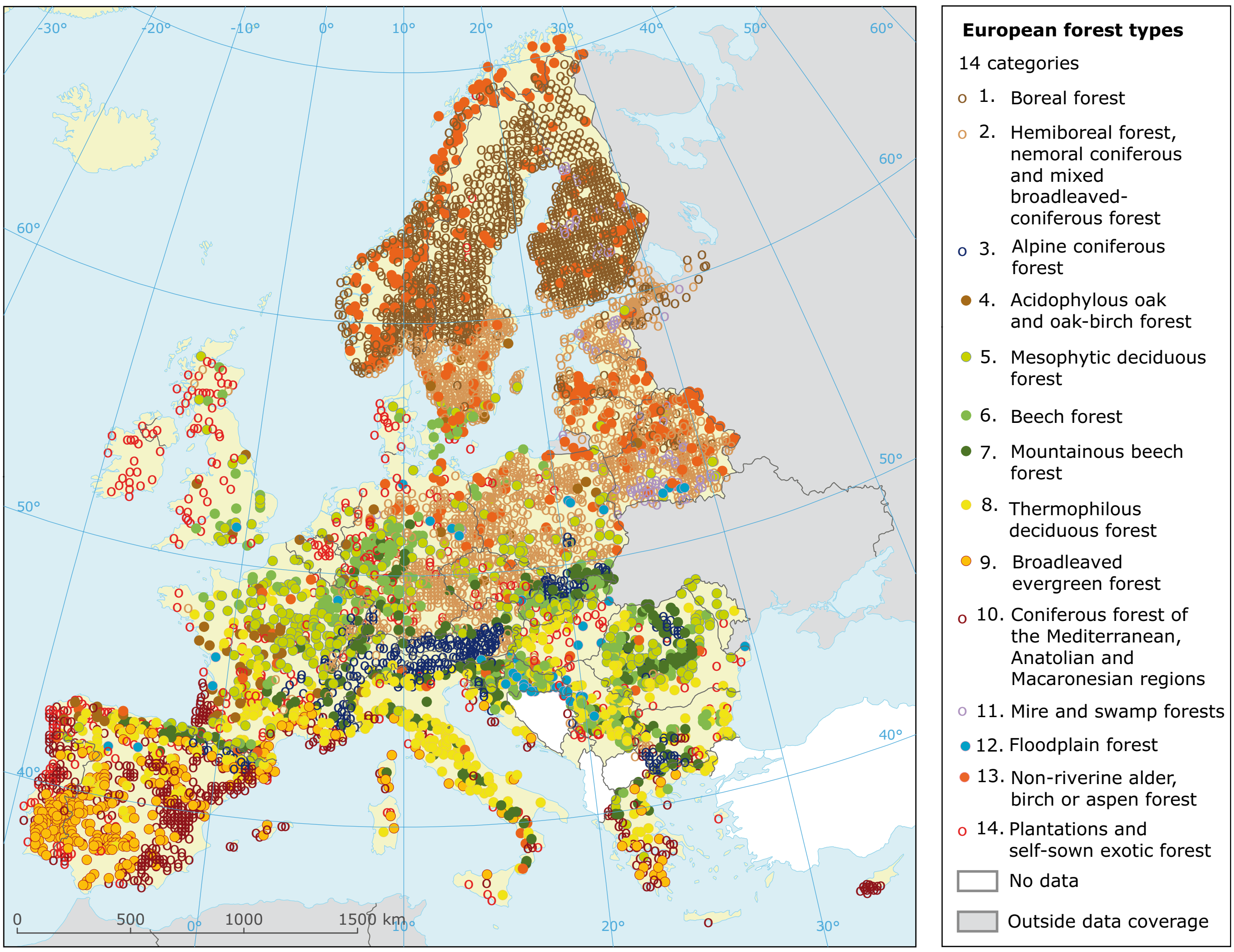
3.3 European forest types for assessment of forest conditions

There is a large variation in the forests of the European region both in relation to ecological and socio-economic conditions, as well as technical requirements for forestry and their major threats. This variation has led to a major activity during the last decade, involving a number of experts from most European countries, to develop a forest typology which can be used for a European-level assessment of forest condition and policy actions. This has resulted in a proposed European Forest Type scheme distinguishing 14 main categories of forests (EEA, 2006b):

1. Boreal forest;
2. Hemiboreal forest and nemoral coniferous and mixed broadleaved-coniferous forest;
3. Alpine coniferous forest;
4. Acidophylous oak and oak-birch forest;
5. Mesophytic deciduous forest;
6. Beech forest;
7. Mountainous beech forest;
8. Thermophilous deciduous forest;
9. Broadleaved evergreen forest;
10. Coniferous forest of the Mediterranean, Anatolian and Macaronesian regions;
11. Mire and swamp forests;
12. Floodplain forest;
13. Non-riverine alder, birch or aspen forest;
14. Plantations and self-sown exotic forest.

These categories, which reflect the variation in the main factors that determine European forest biodiversity, are briefly presented in Annex 1. The distribution of the forest type categories in Europe is shown in Map 3.1. This allows a preliminary

Map 3.1 Classification of the ICP Forests Level 1 plots with respect to main categories of the European Forest Types



Note: Forest category coding follows Annex 1. Regarding ICP Forests, see Sections 4.6 and 5.4.

Source: BioSoil project (EC, 2007).

evaluation of the relative frequency of categories for European countries and suggests an average of six categories per country. A few countries were found to be more variable and the maximum number of twelve categories was found in France. The classification scheme, including keys for classification and more detailed descriptions of categories and types, is presented in a report published by the EEA (EEA, 2006b).

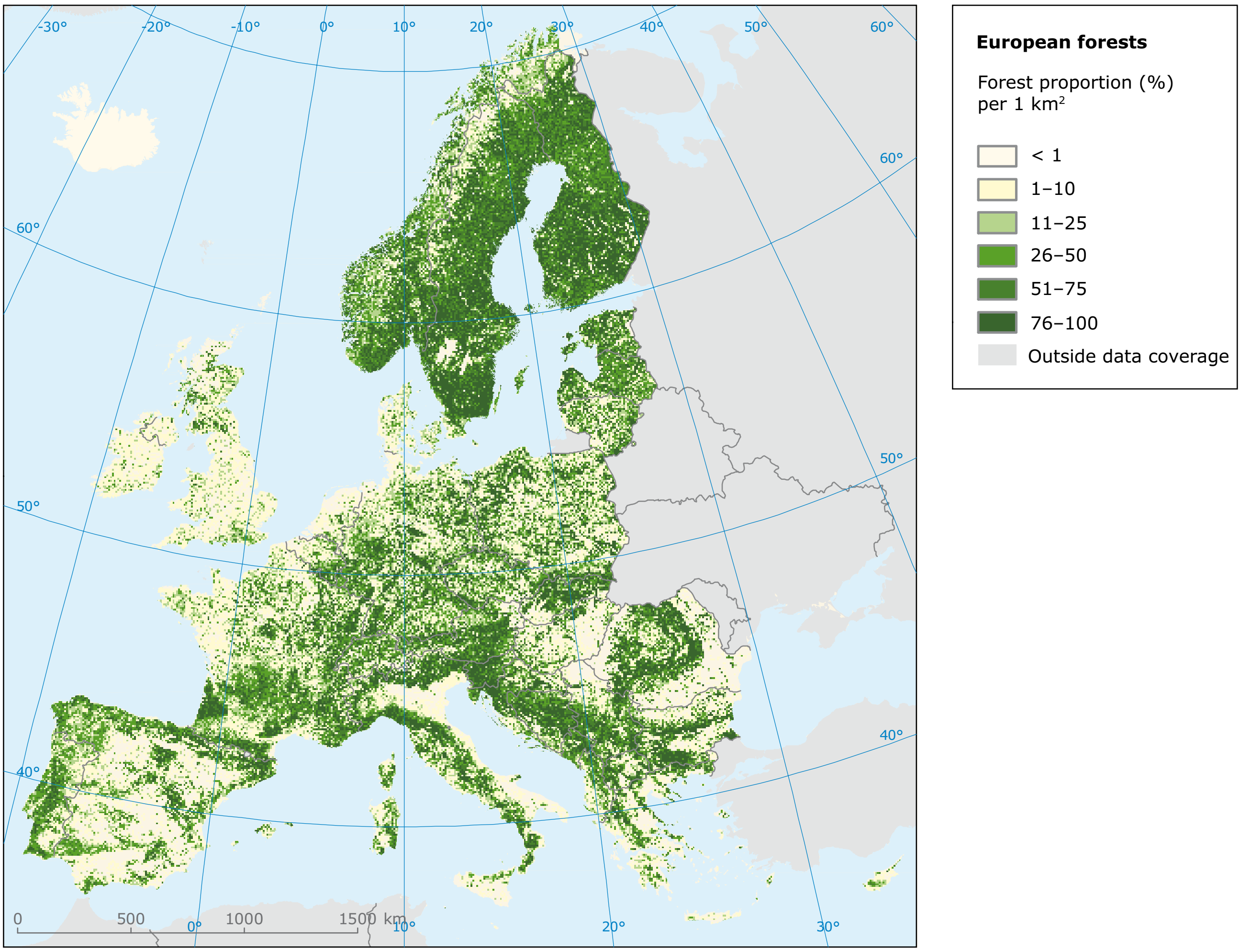
The European Forest Type classification — including more extensive information on each forest type in the report by EEA (2006b) — gives an introductory overview of the European forests. It describers the 14 main categories and under each category there are a number of specific types of forest (currently a total of 76 types). The classification sets the scene for further investigation of the biological diversity in European forests.

For European policy the most important use of the classification is to serve as a framework for assessing the state of forest biodiversity and how the main threats vary in different parts of Europe. The classification level of 14 main forest categories is currently being discussed within the MCPFE as a potential basis for improved future reporting of the state of European forests. As the system is new, the forest data reported up until now are not specified according to these categories (MCPFE, 2007). Testing of the scheme is currently in progress. In this report the main categories of the European Forest Types are qualitatively referred to when the different issues are discussed.

3.4 Mosaic of landscapes and fragmentation

Before human settlements and agriculture much of the European land area was covered by forest. Human activities have altered the area and distribution of forest. As shown in Map 3.2, today areas with very little forest area are found in western

Map 3.2 Pan-European forest and non-forest map, 2000



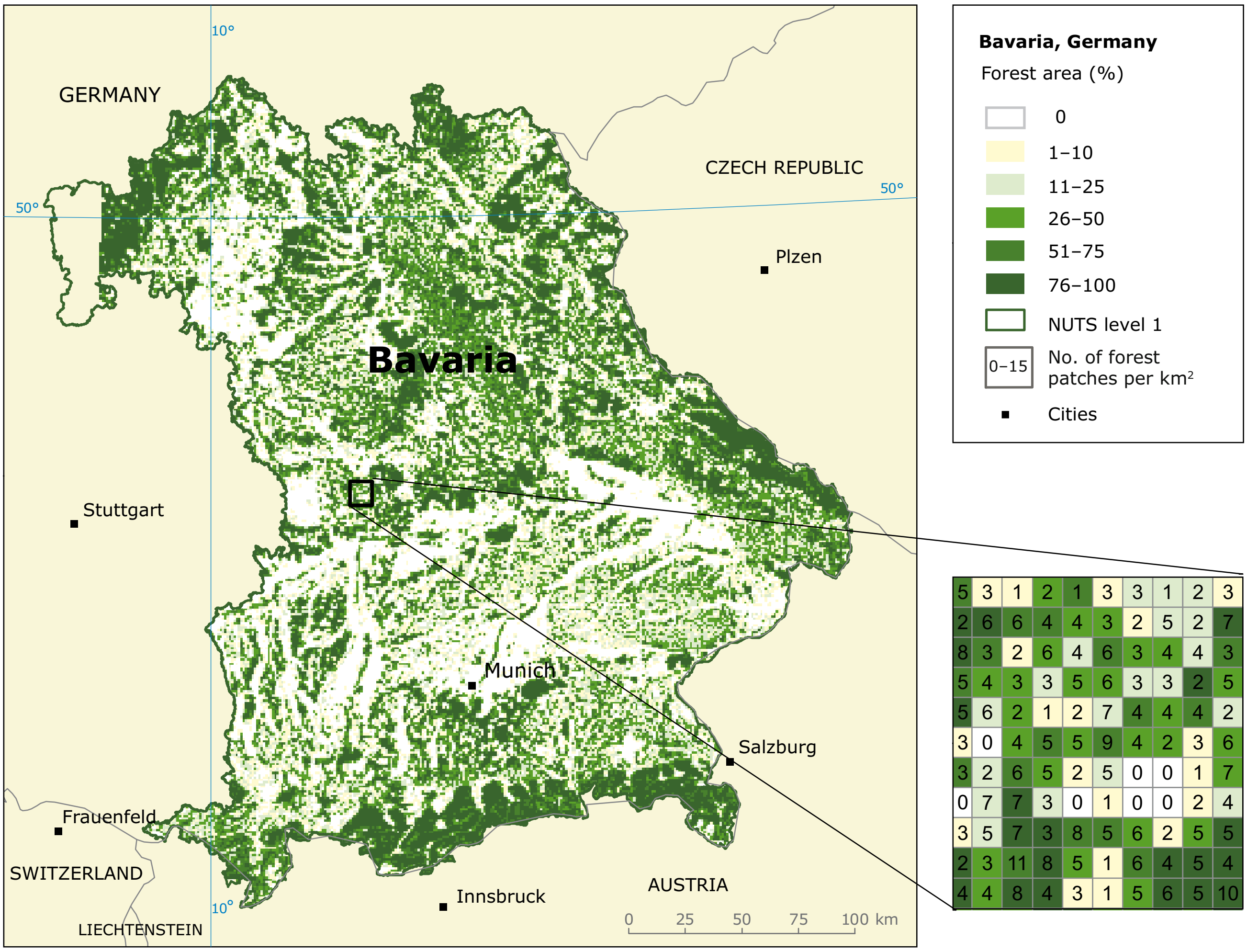
Source: EC, 2007a.

Europe and the Mediterranean. The spatially most extensive forest cover is found in the northern boreal forests, while the forests of central Europe are mainly alpine coniferous forests and mountainous beech forests categories (Annex 1) which remain unfragmented. There are also examples of landscapes dominated by forest plantations, e.g. in Scotland, Ireland, southwest France and the Mediterranean region. Several forest categories, such as the mesophytic deciduous forest and lowland to submountainous beech forests, dominate the landscape in parts of Europe, but are also found in more or less fragmented forest landscapes. Floodplain forests are scarce in most of Europe today.

Landscape gradients, ranging from areas of continuous forest cover to transitional zone of gradually decreasing forest cover meeting finally with open agricultural and built land, can be found in several European countries (Map 3.3). The transitional zone typically shows a mosaic pattern between forest and agricultural fields and is potentially rich in forest edge habitats. Similar mosaic patterns can also be identified in many European landscapes lacking clear gradients. Development in agriculture has reduced the extent of such transitional or mosaic landscapes, by abandoning marginal fields in the forest dominated regions and removing small forest patches in the more intensively used agricultural landscape. Agricultural intensification has also decreased the amount and quality of forest edge habitats.

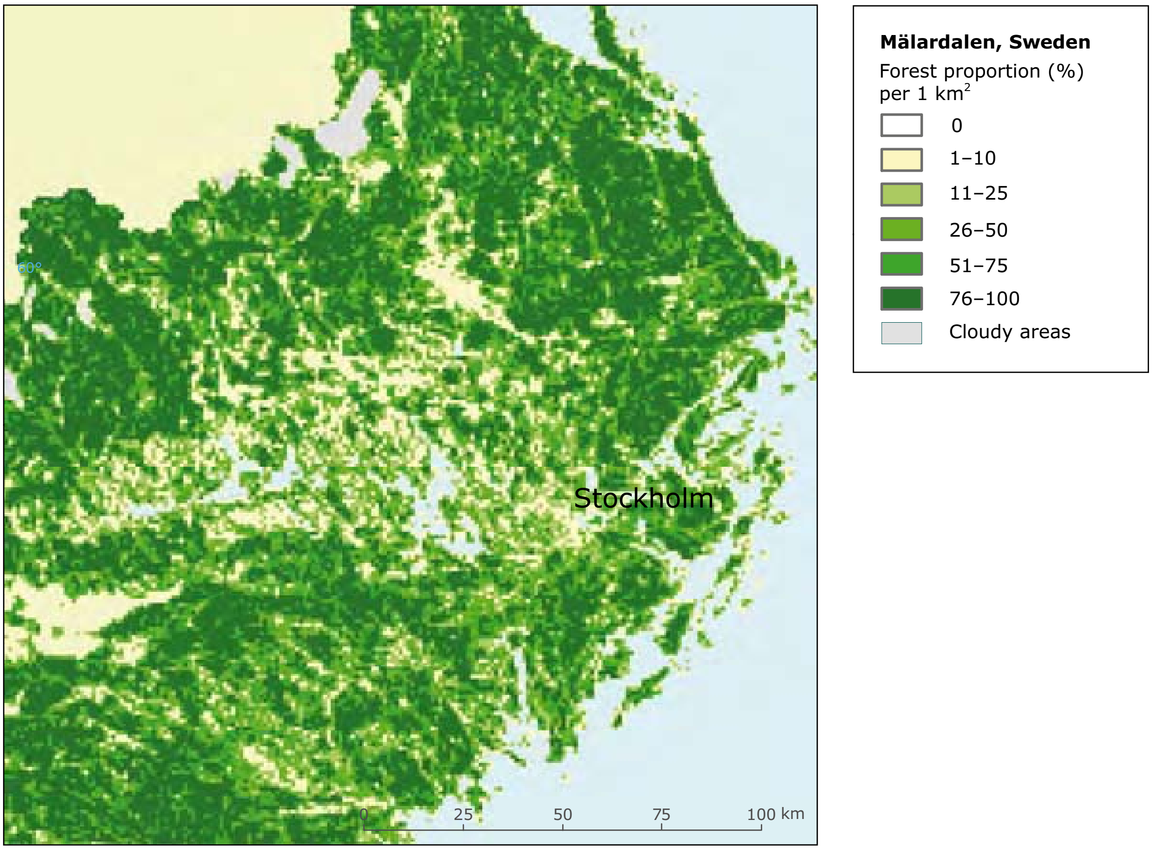
Forest fragmentation impacts biodiversity in a complex way and on all spatial scales, depending on species habitat needs, population dynamics, dispersal ability and interactions with the biological community. Larger areas of more or less continuous forest are required to host a number of species

Map 3.3a Example of landscape gradients with varying forest cover in Bavaria, Germany



Source: GSE Forest Monitoring, 2007.

Map 3.3b Example of landscape gradients with varying forest cover in Mälardalen, Sweden



Source: GSE Forest Monitoring, 2007.

in viable populations. This is the case in Europe for large forest mammals, such as the brown bear (*Ursus arctos*), the moose (*Alces alces*), and birds like the capercaillie (*Tetrao urogallus*), and a number of woodpecker species (Mikusinski and Angelstam, 2004).

Over time, increased forest-fragmentation leads to subdivision of populations, higher vulnerability to disturbances, alterations of species interactions and ultimately extinction. Forest 'interior species' increasingly suffer edge effects when forest area is reduced, for example: changes in micro-climate (sunlight, wind, moisture etc); invasions by alien species; alterations of species interactions (predation, herbivory, pollinator competition, nest competition); and increased human pressure (noise, pets, hunting). On the other hand, increasing amounts of forest edge potentially favours species adapted to edge habitats. There are numerous examples of European forest species of a wide array of taxa suffering from fragmentation and edge effects: forest lichens affected by changes in micro-climate; invasive trees establishing in forest edges (Section 4.5); and increased predation and competition for nest holes affecting forest birds breeding close to edges (Sjöberg and Ericson, 1997, Angelstam, 2004, Braziatis and Angelstam, 2004).

Studies of landscape gradients and mosaic patterns show that loss of species and populations is a function of habitat area (Fahrig, 2002), but loss is not linearly related to forest cover. 20–30 % forest cover has been identified as the threshold for the occurrence of several birds and mammals in the boreal and other northern and central European forests (Andrén, 1994, 1999; Hanski, 2007). Below a forest cover of about 30 %, it can be assumed that further fragmentation will affect the existence of most forest habitat-dependent species. Other species may be better adapted to inhabit forest patches of fragmented landscapes but strict forest species — even with small area requirements — may not survive in the long term if the populations in the patches become isolated and suffer from 'edge-effects', such as increased predation and herbivory from species common in surrounding habitats (Fahrig, 2002).

In regions with low forest density — where the forests are small and occur in scattered patches throughout the landscape — the protection of forest biodiversity would be greatly enhanced by linking fragmented forest habitats into forest habitat networks. This has been intensively discussed in connection to the Natura 2000 process (Section 5.2), with concerns raised of the long-term effectiveness of the established network of designated areas, not least in a climate change perspective. As an example of national action, in the United Kingdom the creation of functional habitat networks is one objective of the forest strategies of the four UK regions (Peterken, 2002).

Generally, in Europe, loss of forest habitat and the creation of fragmented landscapes have taken place over a long period. The most significant processes affecting the extent of forest land area in Europe and which have knock-on impacts on forest fragmentation are:

- Spontaneous re-growth of abandoned agricultural land (mainly extensively used grazed areas in the Mediterranean region);
- Afforestation of abandoned agricultural land and peat land with plantations;
- Urban sprawl and building of roads and other infrastructure — land uptake by urban and other artificial developments mainly affect farmlands, but some 80 000 ha of forest and transitional woodland shrub was consumed between 1990 and 2000 in the 23 European countries covered by satellite data for this period (EEA, 2005).

As shown in Section 3.1, the current net effect of these processes is an increasing forest area in Europe.

There are often quite significant dynamics within forest areas due to the mosaics of forest stands in different development stages (Box 3.3). The main processes in Europe influencing this 'within-forest' or 'forest-stand dynamics' are currently both natural and anthropogenic in origin:

- Fellings of wood for harvest (as a result of 'forestry' or less regulated use). From a landscape perspective it is mainly relevant to consider clear-cutting of stands ranging from less than one to several hectares. Clear-cutting is the dominant practice in coniferous stands including plantations (Section 4.2).
- Natural fellings by wind (or by avalanches in mountain areas) occur regularly in most forest categories. More extensive 'storm damage' affecting large forest areas has occurred in recent decades for example in central Europe (France) and northern Europe (south Sweden) (Section 4.4).
- Biotic damage affecting entire stands (for example by insect attacks) is only significant in a few forest types such as mountain birch forest ('non-riverine alder, birch or aspen forest' category) and in some plantations. Difficulties in regenerating forest due to high grazing pressure of overstocked game species are significant in many European forests (Section 4.4).
- Forest fires, largely of anthropogenic origin, affect coniferous plantations and other forests in the Mediterranean region (Section 4.4). Natural forest fires, once significant, are now effectively controlled in the Boreal forests.

As highlighted for core forest area cover in the Box 3.3, and in contrast to the relatively small changes in total forest land area (Section 3.1), the spatial dynamics in mosaics of forest stands in different development stages is quite significant even over a short time period.

3.5 Old forests are important for many species

Forest landscapes in Europe, comprising forest stands of all natural ages and development stages, are today found mainly in the northern and eastern regions (Section 4.2). Most significant are the large areas belonging to the boreal forest category, which often mixed forests with open or forested mires (Annex 1). There are old forests with little recent human impact belonging to most forest categories remaining in the otherwise intensively used European landscapes. Most of these forest patches are relatively small (only a few hectares) but exceptions exist, the most well-known being the Białowieza Forest in Poland and Belarus (Box 3.1). Significant areas of old forests also occur as scattered relics in the mountainous areas of the Alpine, Balkan and Carpathian regions (Diaci, 1999; Diaci and Frank, 2001). Such forests are usually reported as 'forest undisturbed by man' (Section 3.2).

As a rule, cutting in the forests takes place at earlier stages of development, whereas maintaining trees and stands up to their biological and ecological age limit is generally not considered economic in

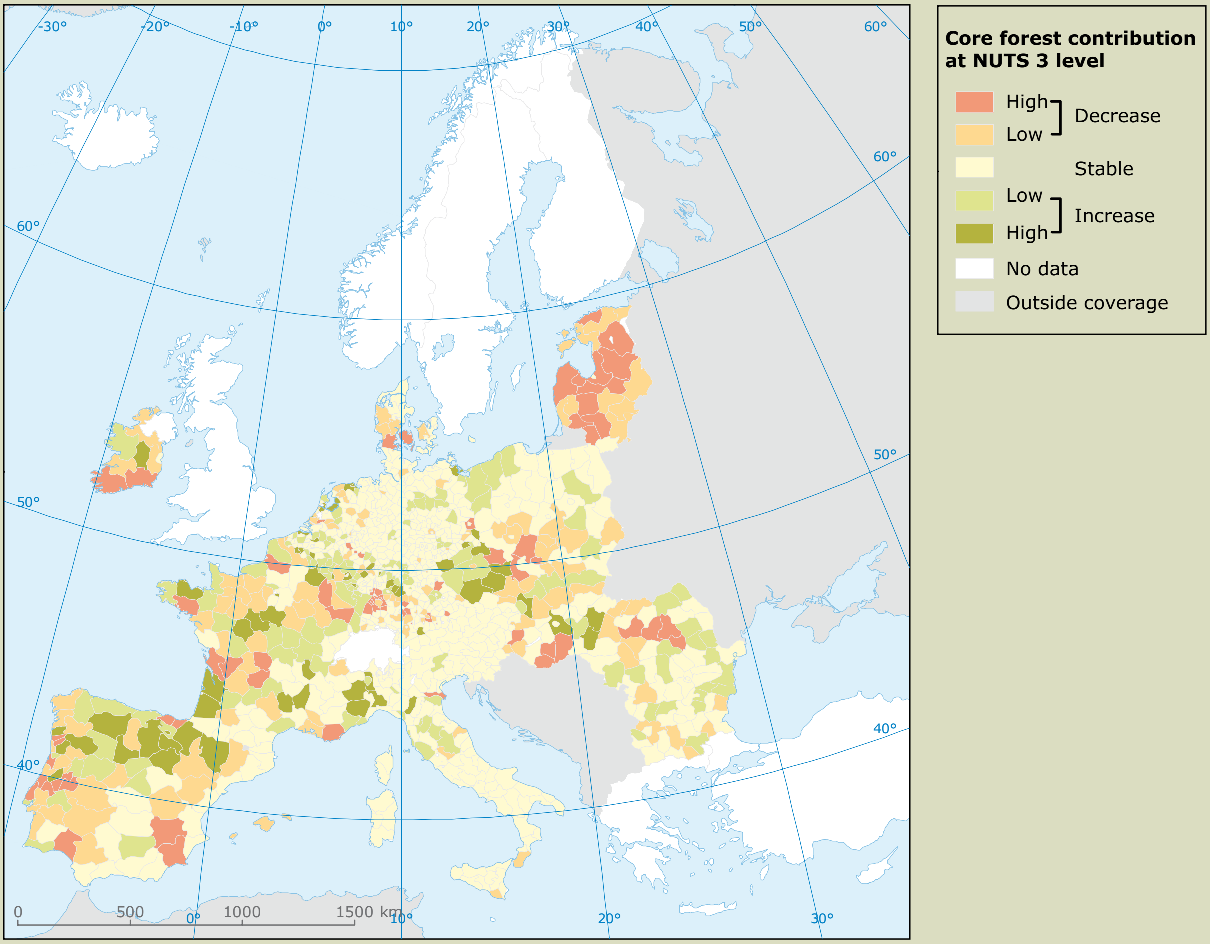
Box 3.3 Dynamics of forested landscapes in Europe

Several forest landscape pattern parameters can be studied with spatial analysis techniques. An important such parameter is 'core forest' calculated as the area of forest patches minus forest area influenced by forest edge dynamics. Core forest areas thus indicate interior areas of a forest patch that retain similar abiotic and biotic conditions to pre-fragmented conditions and do not experience strong influences from neighbouring patches of other land categories (Rutledge, 2003). In this way core forests are an indicator of the overall stability of the forest ecosystem. The methodology (interpretation of satellite images) does not recognize young forest stands but in a stable landscape the total area of core forest should be stable over time.

Map 3.4 shows internal dynamics of the forested landscape by changes in core forest areas between 1990 and 2000 for 21 EU Member States (data by province, NUTS 3 level ([7])). Although a decade is a short time period with respect to forest stand dynamics, considerable changes in the forest landscape pattern took place during this period, and a number of areas experienced increases or decreases in amount of core forest. The implication of this for forest biodiversity needs to be assessed. Less than half the investigated area had a stable core forest area over the decade. The areas that did maintain stable core forest was due to the area of mature forest remaining stable or a balance in any reduction of mature forest area by an increase in growing younger stands.

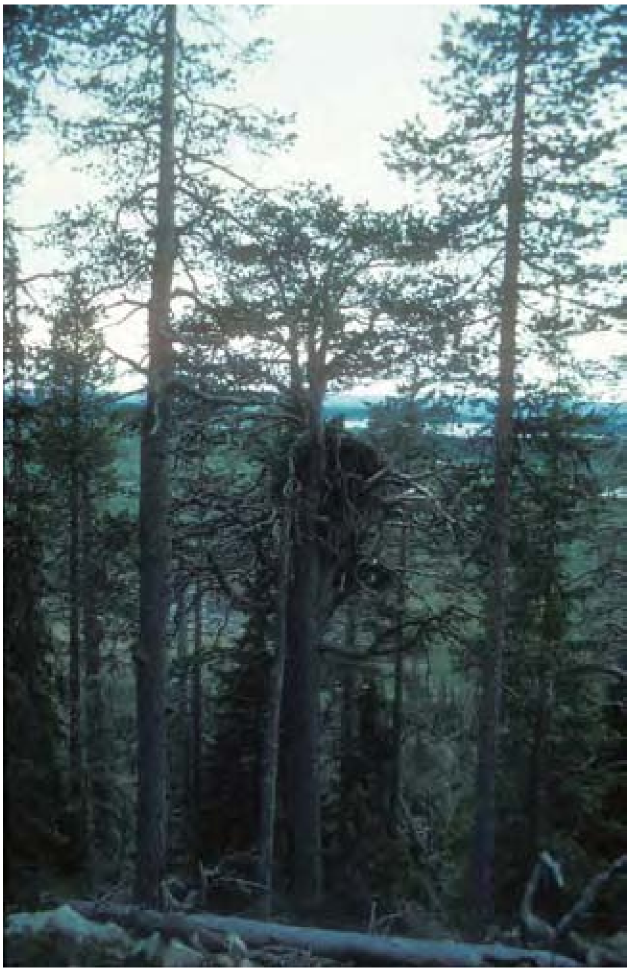
Source: Estreguil *et al.*, 2007.

Map 3.4 Internal dynamics of forested landscape by changes in core forest areas, 1990–2000



Source: Estreguil *et al.*, 2007.

([7]) See http://ec.europa.eu/eurostat/ramon/nuts/basicnuts_regions_en.html.



Typical nesting place of the golden eagle, Aquila chrysaetos, in Boreal forest of northern Sweden

Photo 3.4: © M. Tjernberg

Note: In this area the species breeds in large trees, having branches strong enough to support the large nest. An investigation of 165 nesting trees showed a preference for the larger trees of this forest category, mainly pines *P. silvestris* with an average diameter of 53 cm.

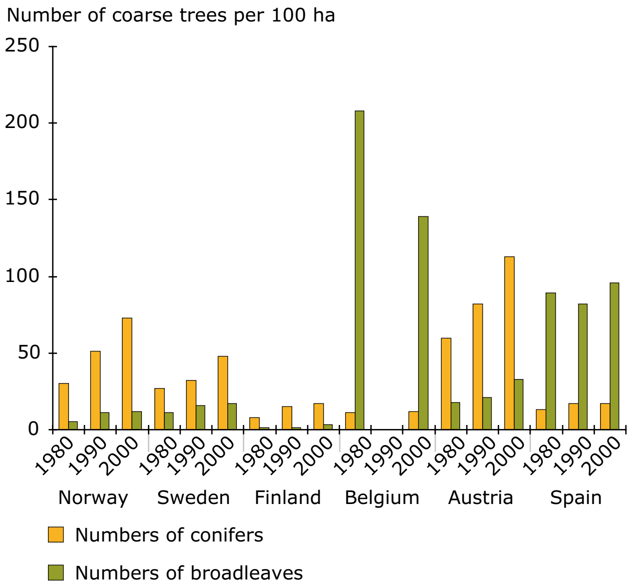
Source: M. Tjernberg, 1983.

modern forestry practices in Europe. However, there an increasing trend throughout Europe to let the forests grow older before cutting (Section 5.1). A broad range of factors has contributed to this which includes not only environmental concerns, but also changes in ownership and low economic return of forestry operations. Forecasts show that there will be an increase in the older age classes of the forest area available for wood supply in spite of the increasing demand for roundwood (Schelhaas *et al.*, 2006).

A large number of species are found only in the late forest succession stages ('old forests'). The value of old forests for biological diversity is dependant on several factors such as: time since human interventions; forest continuity; a diverse horizontal and vertical stand structure; and the occurrence of large and also dead trees. Some of these characteristic features of old forests can be established, often in a surprisingly short time, in a stand left to free development or managed to promote such development. Forest continuity is necessary to maintain several species with low dispersal ability. Such species are, as a rule, absent in forest stands with recently developed old forest features.

A distinguishing trademark of old forest is that they are relatively undisturbed by human activity. Such forests vary significantly in structure depending on the forest type and bio-geo-climate zone. They are generally naturally regenerated and dominated by a range of indigenous tree species. This includes considerable variation within the stand as regards tree size, age and spacing and trees that are large for the species and site combination. Their accumulation of dead standing trees (snags) and fallen trees is also much greater than in younger forests. Large trees are often valuable for the epiphytic flora and may have other features such as dead and hollow parts and large branches that are important for a number of species (Photo 3.4). As can be seen in Figure 3.2 there are indications that the occurrence of large trees has increased during recent decades in northern and central Europe.

Figure 3.2 Trend data showing the number of large trees (> 70 cm in southern and central Europe and > 50 cm in northern Europe) per 100 ha forest area for six European countries



Note: Belgium includes the Walloon region only.

Source: Data provided by European National Forest Inventory Network (ENFIN).

3.6 Deadwood is an important forest-stand quality

Deadwood or coarse woody debris — dead standing and fallen trees or parts thereof — is an important substrate for a large number of forest species such as insects and other invertebrates, lichens, bryophytes and fungi (Photo 3.5 and Figure 3.3). In addition, several mammals and birds use hiding and nesting places in such trees or forage on invertebrates living in deadwood. Because of a lack of deadwood, many of the dependent species are endangered in production forests (MCPFE, 2002).

Quantities of deadwood in Europe have greatly decreased since the middle of the nineteenth century due to intense forest exploitation and widespread burning of small wood pieces and other leftovers. Moreover, classical forest management is usually based on rotations that are shorter than natural longevity of tree species and so the number of old big trees in forest is usually low. However, nowadays, in many European countries, initiatives have been taken to increase the amount of deadwood in forests. On the other hand the increased interest in forest for energy production may threaten this positive trend (Sections 2.2 and 4.3).

European reporting of deadwood was introduced to the MCPFE in 2007. Official figures are therefore available for 15 countries ([8]) in the EEA region (Table 3.1). Although biodiversity-related critical values for deadwood are not available, it can be stated that the amount of deadwood in most countries (where data available) is rather low.

In a few countries (Austria, Finland and Sweden), information about deadwood, for example the proportion that was judged to be still usable such as firewood, has been gathered for several decades within national forest inventories. This information is very valuable as it indicates that the amount of non-decomposed deadwood has increased over recent decades (Figure 3.4). The amount of deadwood considered in Figure 3.4 is considerably lower than the more comprehensive amount of deadwood reported to MCPFE (Table 3.1), which also is a more relevant basis for future biodiversity estimates.

Deadwood can be considered as an array of microhabitats continuously evolving in time towards increasing decay and distinguished by associated species. The quantity of deadwood occurring in natural forests in the different European Forest Type categories depends on many factors such as tree species composition and structure, development stage, type and frequency of natural disturbance in the region, type of management, and soil and climatic characteristics.

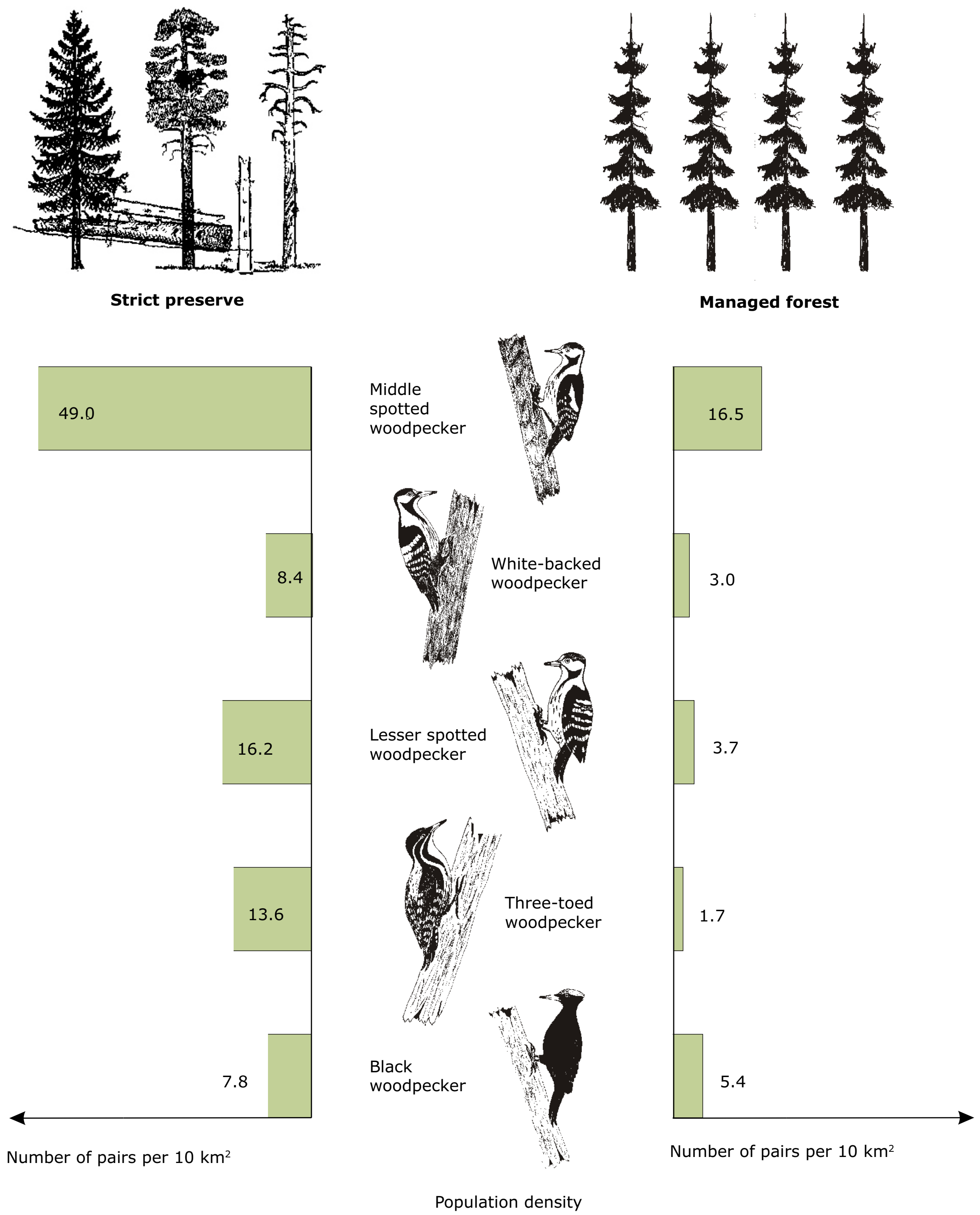
Standing and lying deadwood offer a wide array of niches for other organisms such as polyphorous fungi in the Białowieza forest, Poland

Photo 3.5: © T-B. Larsson

The natural occurrence of deadwood and the importance of coarse woody debris for biodiversity thus differ between the European Forest Types. As an example, Scots pine forest in the Scottish Highlands — belonging to the category 'Hemiboreal forest and nemoral coniferous and mixed broadleaved-coniferous forest' (Annex 1) — could be considered to naturally contain deadwood volumes in excess of 100 m^3/ha. In comparison old pine plantations in the Scottish Highlands frequently contain deadwood volumes in the range of 30 to 50 m^3/ha (Humphrey *et al*., 2004). In a recent study of beech forest reserves across Europe, Christensen *et al*. (2005) found volumes of deadwood ranging from almost 0 up to 550 m^3/hectar. Significantly more deadwood was found in the 'Mountainous

([8]) Figures for one additional country, Denmark, have been provided by the Danish National Forest Inventory.

Figure 3.3 Woodpecker population densities in managed and natural forest on comparable sites in the Białowieza forest area, Poland



Note: A main difference between the natural forest (strictly protected forest in the Białowieza National Park) and adjacent the managed forests is the amount of deadwood, see also Box 3.2.

Source: Bobiec *et al.*, 2005.

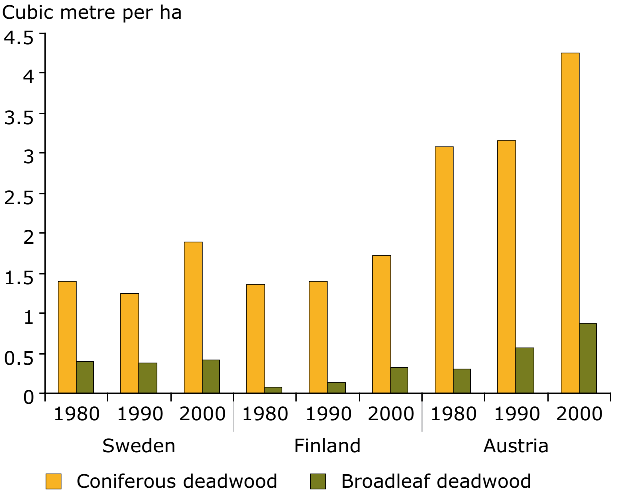
Table 3.1 Average volume of standing and lying deadwood in forest and other wooded land (OWL), 2005

Country	Volume of deadwood			Volume of deadwood		
	Forest			OWL		
	Lying	Standing	Total	Total	Standing	Lying
	m³/ha			m³/ha		
Albania	-	0.48	-	-	0.06	-
Austria	13.90	6.10	20.0	-	-	-
Belgium	4.13	2.82	6.95	-	-	-
Cyprus	-	0.94	-	-	-	-
Czech Republic	6.80	4.80	11.60	0.0	0.0	0.0
Denmark	1.4	2.9	4.3	-	-	-
Estonia	5.40	6.30	11.70	1.30	0.50	0.80
Finland	4.30	1.30	5.70	0.70	0.30	0.40
Hungary	-	7.16	-	-	0.0	-
Italy	8.29	3.98	12.27	8.58	-	-
Latvia	9.80	6.40	16.20	-	-	-
Lithuania	23.0	-	-	3.0	-	-
Luxembourg	7.20	4.40	11.60	-	-	-
Netherlands	4.90	4.34	9.24	0.0	0.0	0.0
Sweden	3.80	2.30	6.10	0.80	0.50	0.40
United Kingdom	3.10	0.80	3.90	0.0	0.0	0.0

Source: MCPFE, 2007; Danish National Forest Inventory 1st cycle 2002–2006, 2008.

beech forest' category compared to the 'Beech forest' of the lowlands. A considerably lower amount — for beech 10–20 times less (Christensen *et al.* (2005), see also Table 3.1 — of deadwood is frequently found in production forests of forest categories where deadwood is a characteristic natural feature (e.g. in boreal forests, alpine coniferous forest, broadleaved forests of categories 4–7, Annex 1).

Figure 3.4 Trend data showing an increase in volume of non-decomposed deadwood within the forests of three European countries



Source: ENFIN.

Floodplain forests and mire and swamp forests (European Forest Type categories 11 and 12) naturally hold relatively large shares of deadwood. Floodplain forests are nowadays relatively rare, but the remaining forests in Europe within these categories are normally not intensively used by forestry and may hold close to natural deadwood volumes. However, for some types and in some areas, the use may be very intense.

It should be noted that forest plantations with exotic tree species (European Forest Type category 14) may be managed to promote deadwood, allowing native biodiversity to exist in such stands. An investigation of the extensive Sitka spruce, *Picea sitchensis*, plantations in Ireland stressed the importance of retention of standing and fallen dead trees (Smith *et al.*, 2005) (Section 5.1). In Italy a LIFE-project has supported felling of invasive tree species to increase amount of deadwood (Cavalli and Mason, 2003).

The negative effects of leaving deadwood in forests and providing substrate for pest insects has been a long-standing concern in European silviculture. However, less than 0.5 % of wood-dwelling insects are classified as major economic pests (Branquart *et al.*, 2003) and a continuous amount of deadwood can be expected to maintain more stable and limited populations of at least some pathogenic insects and their natural enemies, therefore reducing the risk of outbreaks. However, in the Mediterranean

Box 3.4 Veteran trees are biodiversity repositories

Veteran trees, i.e. trees older than others in the area, are generally host to a high number of species by being big, structurally diverse, offering deadwood at different stages and by offering stable conditions for species with low dispersal ability.

The Cerambyx longhorn beetle, *Cerambyx cerdo*, is widely distributed in Europe and usually lives in deadwood of standing veteran oak trees (*Quercus spp.*) and other deciduous species. The species, albeit quite common in some areas of south Europe, is classified as 'Vulnerable' (IUCN, 2008) which means the species is facing a risk in the medium-term future. Within the European Union the species is reported in 964 Natura 2000 areas, with significant populations in certain sites.

The main threat to the species is the felling of old oak trees, often resulting in replacement by other non-native tree species. Some veteran oak trees, being relics of a traditional land-use, will also gradually disappear in the management of production forests. In southern European countries extensive forest fires, see Section 4.3, are an important cause of reduction in species habitat.

To conserve *Cerambyx cerdo* and a large number of other saproxylic (deadwood-dependant) insects, veteran trees must be protected and new trees allowed to develop within the forest management practices which, to some extent, may require set-aside of forest stands. In Europe there is also a need to educate forest managers and the wider public to understand the role of deadwood and veteran trees for biodiversity. For generations, people have considered deadwood and dying trees as something to be removed from forests, either to use as fuel, or simply as a necessary part of good forest management.

Source: Wildlife and Sustainable Farming Initiative, 2007; The Encyclopedia of the Swedish Flora and Fauna, 2007 (photo *Cerambyx*).

Photo 3.6: © M. Holmer

Photo 3.7: © T-B. Larsson

forests and particularly in coniferous plantations, the amount of deadwood and litter needs to be controlled to reduce fire risks.

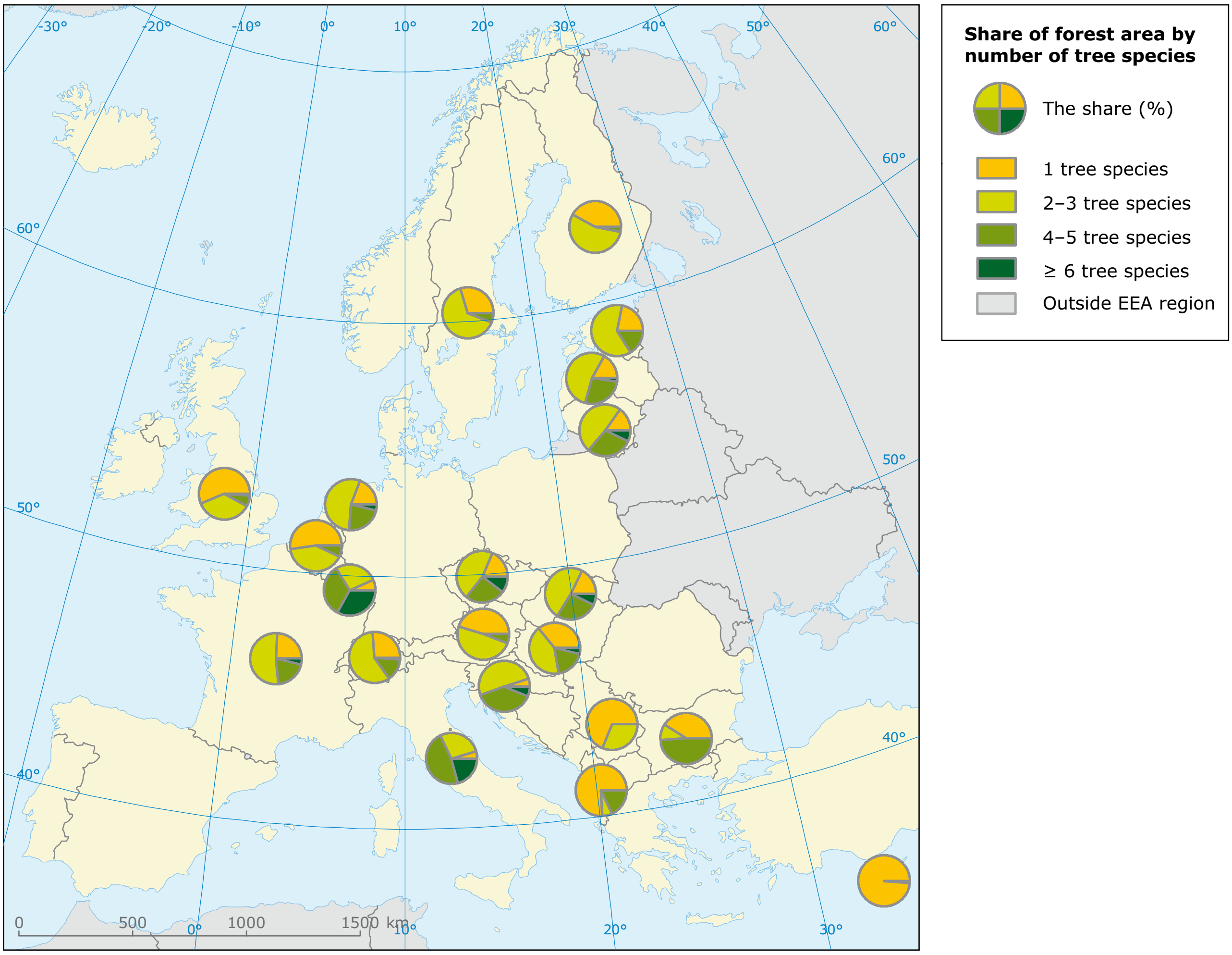
3.7 Trends in selected species

Tree species trends

The composition of the tree species is an important factor to the development of forest biodiversity. The MCPFE (2007) reported a general increase in the area of stands with a mixture of coniferous and broadleaved tree species, cf. the state 2005 shown in Map 3.5. Generally it can be said that forests have been managed to become more diverse. The area of forests with 2–3 tree species as well as that with 4–5 tree species has increased considerably between 1990 and 2005 (MCPFE, 2007). This rather rapid change is remarkable as forest management works with long management cycles of between sixty and over a hundred years.

Meanwhile the area of single-species forests has slightly decreased. It must be considered, however, that some natural forest ecosystems have only one or two tree species, including natural boreal pine forests on dry sites, natural sub-alpine spruce stands and beech forest growing in favourable conditions in lowlands. At the same time, across Europe tree species composition also reflects the differences in biodiversity between the biogeographic regions (natural vegetation zones, MCPFE, 2007).

Map 3.5 Share of forest area by number of tree species



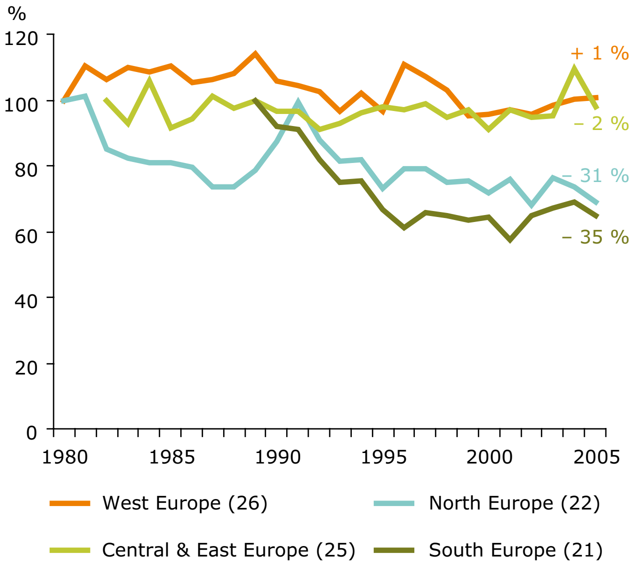
Source: MCPFE, 2007.

Forest bird population trends

One of the best-developed European biodiversity datasets comes from the pan-European Common Bird Monitoring programme, which includes 28 common forest bird species in 20 countries within the EEA region. A European-level biodiversity index, based on selected common birds, has been developed in cooperation with national bird monitoring networks (PECBM, 2007, EEA, 2007c). This European bird index, however, has proved difficult to link to any overall assessment of changes in forest conditions. A regional analysis of the common forest birds reveals that in northern and southern Europe the common forest birds show a declining trend while in western and eastern Europe, populations have remained relatively stable (Figure 3.5). It has been suggested that intensive forest exploitation may be a contributing factor to this decline in forest bird populations in northern Europe whilst the negative trend in southern Europe reflects the frequency of fires (PECBM, 2007). However, more research and analysis is needed to understand the forest bird data and the work to include forest birds in the above 'common birds indicator' is ongoing.

As an example of the further analysis needed, Figure 3.6 presents contrasting population trends for three relatively well-studied forest bird species. The lesser-spotted woodpecker, *Dendrocopos minor*, and willow tit, *Parus montanus*, both require deciduous forests with old trees and deadwood. Both species have shown a steeper decline in western Europe than in central and eastern Europe (Figure 3.6a). The fact that both are resident species suggests that the quality of forest, particularly the proportion and quality of deciduous forest, may be a factor explaining the different trends within the European regions. In contrast, the collared flycatcher,

Figure 3.5 Regional indicators of common forest birds in four European regions



Note: The numbers in parentheses show the numbers of species in each indicator

Source: PECBMS, 2007.

Ficedula albicollis has shown one of the greatest increases within Europe (Figure 3.6b). The core of its population lies in central and eastern Europe, where the large areas of broadleaved forests provide conditions which may be more favourable to the species. The dependence of the collared flycatcher on broadleaved forests may thus help to explain the differences between trends in central and eastern Europe compared to northern and western Europe.

Threatened species

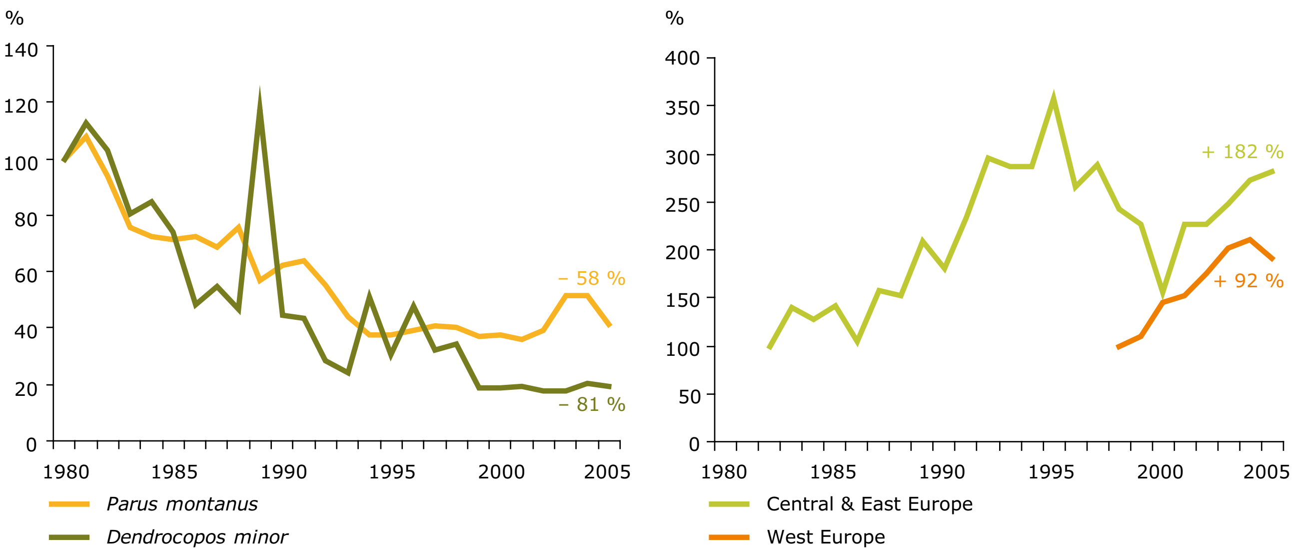
Data reported to MCPFE provides some insight to the situation of threatened tree and forest vascular plant species in various European countries. An overview is given in Table 3.2 of the state of threatened forest-occurring species of trees, birds, mammals, other vertebrates, invertebrates, vascular plants, cryptogams and fungi (for countries with available data) in 2005. The data provided seem heterogeneous and country comparisons and other interpretation should be made cautiously. This is in particular the case for assessing trends in comparison with earlier reporting (e.g. UNECE/FAO, 2000). However, it is evident that a relatively large number of forest species are under threat in Europe.

The European Plant Conservation Strategy states: 'If the steady decline of plant diversity is to be halted, a thorough understanding of the European flora is needed. This must include full listing and

Figure 3.6 Trends in three European forest birds; lesser spotted woodpecker, *Dendrocopus minor*, willow tit, *Parus montanus* (a) and collared flycatcher, *Ficedula albicollis* (b)

a) Lesser spotted woodpecker *Dendrocopus minor*, willow tit, *Parus montanus*

b) Collared flycatcher, *Ficedula albicollis*



Source: PECBMS, 2007.

Table 3.2 Numbers of threatened forest-occurring species of trees, birds, mammals, other vertebrates, invertebrates, vascular plants, cryptogams and fungi in 2005

Country/region	Trees	Birds	Mammals	Other vertebrates	Other invertebrates	Vascular plants	Fungi
Austria	11	15	11	18	—	270	97
Albania	32	—	—	—	—	—	—
Belgium	4	11	—	—	—	14	—
Bosnia and Herzegovina	1	—	—	—	—	—	—
Bulgaria	0	13	2	1	8	31	0
Cyprus	1	12	1	2	—	17	—
Czech Republic	1	248	31	47	0	771	582
Finland	2	8	4	0	284	35	288
Ireland	1	—	—	—	—	—	—
Italy	2	16	21	3	—	—	—
Latvia	3	19	9	2	46	76	28
Lithuania	0	0	2	—	4	—	—
Luxembourg	0	9	—	—	—	61	—
Norway	1	7	2	4	194	14	245
Serbia	34	117	94	60	250	213	55
Slovakia	7	22	7	—	—	207	77
Slovenia	2	43	23	30	227	—	82
Sweden	4	15	8	4	335	45	420
United Kingdom	10	0	4	0	38	32	88

Note: Threatened species include the IUCN 'vulnerable', 'endangered' and 'critically endangered' categories.

Based on available data for countries in the EEA region.

Source: MCPFE, 2007.

assessment of our wild plants, their abundance, and monitoring of change in their distribution and status' (CoE, 2002). This statement could be widened to include both fauna and flora and presently several efforts are made to increase knowledge about threatened forest species. Better knowledge of species distribution and population development together with a better understanding of threat factors, may upgrade the assessed threat status of a few species but also could add large numbers of earlier neglected species to the list, in particular those from previously unconsidered taxonomic groups (Table 3.2 and Box 3.5).

Box 3.5 Finnish programme maps poorly known threatened forest species

In general, the knowledge of Finnish fauna and flora is of relatively high quality. However, the last red-data listing of threatened species (2000) showed that two-thirds of the 43 000 species in Finland are still insufficiently known to assess their threatened status. In Finland, the PUTTE research programme of poorly known and threatened forest species (2003–2007) responded to this lack of information, and has provided new information for 3 000–4 000 species not included in the previous evaluation of threatened species. The PUTTE programme focused on the most poorly known groups of organisms, particularly invertebrates and fungi. The projects covered for instance aphids, hoverflies, sciarids, the fungal genera *Cortinarius, Ramaria*, and *Tremella* as well as epibryous and lichenicolous microfungi. During the programme almost 1500 new species for Finland were identified, of which 185 were previously unknown to science.

PUTTE is part of the south Finland forest biodiversity programme METSO, which in turn is part of the Finnish national forest programme. The Ministry of the Environment has financed the PUTTE programme annually with EUR 1–1.6 million during 2003–2007. The programme, which includes forty projects, is the biggest investment so far in taxonomic research in Finland (Finnish Environment Institute, 2008).

Source: Juslén *et al.*, 2008; Finnish Environment Institute, 2008.

The European mammals assessment

The first comprehensive assessment (across 25 EU Member States) of the conservation status of mammals in Europe was undertaken by IUCN (2007). The assessment concludes that, out of 104 European mammal species which depend to a certain extent on forests in their life cycle, the following numbers of species are considered as threatened by IUCN:

- Two are 'critically endangered'. These are: a small mammal — the Bavarian vole (*Microtus bavaricus*) and a large carnivore — the Iberian lynx (*Lynx pardinus*). It is to be noted that the Iberian lynx, a species found in areas with forest and silvo-pastoral systems, is also considered as the world's most endangered feline species. Habitat loss and degradation, as well as the disappearance of food resources (rabbits) are contributing to its steadily declining trend. Today, there are no more than 38 breeding females in the wild (WWF, 2007).

- Three species are 'endangered', mainly due to their endemism, and are principally bats from the Macaronesian region (*Nyctalus azoreum*, *Pipistrellus maderensis* and *Plecotus teneriffae*).

- Six species are classified as 'vulnerable' namely the bison (wisent), (*Bison bonasus*), the wolverine (*Gulo gulo*), the Corsican hare (*Lepus corsicanus*) — partly due to its endemism, and three further bat species (*Myotis bechsteinii*, *Plecotus sardus* and *Rhinolophus euryale*).

- Eleven other forest-related mammal species are classified as 'near threatened' and these include four bat species (*Myotis dasycneme*, *Myotis punicus*, *Rhinolophus ferrumequinum* and *Rhinolophus hipposideros*), the European rabbit (*Oryctolagus cuniculus*), the Siberian flying squirrel (*Pteromys volans*), the garden dormouse (*Eliomys quercinus*), the wild cat (*Felis silvestris*), the western polecat (*Mustela putorius*), the brown bear (*Ursus arctos*), and the lynx (*Lynx lynx*).

It is worth noting that the lynx (*Lynx lynx*), was eradicated from most parts of Europe in the 1950s, only surviving in the north and the east. In Sweden and Finland the lynx population has expanded during recent decades, partly due to recolonisation from Russia (in case of Finland) and partly through the removal of state bounties and a better regulation of hunting in Sweden (ELOIS, 2007). In western Europe, the lynx population has also expanded following successful reintroduction initiatives initiated in the 1970s.

Rabbits (*Oryctolagus cuniculus*) are listed as near threatened in Europe (IUCN, 2007). It might seem surprising that rabbits are seen as near threatened in some parts of Europe when they are also considered invasive in many others (see Annex 2). However, the rabbit populations in parts of its native range in southwestern Europe have experienced dramatic declines in recent times. Populations e.g. in the Donaña National Park declined by 60 % after the first wave of the epizootic, rabbit hemorrhagic disease (RHD) in 1990, and have continued to decline steadily. Current populations were assessed at less than 10 % of the population before the occurrence of RHD (Moreno *et al.*, 2007). Rabbits are an important prey species for top predators and the decline in rabbit populations are having an effect on endangered predator species such as the Spanish imperial eagle (*Aquila adalberti*) and the Iberian lynx.

As the assessment of European mammals presented by IUCN is very recent, it is understandable the conclusions only match partially the conservation priority actions defined in 1992 to be undertaken through the EC Habitats Directive (see below).

Species of Community interest

With the implementation of the EC Directive 79/409/EEC of 1979 on the conservation of wild birds ('Birds Directive') and the EC Directive 92/43/EEC of 1992 on the conservation of natural habitats and of wild fauna and flora ('Habitats Directive'), the European Union has taken responsibility for conservation actions on a number of species and habitats recognized as being of special Community interest. For bird species listed in Annex I of the Birds Directive, habitats listed in Annex I, and plant and animal species listed in Annex II of the Habitats Directive, the EU Member States have to designate and further manage adequately Natura 2000 sites (see Section 5.2).

For instance:

- out of 195 bird species listed in Annex I of the Birds Directive, 67 are forest-related, of which 7 are globally threatened — often due to strict endemism — and have therefore benefited from specific action plans. These are the imperial eagle (*Aquila heliaca*), the lesser kestrel (*Falco naumanii*), the long-toed pigeon (*Columba trocaz*), the laurel pigeon (*Columba junoniae*), the dark-tailed laurel pigeon (*Columba bollii*), the blue chaffinch (*Fringilla teydea)* and the Azores Islands bullfinch (*Pyrrhula murina)*.

- out of 54 mammal species listed in Annex II of the Habitats Directive, 26 are forest-related, of which 7 are identified to be priority species, namely the Siberian flying squirrel (*Pteromys volans)*, the wolf (*Canis lupus* — only some European populations), the brown bear (*Ursus arctos* — only some European populations), the wolverine (*Gulo gulo)*, the Iberian lynx (*Lynx pardinus)*, the Corsican red deer (*Cervus elaphus corsicanus)*, and the bison (wisent) (*Bison bonasus)*.

The causes of population development are often multi-factoral and hard to evaluate. There is thus little information yet on the effect of the implementation of these two directives on the overall conservation status of the targeted species and habitats.

For birds, the most comprehensive insight is provided by an assessment report prepared by Birdlife International in 2004 at the 25th anniversary of the Birds Directive. This report shows that among species in which populations have increased over the decade 1990–2000 — probably partly due to implementation of the Birds Directive — are some Mediterranean forest bird species as well as some bird species of marine, coastal and inland wetlands (Birdlife International, 2004).

As part of the implementation of Article 17 of the Habitats Directive, countries have the duty to report every six years on the overall conservation status of species (and habitats) of European community interest listed in the Habitats directive, on both national and biogeographic scales. A major report is currently under way and a comprehensive European-level assessment is expected to become available in 2009.

3.8 Genetic diversity of European forests

Long-term conservation of forest genetic diversity is fundamental for biodiversity conservation and sustainable forest management. The purpose of forest gene conservation is thus to safeguard the potential for adaptation to changed environmental conditions by maintaining evolutionary processes within tree populations (Eriksson *et al*., 1993).

Data collected from the European Forest Genetic Resources Programme (EUFORGEN) confirms that gene conservation of European forest trees relies primarily on *in situ* conservation ([9]). In this context also the tree genetic material — in particular of the economically most important species — selected as a basis for seed tree orchards, should be taken into account. There are more gene conservation and seed production areas available for widely distributed and economically valuable tree species. A report to the 2007 Ministerial Conference on Protection of Forests in Europe reveals that a group of seven economically important and widely distributed tree species account for 80 % of the total area managed for *in situ* gene conservation production (*Fagus sylvatica, Picea abies, Pinus sylvestris, Abies alba, Quercus petraea, Larix decidua* and *Quercus robur*) with rather less for species with scattered distribution or those not used intensively in forestry (MCPFE, 2007).

For Norway spruce (*Picea abies)*, based on information supplied by the EUFORGEN network, there was a total of 258 138 ha for *in situ* conservation in 19 countries in 2002. In addition to these efforts, 3 472 ha were managed as seed orchards to meet the high demand for planting of Norway spruce. The large total *in situ* area for Norway spruce partly reflects the fact that generally protected forest areas are to some extent reported as gene conservation areas (MCPFE, 2007).

However, for forest regeneration there is a widespread use of spruce seed originating from non-native populations for example in Sweden, where provenances of east-central European origin are often used (which combine a high productivity with a sufficient climatic adaption). From a general biodiversity point of view, the genetic variability of the introduced material tends to be considerably lower compared to local provenances and the impact on the genetic composition of native tree populations is unknown (Laikre and Ryman, 2006; Laikre *et al*., 2006).

An example of *ex situ* conservation relates to elms, *Ulmus* spp., which in Europe are seriously threatened by the fungal elm disease, *Ophiostoma novo-ulmi* (Section 4.5). An EU-funded project established a core collection with more than 850 elm clones and nearly half of the clones are also preserved as cells in liquid nitrogen (Collin *et al*. 2004). In the case of the black poplar *(Populus nigra)*, *ex situ* collections have been established to safeguard genetic resources of the species. The black poplar is threatened by

([9]) Explanation of terms, see Annex 3.

habitat alteration due to agriculture, urbanization of floodplains and hydraulic engineering of rivers, which has destroyed natural populations in many parts of Europe (Lefèvre *et al.*, 2001).

Less than one-third of the European countries have well-established national programmes on forest genetic resources, while only informal programmes occur in a further third of countries (Koskela *et al*., 2004). An additional problem for practical implementation of gene conservation efforts is that they are often loosely connected to the overall national forest programmes.

There is legislation in the EU to control the trade of forest reproductive material between countries to avoid transfer of pest and diseases and to avoid the use of seeds or planting of stock with low genetic quality. There are also regulations that specify detailed rules concerning the format of national lists of the basic material of forest reproductive material (EC, 2002b). Nevertheless, there are no statistics available on how the reproductive material is used throughout Europe for assessing the impact on forest genetic diversity (Schuck and Rois, 2003).

4 Use of forest resources and other anthropogenic factors having an impact on forest biodiversity and ecosystems

4.1 Forest use in traditional economies and the development towards today's multifunctionality and industrial use

Forests in Europe, being a dominant natural land-cover, have always been of great importance to man. As long as the forests were seemingly limitless in extent, there was little concern to protect or sustainably manage them, but when they became scarce, human migration and conflict often began. As early as the fifth century BC, the ancient Greek Plato wrote about the effects of unsustainable use of forests, including erosion and its detrimental effect on agricultural productivity. A century later, Aristotle saw timber as one of the necessary properties of the virtuous leader of the well-run state. Early reference to coppice management systems is noted by the Latin writer on agriculture, Columella in the first century AD (Farrell *et al.*, 2000).

During the centuries up to and including the Middle Ages, the majority of the population in Europe was located in small village-based communities which used the forest areas for grazing and the collection of fodder for livestock, bee-keeping, picking of berries, nuts, fruits and herbs as well as hunting and trapping. In this traditional, largely self-supporting economy, the availability and quality of grazing land as well as fodder for livestock during winter (in areas dependent on this) was probably the ultimate limiting factor for the human population. This village system was characterised by more intense cultivation and fodder production around the settlements, while more or less intensely grazed land was located further from the village, a pattern still having an impact on biodiversity today. When populations became larger there was a use of all available forest land and consequently a number of forest species only survived in less accessible areas. These remote areas could, however, be utilized for temporary grazing as part of transhumance systems or more scattered settlements. Today specific biodiversity values found in seemingly untouched forests can often be ascribed to such cultural influences (Agnoletti, 2006).

During a long period, up to and including the Middle Ages, a fairly stable household technology made the forest cover and density vary considerably on a regional landscape scale according to the size of the human population. The intensity of use increased during good times, but also faced periods of decrease, due to disease (most notably bubonic plague) and different types of conflicts (including severe feudalism and over-taxation). Although many forest species adapted well to this 'landscape dynamic', some had lower dispersal ability and are even today still largely confined to areas having a long history of permanent forest cover (Honnay *et al.*, 2004).

However, not all potentially accessible forest land was subject to the traditional use by the local inhabitants. The interest of kings and nobility in game and hunting led to setting aside large areas as hunting reserves with severe penalties for poaching and cutting of wood. Without doubt, this has secured the regional survival of several big game species as well as areas of uninterrupted forest continuity (Hansson, 1992) (Box 3.1).

The gradual process of industrialisation in Europe significantly accelerated during the 19th century, initially through mining and metal-based industries which demanded supplies of wood and charcoal for fuel and construction. Tree felling for this purpose, combined with more intense grazing by livestock and expanding agriculture to feed the increasing population, led to deforestation of much of the land area.

The above brief and schematic description of the importance of forests to man is in principle applicable to most of the European area. However, there was a considerable regional variation with regard to the intensity of forest use and also in the time when various forest uses were introduced or abandoned. As an example, forestry was relatively well-organised over most of continental Europe by the mid-1800s, while further north, most notably in boreal forests, this was the start of difficult period for forest biodiversity. To feed an increasing human population all available land was grazed by

Box 4.1 Traditional silvo-pastoral systems and biodiversity

Silvo-pastoralism is a traditional land-use combining trees and livestock (pigs, sheep, goats, cows or bulls — all of traditional breeds), using the same unit of land for multiple products.

Biodiversity is promoted by the long continuity of land use and the more complex ecological structure, compared to today's open farmland and closed forests. The benefits for biodiversity are not least connected to old trees in the areas where silvo-pastoral systems have played an important role. Research indicates that silvo-pastoralism with an adequate stocking rate simulates the varied forest structure when mega-herbivores were still an important factor in European forests. The silvo-pastoral systems may thus provide a habitat for forest species confined to forest gaps and early succession stages. The periodic grazing will increase the plant diversity and favour plant species adapted to soil disturbances. Overgrazing may cause problems with regeneration and reduce ecosystem quality, but also complete exclusion of grazing may diminish the species diversity and tree regeneration, as some ground vegetation species may dominate and shade out the tree seedlings or other ground vegetation species. Thus, the damage caused by overgrazing depends on the type and number of animals, the fodder available and the seedling species and abundance.

In earlier times, silvo-pastoral systems occurred all over Europe. Well-known in the Mediterranean, and to some extent still active there, are the Spanish *dehesas*, the Portuguese *montados* and the Italian *pascoli arborati* (main tree species, *Quercus suber, Q. ilex, Q. pubescens*) and the Greek *kouri* (*Quercus sp., Juglans sp., Castanea sp.*). The *dehesas* are identified as a habitat of special European Community interest (Section 4.2), and contain bird

Photo 3.6: © M. Rois Diaz

and mammal species listed under the EU Habitats Directive and EU Birds Directive, e.g. imperial eagle (*Aquila adalberti*), and the black vulture (*Aegypius monachus*). If the silvopastoral practices are abandoned, some of the typical species might decline in abundance, as has already happened with the bearded vultures (*Gypaetus barbatus*). A number of other endangered species in Europe would also experience more favourable conditions if landscapes were managed under extensive traditional silvo-pastoral regimes. With regard to conservation of indigenous breeds of domestic animals, silvo-pastoralism could also play an important role as a traditional husbandry system

Source: Rois Diaz *et al.*, 2006; Rois Diaz *et al.* (submitted).

livestock and/or used for fodder production. Large predatory mammals and birds, perceived as a threat to the livestock, were persecuted. Other large forest mammals were 'out-competed' or heavily hunted. Important game species, such as the moose (*Alces alces)*, was brought close to extinction. The pressure on the populations of these predatory and game species was alleviated by increased productivity in agriculture, emigration, and legal measures to safeguard the predatory species and threatened game. However, in much of Europe by the late 19th century the emerging forest industry perceived the forest resources as unlimited, and this presented a new threat to the forests. The focus was on cutting the large, most valuable trees and the actors had little concern for re-growth and silviculture. This approach resulted in impoverishment of the forest conditions and some areas have still not fully recovered.

Other parts of Europe were less influenced by the industrial development and these forests are largely still under traditional use related to local housekeeping, such as grazing, fodder production, hunting, mushroom picking, and collection of firewood, the latter becoming increasingly commercial. This is significant in several regions of the Mediterranean and south-east Europe.

A recent process in a number of eastern European countries is the transition of economic and societal structures. Changes in ownership, the changing market for forest resources, and legislation have a number of impacts on the use of forest resources and pressure on biodiversity.

To understand the present production demands and other pressures on European forests and the potential impact on biodiversity, which will be the focus of the following sections of this chapter, a starting point is forest ownership and the current relative importance of the forest sector in the economies of European countries.

Different categories of forest owners may have different specific objectives, attitudes, knowledge and ambitions for forest management and biodiversity concerns. In Europe this is the case particularly for the numerous family forest owners (e.g. Hogl *et al*., 2005, Enggrob Boon and Meilby, 2007). Forest ownership patterns vary widely in Europe, reflecting varying political histories. On the whole, of the region covered by the EEA member and cooperating countries, only about 40 % of forests are publicly owned, leaving some 60 % in private hands. The countries with the highest levels of private ownership are Portugal (93 %) and Austria (80 %) followed by France, Norway and Slovenia (all around 75 %). However, in the new EU Member States (see Chapter 1) and other east European countries, the situation is quite opposite, with only ca 30 % of forests being owned privately (UNECE/FAO, 2005; MCPFE, 2007).

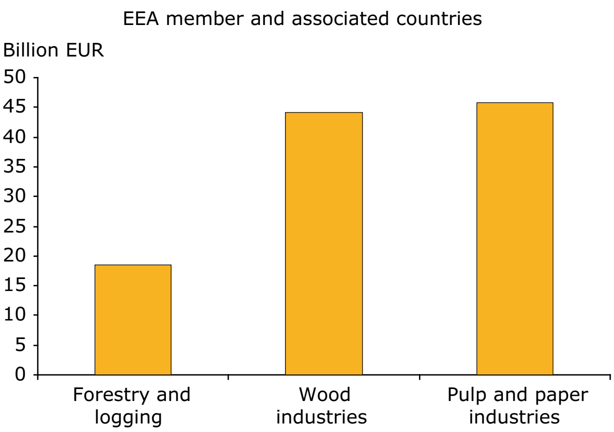
An important part of the economic pillar of sustainable forest management in most of Europe is the supply of raw material to be further processed in the pulp & paper and wood industries. A relatively straightforward measure of the macro-economic importance of the forest sector of a country and its role in rural development is the contribution of forestry and forestry operations as well as the further manufacturing of wood and paper products to the gross domestic product. In absolute terms, it is evident that 'Forestry and logging' and 'Wood industries and Pulp and paper industries' constitute an important industrial sector (Figure 4.1). The contribution to national gross domestic product by the forest sector is considerable in several European countries, e.g. Finland, Estonia and Latvia (MCPFE, 2007). However, for the European Union as a whole the forest sector, including the forest industries, only make up about 1 % of the total gross value added (Eurostat, 2008).

Furthermore, the forest sector directly employs more than 3.2 million people in the EEA member and collaborating countries (MCPFE, 2007). To this figure should be added the large number of family entrepreneurs and active family forest owners. While the number of employees in the wood industries has increased by more than a third over the past two decades, the opposite trend has been observed with forest workers. In the pulp and paper industries, the number of employees has also seen a decline of about 15 % during this period.

In Europe, there is an increasing interest in producing bioenergy from forests, as reflected by several EU policy targets in the field of renewable energy (EC, 1997; EC, 2001; EC, 2003a; EC, 2005a; EC, 2008). Energy from wood resources is both traditionally important for heating of households in rural areas and, increasingly, for industrial use (heating, electricity and biofuel). Available data for wood energy use probably gives an underestimation, mainly because of measurement problems related to local use (MCPFE, 2007). The contribution of wood energy to total energy consumption varies between 35% and a few %, as reported by 24 of the EEA member and cooperating countries (Figure 4.2).

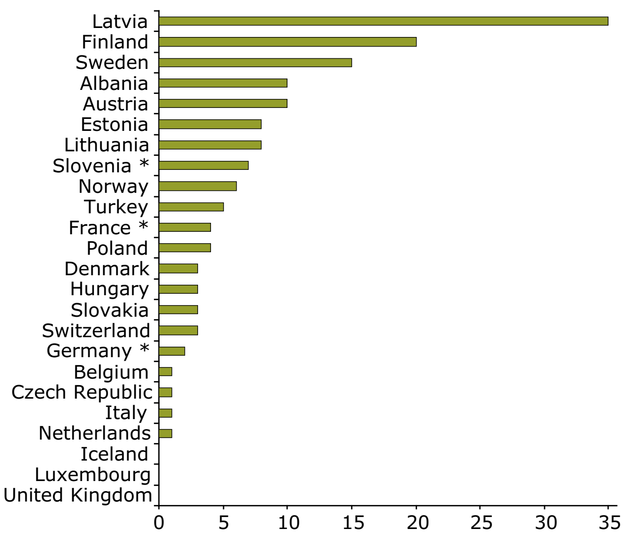
The emerging and future demand in Europe for managing forests where carbon sequestration is a

Figure 4.1 Forest sector gross value-added, 2005



Source: MCPFE, 2007.

Figure 4.2 Contribution of wood energy to total energy consumption, 2005



Note: * 2000 values were used for France, Germany and Slovenia.

Source: MCPFE, 2007.

main objective as well as managing the potential implications for forest biodiversity will be one of the future challenges (Sections 2.2 and 4.7).

The forest sector is of special importance in European countries in transition towards free-market conditions, notably because wood is an easily accessible resource to contribute to overall economic growth which also has positive implications for domestic demand (Kangas and Baudin, 2003).

Knowledge of the economic importance of the forest sector, including the increasing use for bioenergy, is necessary for understanding the potential impact in different European regions of forestry and the specific forestry operations on forest biodiversity. It should be noted that the environmental effects, including effects on biodiversity, of the transport of the wood from the forest to the industries, and of the industrial processing are outside the scope of this report, as these affect a wider range of ecosystems such as terrestrial, aquatic, marine and/or environmental issues, including human health.

European forests are increasingly managed to provide multiple goods and services of which production for the forest sector is just one, albeit an important, objective. In many countries, hunting represents a considerable contribution to the local economy. For example, the total turnover generated by hunting in Germany is around EUR 750 million, compared to EUR 475 million in Austria and some EUR 170 million in Finland (FACE-Europe, 2007) whilst in Sweden, the annual value of hunting is estimated at EUR 330 million (Mattson *et al*., 2007). It is however, difficult to assess in monetary terms the total value of game and hunting: meat and trophies are only traded to a limited extent, the costs and values of hunting access on private land owned by the hunters or on freely accessible land are often not always accounted for, and the life-style and recreational values are also not easily taken into account. The importance of hunting is also shown by the main forest game bag, as exemplified by four Nordic countries (Table 4.1). The moose (*Alces alces)* — much bigger than deer, is by far the most important game species in Sweden, Finland and Norway, while in Denmark, outside moose distribution, the roe deer (*Caprimulgus caprimulgus)*, is the most important forest game species.

Other forest products having significant, but complex, values are mushrooms and berries. In most European countries the picking of mushrooms and berries is important, but as this is largely for private use there is no European-level estimate of the value of this resource (cf. MCPFE, 2007). However, in many rural contexts, in Italy for example, the revenue from the sales of collection permits for mushrooms (including truffles) is considered higher than the revenues from wood production (Petenella *et al*., 2005, 2006; Pettenella and Kloehn, 2007).

The European forest ecosystems provide important non-market services including regulating services, such as water purification, soil protection and carbon sequestration, as well as cultural services, including recreation and existence values (Section 2.2) to the European citizens. To give just a few examples, a substantial share of the European forests are specifically designated as protective forests around water reservoirs (ground water and aquifers); in alpine areas forests are managed to provide protection against avalanches, and in coastal areas to protect against wind and soil erosion. Thus, the area of protective forest in the EEA member and cooperating countries is estimated to be almost 20 million ha, slightly more than 10 % of the total forest area (MCPFE, 2007). In the future, the non-monetary economic values of forests may be considered much larger than the direct monetary revenues from wood, hunting or other non-timber products, and there will be an increasing need to take this into consideration when planning the use of forests (Section 2.2.).

Table 4.1 Yearly bag (mean 2000–2004) of main forest game species in Nordic countries

	Sweden	Finland	Norway	Denmark
Moose, *Alces alces*	103 282	73 673	37 705	0
Roe deer, *Caprimulgus caprimulgus*	159 440	1 764	29 660	105 040
Red deer, *Cervus elaphus*	1 940	0	24 351	3 640
White-tailed deer, *Odocoileus virginianus*	0	19 459	0	0
Wild boar, *Sus scrofa*	12 360	0	0	0
Capercaillie, *Tetrao urogallus*	22 022	33 560	10 940	0
Black grouse, *Tetrao tetrix*	26 113	131 980	27 500	0

Source: The Swedish Association for Hunting and Wildlife Management, Finnish Game and Fisheries Research Institute, Statistics Norway, and National Environmental Research Institute of Denmark.

In the following sections we deal more in detail with the impacts on biodiversity of utilisation of forest for the production of wood from forest industries and bioenergy requirements as well as from a number of threats such as fire and other damaging events, invasive alien species and long-range air pollution. A final section addresses climate change, which on a longer term can be expected to have great significance for European forest ecosystems, but which already today requires sustainable forest management to take adaptation and mitigation measures into consideration.

4.2 Wood production and consideration of biodiversity

The main forestry activity today in Europe aims at the production and harvesting of wood, even though the economic value of a wider variety of goods and services is receiving increased attention (Section 4.1). Silviculture, aiming at securing the availability of wood resources, has a long tradition in Europe but has over recent decades developed into multi-purpose forestry as reflected by the principles of sustainable forest management accepted by all European countries (MCPFE, 2007) (Section 5.1).

The basic forest management unit aimed at the production and harvest of wood is the forest stand, which is a congruous area of forest to which a uniform silvicultural treatment is applied. Forest biodiversity is indeed affected by silviculture, since this determines the composition of tree species and the tree genetic origin (provenance), the tree density and horizontal structuring, the distribution of age classes and rotation periods, regeneration measures, etc. The biodiversity values of forests are negatively influenced particularly by intensification measures like drainage of peatlands and wet forest, fertilizer use and certain forest-tree genetic improvement practices, including application of biotechnology, and a 'too efficient' suppression of natural disturbances like fires and pests (EEA, 2006a).

Three important phases of the 'forest management cycle' for assessing management impacts on forest biodiversity are cutting, regeneration and growth (EEA, 2006a). In much of the forest management programmes in place in Europe a stand passes through each of these phases at different times. In principle this simple model also applies to 'continuous forest cover' and similar management strategies (Section 5.1), operating with one or more stands, with each stand (group of stands) including all three phases of the cycle.

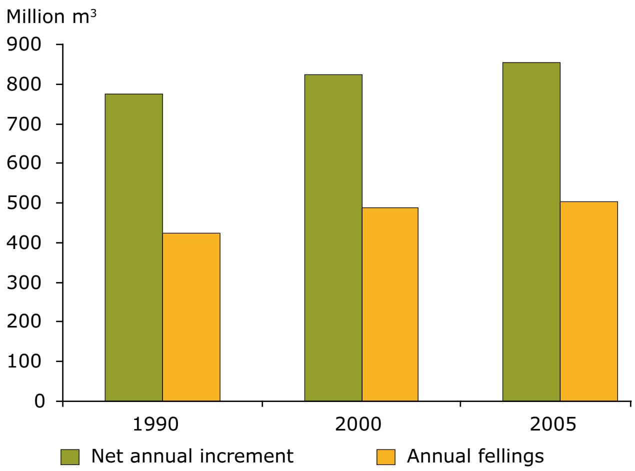
The cutting phase

The biodiversity potential of a forest stand depends to a considerable extent on the way in which the trees are harvested, such as their age, size of the cut area and volume of wood extracted by felling. The method and area of cutting — ranging from single-tree harvest to clear-felling of the entire stand — not only directly affects forest biodiversity but also the site conditions (soil condition, nutrient balance, hydrology, climate, etc.). The amount of wood harvested must not, in the long run, be greater than the increment in forest biomass if the forest resource is not to be overexploited. The development of felling compared with increment is thus an important indicator of forest biodiversity.

The annual ratio of felling to increment of the growing stock on forest land available for wood supply (Annex 3) has long been taken as an indicator for the sustainability of the use of the forest wood resource (MCPFE, 2002). A ratio lower than 100 % indicates an overall forest management that harvests less wood than accumulates in the forest in a year, which creates a sustainable use of the forest resources if applied consistently over time.

For EEA countries as a whole, the average annual felling accounted for around 59 % of the net annual increment of the growing stock in the year 2005 (Figure 4.3). The figure also shows that generally in Europe there has been a continuous incremental increase in stock growth balanced by increased

Figure 4.3 Overall development 1990–2005 in the 32 EEA member countries of net annual increment in growing stock and annual fellings of forest available for wood supply



Source: MCPFE, 2007.

felling during the past decades. As discussed in Section 3.2, there is thus currently a build-up of the growing stock on forests. Of the several factors that have contributed to this, forest management is considered the most important (Section 4.2). The proportion of felling to the total increment is forecast to increase to between 70 % and 80 % by 2010. This is due to an expected increase in demand for wood in the wider European region as a consequence of factors such as development of Eastern European markets (MCPFE, 2007; Schelhaas *et al*., 2006).

The data presented in Figure 4.3 are based on national-level reporting and give a useful general indication of sustainability; they do not, however, identify problems of 'unsustainable' forest management or exploitation at more local levels. Nor do they provide any guarantee that individual harvesting operations are carried out with the necessary biodiversity considerations in mind. The area and timing of forest felling affects the habitat mosaic of the forest landscape including, for example, fragmentation of areas covered by mature forest. The effect on forest species is linked to the ecological requirements in habitat structure of the species in question, and the ability of the particular species to adapt to changing environments. The clear-felling, in forest categories for which this is an accepted practice, has been heavily debated from a nature-conservation point of view and some information is available (Box 4.2). However, at present there is no European-level monitoring allowing further ecological assessment of individual harvesting operations.

Box 4.2 Changes in clear-felling practices might favour the capercaillie

The capercaillie, *Tetrao urogallus*, occurs in viable populations in northern European forests that are heavily influenced by forestry. To a certain extent, the species is dependent on large areas of mature forest. When the predominant harvesting method is clear-felling, this leads to the fragmentation of mature stands, which in turn introduces a risk of creating a landscape mosaic unfavourable for the capercaillie.

Photo 4.2: © K. Sjöberg

Clear-felling influences the capercaillie directly, by reducing the area of suitable habitats, as well as by influencing the habitat quality at different stages of the bird's lifecycle at different times of the year. Research indicates that when the patches of clear-felling are sufficiently small, the capercaillie may perceive the forest landscape as one single forest area. Such a landscape will thus support larger capercaillie populations compared with a landscape with the same total area of more extensive clear-felling.

Figure 4.4 Decreasing the size of clear-felled patches as shown in a boreal forest landscape in Hälsingland, Sweden

Source: Rolstad and Wegge, 1987, 1989; GSE Forest Monitoring.

The regeneration phase

At the point of regeneration after felling or when establishing afforestation on land which has not been forested for a long time, a choice is made with regard to whether the trees making up the new stand should be established naturally, by seeds from remaining or neighbouring parent trees, or whether the area should be planted afresh.

Natural regeneration is often associated with a diverse tree species composition, and builds on the gene-pool of the previous tree population, which is good if the genotype is favourable. However planting is often the preferred method on certain sites and/or regions because homogeneous stand establishment is achieved more quickly with less management. Planting may also be preferred because it also allows 'improved' genetic plant material. As mentioned in Section 3.2, forest plantations with non-indigenous tree species are of relatively limited importance in Europe. Some main arguments for choice of regeneration strategy and a preliminary description of current practise in the European forest categories are presented in Table 4.2. Recent reporting by the countries (Figure 4.5) reveals a high variation between preferring planting and/or seeding to natural regeneration, including coppicing, no doubt largely reflecting prevailing forest type categories. However, it should be noted that overall in Europe a tendency towards increased natural regeneration can be observed (MCFPFE, 2007).

The growth phase

There are several indications that the management of growing forest stands (or perhaps to some extent the lack of active silviculture) in Europe today allows forests to develop in a more favourable way from a biodiversity point of view:

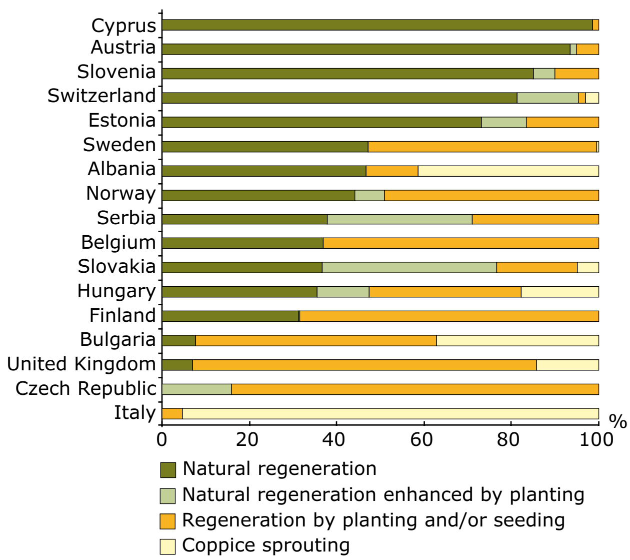
- The standing volume of forest growing stock in Europe has continued to increase in recent decades. As felling takes place mainly earlier than in a natural 'forest cycle' (expected natural physiological or ecological limit of tree age), it is noteworthy that there is now a tendency to let the forests grow older. This may partly be a result of a more widespread close-to-nature management (Section 5.1).

- A distinguishing feature of older forests is the presence of relatively larger trees, and for such trees there is a positive trend in occurrence (Figure 3.2). Such trees are often valuable hosts for epiphytic flora, and may contain dead and hollow parts that are important for a number of forest species.

- Awareness of the importance of deadwood as a substrate for a large number of insects, lichens, bryophytes, and fungi has become widespread only within the past decade. The amount of dead timber that should be retained within managed forests is a subject of debate but as, a general rule, will probably amount to the more the better (the main exception being fire-prone plantations, Sections 3.6 and 4.4). Forestry practices in many European countries nowadays aim at increasing the amount of deadwood in the forests (Sections 3.6 and 5.1). Actions needed depend on forest types and situations, but some general principles are emerging. Management interventions should generally consider leaving a certain amount of deadwood on the ground after felling, the creation of artificial standing dead trees (snags) or leaving a number of standing trees after felling to develop freely in the new stand.

Tree species composition, i.e. the relative abundance of tree species within a forest area, is the first of the biodiversity indicators established in the MCPFE reporting procedure (MCPFE, 2002). The outcome

Figure 4.5 Forest regeneration strategies in selected EEA member and cooperating countries (reporting this information)



Note: Coppice sprouting can be considered a form of natural (vegetative) regeneration. The figure refers to the percentage of the area regenerated in even-aged and uneven-aged forests in 2005

Source: MCPFE, 2007.

Table 4.2 Main preferred choice of forest regeneration with respect to European Forest Type category — a preliminary assessment

Regeneration type	Advantages	Disadvantages	Significant in the following European Forest Type categories (Annex 1)
Natural regeneration	Higher density of re-growth opens for natural selection processes. Establishment over successive years may correspond to natural succession. No cost for plant material and planting. Often perceived favourably by general public.	Impossible if no suitable parent tree species or provenance is available. May take long time, be risky or not work at all on unsuitable sites or in unfavourable climate with irregular seed production of parent trees. May require expensive thinning of plant material to produce large trees.	1. Boreal forest (dry pine forests) 2. Hemiboreal forest and nemoral coniferous and mixed broadleaved-coniferous forest (most area) 3. Alpine coniferous forest (in particular spruce or spruce-silver fir forests) 4. Acidophilous oak and oak-birch forests 5. Mesophytic deciduous forest 6. Lowland to submountainous beech forest 7. Mountainous beech forest 8. Thermophilous deciduous forest (coppicing) 9. Broadleaved evergreen forest 10. Coniferous forest of the Mediterranean, Anatolian and Macaronesian region (limited forestry fellings) 11. Mire and swamp forests (only some types subject to forestry fellings) 13. Non-riverine alder, birch or aspen forest
Natural regeneration aided by planting.	May increase/enforce a desired species composition and/or the genetic diversity of parent trees.	Site conditions must be suitable for both regeneration types.	3. Alpine coniferous forest (in particular spruce or spruce-silver fir forests) 4. Acidophilous oak and oak-birch forest
Planting or seeding achieving pre-determined species composition	Only possible method if parent trees are not available on or near site. Chance to steer towards native species and provenances. On some sites often the most feasible method to achieve afforestation and regeneration of desired species in foreseeable time. Controlled plant density brings down need for management. Seeding may potentially have most advantages of natural regeneration.	May need extensive site preparation. May disadvantage certain elements of biodiversity e.g. by 'speeding up' natural forest succession. May not be perceived favourably by general public. Seeding subject to additional predation and also have several disadvantages mentioned under natural regeneration.	1. Boreal forest (most area) 6. Lowland to submountainous beech forest (at high costs) 10. Coniferous forest of the Mediterranean, Anatolian and Macaronesian region (limited forestry fellings) 14. Plantations and self-sown exotic forest (by definition)
Planting or seeding aided by natural regeneration	Natural regeneration often supports spot-failures in plantings and seeded forest which contributes both to the overall production of the stand and, sometimes significantly, to biodiversity.	Sub-optimal in high-intensity forest production schemes.	1.Boreal forest (to varying extent) 2. Hemiboreal forest and nemoral coniferous and mixed broadleaved-coniferous forests (part of area)

of the recent reporting on tree species numbers is discussed in Section 3.7. The geographical pattern is quite striking and shows an increased occurrence of multi-species stands in central and south Europe, most probably reflecting both prevailing forest type categories and silviculture practices (MCPFE, 2007). However, a well-founded assessment based on this indicator would require that data are reported by forest type (countries have in principle agreed to do this — MCPFE, 2002), and that reference values are established for the natural or desirable tree species composition.

4.3 Wood for renewable energy and ecological restrictions

Forest resources have been identified as an increasingly important source of renewable energy supply in Europe (Section 4.1). There are several different categories of woody biomass that contribute to renewable energy supply, including industrial wood residues such as saw-dust, black liquor, recycled wood (e.g. demolition wood from old buildings) or recycled paper. The environmental concerns connected to these resources are not dealt with here. The following section will focus only on the use of woody biomass from existing forests. A specific issue on a European level, treated politically as part of agriculture, is biomass from short-rotation forestry producing wood chips from plantations of, e.g. poplar, *Populus* spp., willow, *Salix* spp., or *Eucalyptus* spp.

As part of a wider assessment on how much bioenergy Europe can produce without harming the environment (EEA, 2006c) a study was carried out on potential biomass extraction on forest land, given specified ecological restrictions. In the following section we will refer to the main findings of this study, for further information and references (see EEA, 2007b). The study focused on two categories of resources that can be extracted from existing forests:

- Forest residues resulting from felling, e.g. those parts of the tree (branches, tops etc.) that are not removed in the roundwood extraction. In many European countries today this is the most accessible forest resource for bioenergy (e.g. Swedish Forest Agency, 2007a).

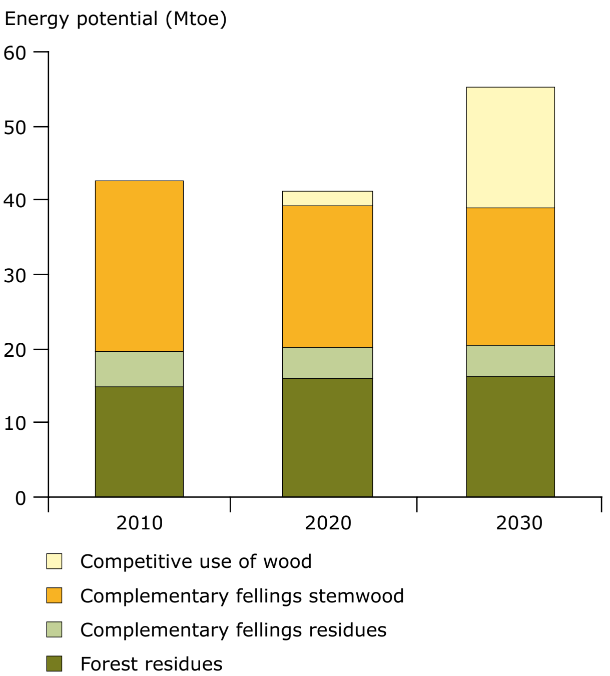
- A 'complementary fellings', could in principle be a source for bioenergy, due to the current discrepancy between felling and growth increment (Section 4.2). In practice, a number of obstacles of economico-technical and silvicultural-biological nature must be overcome.

Additionally, part of the wood resources harvested today for forest industries could be used instead for bioenergy ('competitive use'). This will however require a dramatic development of the price-relationships and/or involve substantial subsidies and far-reaching political decisions.

The findings of the EEA study on how much biomass can be harvested from forests under environmental restrictions are shown in Figure 4.6. The estimate is conservative but allows for a considerable increase compared to the present. Using wood biomass in competition with the present industrial use of wood is only indicated as a long-term option.

Identifying environmental restrictions was a main objective of the study. A review of literature demonstrated that intensified use of forest biomass (residues) could possibly have negative impacts on site nutrition and/or biodiversity. Whole-tree harvesting was considered unsuitable on poor soils, steep slopes and other sensitive sites. On the other hand, this more intense extraction of forest biomass is also recognized as a way to balance the anthropogenic nitrogen deposition because it

Figure 4.6 Estimated forest biomass resource potential for bioenergy in EU-21 from 2010–2030



Note: EU-21 refer to EU-25 excluding Cyprus, Greece, Luxembourg, and Malta.

Source: EEA, 2006c.

counteracts nitrogen accumulation (Section 4.6). From a biodiversity point of view, the effects of these changes on site conditions could be reflected in the ground vegetation and soil biodiversity. This will however need further research.

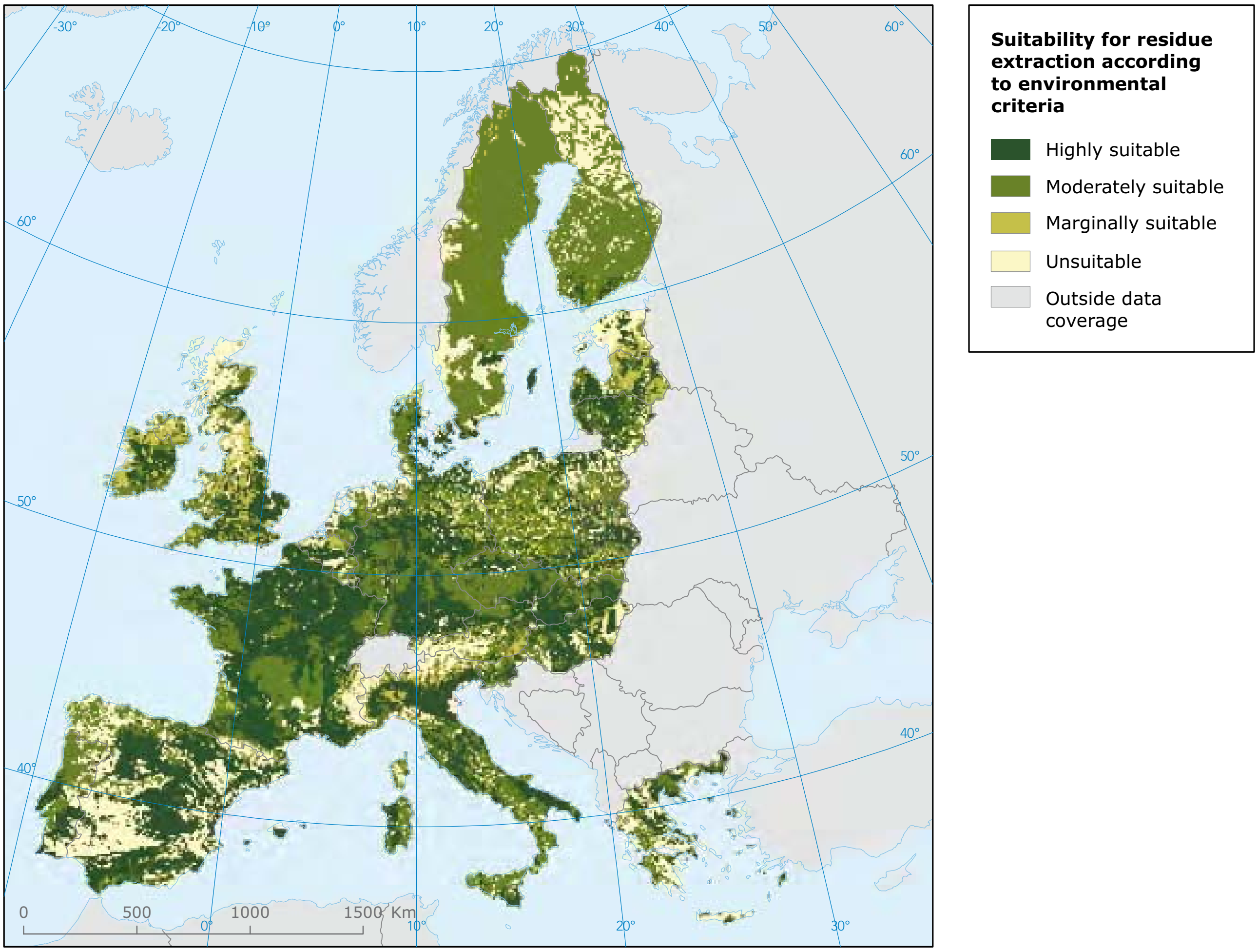
The constraints on residue removal that were considered included site fertility, soil erosion and soil compaction. In line with this, Map 4.1 shows an assessment of suitable areas in Europe for forest residue extraction. Areas identified as highly and moderately suitable seem accessible for at least one generation of fellings with residue extraction without any compensatory measures to restore nutrient balance.

In particular 'complementary fellings' could be further constrained by biodiversity considerations, such as a demand for a higher share of deadwood in managed forests and longer rotation periods, plus an increased share of protected forests would decrease the biomass potential from complementary felling as indicated in Figure 4.6.

A special warning is needed against using deadwood as a potential resource for bioenergy in Europe. As discussed in Section 3.6, deadwood is an important stand quality for forest biodiversity, the occurrence of which should generally be further promoted in Europe. The potential future use of deadwood as a resource for bioenergy in Europe, can be expected to conflict with aims to preserve forest biodiversity.

The positive effect of more intense forest harvest, as an adaption to the nitrogen deposition (Section 4.6) and fertilization to increase biomass potential, must be further analysed. Because of the limited

Map 4.1 Suitability for residue extraction according to environmental criteria in EU-25



Note: The above site suitability map does not consider fertilisation as an option on nutrient-poor soils. If ash recycling were considered on podzol areas, the suitability would be higher, especially in Finland and Sweden.

The reduction in risk for compaction of soil when frozen during winter months has not been taken into account, which probably has resulted in underestimating the suitability in e.g. northern Finland.

Source: EEA, 2006c; 2007b.

time horizon of the study, implications of forest management adaptations were not considered. The scenario on forest resources available for bioenergy would also be different with a possibility of an increased use on forest land of fast-growing short-rotation forest crops such as aspen, willow or eucalyptus.

Within the study time horizon of 10–20 years, there will not be a significant amount of wood biomass coming from new forest generations. All the removed biomass will still be harvested from the past forest management systems.

4.4 Forest fires and other damages

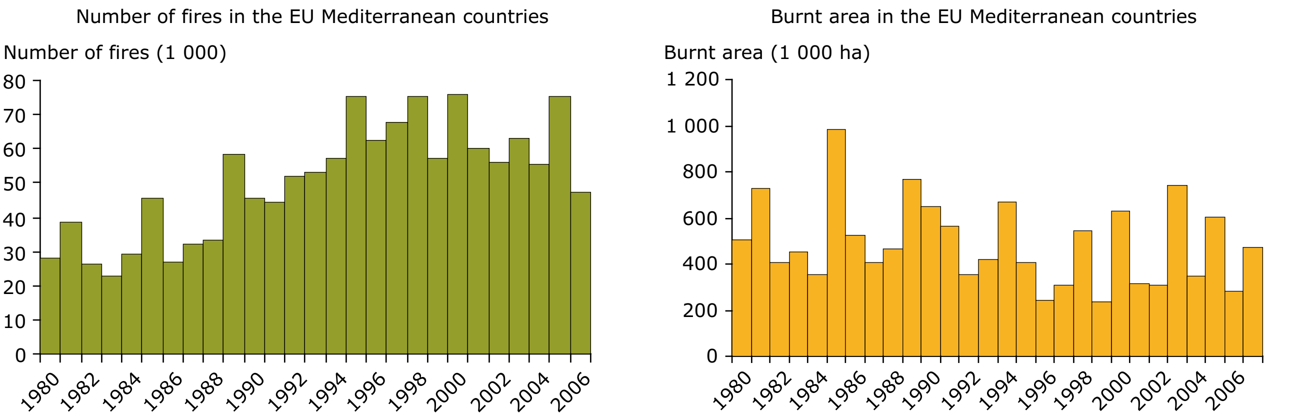
The most drastic damages to forests in Europe are caused by forest fires and wind storms. Forest fires occur every year and burn, on average, about 500 000 hectares of forests. The number of fires and area burned in EU Mediterranean countries are shown in Figure 4.7. The number of fires in the last decade has increased with respect to the previous one. However, the area burned by these fires has not increased significantly due to the improvement of forest fire fighting means in the countries. Although fires occur all over Europe, their frequency and intensity is highest in the Mediterranean region. About 95 % of the total area burned by forest fires is located in this region, and most of this damage is caused by summer forest fires (EC, 2007b). In addition to the destruction of vegetation, forest fires produce other damaging effects to the environment. Among these are the emissions of particle and gases (e.g. CO_2) into the atmosphere, outflow of mineral nutrients, the destruction of the organic layer of the soil, and the changes in the water infiltration rates in the soil, which makes burnt areas prone to erosion, soil loss, and landslides (Doerr and Cerdà, 2005; MacDonald and Huffman, 2004). The incidence of recurrent fires in southern areas of Europe in addition to droughts may lead to desertification.

Due to high temperatures and low moisture content of vegetation, forest fires cause near total destruction of the vegetation, which results in damages to the animal species that live in the forest. For instance, fires in 2007 burnt more than 100 000 ha of forests within special protection areas of Natura 2000 in the EU Mediterranean countries. The destruction of forests reduces the forest area, but also affects the connectivity among forest patches, reducing the capacity for animals to move. The impact of forest fires in the Peloponnese (Greece) in 2007 on the available habitat of an endangered mammal species is shown in Box 4.3.

Fire is an important natural disturbance factor also in Boreal forest. The effective fire control is actually a significant factor explaining why some forest species are threatened (e.g. Esseen *et al.*, 1997). In northern Europe, nowadays controlled forest fires — often prescribed burning of cut areas — is used to restore and enhance biological diversity (Vanha-Majamaa, 2006).

Although the frequency of extensive wind storms is not as high as that of fires, wind storms have caused serious damage to forests and human infrastructure in Europe in the last decades. The most serious events occurred in 1999, 2004, 2005, and 2007 with

Figure 4.7 Number of forest fires and burnt area in the EU Mediterranean countries



Note: Preliminary data of burnt areas for 2007.

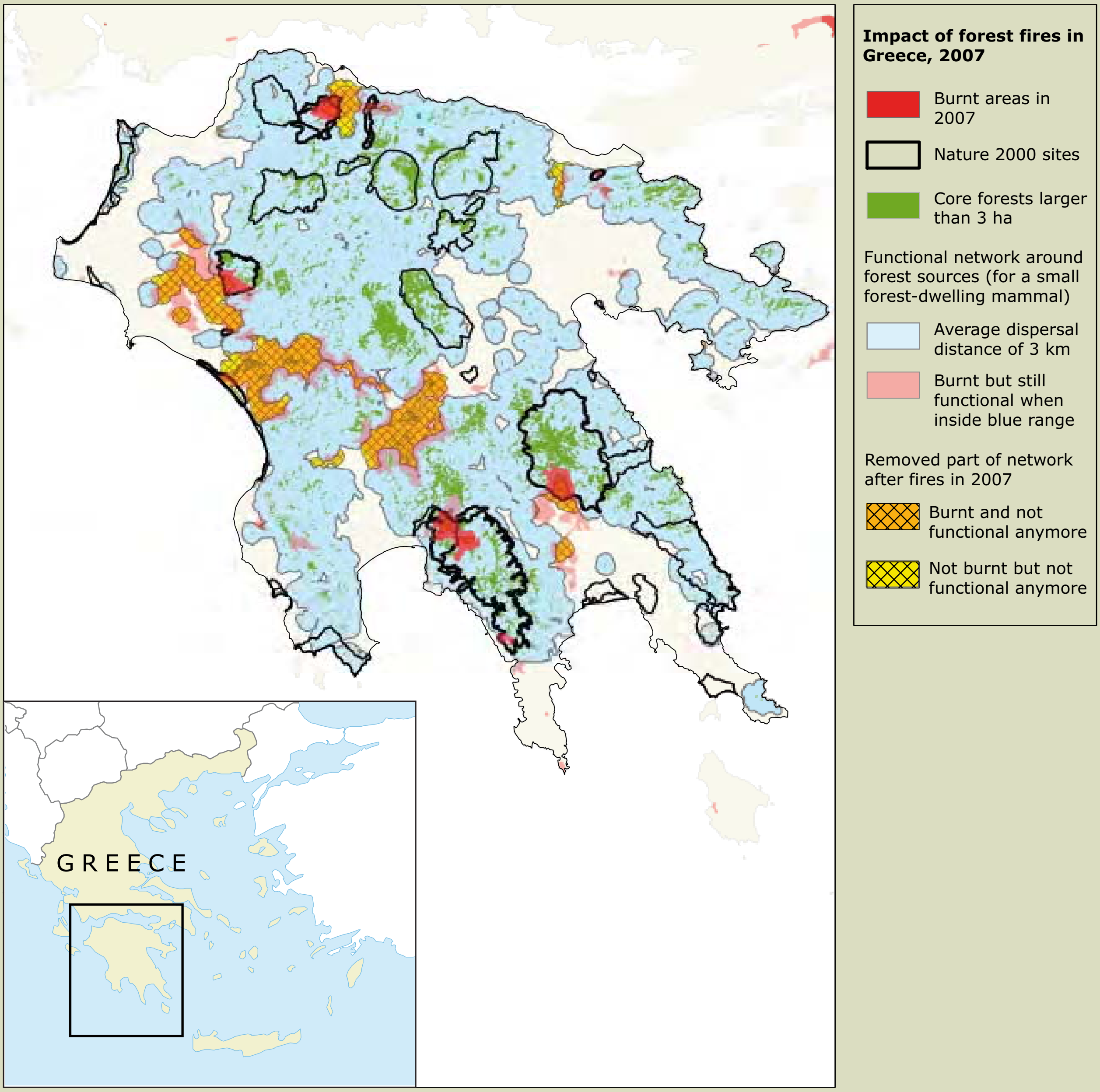
Source: European Forest Fire Information System (EC, 2006b).

Box 4.3 The forest fires in Greece in 2007

Greece was affected by catastrophic forest fires in 2007. The total burnt area amounted by end August to ca 270 000 ha, of which ca 150 000 ha was forest land. 11 % of the burnt areas, i.e. more than 31 000 ha, were in 24 designated Natura 2000 sites (EC Birds and Habitats Directives) and mainly located in Peloponnese.

Map 4.2 provides an example of the impact of fires on the functional territory of a forest-dwelling mammal like the wild cat (*Felis silvestris*). This mammal has an average dispersal distance of 3 km, prefers wooded core areas of a minimum 3 hectares, and avoids open ground including burnt areas and that resulting from infrastructure and populated regions. Its movement was modelled before and after fire using the resistance that the landscape presents to its activities and the forest sources areas from which the animal originated. Due to fires, available territory size was reduced and became less connected as shown by the increased number of networks (18 versus 16). The sections of the networks destroyed by fire (yellow shade) extended partly across six Natura 2000 sites and amounted to an area of 104 185 ha, representing a loss of 7 % of the initial network.

Map 4.2 Impacts of fires in 2007 on the functional territory for forest-dwelling mammal species occurring in the Peloponnese



Source: Estreguil and Rodriguez-Freire, 2008.

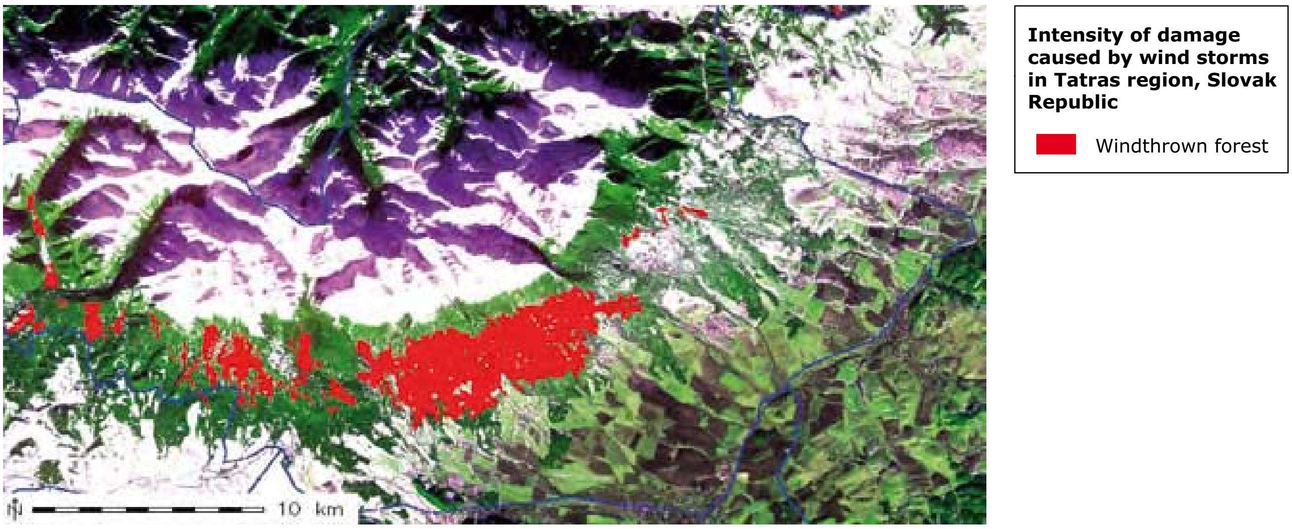
the storm of 1999 bringing the most catastrophic damage to central Europe. In many cases, the whole tree layer of the forest was blown down by the storm. An example of the damages caused by the storm of December 2004 in the Tatras region of Slovakia is presented in Map 4.3. In January 2005, a severe storm raged through northern Europe, damaging approximately 75 million cubic meters in Sweden alone (Swedish Forest Agency, 2005). Another great storm damaged central European forests in 2007 (Map 4.4).

The damaged areas may then be subjected to further damage from other causes, such as insects and forest fires. In some cases, a major issue in certain areas is the avoidance of population increases in bark beetles (Fam. *Scolytidae*) breeding in damaged and fallen trees and logs remaining in the forest and capable of inflicting massive damage in the surrounding forests not directly affected by the storm. The damage caused by storms in central and western Europe in the last decades added impetus to the changes in silvicultural practices (Section 5.2). For instance, changes from coniferous to broadleaved species, and from uniform to irregular stands continue to take place, especially in France and Germany as well as in the United Kingdom.

In the report to the 2007 Ministerial Conference on the Protection of Forests in Europe the categories found to cause the most extensive damage to forests in 2005 were, 'wildlife and grazing' followed by 'insects and diseases' (Figure 4.8). From a forest biodiversity viewpoint a certain level of impact on the forest from biotic agents (i.e. naturally occurring species) must be regarded as part of the natural functioning of the forest ecosystem. Only when the degree of impact exceed natural levels and are promoted by human actions, can such impacts be regarded as 'damage' from a strictly ecological point of view. However, human interests must be balanced against forest biodiversity, within the context of multi-functionality of the forests, and the management may aim to reduce damage below 'a natural level'.

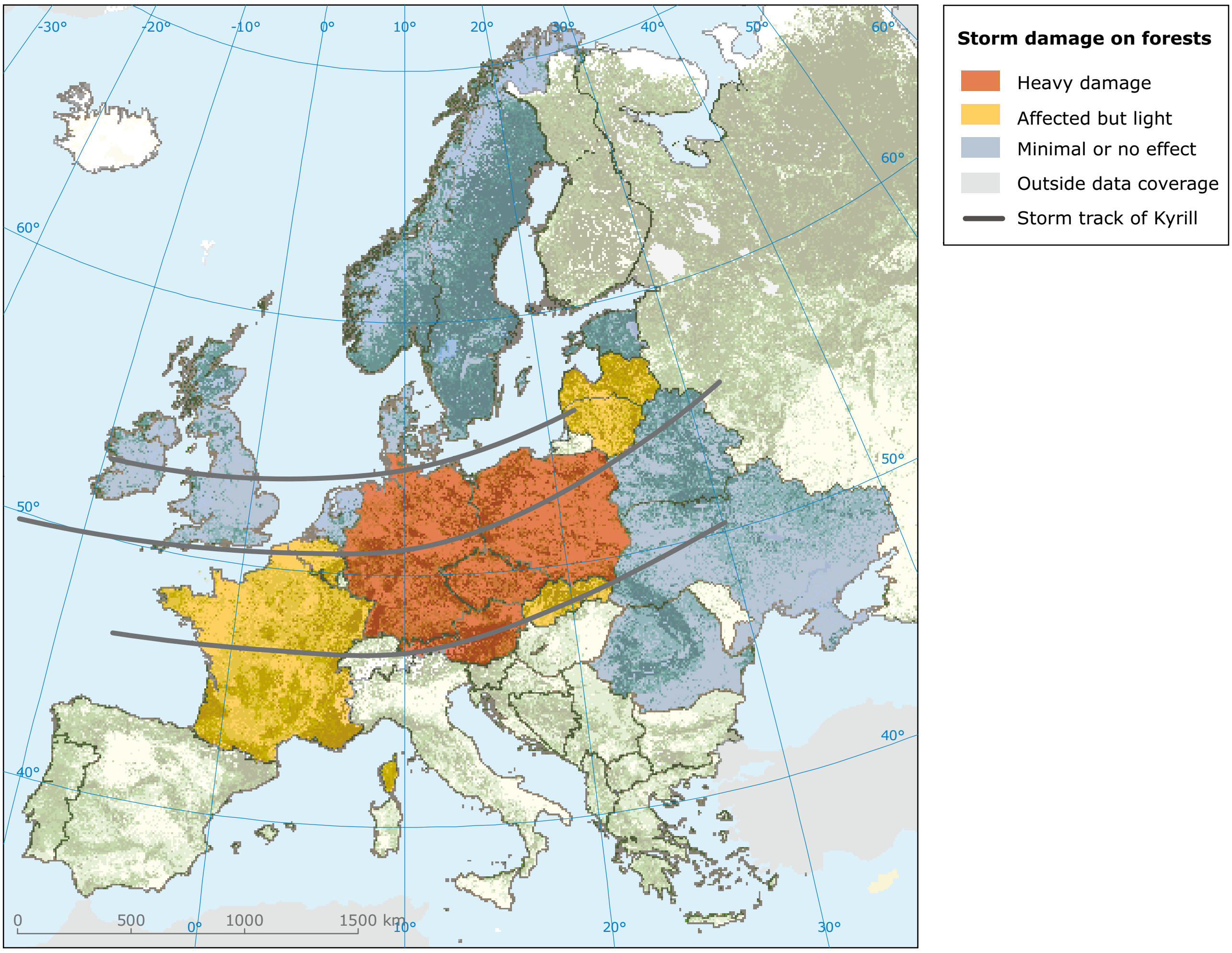
Game populations are so dense in many continental forests that forest areas require expensive fencing in order to allow regeneration to occur. The large area reported subject to damage by 'Wildlife and grazing' indeed reflects game management towards dense game populations. Sweden reported a large area of damage, amounting to around 2 900 000 hectares, largely of young pines (*Pinus sylvestris)* caused by browsing moose (*Alces alces*) during the winter

Map 4.3 Intensity of the damage caused by wind storms (Tatras region, Slovak Republic)



Source: EC, DG JRC Institute for Environment and Sustainability.

Map 4.4 The storm 'Kyrill' in January 2007 brought much destruction in central Europe, including a forest loss of 45 million cubic metres of standing timber

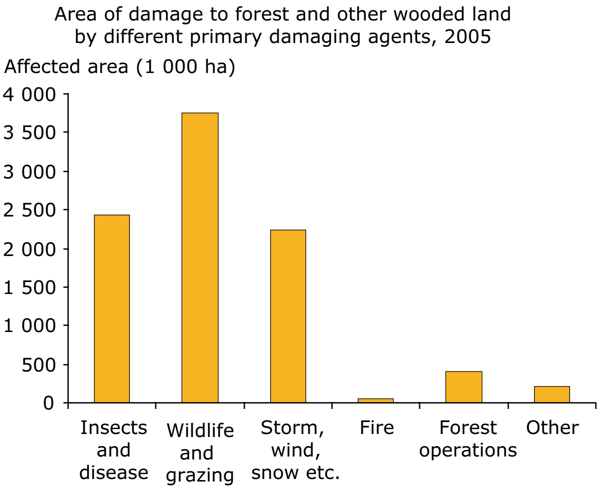


Source: CONFOREST, 2007.

(Swedish Forest Agency, 2007b). It is not considered economically feasible in the boreal forests to fence forest-regeneration areas against moose except for seed orchards (Section 3.8); public resources have been prioritized to fence the major highways to reduce traffic accidents. In Scotland the natural regeneration of pine (*Pinus sylvestris*), which would allow plantation areas to develop towards the natural hemiboreal forest conditions, is to a large extent prevented by the grazing damage caused by the dense populations of red deer (*Cervus elaphus*). On the other hand, the relatively high amount of damage reported for Italy, almost 500 000 ha, more likely is influenced by the fact that forests, in particular in the southern part of the country, are still subject to extensive grazing by livestock (APAT, 2007). Grazing (including trampling) by domestic animals may have negative effects on forest production and ecosystems. It may be difficult (or even impossible) to cater for the (sometimes conflicting) interests between forest owners, traditional communities and biodiversity. Grazing by livestock may not generally have a negative effect on biodiversity, as the grazing may allow the development of a forest structure similar to the original pre-historic forest in which mega-herbivores grazed (Bengtsson *et al*., 2000), see also Box 4.1.

According to predicted climate change scenarios the frequency of natural hazards will increase in Europe. Drought and deforestation are two of the major causes of desertification in Europe, being a significant process in the Mediterranean. Phenomena such as flood, fires and wind storms will increase in frequency and intensity in the future (Section 4.7). Increases in summer temperatures and

Figure 4.8 Area of damaged forest and other wooded land by biotic agents



Note: Data: Albania, Austria, Bulgaria, Cyprus (partly), Czech Republic (partly), Estonia, Finland, France (partly), Hungary, Italy, Norway (partly), Portugal (partly), Serbia, Slovakia, Slovenia, Sweden, Turkey (partly), the United Kingdom.

Source: MCPFE, 2007.

spring droughts may lead to catastrophic conditions of forest fires in the Mediterranean region. Pest and diseases will take advantage of warm temperatures and may become more damaging than under the current conditions.

4.5 Invasive alien species in European forests

A large, and increasing, number of alien, non-native, species have established in Europe. Introduction of an alien species may be intentional in forestry, horticulture, and game management. The planned release, and even keeping in captivity, of alien game and freshwater fish species that may negatively impact natural biodiversity is regulated in most European countries. Uncontrolled releases of pets or escapes from gardens, for example, are significant. However, nowadays most alien species arrive un-intentionally as a result of the increased global travel, transport and trade (EEA, 2007a, c).

Of all the approximately 10 000 alien species found in terrestrial, freshwater and marine/coastal ecosystems in Europe (DAISIE, preliminary results) only a relatively small number contribute significantly to current negative impacts on biodiversity and human interests. In order to assess in detail how invasive alien species contribute to the loss of biodiversity in Europe and prioritise actions, the European Environment Agency established a list of 'Worst invasive alien species threatening biodiversity in Europe' comprising those species recognized by experts as having a serious impact ([10]) on biological diversity of Europe. The species listed, in addition to their impact on biodiversity, may have negative consequences for human activities, health and economic interests (e.g. as a pest, pathogen or a vector of disease). Presently the list 'Worst invasive alien species threatening biodiversity in Europe' comprises 168 species/species groups (EEA, 2007b). Among these problematic invasive alien species, 33 can regularly be found in European forest ecosystems or are dependent on trees (Annex 2).

One can make several general observations on the forest- and tree-dependent worst invasive alien species threatening biodiversity listed in Annex 2:

- Forest- or tree-dependent species on the list can be found in all European countries. Information on distribution and impact may vary between countries and it should be noted that in some countries a species on the list may occur but not yet be invasive.
- The number of worst invasive alien species in forests is seemingly low in relation to other European ecosystems, taking into account the extent of forests in Europe. One could also assume that establishment of alien species is mitigated by the fact that forest ecosystems in Europe are in a relatively natural condition.
- The introduction of the worst invasive alien species has taken place over a long period of time with 15 species being established before 1900, 8 species during the period 1900–1950, and 10 species thereafter. There is no alarming increase in species numbers of this category in

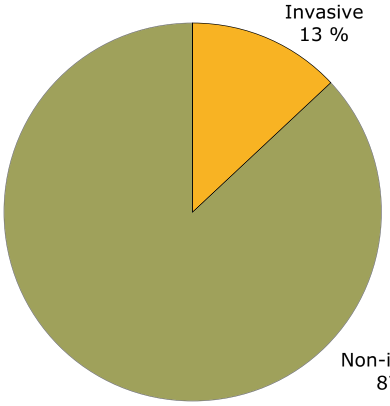
([10]) By serious is meant e.g.:
- severe impacts on ecosystem structure and function (alteration of habitat, competing with native species, entering food chain, altering energy and nutrient flow, etc.);
- replacement of native species throughout a significant proportion of its range;
- hybridization with native species;
- threats to unique biodiversity (e.g. habitats in need of conservation measures, isolated ecosystems, endemic species).

European forests but one should note the recent increase in invertebrates (see next bullet).

- Introduction of pathogens and invertebrate pests on imported wood and other forest products may pose a significant threat to European forests. Species of concern include the Asian longhorn beetle as well as the pinewood nematode. Effective control at ports of entry is needed.

Although European forestry is largely based on native tree species (Sections 3.2 and 3.7), deliberately introduced tree species are important in some countries. For forestry purposes fast-growing conifers such as Sitka spruce (*Picea sitchensis)*, lodgepole pine (*Pinus contorta)*, Douglas fir (*Pseudotsuga menziesii)* and western hemlock (*Tsuga heterophylla)* have all been used as well as a few broadleaved species, most notably the Australian eucalypts (*Eucalyptus* spp.). The ecological characteristics of these species often create significantly different forest ecosystems than native trees, but this alone does not qualify the planted trees to be considered invasive. In the report to MCPFE (2007), countries classify only 13 % (ca 700 000 ha) of the area covered by introduced forest tree species as occupied by invasive species (Figure 4.9). One of the countries reporting substantial areas occupied by invasive tree species was Italy (MCPFE, 2007) as outlined in Box 4.4.

Figure 4.9 Forest area covered by introduced, non-native, tree species



Source: MCPFE, 2007.

4.6 Long-range air pollution

Extensive forest damage during the 1970s in central Europe and the concern that this could be caused by air pollution led to the establishment of the International Co-operative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) by the UN Economic Commission for Europe under its Convention on Long-range Transboundary Air Pollution (CLRTAP) in 1985. In 1986, the European Union (EU) adopted the EU Scheme on the Protection of Forests against Atmospheric Pollution. Since then the EU and ICP Forests have been monitoring forest condition in close cooperation, and forest monitoring in the countries has now been operational for more than 20 years (ICP Forests, 2005). Since 1986, the EU has supported its Member States in this monitoring by making it a legal obligation and providing co-financing through several EC Regulations, the latest being Forest Focus, which expired at the end of 2006. The new LIFE+ Regulation approved in 2007 provides a financial mechanism that may allow the follow-up of forest monitoring activities through the participation of the countries in projects with this aim. However, there is no obligation for the countries to participate and no legal obligation to report on forest monitoring. One of the objectives of the foreseen forest monitoring activities under LIFE+ is the establishment of a single system for the collection of forest information in the countries, thereby establishing synergy between the existing national forest inventories and the forest condition monitoring networks.

To monitor the effects of long-range air pollution and deposition on the forest ecosystem, a double network was set up. In the first network (level 1), points are systematically distributed in 16 x 16 km grids covering the participating countries. The aim of the level 1 scheme is to achieve a representative sample of forest condition. Due to the large number of points and the requirement of yearly assessments, forest condition had to be measured by relatively simple indicators considered to reflect tree vitality. Crown condition (defoliation) was thus selected as a fast-reacting indicator reflecting several environmental factors which can be assessed with reasonable effort at the European-wide scale.

In order to gain a better understanding of the impact of air pollution and other stress factors on forest ecosystems and to attempt to quantify cause-effect relationships, a system of plots for more intensive monitoring was established in the mid 1990s (level 2). On these plots a number of additional surveys take place at differing intervals;

Box 4.4 Invasive alien tree species which threaten forest biodiversity in Italy

The black locust, *Robinia pseudoacacia*, the tree-of-heaven, *Ailanthus altissima*, and the black cherry, *Prunus serotina*, are three alien tree species that are becoming a threat for forest ecosystem conservation in Italy. *Robinia* has been widely used in Italy, as elsewhere in south and Central Europe, for a variety of purposes such as ornamental, timber, firewood, re-vegetation of dry land and providing nectar for honey production. Pure *Robinia* stands in Italy comprise > 100 000 ha which are generally coppiced for wood production. *Ailanthus* has been mainly employed as an ornamental or along roads. Both species affect biodiversity by their vigorous growth and tendency to compete with the native vegetation. Italian landscapes are often characterized by fragmentation of forest areas, mainly of indigenous species. *Robinia* and *Ailanthus* tend to invade such stands when tree density is strongly reduced or where clear felling is the traditional form of management. *Prunus serotina* occurs mainly in lowland forests in northern Italy where it forms thick shrub stands which prevent the regeneration of native species.

There is in particular a need to control these alien species in forest areas with a high conservation and/or landscape value. Experimental trials on control of *Robinia* and *Ailanthus* focus on mechanical treatments at the single-tree scale (topping and girdling at different heights). In addition, alternative management approaches at the stand and landscape level can be used such as the encouragement of a dense undergrowth of native broadleaves in conifer stands to pre-empt alien species regeneration or by maintaining buffer strips of uncut dense stands of native species along edges bordering stands or groups of *Robinia* or *Ailanthus*. A further species, *Prunus serotina*, is also difficult and costly to control, as it can regenerate easily both by seeds and by sprouts. It can be reduced by frequent cutting, but the best management practice is probably to maintain a dense canopy closure of native species in the forest stands. Some experimental trials in this direction have been conducted in Lombardy, in the Regional Park of Ticino Valley, where black poplar (*Populus nigra*) and white poplar (*Populus alba*) have been planted to mitigate the spread of *Prunus serotina*.

Spontaneous regeneration of Robinia pseudoacacia regeneration under stone pine stands. Parco della Versiliana, Lucca

Photo 4.3: © S. Nocentini

Ailanthus has a prolific seed production

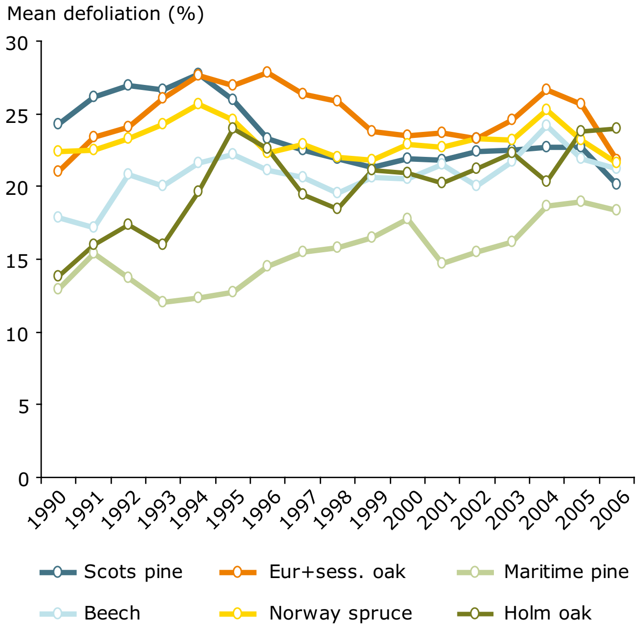
Photo 4.4: © T-B. Larsson

Source: Susanna Nocentini, University of Florence; Claudio Piccini, APAT, Rome.

including the measurement of deposition (chemical composition of rain water), ambient air quality, foliar analysis, and the assessment of ground vegetation, soiland related factors. The number and location of the level 2 plots was largely decided by the participating countries and generally reflected species and/or locations considered important to that country. Therefore, the level 2 scheme does not provide a consistently representative sample of European forests, a fact which rather limits the geographical comparison of the results.

Nevertheless, the network consists of more than 6 000 level 1 plots and some 860 level 2 plots within 41 participating European countries and constitutes one of the largest harmonized bio-monitoring networks in the world (ICP Forests, 2005). Harmonisation of the methods used was achieved through detailed common manuals. Participating countries report level 1 data to the Programme Coordination Centre in Germany, and level 2 data to the European Commission Joint Research Centre. The state of forest condition in Europe is presented in yearly executive and technical reports. This information on forest condition was included in the MCPFE report on the State of Europe's Forest (MCPFE, 2007) and European Environment Agency reports of the State of Europe's Environment (EEA, 2005, 2006).

Figure 4.10 Development of defoliation 1990–2006



Source: ICP Forests, 2007.

Due to the efforts of European countries in line with CLTRAP, SO_2 emissions to the atmosphere in Europe were reduced which has been one of the most significant international environmental success stories. Over an evaluation period 1996–2001, sulphate deposition was shown to decrease over most of the intensive monitoring plots in northern, central and western Europe. The long monitoring series of crown condition revealed an overall increased defoliation from the start in the 1980s, which stabilized from the 1990s onwards (Figure 4.10). The current defoliation status in much of the European forest fluctuates around 15–25 % and shows no indication of loss of tree vitality. Tree defoliation is liable to both a high spatial and temporal variation whilst also strongly reflecting annual climatic conditions and consequently a substantial increase during dry years is often found. Additionally there are variations due to species diversity and tree age. For example, the two southern European species, holm oak (*Quercus ilex)* and the maritime pine (*Pinus pinaster),* show a less pronounced increase in defoliation compared to other major tree species. Mean defoliation for these species was less than 15 % in 1990 and then increased to around 25 % in the case of the holm oak and just below 20 % in the maritime pine, by 2006.

Today, awareness of air-borne nitrogen deposition to forests and its effects on the forest ecosystem has increased. So far, efforts in Europe to bring down the emissions of nitrogen to the atmosphere have not been as successful as the 'sulphur story' (Fischer *et al*., 2007). Effects of nitrogen deposition on defoliation are ambiguous and might reflect their acidification potential on the one hand and a eutrophication effect on the other. The increased nitrogen status of the forest is likely to be an important factor behind the increase in forest growth noted in Section 4.2. However, increase of available nitrogen, considered a limiting factor in terrestrial ecosystem productivity, could be expected to influence significantly forest biodiversity towards communities adapted to eutrophic conditions. An analysis of the ground vegetation on level 2 plots showed that nitrogen-indicating species were clearly more frequent on plots with high nitrogen deposition. It has not yet been possible to detect overall changes in ground vegetation species composition related to nitrogen availability during the relatively short period these assessments have been carried out at a European level. However, more detailed national analyses have given some indications for certain forest types, such as in Italy where the number of species was shown to decrease in beech forests where nitrogen deposition exceeded critical loads (Lorenz *et al*., 2006).

An evaluation of Forest Focus concluded that the network has been mainly successful in achieving its original objectives and that the datasets are unique and large and should be further utilized by scientists and policy makers (Freer-Smith *et al*., 2006). In line with this, during recent years the ICP Forests monitoring network (in particular in the EU Member States by specific support of the Forest Focus regulation) has investigated the potential to address a wider range of environmental issues related to soil condition, biodiversity and climate (Section 5.4).

4.7 Climate change and carbon stock

The interactions to be predicted between climate change and forest ecosystems are quite complex. On the one hand, climate change can be expected to alter forest ecosystem conditions through higher mean annual temperatures, changed precipitation patterns and more extreme weather events such as heat waves and storms. On the other hand, forests and forest activities can play a significant role in climate change mitigation through the reduction of global deforestation and forest degradation, thereby enhancing the carbon sequestration rate in existing and new forests, providing wood fuels as a substitute for fossil fuels and by providing wood products to replace more energy-intensive materials.

Effects of climate change on forest ecosystems

The most recent evidence presented in the IPCC Fourth Assessment Report indicates that average northern hemisphere temperatures during the second half of the twentieth century were very likely higher than during any other 50-year period in the last 500 years and likely the highest in at least the past 1 300 years (IPCC, 2007). Projections for the twenty-first century suggest that the climate will change faster than at any other time in at least the past 10 000 years.

The projections for the European climate predict mean temperatures are likely to increase more than the global mean in the twenty-first century (Christensen *et al*., 2007):

- the largest warming is likely to be in northern Europe in winter and in the Mediterranean area in summer;
- annual precipitation is very likely to increase in most of northern Europe and decrease in most of the Mediterranean area;
- in central Europe, precipitation is likely to increase in winter but decrease in summer;
- risk of summer drought is likely to increase in central Europe and in the Mediterranean area;
- the duration of the snow season will most probably be reduced and snow depth is likely to decrease in most of Europe.

It is thus expected that climate change will lead to increased abiotic and biotic disturbances, including drought, salination, increased frost risk in spring and autumn and increased insect and pathogen damage. The changes will also affect the biology, phenology, growth and distribution of species and the species composition of forests in Europe. A multitude of studies based on field research and ecological modelling affirm that the responses of European forests to climate change may be considerable (e.g. Maracchi *et al*., 2005; Dormann *et al*., 2007). As an example Kellomäki *et al*. (2005a) carried out an analysis of the potential effects of changes for four different regions in Europe (Table 4.3). It should be noted that changes in the frequency and degree of extreme climatic events (such as droughts and floods) may have a greater effect on forest ecosystems than the changes in the projected average climate (Lindner, 2007).

Thuiller *et al.* (2005), in projecting late twenty-first century distributions for 1 350 European plants species under seven climate change scenarios, showed that many European plant species could become severely threatened and more than half of the species studied could be vulnerable or threatened by 2080. Furthermore, species from mountains, having narrow habitat tolerances, were found to be particularly sensitive (possibly 60 % species loss). The boreal region was projected to lose few species, although gaining many others from northward immigration. The southern European regions today characterized by hot and dry summers, and thus hosting species that tolerate strong heat and drought, were likely to adapt to future conditions, under the scenarios considered.

Climate change will significantly alter phenology (time of budburst, flowering, fruit maturation, leaf colouring etc.). Data on trends in phenology in European species have been collated under the COST Action 725 'Establishing a European data platform for climatological applications' (COST 725, 2007). A meta-analysis of these data — 125 000 observational series of 542 plant species

Table 4.3 Impacts of climate change on forests in Europe

	Boreal	Atlantic	Continental	Mediterranean
Seed crop/regeneration potential	+	+/–	+/–	–
Tree growth	+	+/–	+/–	–
Storm/wind/snow disturbance	+	+	+	
Insect pest/disease disturbances	+	+	+	+
Competition capacity of conifers in relation to deciduous species	–	–	– (d)	
Competition capacity of species vulnerable to arid conditions			–	–
Zones suitable for tree species move northwards and upwards			+	
Exotic species invasions				+
Extension of shrublands				+
Fire risk	–	+ (d)	+ (d)	+

Note: Key: + indicates that there is an increase; – a decrease; +/– an increase/decrease depending on the conditions or whether soils have high/low water-holding capacity (Continental and Atlantic) or whether there is increase/decrease in precipitation (Continental only); + (d) increase depending on the conditions – on soils with a low water-holding capacity (Atlantic and Continental) and with decreasing precipitation (Atlantic); – (d) decrease depending on conditions in regions with high precipitation and on soils with high water-holding capacity.

Source: Adapted from Kellomäki *et al.*, 2005a.

(including forest trees) and 19 animal species — has shown that the phenology of the species studied is undoubtedly responsive to temperature and that the patterns of observed changes in spring match the measured national warming across 19 European countries (Menzel *et al*., 2006).

The potential climate change effects on tree growth indicated in Table 4.3 have been modelled by Eggers *et al*., 2007. The scenarios predict substantial increased annual increment particularly in northern Europe, while forest productivity is expected to decrease in the Mediterranean. Other studies confirm that in northern Europe, climate change will increase net primary productivity and biomass of forests (e.g. Kellomäki *et al*., 2005b; Boisvenue and Running, 2006).

To conclude, the ecological conditions of the northern European forests are expected to develop towards higher productivity and energy flows along with more complex species communities whilst, by contrast, the ecological conditions in southern Europe are in danger of becoming more severe resulting in degraded ecosystems. There are several management challenges related to this, including:

- Regeneration of forests, particularly those involving tree species which need to grow for a long time before harvesting, must be planned taking changed climate into account. This may influence the regeneration method including the selection of species and their provenance (Sections 3.8 and 4.2);
- On a landscape perspective, forest and habitat connectivity must be ensured to allow migration of species and populations. Forest restoration should be planned and encouraged to increase connectivity (Section 3.4);
- The number of and impact caused by invasive alien species is expected to increase, in particular in northern Europe. An early warning system is needed (Section 4.5);
- The changed ecological conditions in southern Europe will need careful water management and increased actions to control such factors as forest fires and land degradation (Section 4.4).

The role of forests in climate change mitigation strategies

The world's forests have an important role in the global carbon cycle. Forests represent the largest terrestrial carbon stock and forest soils contain approximately 39 % of the global soil carbon (Lindner *et al.*, 2004). Forests act both as sources and sinks, and as such they exchange massive amounts of CO_2 with the atmosphere. They do this through natural processes (such as photosynthesis, respiration and decay) and biotic and abiotic disturbances (such as fires, storms, pest and disease damage, herbivory in unmanaged systems,

Box 4.5 Climate change and European small passerine forest bird populations

Photo 4.5: © K. Sjöberg

A major population study has been carried out of two forest passerine birds in western and northern Europe — the great tit, *Parus major*, and blue tit, *Parus caeruleus*. It demonstrated a correlation between a decline in the proportion of second broods (tits are facultatively double-brooded), and an earlier laying date. This is linked to the fact that with warmer spring temperatures, caterpillars — the main food for nestlings — develop faster, and hence the period of high levels of food abundance is shortened. If this trend continues due to climate change and ultimately no second clutches are produced, then the number of fledged off-spring will decline, with possible negative effects on the dynamics of these bird populations

Source: Visser *et al.*, 2003.

deforestation and forest degradation, and wood removals).

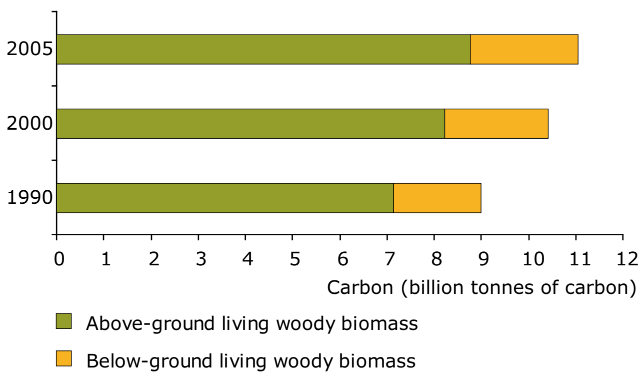
The total amount of carbon stored in the above- and below-ground living woody biomass in EEA member and cooperating countries amounts to about 11 billion tonnes, as shown in Figure 4.11 (MCPFE, 2007). Recent data thus suggest that the amount of carbon in forests is steadily increasing. This corresponds to the increase in growing stock as referred to elsewhere in this chapter.

Forest litter and soils also store substantial amounts of organic carbon (humus) but knowledge on these components remains limited (MCPFE, 2007), see however Table 4.4.

Release of forests' carbon reservoirs occurs in particular when forests are burned or harvested by clear-felling. The potential of management to increase carbon sequestration in terrestrial ecosystems is an area of intensive research because of the Kyoto Protocol regulations that allow nations to include certain carbon sinks when reporting on their commitments to curb the increase of global atmospheric CO_2.

Concerns have been raised that forestry management with a carbon component may conflict with biodiversity considerations. Strategic management of forest landscapes for biodiversity as well as for carbon sequestration is discussed by Larsson *et al.* (2007). Natural forest is a biodiversity repository as well as a store for large amounts of carbon. A main issue both for biodiversity and carbon is that forest ecosystems are naturally dynamic and subject to disturbances and successions. These disturbances should be maintained from a biodiversity point of view, to allow survival of species adapted to the different succession stages, while the potential carbon release from these disturbances needs to be minimised. Most European forests are semi-natural, i.e. human impact has already modified the natural conditions to a varying extent. As discussed in this report, these disturbances are good for maintaining and

Figure 4.11 Evolution of carbon in above- and below-ground woody biomass



Source: MCPFE, 2007.

Table 4.4 Carbon storage in different European forest ecosystems

Carbon pool C (t ha^{-1})	Boreal forests, Sweden	Broadleaved woodlands, the United Kingdom
Above-ground living biomass	35	100
Below-ground living biomass	10	28
Deadwood	0.85	2.0
Litter	31	3.3
Soil organic carbon	45	335
Total	**122**	**468**

Source: Larsson *et al.*, 2007.

enhancing forest biodiversity, but their impact on carbon sequestration also needs to be considered.

In the present semi-natural forests of Europe, two important forest features are generally not favoured by forestry: late succession stages and deadwood. However, both are of importance to carbon stock as well as biodiversity. In Europe only about two-thirds of the annual increment is harvested from the forests (Section 4.2). As a consequence wood volumes are increasing — to some extent a feature of late succession — resulting in an increase in carbon stock (i.e. acting as a carbon sink). Another opportunity to favourably combine carbon sequestration and biodiversity policies is to increase the amount of deadwood, which is increasing slightly in most of Europe (Section 3.6). It increases the carbon sink and is favourable for biodiversity.

The most efficient carbon sequestration, in the short term, may be from intensively-managed highly productive forests, including forest plantations, which could be expected to bind large amounts of atmospheric carbon. However, promoting this forest type opens up a potential conflict between climate and biodiversity objectives (Section 2.2).

Box 4.6 The UN Convention on Climate Change

The United Nations Framework Convention on Climate Change (UNFCCC) has established a framework to address the increasing concentrations of greenhouse gases (GHGs) in the atmosphere and to mitigate their adverse effects. The UNFCCC thus urges parties to adopt measures to enhance and conserve ecosystems such as forests that act as sinks and reservoirs of GHGs.

The Kyoto Protocol, adopted in 1997, supplements the UNFCCC with an enforceable agreement and quantitative targets for reducing GHG emissions during the period 2008–2012 (first commitment period) by industrialised countries. A selection of land use, land-use change and forestry (LULUCF) activities were included in the Kyoto Protocol for the mitigation of carbon emissions and as a mechanism for countries to meet their commitments to reduce net emissions to the atmosphere. LULUCF activities reported under the Kyoto Protocol to the UNFCCC include mandatory ones under Article 3.3 (direct human-induced afforestation, reforestation and deforestation activities since 1990) and voluntary ones under Article 3.4.

The Marrakech Accords dictate which LULUCF activities are to be included under Article 3.4 (forest management, cropland management, grazing land management and re-vegetation) and provide rules on how they are to be accounted in the first commitment period. In particular, forest management was included with a capping system and a gross-net accounting system. In addition, countries were given some flexibility with the definition of forest, to account for national circumstances and data availability.

However, according to an EEA assessment based on estimates submitted by EEA member countries towards their respective targets under the Kyoto Protocol, the annual net carbon stock change under Articles 3.3 and 3.4 during the first commitment period of the Kyoto Protocol is a relatively small component in the overall carbon accounting and also includes net carbon accounts from sectors such as industry and transport.

Upcoming negotiations on a post-2012 agreement provide an opportunity to reassess, extend the list of eligible LULUCF activities, and possibly simplify the inclusion of LULUCF activities in the international climate change regime.

Source: UNFCCC, 2002; EEA, 2007; Schlamadinger *et al.*, 2007.

5 Actions and capacity-building for sustainable forest management and safeguarding biodiversity

5.1 Activities towards sustainable use of forest resources in Europe

The use of forest resources for the traditional household was regulated through a complex and set of local laws, agreements and traditional rights. One of the first biodiversity resources to be subject to state regulation was hunting rights for a number of game species, which were reserved for the king and nobility. Hunting is still subject to very close regulation in Europe, and has generally been a success in the sense that viable populations of the targeted species have been maintained. The main exception is the large predatory mammals, which have been exterminated in some countries, albeit deliberately and in line with actual policies.

European forestry first focused on securing the sustainable yield of wood as reflected by the statement by the German mining administrator von Carlowitz (1713), 'forest resources should be used with caution to achieve continuity between increment and fellings'. The main focus became controlling the pressure of the emerging wood-based industries to ensure the continued productivity of the wood resource. This demanded forestry practices based on knowledge of site conditions, suitable tree species, regeneration methods and stand management.

Concerns about biodiversity and nature protection have, during the last century, led to protection of forest areas and development of forest management strategies to address the multiple functions of forests. In 1992, the United Nations Conference on Environment and Development in Rio de Janeiro defined a new paradigm, the 'Forest Principles', for the conservation and sustainable development of forests and their multiple functions and uses. For regional forest processes, these principles have been guiding the further development of sustainable forest management, such as within the Ministerial Conference for the Protection of Forests in Europe (MCPFE) (Figure 5.1). Sustainable forest management as defined by MCPFE has been recognised as a commendable example of implementation of the CBD ecosystem approach (MCPFE, 2006; CBD, 2003).

Within the EU, forest and biodiversity policies and measures of implementation are presented in strategies and action plans. The EU Forest Action Plan 2007–2011 presents a set of key actions to work towards the common vision of 'Forests for society: long-term multifunctional forestry, fulfilling present and future societal needs and supporting forest-related livelihoods'. In line with this the EU Forest Action Plan focuses on four main objectives:

- to improve long-term competitiveness;
- to improve and protect the environment;
- to contribute to the quality of life;
- to foster coordination and communication.

As there is no basis for a specific and comprehensive forest policy in the EU treaties, the EU Forest Action Plan should be perceived as an 'instrument of coordination between different Community actions, as well as between Community actions and the forest policies of the Member States' (EC, 2006c).

To harmonise the forest policy development in European countries MCPFE signed up to a 'MCPFE Approach to National Forest Programmes in Europe' in 1993 (MCPFE, 2007). Map 5.1 shows the present status of national forest programmes in Europe. The national differences largely reflect the different roles of forest in the various countries and the resulting political need (or not) to establish official forest programmes.

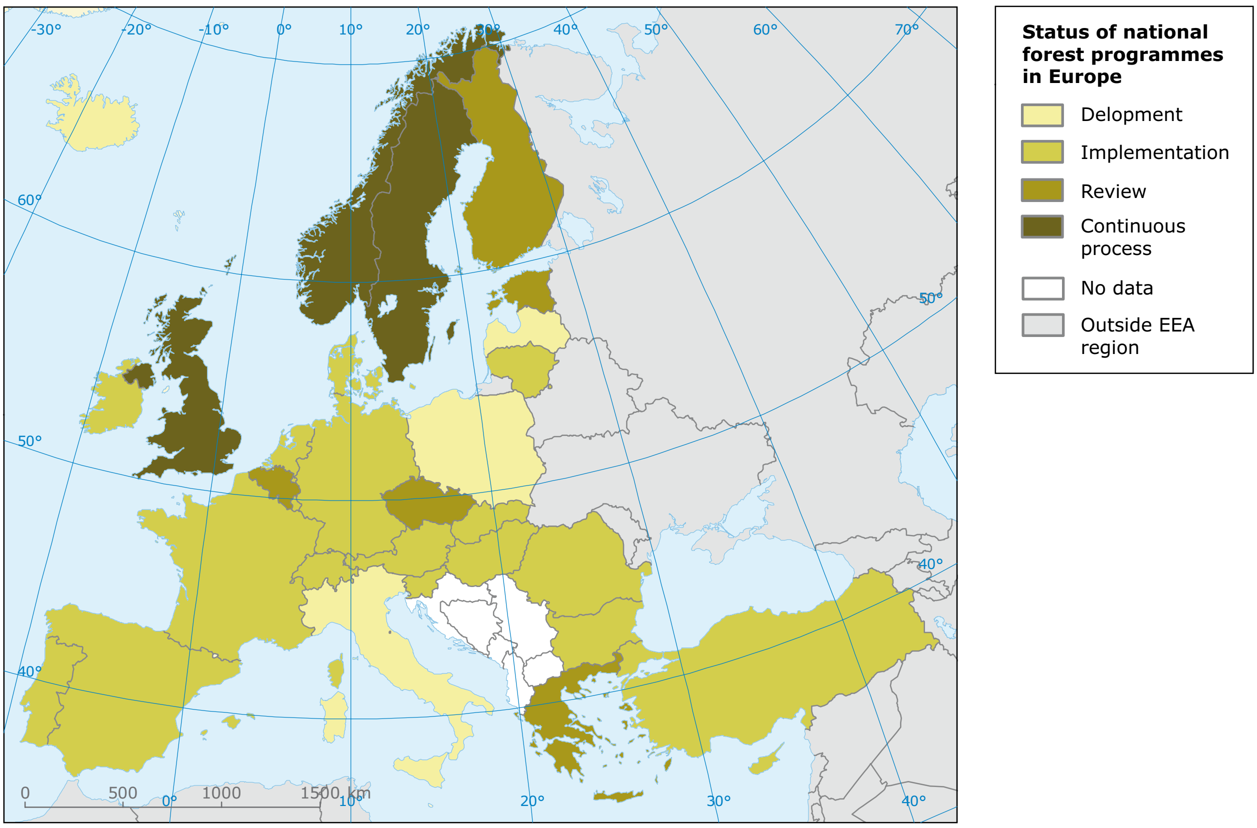
In addition to the political recognition, private sector initiatives also enhance the implementation of strategies effectively protecting biodiversity. Certification of sustainable forest management helps achieve goals for protecting and managing biodiversity, combating illegal logging and possibly, in the future, also supporting monitoring and certifying carbon sequestration. Certification can thus be seen as a market initiative to inform consumers of wood products that these products originate from forests that are used and managed in a sustainable way. This is verified by an audit by an independent third-party and is measured against a number of criteria, which are specific to each certification scheme. Certified forests do not necessarily have a high biodiversity value, but it opens possibilities for the introduction of more biodiversity-oriented management. An overview of the coverage by two of the most important certification schemes in Europe, the Forest Stewardship Council (FSC) and the Pan-European Forest Certification (PEFC) scheme is given in Figure 5.2.

Several European countries (e.g. Austria, Denmark, Estonia, Finland, Germany, Sweden, Switzerland and the United Kingdom) state in their thematic reports on forest ecosystems submitted to the CBD (2001) that strategies, legislation and technical guidance increasingly promote environmentally-friendly forest management methods. These include: setting aside valuable forest types and introducing practices which reflect natural disturbance regimes; reducing clear cut areas; increasing natural regeneration; retaining trees beyond their 'economically' optimal rotation; increasing species and stand structure diversity; promoting native species; increasing dead wood; reducing the use of pesticides and forest harvesting damages; and regulating game.

This change in management practices is most conspicuous in western and central European countries (Nabuurs *et al.*, 2002). In Belgium for example, all forests owned by the Flemish region are managed according to a set of defined close-to-nature forest management principles, a framework to assess the forest functions and a method for quality control (De Schepper *et al.*, 2001). The public forest administrations in central Europe show an increasing interest in the conversion of coniferous forest back to broadleaved forest on sites naturally belonging to such forest categories. Von Teuffel *et al.* (2004) estimated the potential area for such conversion measures to be well over 1 000 000 ha (for 14 European countries).

There have been several projects to improve biodiversity conditions of forest plantations,

Map 5.1 Status of national forest programmes in Europe



Source: MCPFE, 2007.

probably the most hotly-debated forest category from a biodiversity point of view (Section 3.2). The effect of increased diversity of tree species on reducing the risk of pest outbreaks is investigated in significant studies and experiments on a large maritime pine (*Pinus pinaster*) plantation area for in southwest France (Jactel *et al*., 2006; Jactel and Brockerhoff, 2007). In Ireland the BIOFOREST project studied options for improving biodiversity of forest plantations of mainly Sitka spruce (*Picea sitchensis*). Irish forest policy aims at substantially increasing the forested area, with site selection for afforestation taking into account a number of biodiversity-related issues, such as avoiding species-rich farmland habitats, and creating a landscape structure suitable for the hen harrier (*Circus cyaneus*), a flagship bird species. In addition to birds, the research comprised of a large number of biological taxa. As a result of the first period of studies, 57 recommendations were forwarded to operational forestry (Iremonger *et al*., 2006). The follow-up (PLANFORBIO) will expand the study to include canopy-living invertebrates, study biodiversity of forests composed of tree species mixes, and explore options to remove the invasive alien species *Rhododendron* (Section 4.5).

Figure 5.1 Overview of the Ministerial Process for the Protection of Forests in Europe (MCPFE)

Note: All EEA member and cooperating countries, as well as the EU have signed up to MCPFE.

Source: Modified from MCPFE, 2008.

5.2 Forest protection in Europe

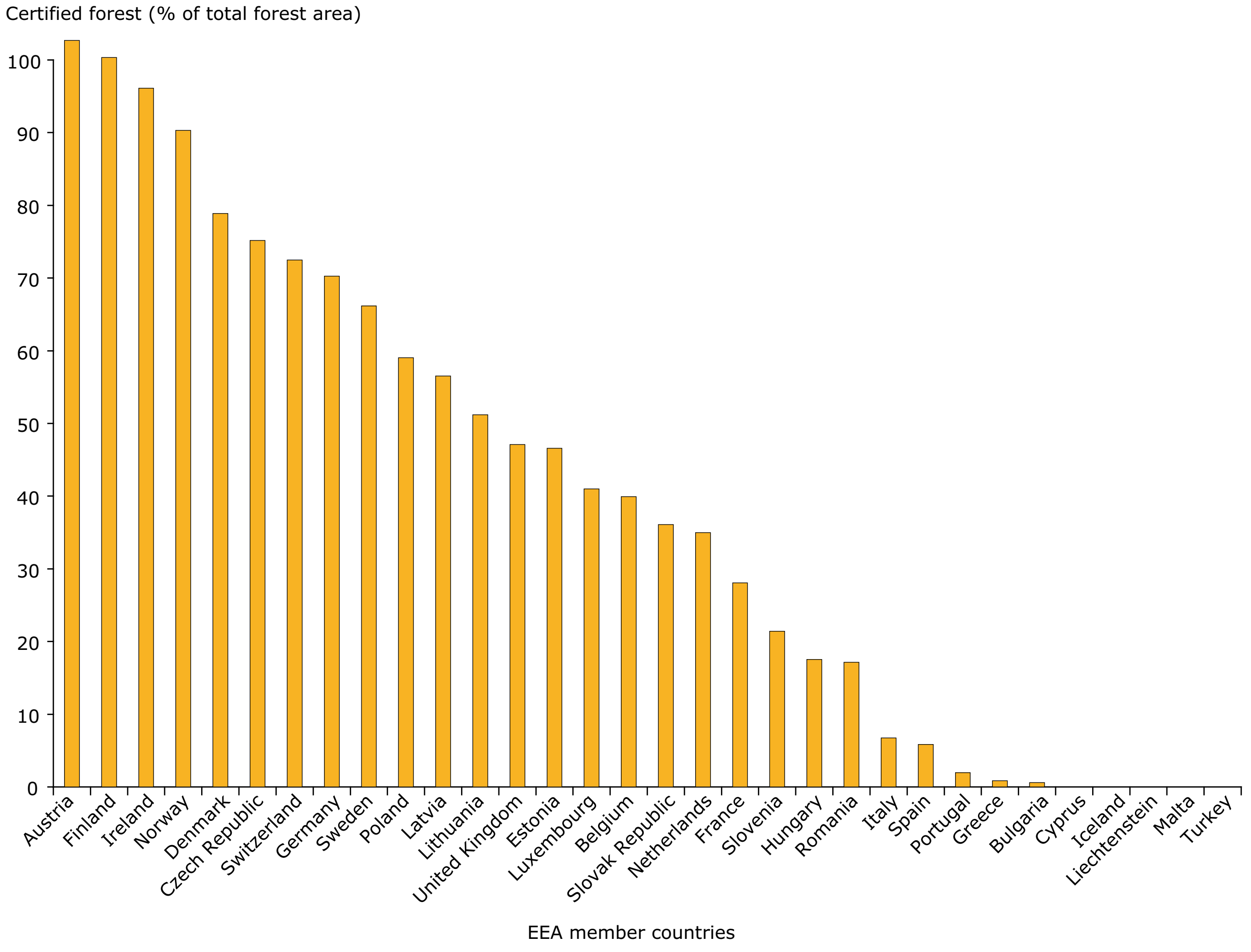
The most straightforward measure to safeguard biodiversity is through forest protection. However, forest protection has become a more complex and varied activity in Europe as compared to other continents that still host huge areas of untouched forests. Protected forests in Europe thus comprise areas with a great variation in the naturalness of the forests, in protection regimes and activities permitted and in protection objectives (Parviainen and Frank, 2003). In Europe, as much as elsewhere in the world, land use and its history has played an important role in what can be considered the current state of protection of forests.

Forests are protected in Europe according to different national and regional legislation and this is supported by specific EU legislation which provides for the conservation of a range of forest habitats and their flora and fauna that are considered to be of European importance for nature conservation.

National forest protection regimes

The EEA member and collaborating countries reported to an overall increase in the protected forest areas over the period 2000–2005 (MCPFE, 2007). Figure 5.3 shows the development of protected forests according to the MCPFE classes 1 and 2 (MCPFE, 2002; COST E27, 2007a,b) ([11]):

Figure 5.2 Forest area under certification, 2007



Note: Some double counting might occur as forest areas may be certified by different schemes at the same time.

Source: PEFC and FSC.

([11]) A third MCPFE class covers areas where the main management objective concerns 'Protective functions'.

Box 5.1 Urban woodland for healthy cities

Photo 5.1: © C. Konijnendijk

Many European cities have owned and managed woodlands for centuries. Initially, in the Middle Ages, the main reason was to secure the supply of fuelwood and timber. Later, other forest functions, such as providing opportunities for outdoor recreation, motivated the involvement of cities. Due to their specific history, urban woodlands are typically small-scale and fragmented. Although municipal authorities are most important, the ownership of urban woodlands also includes a wide range of public and private owners. The particular history of urban woodlands has often resulted in high species diversity, including exotic trees which were often first introduced in and near cities. Many urban woodlands are former royal hunting grounds, which has resulted in a high proportion of ancient trees. However, as a result of ongoing peri-urban afforestation across Europe, other urban woodlands have a very young tree population.

Urban woodlands play an important role in today's urbanised Europe, offering settings for recreational activities, attracting thousands of visitors each year. They help to promote people's mental and physical well-being, as well as protecting drinking water resources, mitigating air pollution and ameliorating the urban mesoclimate. Urban woodlands also have an important educational role, helping to provide local identity and distinctiveness in an increasingly urbanised European landscape.

Urban woodlands are usually managed with silvicultural approaches which aim to create variety, for example in form and function, at landscape, woodland, as well as stand level. Forestry operations are mostly small-scale and not primarily aimed at wood production. Clear cutting seldom occurs, or is restricted in its extent, partly because of public pressure. In many places, public and private actors have joined forces in the development of better, multifunctional forests and green spaces in and near urban areas.

Source: C. Konijnendijk, Forest and Landscape, Copenhagen; Konijnendijk, 2001.

- Class 1 concerns forests and other wooded land where the main management objective is 'Biodiversity', with either no or minimum intervention or conservation through active management.

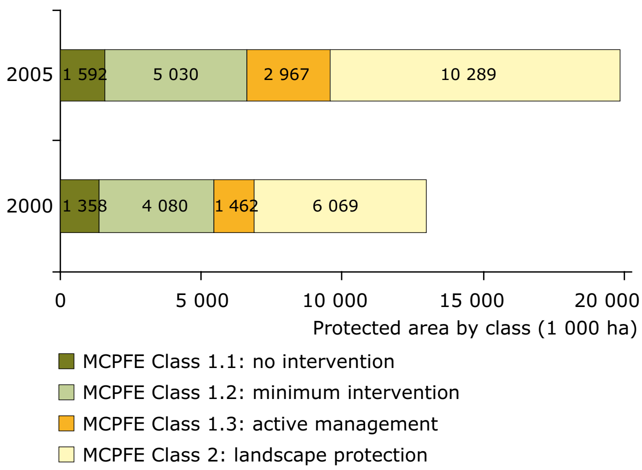
- Class 2 concerns forest and other wooded land where the main management objective is the 'Protection of landscapes and Specific Natural Elements'.

It should be noted that although Figure 5.3 indicates an increase in protected areas, it is difficult to judge the extent to which it is a genuine increase, or a result of more accurate reporting by the countries.

Forest protected under the EU Natura 2000 network

In the European Union the EC Directive 79/409/EEC of 1979 on the conservation of wild birds ('Birds Directive') and EC Directive 92/43/EEC of 1992 on the conservation of natural habitats and of wild fauna and flora ('Habitats Directive') are at the core of the nature conservation policy, defining

Figure 5.3 Area of forest and other wooded land protected to conserve biodiversity, landscapes and specific natural elements in the EEA member and cooperating countries



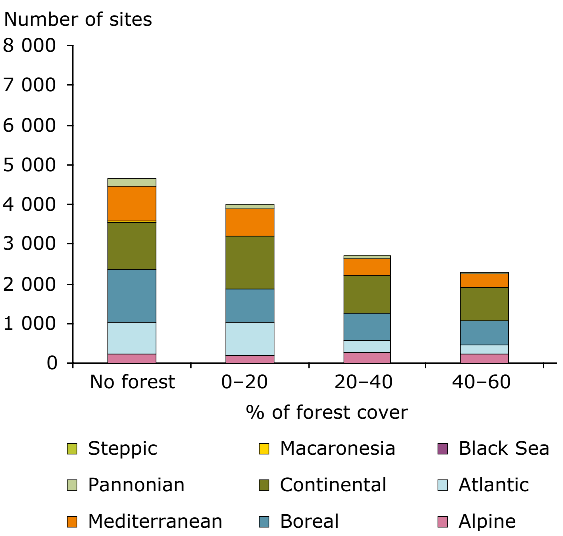
Source: MCPFE, 2007.

a common framework for the conservation of wild flora and fauna species as well as habitats recognised as being of European community interest. As part of the implementation of these two directives, EU Member States have to propose and then designate sites to ensure the conservation of selected species and habitats listed in the annexes of the two directives. The resulting network of sites is called the Natura 2000 network.

The 'Special Protection Areas' designated under the Birds Directive have to be protected by national legislation by the date of submission to the European Commission. For sites to be designated as 'Special Areas of Conservation' under the Habitats Directive, the procedure is slightly different. National proposals of sites are assessed within a European biogeographic context through a lengthy consultative process which involves national authorities, the European Commission, the European Environment Agency, scientists and NGOs, as well as representatives of nature users (farmers, foresters, hunters, anglers, etc.). This results in the establishment of a formal Community list of sites. The EU Member States then establish the necessary conservation measures.

In December 2007, some 21 574 sites have been proposed under the Habitats Directive, and 4 850 sites have been designated under the Birds Directive, covering in total about 19 % of the EU

Figure 5.4 Forest cover of sites proposed under the Habitats Directive



Source: Natura 2000 database, ETC/BD.

land area. Based on the reporting by countries, it is estimated that about 13 % of the EU-27 forest surface is included in Sites of Community Interest under the Habitats Directive (Natura 2000 database, 2007).

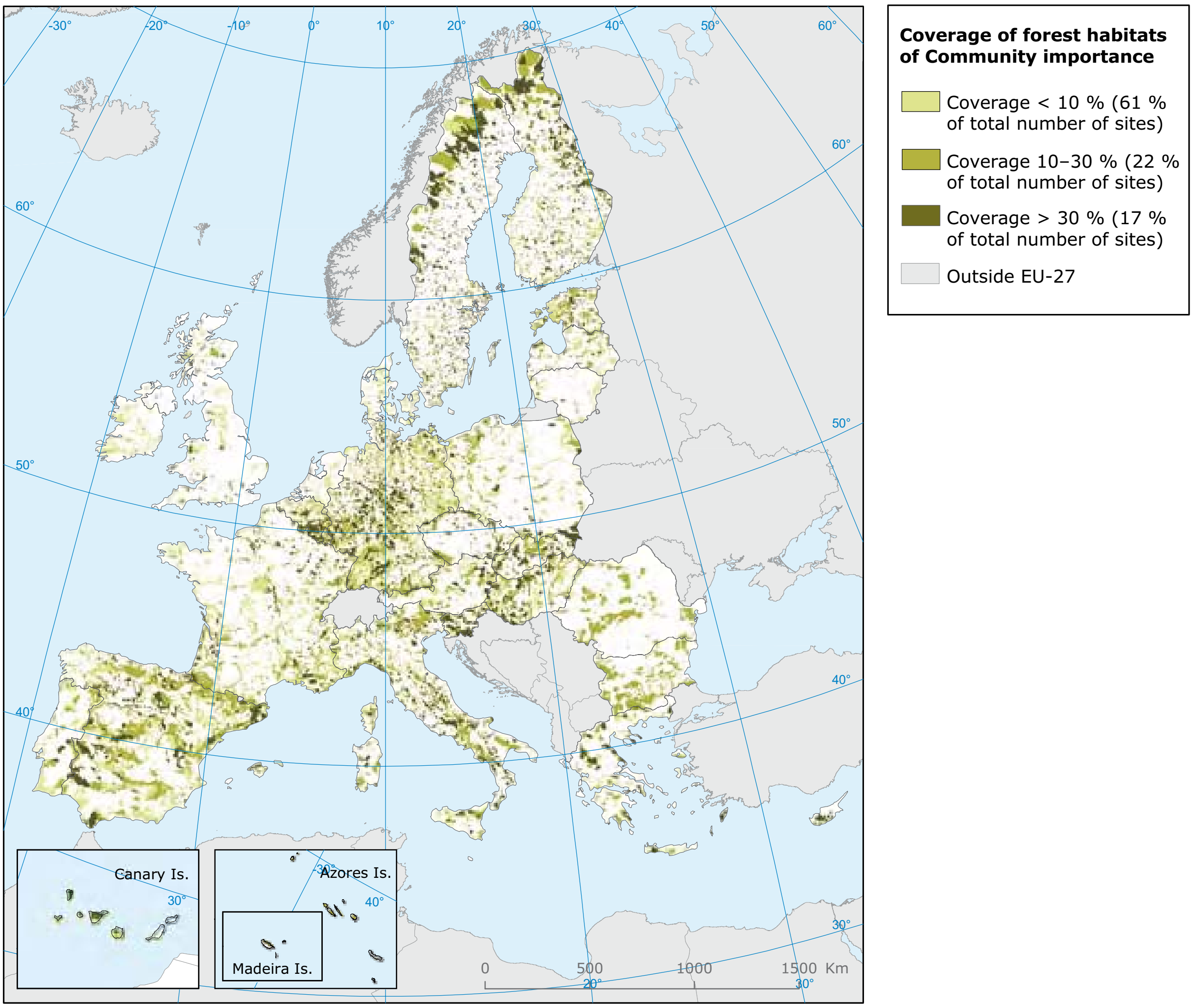
However, the forest coverage of sites varies a lot depending on the biogeographical context — most sites with high forest coverage are in the Boreal and Continental regions (Figure 5.4 and Map 5.2). It should be noted that 22 % of the sites in the Boreal region and 18 % in the Continental region do not have any forest component. Not surprisingly, forest coverage is very low in the Pannonian region and in the Steppic region. In the Atlantic region, the forest cover of sites is relatively low. Mediterranean shrubs and maquis are not taken into account in the assessment.

As indicated in Section 3.7, 85 targeted forest habitat-types, considered of special Community interest, are listed in Annex I of the Habitats Directive. Map 5.2 shows the share of sites proposed under the Habitats Directive across the EU-25 which include one or several such habitats, up to various coverage levels. Finally, Table 5.1 shows these habitat types by the categories of the European Forest Types (Annex 1). It should be noted the habitats considered of special Community interest were not identified to reflect the European Forest Types in a representative way.

Although the objective 'to ensure a favourable conservation status of the ecosystems, habitats, species and landscapes of European importance' is defined at the European level, each country is left to decide how to achieve this. Depending on a national legislative framework and conservation objectives of sites, preference will thus go to strict protection or integrated management planning. Some sites raise socio-economic issues and finding the best way of reconciling these various concerns is also one of the network's aims.

The European Commission has developed a set of non-mandatory guidelines for the management of forests within Natura 2000 sites (EC, 2003c). These guidelines provide a broad framework, based on interpretation of Articles 4 and 6 of the Habitats Directive which aim at ensuring that land-use practices do not lead to a deterioration of the conservation value of the Natura 2000 sites, as well as on the widely recognised criteria for sustainable forest management adopted by the MCPFE (Figure 5.1). However, it is recognised that the concrete negotiations for management plans

Map 5.2 Sites proposed under the Habitats Directive (Natura 2000 sites) which include at least one of the 85 'forest habitat-type' listed in Annex I of the Directive



Note: The total forest cover of individual sites may be higher.

Source: Natura 2000 database, December 2007; EC-DG Env; ETC/BD.

or measures at site level will be conducted by the stakeholders and local authorities involved. It is thus stated that:

- It is preferable to designate perimeters with a sufficient extension to allow conservation objectives to be integrated into existing management plans, rather than to designate small plots corresponding exactly to the descriptions in the habitats reference guide.

- Conservation of habitats and species at the level of an entire site should be the result of measures in favour of habitats and species for which the site was designated, leading to a stable biodiversity offer' for the site as a whole. It is self-evident that, in the case of cyclical interventions (in space and in time) such a situation is more easily attained on sites covering larger surfaces.

- Interventions leading to temporary disturbance of forest cover on a limited space (e.g. group cuttings) or with a limited intensity (e.g. thinning) are legitimate, provided that they allow recovery of the initial situation by natural regeneration, even if several stages of natural succession have to follow one another.

The guidelines also recall the main legal requirements for forest management resulting from the Habitats Directive:

- Nature conservation measures have to be considered for each Natura 2000 site, in the form of appropriate statutory, administrative or contractual measures. The development of a management plan is recommended (Article 6(1)).

Table 5.1 Forest habitat types identified as of special European Community interest in the EU Habitats Directive (Annex I) by European forest type categories

European forest type category	No of Annex I habitat types	Annex I priority habitat-types
Boreal forests	3	Western Taiga
Hemiboreal forest and nemoral coniferous and mixed broadleaved-coniferous forest	6	Fennoscandian hemiboreal natural old broadleaved deciduous forests rich in epiphytes Taxus baccata woods of the British Isles
Alpine coniferous forests	5	Subalpine and montane *Pinus uncinata* (*P. mugo subsp. uncinata*) on gypsum or limestone
Acidophilous oak and oak-birch forest	4	Eastern white oak woods
Mesophytic deciduous forest	7	Pannonic woods with *Quercus petraea* and *Carpinus betulus* Pannonic inland sand dune thicket *Tilio-Acerion* forests of slopes, screes and ravines Caledonian forest
Beech forest	6	Western pontic beech forests
Mountainous beech forest	11	Apennine beech forests with *Taxus* and *Ilex* Apennine beech forests with *Abies alba* and beech forests with *Abies nebrodensis* Dobrogean beech forests
Thermophilous deciduous forest	12	Pannonian woods with *Quercus pubescens* Euro-Siberian steppic woods with *Quercus spp.*
Broadleaved evergreen forest	8	Scrub and low forest vegetation with *Quercus alnifolia* Palm groves of *Phoenix* Macaronesian laurel forests
Coniferous forest of the Mediterranean, Anatolian and Macaronesian regions	12	(Sub-) Mediterranean pine forests with endemic black pines Southern Apennine *Abies alba* forests Endemic forests with *Juniperus spp.* *Tetraclinis articulata* forests Mediterranean *Taxus baccata* woods *Cedrus brevifolia* (*C. libani subsp. brevifolia*) forests
Mire and swamp forests	2	Bog woodland Fennoscandian deciduous swamp woods
Floodplain forest	7	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior*
Non-riverine alder, birch or aspen forest	2	Natural forests of primary succession stages of land upheaval coast

Note: Annex I habitats considered in the category 'broadleaved evergreen forest' include also 'Dehesas with evergreen Quercus spp.' (not listed under 'Forest' in Annex I). Two of the Annex I habitats occur in two forest categories.

Source: EC, 1992; EEA, 2006b.

- The economic and social functions of the forest should also be taken into account.

- The conservation status of the site, in relation to the quality of the habitat and the conservation value for the species, must be maintained or improved.

- Projects or plans which might have a negative impact on a Natura 2000 site must undergo an appropriate assessment (Article 6(3)).

- The quality of the site must be periodically monitored and reported on by the competent Member State authorities.

The EU financial mechanism LIFE-Nature is dedicated specifically to the implementation of the Birds and Habitats Directives. Forest projects that have been funded under LIFE-Nature since 1992 include 209 actions aimed at the conservation of natural habitats and of wild fauna and flora that is extensively targeted at the operation of the Natura 2000 network. Typically, these include projects focusing on forest management, enhancing biodiversity and more ecologically-friendly forms of forestry. Achieving a balance between nature conservation and the economic aspects of land use, and of farmers and landowners rights are other key objectives (EC, 2006d).

Towards an integrated perspective

The Convention on Biological Diversity has in connection with the Expanded programmeof work on forest biological diversity presented the target that 10 % of each of the world's forest types are effectively conserved (CBD, 2006b). It

Box 5.2 Restoring grouse populations in the Black Forest in Germany

Male capercaillie

Female capercaillie

Photos 5.2: © K. Sjöberg

A LIFE-Nature project was implemented in the southern Black Forest in Baden-Württemberg, Germany with the aim to develop forestry practices more compatible with the ecological requirements of the capercaillie (*Tetrao urogallus)* and the hazel grouse (*Bonasa bonasia)*. These two forest-dwelling birds are endangered in central Europe. Their populations have been falling rapidly, not only in the southern Black Forest, but also in other central European mountain ranges such as the nearby Jura and the Vosges. Crucially, the project succeeded in implementing sustainable and economic solutions for the grouse that are acceptable to all sectors — forestry, hunting, tourism and nature conservation.

Apart from being successful in levelling off and even slightly increasing the grouse populations, the LIFE-Nature project had important effects in bringing people together: foresters and forest workers started to think about nature protection and the needs of the grouse, as part of their work. Indeed, as a measure of the project's continuing success, most of the area's foresters are firmly committed to managing their forests in a manner that does not harm the capercaillie. Monitoring of the birds by hunters and foresters is also still ongoing: this work is two-thirds voluntary, with the rest funded by the Federal State of Baden-Württemberg.

Source: EC, 2006d.

has also been suggested that strict protection of forests for preserving biodiversity at national level is needed at ca. 10 % of the European forest area (e.g. Hanski, 2003; Lõhmus *et al*., 2005).

Based on Figure 5.3 and the total area of forest and other wooded land (Section 5.2) it can be calculated that 5.8 % of the area of forest (and other wooded land) in the EEA member and cooperating

Box 5.3 Flexible forest protection in Sweden

Photo 5.3: © T-B. Larsson

In Sweden about 900 000 hectares of productive forest land are formally protected as national park, nature reserve, habitat protection areas and nature conservation agreements (2006). This is about 4 % of Sweden's forest area.

In addition to permanent protection, there are a range of private and voluntary protection agreements for forest land. Time-limited private law agreements regarding protection and management of certain areas have successfully been introduced, i.e. nature conservation agreements ('Naturvårdsavtal'). Such nature conservation agreements complement public law protection measures and can be used in a variety of ways, e.g. to expand a habitat protection area with a buffer zone and/or to protect a succession habitat which is not favoured by normal forest practices. The agreement is signed between the landowner and the Swedish Forest Agency, normally for a period of 50 years, and specifies the restrictions or adaptations in the forest practices as well as an agreed payment to the landowner. In 2006, conservation agreements had been signed for around 18 000 ha of forest area, mainly in the mountain region.

'Voluntary protection' of forest land has also been introduced. These are non-binding commitments by forest owners to set aside forest areas that are valuable for nature protection. By 2006 the estimated area of voluntary protected forests was about 1 000 000 ha (of which some 200 000 ha were in the mountain region). Several of these areas do not have the ecological qualities which would justify long-term set-asides, but may be valuable for biodiversity in a landscape perspective. The proportion of land set aside differs between types of forest owners — large and medium sized forest owners have voluntarily protected some 6 % of their forest areas, while small-scale forest owners have set aside less than 2 %. The main driving force for voluntary protection is environmental certification schemes.

A main advantage of this flexible approach to forest protection is that it allows for future revision in light of improved knowledge on biodiversity and the ecological prerequisites for biodiversity conservation.

Source: Swedish Forest Agency.

countries is managed with biodiversity as the main management objective. In comparison, areas designated by the EU Habitats Directive make up as much as 13 % of the forest area of the 27 EU Member States. However, as this designation does not exclude wood harvest this higher figure cannot be directly related to the CBD target (see also Section 2.1).

In fact, there are several reasons why the CBD target is only partly relevant for European conditions. Even the boreal forests, the largest forests 'undisturbed by man' (Section 3.2), do not have areas set-aside that are large enough to independently maintain populations and ecological functions. From an ecological point of view, protected forest areas in Europe must be established and managed as part of a landscape that comprises areas with ongoing forestry activities ('semi-natural forest'), forest plantations, and other human activities. Few places in Europe are devoid of human settlements and protection of forests can sometimes conflict with other human interests. However, there are also signs that protected forest areas bring benefits to local communities. More research is needed into the socio-economic aspects of protected forest areas, in order to support European policy-makers in establishing and managing such areas (COST E27, 2007; Larsson, 2007).

In line with this integrated perspective, new approaches are needed, such as voluntary contributions to the protection of forests and safeguarding habitats. Voluntary protection can be regarded as contributing to protecting biodiversity only if a long-term commitment (minimum 20 years) is the basis of the establishment of these types of protected forest areas (e.g. Frank and Müller, 2003) (Box 5.3).

In an increasingly fragmented European landscape, the resilience of forest ecosystems and the effectiveness of protected areas are jeopardised if the surrounding environment is inadequate to ensure species dispersal and migrations. Ensuring connectivity between core areas of important protected or unprotected ecosystem types, such as forests, is an increasing concern, particularly in the face of climate change across Europe (Bonnin *et al.*, 2007; Sections 3.4 and 4.7). The networks of protected forest areas should thus not be seen in isolation but as a part of an overall forest management strategy (Section 5.1). An efficient strategy for forest protection will require large-scale international cross-border approaches (Parviainen and Frank, 2003) and within the EU, the Natura 2000 process provides an opportunity for this.

The Pan-European Ecological Network (PEEN) is an initiative endorsed by the Environment for Europe Process (Chapter 1), for integrating existing agreements, programmes and activities in the fields of nature conservation, land use planning and rural and urban development, to ensure that a full range of ecosystems, habitats, species and landscapes of European importance are conserved (CoE, 2007). PEEN is not a legal instrument, but its objectives are in line with the EU Natura 2000 process which provides an opportunity for implementation.

5.3 Cross-sector cooperation and coordination

Several European processes aim to integrate biological diversity conservation and sustainable use with forest and other sector policies and programmes. Currently, climate change is high on the political agenda (Sections 2.2 and 4.7). Effective mainstreaming of environmental considerations in sector policies is therefore one of the principal aims of the Pan-European Biological and Landscape Diversity Strategy (PEBLDS) process in view of the direct and indirect effects of some of these policies on the biological and landscape diversity of Europe (CoE, 2007).

Effective international cooperation between the PEBLDS process and the MCPFE has been undertaken especially to form a joint position on the understanding of the conformity between the concept of 'ecosystem approach' as defined in the Convention on Biological Diversity and of sustainable forest management in the MCPFE context (MCPFE/PEBLDS/CoE, 2007).

A Council of Europe ad-hoc working group of senior European officials specified that the following key actions should be taken in the field of forest policy by 2010 (CoE, 2007):

- Countries should further pursue their cooperation with the MCPFE and the Environment for Europe/PEBLDS process and explore possible new priority themes These can include improved connectivity between protected forest areas, transboundary cooperation in the field of forest development and management, clarification and harmonisation of forestry terminology, formulation of guidelines for the conservation and sustainable exploitation of forest biodiversity within pan-European forests along with improvement and dissemination of knowledge concerning these forests and their sustainable management (methods, instruments, etc.).

- These themes will be addressed in connection with other international work in progress, such as the EU Forest Action Plan, the CBD's extended work programme on forest biodiversity (particularly with regard to the ecosystem approach and the issue of the impact of invasive species), the Intergovernmental Working Group on Forests, the United Nations Forum on Forests, and the WSSD implementation strategy. The dissemination of information on good forestry practices by all appropriate means should be facilitated.

Coordination between processes and sectors will be further developed in current fields and extended to new ones in connection with the EU Action Plan for the sustainable management of forests, particularly the objective on enhancement and protection of the environment (EC, 2006c). The EC 6th environment action programme (2001–2010) contains a set of objectives for forests. The EC Biodiversity Action Plan (BAP) for Agriculture mentions possibilities for financing actions for forest biodiversity conservation and sustainable use under the Rural Development Regulation (Regulation 1257/99). The BAP for Nature Conservation stresses the need for full integration of forest biodiversity in the rural development plans developed under the Rural Development Regulation. It also mentions the need to support credible forest certification systems.

While in most EEA member and cooperating countries there are no considerable problems with forest law enforcement and governance (FLEG), European countries, as major wood consumers, have an important role to play in FLEG-related trade issues at the global level. A EU Action Plan for Forest Law Enforcement, Governance and Trade (FLEGT) in 2003 was followed by a Directive for imports of timber in 2005 (EC, 2005b). The FLEGT Action Plan places emphasis on governance reforms and capacity-building, supported by actions aimed at developing multilateral cooperation and complementary demand-side measures designed to reduce the consumption of illegally-harvested timber in the EU, and ultimately in major consumer markets around the world. The European Commission has recently established a FLEGT facilitation project in support of EU FLEGT partnership agreements in developing countries. The project purpose is to assist developing countries to enter into and implement effective partnership agreements with the EU, through the provision of facilitation services and technical assistance to initiate the programmes and to verify and monitor its implementation (EFI, 2007).

EEA member and cooperating countries, through re-iterative policy processes, do have measures in place to address issues that would lead to socio-economic failures or distortions that would result in loss of forest biological diversity. One of the key opportunities for dealing with economic failures and distortions which have a potential negative impact on forest biodiversity has been through the reform of the common agricultural policy (CAP) and the European Agricultural Fund for Rural Development. It is now the case that farmers who plant trees are allowed to retain CAP payments. The Rural Development Regulation stresses the multifunctional role of forestry (Article 30), afforestation of agricultural land (Article 31) and improvement of forest protection values (Article 32). It also stresses bottom-up approaches with the active participation of local communities, as does the ecosystem approach. These areas present opportunities for greater harmonisation (EC, 2005c).

5.4 European support to education, research and monitoring

Higher education in forestry throughout Europe is undergoing a number of reforms connected to the Bologna Process aimed at creating a European Higher Education Area, which introduces a defined three-cycle system of educational levels (bachelor/master/doctorate) to European universities. The European Commission aims to support these efforts with the help of programmes such as the Erasmus Mundus, which also provides a degree programme in European Forestry (EC, 2007d).

The Silva Network has the primary objective to stimulate and facilitate inter-university cooperation in the field of forestry education in Europe. One of the major means to develop cooperation and competitiveness of European higher forestry education has been the use of new information and communication technologies to develop virtual services and educational tools. These included shared regulations and integrated and exchangeable curricula, and the full recognition of studies from different universities throughout the Europe (Silva Network, 2007; Tahvanainen and Pelkonen, 2003).

Another example of ongoing activities in the development of forestry education in Europe is the Forest Policy and Economics Education and Research (FOPER) project. It aims at strengthening the capacity of modern forest policy and economics education, training and research in the Western Balkans. The project works towards a permanent training programme in the region, consisting of an international masters course on forest policy and economics, as well as continuous training for professionals already working on these issues (EFI, 2007).

The EU supports coordinated research activities between Member States and associated countries through its framework programmes for research and technological development (EU RTD FP), managed by DG Research of the European Commission. Since the Fifth EU RTD FP (FP5 1998–2002) biodiversity research has been a significant element of the EU environmental research programme in support of European policies. Ecological and biodiversity-related projects have also been supported within research fields aiming at promoting sustainable and innovative use of biological resources, including research programmes on forestry (Table 5.2).

Since biodiversity was given significant attention in the EU RTD from1998 onwards, the European Platform for Biodiversity Research Strategy (EPBRS) has been a forum to promote strategically-important biodiversity research in support of policies and management actions to reduce biodiversity loss, and to make the use of the components of biodiversity sustainable. EPBRS, in the framework of the current six-month EU presidency, invites scientists and science policy-makers to electronic discussions and conferences twice a year (EPBRS, 2007). A series of EU-funded support actions help countries participate in EPBRS and in planning its activities (BioStrat, 2007).

European Cooperation in the field of Scientific and Technical Research (COST) allows the coordination of nationally-funded research and science-related activities in the 34 countries which signed up to the programme(COST, 2007). Actions supported by COST often include harmonisation of concepts and methodologies as well as the synthesis of

Table 5.2 Examples of projects funded by the EU framework programmes for research and technological development with a bearing on forest ecosystem and biodiversity

FP project title	Main objectives
Biodiversity evaluation tools for European forests (BEAR) 1998–2000	To develop an integrated system of indicators of forest biodiversity at regional/national, landscape and stand level for the main European forest types.
Nature-based management of beech in Europe — a multifunctional approach to forestry (NATMAN) 2000–2004	To deliver scientifically-founded policy recommendations and management guidelines for management of beech forests in Europe.
Biodiversity assessment tools project — (BIOASSESS) 2001–2006	To develop biodiversity assessment tools that can be used to rapidly assess biodiversity and measure impacts on biodiversity of major land-use change.
Sustainability Impact Assessment: Tools for environmental, social and economic effects of multifunctional land use in European regions (SENSOR) 2004–2008	To establish relationships between different environmental and socio-economic processes as characterised by indicators considered to be quantitative measures of sustainability.
Forest conservation in a changing world: using the past to manage the future — (Forest Conservation) 2006–2008	To reconstruct long-term vegetation histories of some of largest tracts of undisturbed natural temperate forests in Europe.
Biodiversity impact assessment using species sensitivity scores (BIOSCORE) 2006–2009	To develop a tool for linking pressures from policy sectors to the (change of) state of biodiversity as measured by the presence and abundance of individual species.
Modelling constraints on tree range shifts under climate change: regional and local processes (PHENO-RANGE-EDGE) 2007–2009	To develop an integrative scaling framework linking ecological biogeography with processes in community ecology; precisely identify ecological constraints on species distribution.

Source: CORDIS, 2007.

information. The forest technical committee of COST and its follow-up mechanisms have been important in supporting a wide range of actions (Table 5.3).

The substantial funding provided through the European Commission for research relevant to forest biodiversity in Europe has been largely coherent with the actions identified and agreed within the MCPFE. By facilitating research that involves scientists outside the geographical borders of the EU, as with its approach to atmospheric pollution and forests, the Commission has demonstrated a commitment to supporting forest biodiversity in a wider Europe and thus provided a tangible contribution to the MCPFE (EC, 2002a).

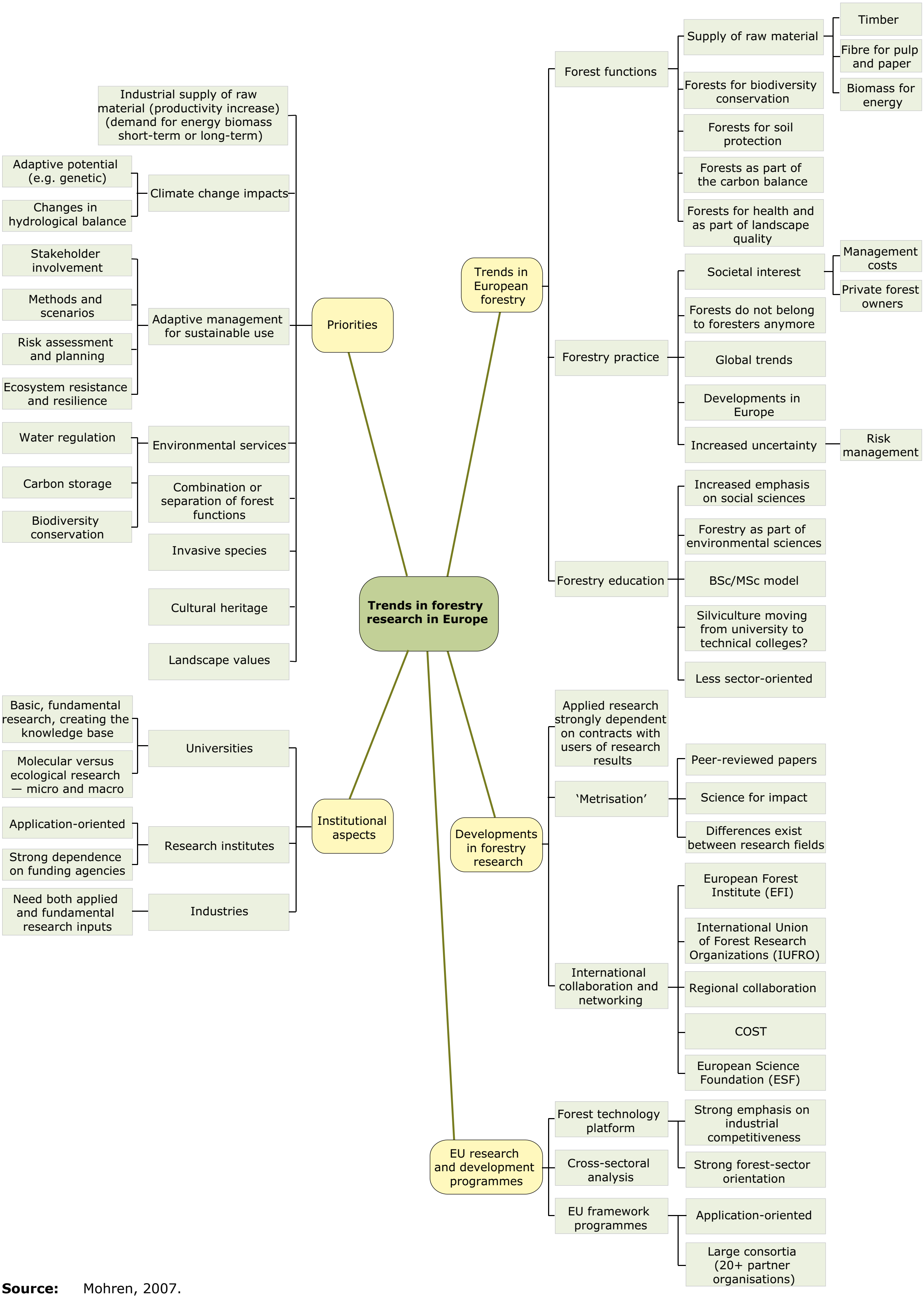
European forest research has become more dynamic and interdisciplinary, thereby reflecting responses to emerging needs towards forests from a variety of stakeholders, such as policy-makers, industry and society at large (Figure 5.5). A big step towards a European partnership for research and development in the forest-based sector was made by setting up the European Forest-Based Sector Technology Platform (FTP) in 2004. The FTP is an industry-driven process, embedded in industry reality (the European Confederation of Woodworking Industries, the Confederation of European Forest Owners and the Confederation of European Paper Industries), and supporting the sector's strategy. The Strategic Research Agenda for

Table 5.3 Examples of forest ecosystem and biodiversity-related COST actions

Cost action title		Main objectives
COST 725	Establishing a European phenological data platform for climatological applications 2004–	To establish a European reference data set of phenological observations that can be used for climatological purposes, especially climate monitoring and detection of changes.
COST E33	Forests for recreation and nature tourism (FORREC) 2002–2008	To improve the quality of information available to policy-makers and forest managers on the recreation and tourism benefits of forestry and to increase the cost-effectiveness of techniques for delivering such benefits.
COST E39	Forests, trees and human health and well-being 2003–2008	To increase the knowledge about the contribution that forests, trees and natural places make, and may make, to the health and well-being of people.
COST E42	Growing valuable broadleaved tree species 2003–2008	To increase the knowledge of growing valuable broadleaved tree species, with emphasis on the production of valuable wood and with the intent to promote non-wood products that can be produced in parallel with, or in addition to, the main product.
COST E43	Harmonisation of national inventories in Europe: Techniques for common reporting 2004–2009	To improve and harmonise the existing national forest resource inventories in Europe. Of three working groups, one deals specifically with harmonised indicators and estimation procedures for assessing components of biodiversity with NFI data.
COST E45	European forest externalities (EUROFOREX) 2006–2010	To improve the quality standards in the valuation of externalities produced by the different types of forest in Europe, agreeing research protocols for investigators to follow.
COST E47	European network for forest vegetation management: Towards environmental sustainability 2005–2009	To reduce dependence on herbicides by developing alternatives that recognise needs for sustainable production, and employ methods that are environmentally sound, socially acceptable, and economically viable.
FP0601	Forest management and the water cycle (FORMAN) 2006–2011	The enhancement of knowledge on forest–water interactions in Europe, and the elaboration of science-based guidelines for the improvement of the management of forests predominantly designated for the production and storage of water.
FP0603	Forest models for research and decision support in sustainable forest management 2006–2011	To promote the development of methodologies to improve forest models to support the sustainable management of forests.
FP0701	Post-fire forest management in southern Europe 2007–2012	To develop and disseminate scientifically-based decision criteria for post-fire forest management, from stand to landscape level planning, by gathering and evaluating research results.
FP0703	Expected climate change and options for European silviculture (ECHOES) 2007–2012	To mobilise and integrate the existing scientific knowledge for European forest policy-makers and managers who have to make decisions on adaptation to and mitigation of climate change.

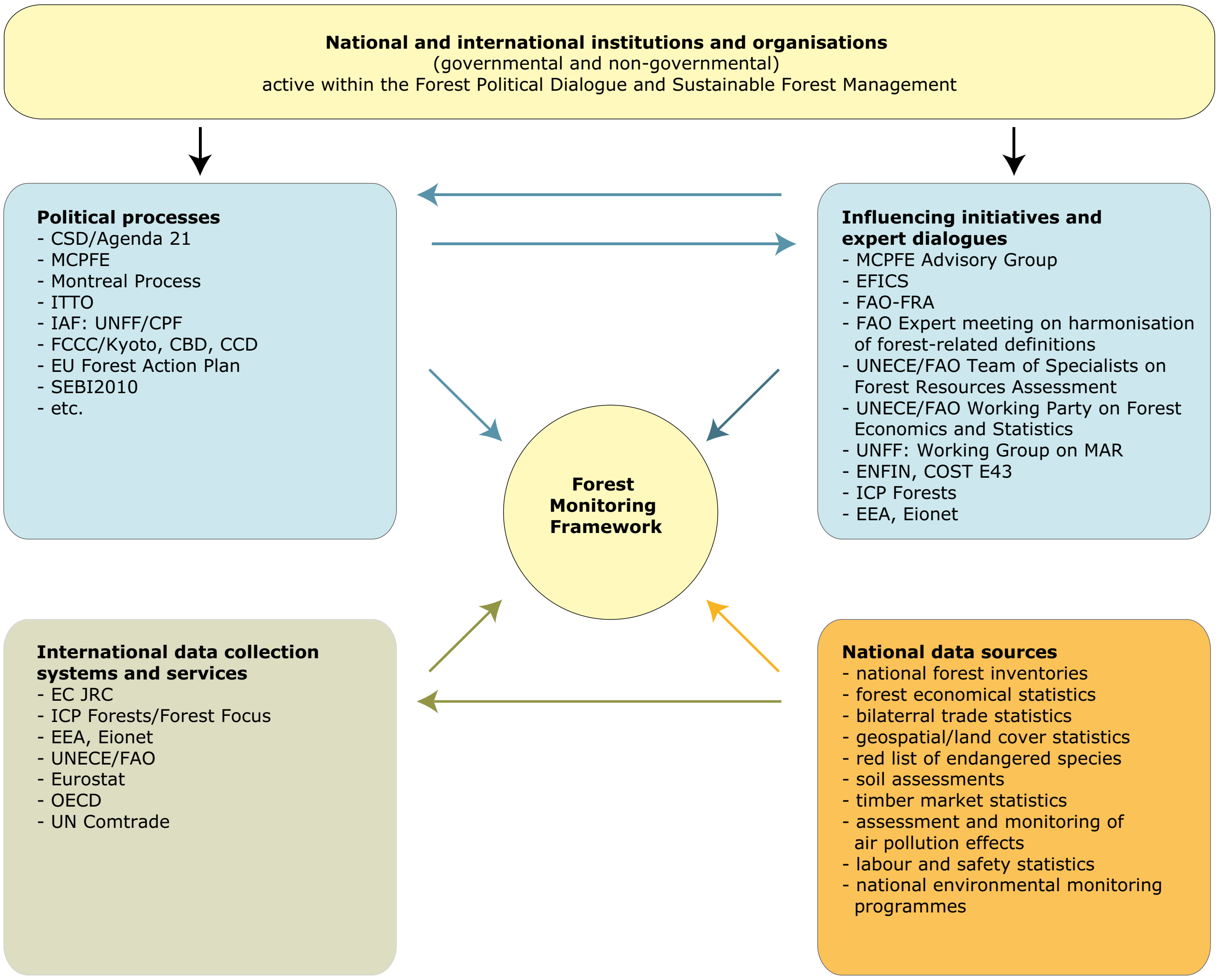
Source: COST, 2007.

Figure 5.5 Trends in forestry research in Europe



Source: Mohren, 2007.

Figure 5.6 Schematic overview of main forest monitoring structure in Europe



Source: Requardt, 2007.

the FTP thus aims at increasing the competitiveness of Europe by developing innovative products and services. By contributing to economic, social and environmental sustainability, the sector works side by side with the EU in reaching goals and strategies set out in Lisbon and Gothenburg. The sector's prime asset is the renewable nature of wood as a raw material (FTP, 2006).

In addition to education and research, an important capacity element to support reporting and assessments on European forests is the systematic collection of data on forests through monitoring networks. There are currently several important, officially established, monitoring initiatives in Europe providing forest data (Figure 5.6).

As regards data, the European Environment Agency (EEA), technically supported by its topic centres, cooperate with its member countries within the European information and observation network (Eionet, 2008). This cooperation comprises data flows related to a number of environmental issues. However, regarding forest, DG Joint Research Centre has among the EC institutions a main responsibility ('Forest data centre'). EEA will focus on e.g. biodiversity and protected areas ('Biodiversity data centre'), which in this report is reflected e.g. in Sections 3.7 and 5.2.

The Global Monitoring for Environment and Security (GMES) is a joint initiative of the European Commission and the European Space Agency, which aims to build up a European capacity for global monitoring of environment and security. GMES contributes to key policies of the European Union, such as the 6th environment action programme and the Strategy for Sustainable Development. Over 100 GMES products and services related to monitoring the terrestrial environment have been identified. Many of these are in support of criteria and indicators, in several cases related to biodiversity. Among the GMES products, 63 are developed for 'operational service' while the rest are for 'research and development' (ETC/BD, 2005) The GMES Service Element for Forest Monitoring delivers earth observation-based maps and data in support of operational monitoring of forest condition and sustainable forest management, mainly to European governmental and associated institutions. This also includes forest biodiversity assessments such as this report (Maps 3.3a, b; Map 3.4).

Reaching the target of halting the loss of biodiversity by 2010 will require an operational indicator framework and monitoring to supply the indicators with data (Chapter 1). Hence, a great effort is currently underway in many national and international organisations to develop and coordinate work on relevant biodiversity indicators for 2010. In Europe, a regionally-coordinated programme was initiated in 2004: the SEBI 2010 biodiversity indicators include two forest-related indicators: 'growing stock, increment and fellings' and 'deadwood', cf. Section 2.1. Data for these indicators are collected largely through national forest inventories. All European countries conduct forest inventories that assess the national forest resources by various parameters such as forest area, growing stock, growth, tree species composition, age classes and fellings. However, national forest inventories differ considerably between countries in relation to the data collected and measurement methods used. An important ongoing initiative to achieve harmonisation of measurements is the European National Forest Inventory Network (COST E43, 2007).

Forest condition in Europe has been monitored over 18 years jointly by the EU and the International Cooperative Programme on the Assessment and Monitoring of Air Pollution Effects on Forests (ICP Forests) under the UN Convention on Long-range Transboundary Air Pollution (ICP Forests, 2005) (Section 3.6). Over the period 2003–2006, the

Box 5.4 Forest Focus biodiversity studies

Silvia Stofer lectures on measuring of epiphytic lichens (ForestBiota)

Photo 5.4: © T-B. Larsson

The Forest Biodiversity Test-phase Assessments (ForestBiota) project (2004–2006) united 10 countries in testing the proposed European Forest Type classification scheme and the following harmonised measurements of important forest biodiversity variables on more than 100 plots:

- stand structure
- deadwood
- epiphytic lichens
- ground vegetation.

The outcome of the project was a methodology for all the above aspects of forest biodiversity which proved to be fully functional in the participating countries.

A much more extensive biodiversity study, comprising the majority of the Forest Focus/ICP Forest plots (Level 1 plots, see Section 4.6), is the BioSoil biodiversity project coordinated by the EC Joint Research Centre. The sampling approach included geo-referencing the plots and development of plot design. It included the following surveys:

- European Forest Type classification
  - verification of actual forest type
- Structural forest diversity
  - diameter at breast height and species composition of all woody plants (including standing and lying trees, living and dead))
  - coarse woody debris, snags, and stumps)
  - canopy closure and tree layering
- Compositional forest diversity
  - ground vegetation (vascular plant species list).

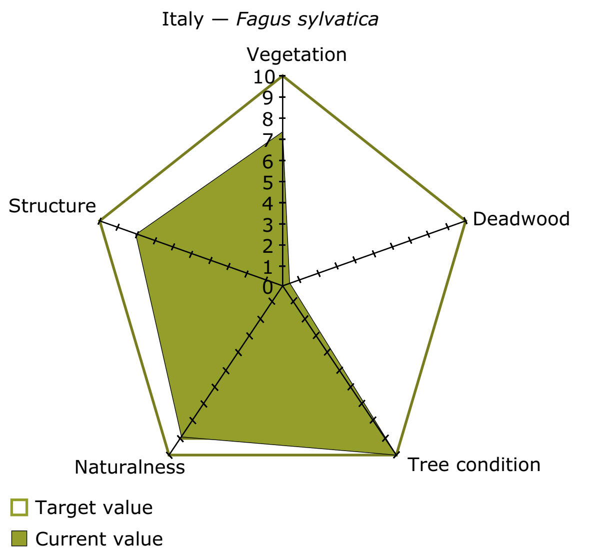
The BioSoil project ended in 2007. Map 3.1, showing geographical distributions of forest types (categories), is an example of a preliminary output. The upcoming Life+ forest biodiversity projects are largely expected to rely on experiences of ForestBiota and BioSoil.

Source: ForestBiota, 2008; BioSoil, 2008; Baastrup-Birk *et al.*, 2006.

European community supported this monitoring through the Forest Focus scheme, which also included fire protection and development of new instruments relating to soil monitoring, carbon sequestration, biodiversity, climate change and protective functions of forests (EC, 2003b). A number of biodiversity studies and demonstration projects were supported; the most notable in this context were the ForestBiota and BioSoil (biodiversity) projects which involved several countries (Box 5.4). The EU Life+ Regulation (EC, 2008c) now gives EU Member States an opportunity to develop new and up-to-date monitoring approaches with a clear added value as regards harmonisation of methodologies and comparability of data.

Monitoring activities supported by the EU Life+ Regulation, which entered into force in 2007, are also expected to address forest biodiversity. This monitoring will provide future data for a 'Forest Status Indicator (FSI)' based on sub-indicators identified and implemented at pan-European and national level, such as tree condition, forest structure, deadwood, plant species composition and naturalness. When fully implemented the FSI will relate the state and trends in each sub-indicator to defined targets (Figure 5.7) (Petriccione *et al.*, 2007). The planned forest monitoring may also support wider assessments of conservation status of habitats and species listed in the Annexes of the EU Habitats Directive (Sections 3.7 and 5.2).

Figure 5.7 An example of presenting the Forest Status Indicator: beech forest in Italy



Source: Petriccione, 2007.

There are several research-funded activities in Europe relevant to monitoring of forest ecosystems. An important framework for long-term terrestrial observation plots is the global Long Term Ecological Research Network (LTER, 2007). LTER-Europe, the EU-funded 'A Long-Term Biodiversity, Ecosystem and Awareness Research Network', was formally established on 15 June 2007 (ALTER-Net, 2007). LTER-Europe unites activities in several European countries and international networks, including ICP Forests.

In addition to the official monitoring, non-governmental organisations significantly contribute to the collection of information about Europe's biodiversity. The Pan-European Common Bird Monitoring Scheme offers a pan-European indicator on common bird populations, for which work is in progress to include forest birds (Section 3.7). Several activities are on-going to bring European bird and forest monitoring communities together to investigate how to best combine assessment methods as well as existing data. Finland, France and Portugal have active cooperation between the national forest inventories and monitoring of forest bird populations, which allows correlation between forestry and bird population trends (ETC BD, 2005).

In spite of all these efforts there is still, in relation to the needs for managing the forests, an unsatisfactory knowledge of forest ecosystems and forest biodiversity throughout Europe. In particular the European-level information on biodiversity composition — both species and gene pools — needs to be strengthened (Sections 3.7 and 3.8). To capture the variation in European forests, data to serve assessment of forest ecosystem conditions and forest biological diversity should be collected according to the European Forest Types (Section 3.3). This information should help to set solid targets and elaborate sustainable management schemes of the forest ecosystems. More extensive and spatially-related knowledge on biodiversity may also help to prioritise actions (Table 2.2). This would also help in developing new approaches such as identifying 'high nature value forests'. The experiences and organisational structures of existing programmes that monitor forests should be maintained, and where appropriate, encouraged to include wider aspects related to biological diversity. Finally it is also necessary to carry out the ecological research needed to understand what is happening.

Annex 1 European Forest Types

European Forest Types: Main categories for developing sustainable forest management and policy at European level. The 14 categories of the scheme can be subdivided into 76 types to further capture the variation in European forests.

European Forest Types	Main characteristics
1. Boreal forest  **Photo:** © K. Sjöberg	Extensive northern, species-poor forests, dominated by two conifers (*Picea abies* & *Pinus sylvestris*). Substantial areas 'undisturbed by man'. Mostly semi-natural forests of primary importance to European forestry; clear-cutting dominates. Fire, the main natural disturbance, is effectively controlled.
2. Hemiboreal forest and nemoral coniferous and mixed broadleaved-coniferous forest  **Photo:** © T-B. Larsson	A forest region south of the boreal with similar characteristics but a slightly higher tree species diversity, including also temperate deciduous trees like *Tilia cordata*, *Fraxinus excelsior*, *Ulmus glabra* and *Quercus robur*. Anthropogenic impact and intense silviculture significant. Apart from natural forests, types originating from old land use, such as wood pastures and grazed land are also significant.
3. Alpine coniferous forest  **Photo:** © G. Frank	The high-altitude forest belts of central and southern European mountain ranges, covered by *Picea abies*, *Abies alba* and *Pinus nigra*. Includes mountain forests of *Picea abies*, *Larix decidua*, *Abies alba* and *Pinus mugo.* Avalanches and snow breaks are significant disturbances, as is, in some areas, grazing of livestock as part of traditional pasturing (today decreasing). Lower regions are subject to intense forestry, favouring even-aged stands and using selection cutting.

European Forest Types	Main characteristics
4. Acidophilous oak and oak–birch forest  **Photo:** © L. Kutnar	Scattered occurrence on less fertile soils in a wide belt from the Atlantic to eastern Europe. Oak species *Quercus robur* and *Q. petraea*, dominate this not very species rich forest. Traditionally managed as coppices.
5. Mesophytic deciduous forest  **Photo:** © G. Frank	Mixed forests on medium-rich soils widely distributed in middle Europe. Mixed and variable forests made up by a relatively large number of deciduous tree species: *Carpinus betulus*, *Quercus petraea*, *Q. robur*, *Fraxinus* spp., *Acer* spp. and *Tilia cordata.* Management has been intense, often creating even-aged stands. Much of the original forest of this category has been converted to agricultural land.
6. Beech forest  **Photo:** © T-B. Larsson	Lowland to submountainous beech forest is widely distributed in Europe. Beech, *Fagus sylvatica* and *F. orientalis* (Balkan) dominate, locally important is *Betula pendula*. Its wide distribution is limited to the north by Europe's low winter temperatures, and to the south by water deficiency. Mostly managed as even-aged forest stands, although traditional coppicing and livestock grazing of wood pastures are still in place in some areas.
7. Mountainous beech forest  **Photo:** © T. Standovár	Beech, *Fagus sylvatica*, creates a significant vegetational belt in the main European mountain ranges. Species composition differs from lowland beech, e.g. mountainous beech forests are home to the northeastern ural owl, *Strix uralensis*. Includes conifers and mesophytic deciduous tree species. Traditionally coppiced for firewood and charcoal. Much of the coppiced stands have been transferred to high forests.

European Forest Types	Main characteristics
8. Thermophilous deciduous forest  **Photo:** © P. Regato	Mixed forest in southern Europe e.g. Mediterranean mountains, dominated by *Quercus* spp., *Acer*, *Ostrya*, *Fraxinus* and *Carpinus* are frequently associated tree species. Limited to the north by temperature and to the south by drought. Long history of cultural influence, which also created the entirely man-made chestnut, *Castanea sativa*, forests. Coppice, once dominating, is today being abandoned, which leads to development of high forest-like structure.
9. Broadleaved evergreen forest  **Photo:** © P. Regato	Dominated by broadleaved sclerophyllous or lauriphyllous trees in the Mediterranean and Macaronesian region. In the Mediterranean it is profoundly shaped by traditional silvopastoralism and coppicing. Water availability is the main limiting factor and environmental conditions are generally harsh (drought, acid soils prone to erosion) and anthropogenic influences intense (fire, grazing, intense wood exploitation for local households).
10. Coniferous forest of the Mediterranean, Anatolian and Macaronesian regions  **Photo:** © T-B. Larsson	A varied group of coniferous forests in Mediterranean, Anatolian and Macaronesian regions, from the coast to high mountains. Dry and often poorly-developed soils limit tree growth. Several tree species, including a number of endemics, of *Pinus, Abies* and *Juniperus* species. Although the forest category is adapted to fire, the frequent anthropogenic fires trigger forest degradation. Subject to silviculture in some regions, favouring even-aged stands.
11. Mire and swamp forests  **Photo:** © K. Sjöberg	Wetland forests on peaty soils widely distributed in the boreal region. Water and nutrient regime determines the dominant tree species: *Pinus sylvestris, Picea abies* or *Alnus glutinosa.* Richer types, e.g. in the hemiboreal region, may include other tree species. Large pristine areas in the north, often creating forest-mire forest-open mire mosaics of little interest to forestry. In the middle and south boreal region, comprises a number of types subject to (more or less successful) draining and e.g. in Finland, to fertilisation to create productive forest stands. Includes in the south species-rich types, and remaining less-impacted areas are often protected.

European Forest Types	Main characteristics
12. Floodplain forest  **Photo:** © L. Kutnar	The water regime including occasional flooding is the main factor impacting this forest category. Floodplain forests are species-rich, complex forest communities once widespread in Europe. Draining to achieve agricultural land and damming and canalisation of rivers has reduced this once very widespread type to fragments. The few remaining floodplain forests of any notable size are usually protected or would deserve to be so. Recently the interest in restoration of riparian forests has increased in Europe as part of river management to avoid flooding.
13. Non-riverine alder, birch or aspen forest  **Photo:** © K. Sjöberg	Pioneer forests dominated by *Alnus, Betula* or *Populus*. Includes the tree-limit (and outer archipelago) belt of (mountain) birch forest in the Fennoscandian region, a fairly extensive type which at present is of little interest to forestry. The key factor determining dynamics of mountain birch is periodic defoliation by insects. Traditional grazing, ongoing or recently abandoned, may be an important factor in this category.
14. Plantations and self-sown exotic forest  **Photo:** © A. Barbati	Plantations of exotic species are frequent only in a few European countries (Section 2.2). Occur on a wide range of site conditions which otherwise would develop forest of above categories. Biodiversity value debated but occurrence of natural species not negligible, in particular if managed with biodiversity concerns. Although in principle well-defined, the identification of forest plantations has in practice created great controversies in Europe.

Source: EEA, 2006.

Annex 2 Forest species on the list of worst invasive alien species threatening biodiversity in Europe

Species on the list of 'Worst invasive alien species threatening biodiversity in Europe' which regularly are found in forest habitats or dependent on trees.

Name	Origin	Distribution in Europe	Intro-duced	Habitat	Impact on biodiversity and human interests
Mammals					
Finlayson's squirrel *Callosciurus finlaysonii*	SE Asia		1990s	Presently mainly in park areas	Competition with European red squirrel; bark stripping of trees
Canadian beaver *Castor canadensis*	N America		1930s	River-forest	Competition with native European beaver; impacts forest by logging and dams.
Sika deer *Cervus nippon*	SE Asia		1860s	Woodlands, marshes and to some extent grasslands	Hybridisation with European red deer; damage to trees
Muntjac deer *Muntiacus reevesi*	E Asia		1920s	Woodlands with areas of open farmland	Feeding impacts woodland flora and inhibits forest regeneration

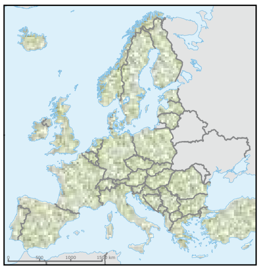
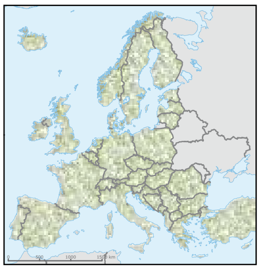
Name	Origin	Distribution in Europe	Intro-duced	Habitat	Impact on biodiversity and human interests
Raccoon dog *Nyctereutes procyonoides*	E Asia		1900s	Forest and agricultural land	Disease vector (animals, humans)
Rabbit *Oryctolagus cuniculus*	SW Europe N Africa		Middle Ages	Wide range of habitats including forests	Impact flora, damage forest trees and decreases vegetation cover (erosion)
Raccoon *Procyon lotor*	C & N America		1920s	Wide range of habitats including forests	Impacts on prey community, disease vector
Grey squirrel *Sciurus carolinensis*	N America		1870s	Forest and park areas	Competition and displacement of the European red squirrel; bark stripping of trees
Insects					
Citrus longhorned beetle *Anoplophora chinensis*	E Asia		2000s	Utilises a number of tree species	Threat to natural forest, fruit trees and woody ornamental plants

Name	**Origin**	**Distribution in Europe**	**Intro-duced**	**Habitat**	**Impact on biodiversity and human interests**
Asian longhorned beetle *Anoplophora glabripennis*	E Asia		2000s	Deciduous trees in urban, rural and forest habitats	Will kill tree used; problem in Europe potentially severe
Horse chestnut leaf-miner *Cameraria ohridella*	Unknown		1980s	Mainly *Aesculus hippocastanum* in urban and park areas	Infected trees are removed
Oak lace bug *Corythucha arcuata*	N America		2000s	Oak trees, occasionally *Castanea, Acer, Malus*	Reduced photosynthesis and premature leaf fall; Potential risk for European oak forests and *Castanea* stands
Fall webworm *Hyphantria cunea*	C & N America		1940s	Orchards and forests	Polyphagous species creating defoliation
Garden ant *Lasius neglectus*	Asia		1980s	Wide range of habitats with presence of trees	Impact on native ant communities and other arthropods

Name	Origin	Distribution in Europe	Intro-duced	Habitat	Impact on biodiversity and human interests
Argentine ant *Linepithema humile*	S America		Early 1900s	Wide range of habitats including forests	Competition and displacement of native ant communities
Red palm weevil *Rhyncophorus ferrugineus*	SE Asia		1990s	Palm trees	Impacts the endemic palm tree *Phoenix canariensis* and other palms
Molluscs					
Iberian slug *Arion vulgaris*	SW Europe		1970s	Deciduous forests, grasslands, parks and gardens	Damage to vegetation; decimates native molluscs
Flatworms					
New Zealand flatworm *Arthurdendyus triangulatus*	Australia, New Zealand		1960s	Gardens, parks, farmland, wasteland	Predator on earthworms
Nematodes					
Pinewood nematode *Bursaphelen-chus xylophilus*	N America		2000s	Forests	Attacks pine trees; 'Pine wilt disease'

Name	Origin	Distribution in Europe	Intro-duced	Habitat	Impact on biodiversity and human interests
Vascular plants					
Boxelder *Acer negundo*	NE America		1700s	Edges of forest, riparian and urban areas	Competition with native forest plants
Tree-of-heaven *Ailanthus altissima*	E Asia		1700s	Grasslands, forest gaps, riparian habitats, disturbed places	Competes and displaces the native vegetation
New York aster *Aster novi-belgii agg.*	North America		1820s	Riparian habitats, alluvial forests wet meadows, disturbed sites	Competes with native vegetation and replaces natural forest understorey vegetation
Japanese knotweed *Fallopia japonica* (incl. *Fallopia x bohemica*)	E Asia		1840s	Primarily in moist habitats but also in waste places, roadsides, urban areas	Competes with native vegetation and replaces natural forest understorey vegetation (mostly in alluvial forests)
Giant hogweed *Heracleum mantegazzia-num*	Western Caucasus		1800s	Riparian habitats, grasslands, forest gaps, disturbed sites	Competes with and displaces native vegetation and fauna associated with the vegetation

Name	**Origin**	**Distribution in Europe**	**Intro-duced**	**Habitat**	**Impact on biodiversity and human interests**
Himalayan balsam *Impatiens glandulifera*	Asia		Late 1830s	Predominantly in riparian habitats	Out-competes native herb and grass species
American skunk cabbage *Lysichiton americanus*	N America		1940s	Swamp forests, lakesides	Displaces mosses and vascular plants
Black cherry *Prunus serotina*	N America		1600s	Forests	Competes with native herbaceous vegetation
Rhododendron *Rhododendron ponticum*	SE & SW Europe		Late 1800s	Forests	Replaces natural forest understorey
Black locust *Robinia pseudo-acacia*	NE America		1600s	Forests, pastures and roadsides	Creates large stands that displace native vegetation

Name	Origin	Distribution in Europe	Intro-duced	Habitat	Impact on biodiversity and human interests
Late goldenrod *Solidago gigantea*	North America		1660s	Wet habitats including floodplain forests	Out-competes native forest ground vegetation
Canadian goldenrod *Solidago canadensis*	North America		1880s	Wet habitats including floodplain forests	Out-competes native forest ground vegetation
Fungi					
Dutch elm disease *Ophiostoma novo-ulmi*	Unknown		1950	Elm trees in forests and parks	Aggressive and lethal elm pest
Phytophthora root rot *Phytophthora cinnamomi*	SE Asia		1700s	Forests and several tree species	Cause for decline of several forestry, ornamental and fruit plants and other plant species

Note: Preliminary data on distribution in Europe. Impact may vary in different countries. A few species are native to Europe (native distribution not included in the maps).

Source: EEA, 2007c.

Annex 3 Definitions of main concepts used in the report

Above-ground biomass — All living biomass above the soil including stem, stump, branches, bark, seeds and foliage (FAO, 2004).

Afforestation — Artificial establishment of forest on land which previously did not carry forest within living memory (MCPFE, 2002).

Alien species (synonyms: non-native, non-indigenous, foreign, exotic) — A species, subspecies, or lower taxon introduced outside its normal past or present distribution. Includes any part, gametes, seeds, eggs, or propagules of such species that might survive and subsequently reproduce (CBD, 2001).

Below-ground biomass — All living biomass of live roots. Fine roots of less than (suggested) 2mm diameter are sometimes excluded because these often cannot be distinguished empirically from soil organic matter or litter (FAO, 2004).

Biological diversity — The variability among living organisms from all sources including terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part. Includes diversity within species, between species and of ecosystems (CBD Art. 2).

Carbon sequestration — Retention of carbon in ways that prevent or delay its emission to the atmosphere as carbon dioxide. Silvicultural practices that encourage rapid, long-term tree growth are an example. While 'uptake' is a withdrawal from the atmosphere, 'sequestration' is the accumulation and retention of carbon in a pool (IUFRO, 2008).

Climate change — A change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (UNFCCC, 1992).

Coppice sprouting — The re-growth from coppice stools after the previous stand has been cut (TBFRA, 2000).

Core forest areas — Units beyond a 100 m distance from the forest–non-forest interface. 100 m for the edge width corresponds to edge effects of many interior species and permeability distance for invasive species (Kupfer, 2006; Estreguil *et al.*, 2007).

Critically Endangered — A taxon is Critically Endangered when the best available evidence indicates that it meets any of the criteria A to E for Critically Endangered (IUCN, 2001), and it is therefore considered to be facing an extremely high risk of extinction in the wild.

Deadwood — All non-living woody biomass not contained in the litter, either standing, lying on the ground or in the soil. Deadwood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter or any other diameter used by the country (FAO, 2004). It is up to the countries to define the threshold level for the minimum size of diameter to be reported. Thresholds used should be documented and reported (FAO, 2004) (used in MCPFE, 2007).

Deadwood biomass — All non-living woody biomass not contained in the litter, either standing, lying on the ground, or in the soil. Deadwood includes wood lying on the surface, dead roots, and stumps larger than or equal to 10 cm in diameter or any other diameter used by the country (FAO, 2004).

Ecosystem — A dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit. (CBD, 1992).

Endangered — A taxon is Endangered when the best available evidence indicates that it meets any of the criteria A to E for Endangered (IUCN, 2001), and it is therefore considered to be facing a very high risk of extinction in the wild.

Exotic species — See 'Alien species'.

***Ex situ* gene conservation —** The conservation of components of biological diversity outside their natural habitats (CBD, 1992).

Forest — Land spanning more than 0.5 hectares with trees higher than 5 metres at maturity *in situ* and a tree canopy cover of more than 10 %, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use (FAO, 2004).

Forest area available for wood supply — Forest where any legal, economic, or specific environmental restrictions do not have a significant impact on the supply of wood. Includes areas where, although there are no such restrictions, harvesting is not taking place, for example areas included in long-term utilisation plans or intentions (TBFRA, 2000).

Forest certification — A market-based response to address public concerns that the wood products they buy originate from sustainably managed forests and not from protected areas or from illegal logging. Forest certification thus enables practical implementation of sustainability principles as agreed within policy measures. However, not all certification schemes strictly follow policy guidance.

Forest damage — Forest with damage is forest affected by abiotic, biotic and human induced forest disturbances (See also 'forest disturbance').

Forest disturbance — A disturbance is defined as 'an environmental fluctuation and destructive event that disturb forest health, structure, and/or change resources or physical environment at any given spatial or temporal scale'. Disturbances that affect health and vitality include biotic agents, such as insects and diseases, and abiotic agents, such as fire, pollution and extreme weather conditions (White and Pickett, 1985).

Forest fragmentation — The entire process of forest loss and the splitting of forest areas into more or less isolated and smaller forest patches. This comprises three distinct changes in the spatial pattern of forest across a landscape: reduction of forest area and units; increase of isolation of forest units; and creation of forest edges.

Forest interior species — Species that require core forest areas and suffer edge effects.

Forest stand — A community of trees possessing sufficient uniformity in composition, age, arrangement or condition to be distinguishable from the forest or other growth on adjoining areas, thus forming a temporary silvicultural or management entity (IUFRO, 2008).

Forest type — A category of forest defined by its composition and/or site factors (locality), as categorised by each country in a system suitable to its situation (Montreal Process, 1998, from EEA, 2006).

Forests undisturbed by man — Forest showing natural forest dynamics, such as natural tree composition, occurrence of dead wood, natural age structure and natural regeneration processes, the area of which is large enough to maintain its natural characteristics and where there has been no known significant human intervention or where the last significant human intervention was long enough ago to have allowed the natural species composition and processes to have become re-established.

Growing stock — Volume over bark of all living trees more than X cm in diameter at breast height. Includes the stem from ground level or stump height up to a top diameter of Y cm, and may also include branches to a minimum diameter of W cm (X, Y, W to be specified) (FAO, 2004).

High Nature Value (HNV) farm land — Those areas in Europe where agriculture is a major (usually dominant) land use and where the agriculture supports, or is associated with, either a high species and habitat diversity or the presence of species of European conservation concern, or both (EC and EEA, 2006).

***In situ* gene conservation** — The conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings and, in the case of domesticated or cultivated species, in the surroundings where they have developed their distinctive properties (CBD, 1992).

Invasive alien species — An alien species whose establishment and spread threaten ecosystems, habitats or species with economic or environmental harm (CBD, 2001).

Natural forest — A forest composed of indigenous trees and not classified as a forest plantation (FAO, 2001).

Natural regeneration — Re-establishment of a forest stand by natural means, i.e. by natural seeding or vegetative regeneration. It may be assisted by human intervention, e.g. by scarification or fencing to protect against wildlife damage or domestic animal grazing (TBFRA, 2000).

Natural regeneration enhanced by planting — Natural regeneration which has been combined with artificial planting or seeding, either to ensure satisfactory restocking with the naturally regenerated species or to increase species diversity (TBFRA, 2000).

Near Threatened — A taxon is Near Threatened when it has been evaluated against the criteria but does not qualify for Critically Endangered, Endangered or Vulnerable now, but is close to qualifying for or is likely to qualify for a threatened category in the near future (IUCN, 2001).

Other wooded land — Land not classified as forest, spanning more than 0.5 hectares; with trees higher than 5 metres at maturity *in situ* and a canopy cover of 5–10 %, or trees able to reach these thresholds *in situ*; or with a combined cover of shrubs, bushes and trees above 10 %. It does not include land that is predominantly under agricultural or urban land use (FAO, 2004).

Plantation forest — Forest of introduced species and in some cases native species, established through planting or seeding. This includes all stands of introduced species established through planting or seeding. May include areas of native species characterised by few species, even spacing and/or even-aged stands. Plantation forest is a sub-set of planted forest (FAO, 2004).

Private ownership — Land owned by individuals, families, private cooperatives, corporations, industries, private religious and educational institutions, pension or investment funds and other private institutions. Private owners may be engaged in agriculture or other occupations including forestry (FAO, 2004).

Protected area — The term refers to a geographically defined area which is designated or regulated and managed to achieve specific conservation objectives (CBD, 1992).

Protective forest — Forest managed predominantly for the provision of services such as protection of soil and water, rehabilitation of degraded lands, combating desertification etc. (FAO, 2004).

Provenance — The original geographic source of seed, pollen, or propagules. In forestry literature the term is usually considered synonymous with 'geographic origin', and preferred to 'origin' (IUFRO, 2008).

Public ownership — Land owned by the state (national, state and regional governments) or government-owned institutions or corporations or other public bodies including cities, municipalities and villages (FAO, 2004).

Regeneration — Re-establishment of a forest stand by natural or artificial means following the removal of the previous stand by felling or as a result of natural causes, e.g. fire or storm (TBFRA, 2000).

Regeneration by planting and seeding — The act of establishing a forest stand (e.g. plantation) or re-establishing a forest stand by artificial means, either by planting of seedlings or by scattering seed. The material used may be of indigenous or introduced origin. Planting and seeding may take place on forest, other wooded land or other land (TBFRA, 2000).

Semi-natural forest — Forest of native species, established through planting, seeding or assisted natural regeneration. Includes areas under intensive management where native species are used and deliberate efforts are made to increase/optimise the proportion of desirable species, thus leading to changes in the structure and composition of the forest. Naturally regenerated trees from other species than those planted/seeded may be present. May include areas with naturally regenerated trees of introduced species. Includes areas under intensive management where deliberate efforts, such as thinning or fertilising, are made to improve or optimise desirable functions of the forest. These efforts may lead to changes in the structure and composition of the forest (FAO, 2004).

Silvo-pastoralism — A traditional land use combining trees and livestock (pigs, sheep, goats, cattle) using the same unit of land for multiple products.

Standing volume — Volume of standing trees, living or dead, above-stump measured over bark to top (0 cm). Includes all trees with diameter over 0 cm (diameter at breast height). Includes tops of stems, large branches, dead trees lying on the ground which can still be used for fibre or fuel. Excludes small branches, twigs and foliage. (TBFRA, 2000).

Vulnerable — A taxon is Vulnerable when the best available evidence indicates that it meets any of the criteria A to E for Vulnerable (IUCN, 2001), and it is therefore considered to be facing a high risk of extinction in the wild.

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