European forest types
Categories and types for sustainable forest management reporting and policy

European Environment Agency

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Executive summary

The European forest types — Categories and types for sustainable forest management reporting and policy presents the findings of a study carried out by an international consortium of experts aimed at providing the Ministerial Conference on the Protection of Forests in Europe (MCPFE) with an user-friendly forest types classification. The primary goal of the scheme is to improve the MCPFE reporting on sustainable forest management (SFM) in Europe, with special regard to forest type based SFM indicators.

The document is divided into seven chapters plus a reference chapter, the main contents of the first seven chapters are summarised below.

1. **Reporting on sustainable forest management in Europe** introduces the forest type issue within the overall political framework of the MCPFE process. The seven MCPFE sustainable forest management (SFM) indicators to be reported by forest types are presented (forest area, growing stock, age structure/diameter distribution, forest damage, tree species composition, naturalness, deadwood). Definition and requirements of forest types for the MCPFE indicator reporting are provided and the key-factor concept for forest types delineation is introduced: a suitable forest type classification for MCPFE reporting should identify and reflect those, natural and anthropogenic, sources of variation of forest condition that cause major shifts in state of forest type based indicators. In this respect, limitations of the forest type categorisation currently applied for MCPFE reporting (coniferous forest, broadleaved forest, mixed coniferous and broadleaved forest) are discussed.

2. **The diversity of European forests** outlines the main (historical and present) natural and anthropogenic factors that help in explaining the variety of forests conditions (structural, compositional) found nowadays throughout Europe.

3. **Current and potential forest vegetation in Europe: an assessment** seeks to give a quantitative evaluation of the anthropogenic footprint on forest physiognomy, through a cross-analysis of potential and current forest vegetation maps. Detailed statistics on the current extent and physiognomy of European forests by potential forest types are presented. This technical chapter is mainly designed to provide readers with specific interest in this issue with updated figures on the major differences between current and potential forest vegetation in Europe.

4. *European forest types:* **the classification system** deals with the presentation of the main features of the scheme of European forest types proposed for MCPFE reporting. Limitations of alternative forest classification schemes are discussed. The methodological approach used for the development of the classification is outlined. The hierarchical classification scheme consisting of 14 categories further subdivided into 76 types is introduced. Criteria applied for the delineation of categories and types are given, which could be synthesized in the principle of increasing similarity in the natural conditions and levels of anthropogenic modification affecting the values taken by forest type based MCPFE indicators. As most compilation of national data on MCPFE indicators use National forest inventories (NFIs) ground plot information, the use of types is recommended for stratifying NFIs plots and of the fourteen categories for reporting data on forest type based indicators.

5. **Key to the classification** contains a classification key built upon criteria diagrams and additional explanatory notes accompanying each 'decision box' (cf. also Appendix II). The classification key is mainly intended to provide end-users (MCPFE national correspondents) with classification rules to stratify data sources — mainly ground plots — used to assess MCPFE forest type based indicators according to categories and types. Rules are based on information commonly assessed in a forest inventory, i.e. tree species basal area. In this way, each country can reclassify ground plots according to the European forest types nomenclature and report data on indicators by the categories found in its own territory.

Furthermore, a rough evaluation of the relative frequency of categories for some European countries is provided with an overview map of their distribution. The evaluation is based on a

test carried out on ICP-Level I plots. The main goal of the test is to give a reasonable idea of the possible increase in the MCPFE reporting burden, that would derive from the application of the proposed categorisation. The number of categories found at country level ranges from 1 to 12 and is on average 6.

6. *European forest types* **nomenclature: category and types descriptions** presents the nomenclature of the proposed classification scheme, i.e. a descriptive frame allowing a comprehensive characterisation of the 14 categories and 76 types. The nomenclature strictly relates to the classification key (Chapter 5).

   Categories and types are described and documented using a descriptive frame including: i) class definition: key to the identification of the category; it is a general description of the category in terms of dominant forest species and biogeographical/ecological factors determining its appearance; ii) geographical distribution: present distribution of the category in relation to European biogeographical regions or to other relevant environmental references; iii) types: list and description of the most important forest ecosystems covered by the category, the descriptions include a delineation of the geographical/ecological distribution of the type, tree species composition and other structural and functional characteristics, including silviculture and past and actual human impact; iv) cross-links with Annex I Habitat Directive and EUNIS Habitat Classification, established at the type level.

   Descriptions are integrated with photos to further document the characteristic features of each category. In addition, a synopsis of the unique interplay of ecological conditions and anthropogenic influences affecting the variation of the MCPFE forest type based indicators, at the category level is presented.

7. **Conclusions and perspectives** concludes with remarks on the potential of the forest type classification for the MCPFE reporting and future desirable efforts needed to fully exploit it.

1   Reporting on sustainable forest management in Europe

1.1   Political framework

Sustainable forest management (SFM) is currently widely accepted as the overriding objective for forest policy and practice. Nine regional processes have been launched since the United Nations Conference on Environment and Development in Rio de Janeiro (UNEP, 1992) to develop and implement criteria and indicators (C&I) of SFM (ECOSOC, 2004). Each of these regional processes has its own distinctive set of C&I to measure progress towards SFM.

The Ministerial Conference on the Protection of Forests in Europe (MCPFE) is the high level forest policy process, addressing all dimensions of sustainable forest management (SFM) in the pan-European region. MCPFE involves 44 countries of the European continent (Map 1.1), the European Community and 41 observer countries and international organisations (see: http://www.mcpfe.org). The concept of SFM was firstly defined by the MCPFE in the Resolution H1 of the Helsinki Conference (1993) as: 'the stewardship and use of forests and forest lands in a way, and at a rate, that maintains their biodiversity, productivity, regeneration capacity, vitality and their potential to fulfil, now and in the future, relevant ecological, economic and social functions, at local, national, and global levels, and that does not cause damage to other ecosystems'. Such a concept has been recognised to be consistent with the application of the Ecosystem Approach to forest ecosystems in the pan-European region (MCPFE/PEBLDS, 2006).

A set of pan-European C&I comprising 35 quantitative indicators has been endorsed by the MCPFE process (MCPFE, 2002) to evaluate and report on progress towards implementing SFM in the pan-European region. Six criteria define and characterise the essential elements, as well as a set of conditions or processes, by which SFM may be assessed. Periodically measured indicators reveal the direction of change with respect to each Criterion (MCPFE/PEBLDS, 2006). The MCPFE countries report periodically on this basis and at every ministerial conference, and accordingly a report on the 'State of forest and sustainable forest management in Europe' is issued by MCPFE. These reports aim at providing policy and decision makers with key facts and figures about Europe's forests and SFM and to inform a wider public in a comprehensive and easy-to-read form.

Map 1.1   The 44 MCPFE countries
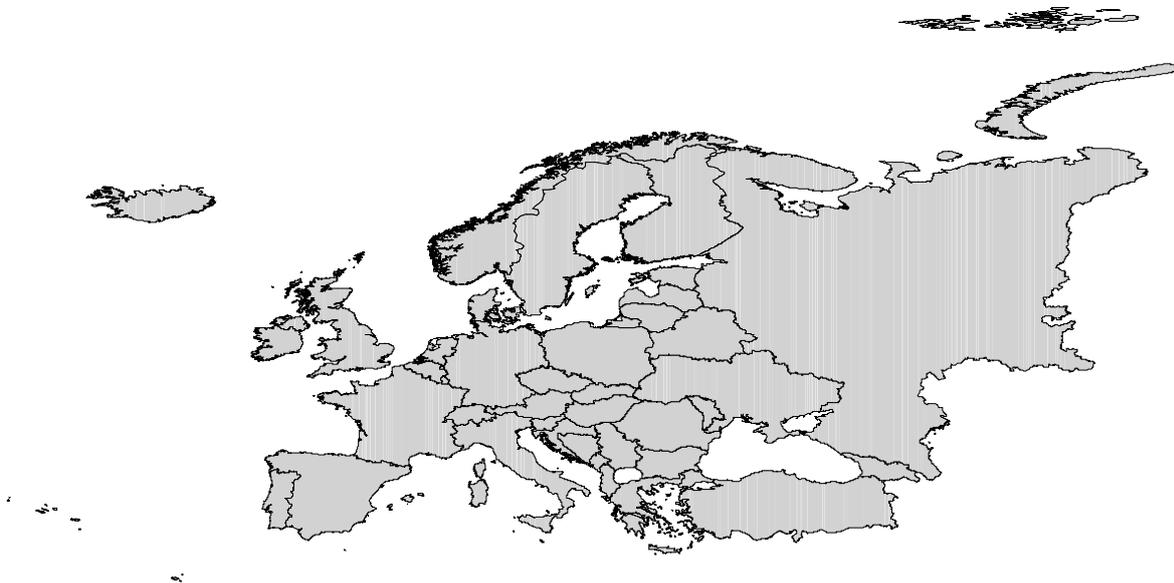
Source: mcpfe.org.

1.2 Forest types and forest biodiversity assessment

Forest biodiversity conservation is considered an integral part of SFM by the MCPFE, in line with global commitments concerning halting the loss of biodiversity by 2010 (cf. EEA, 2006). The MCPFE reporting is, so far, the sole obligation in the pan-European region requesting countries to monitor, assess and report on the maintenance, conservation and appropriate enhancement of biological diversity in forest ecosystems of their own territory (Criterion 4). Three biodiversity indicators under Criterion 4 and four under other criteria are required to be specified by 'forest types' (Table 1.1).

Although forest types are not yet formally defined by the MCPFE, they are considered as a key tool for improving the assessment and monitoring of forest biological diversity in Europe. The MCPFE has officially recognised in Vienna Resolution 4 'the need of improving existing international forest classification, through developing a pan-European understanding on forest classification systems including forest types, naturalness and introduced forest species, in line with the pan-European criteria and indicators for Sustainable Forest Management' (MCPFE, 2005).

In the following paragraph, a clarification on the potential role of forest types in the MCPFE reporting is given.

1.3 Forest types: definition and requirements for MCPFE reporting

A forest type can be generally defined as: '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' (The Montreal Process, 1998). Forest types are a flexible approach to collect and organise forest information in a given region, according to a typology useful for understanding differences which are relevant to a specific application. Forest types optimise SFM assessment (data collection, interpretation and reporting) as much as they are able to separate (and describe) forests significantly different with respect to forest condition, as assessed by SFM indicators (e.g. growing stock, age structure, tree species composition). A suitable forest type classification for MCPFE reporting should identify and reflect those, natural and anthropogenic, sources of variation of forest condition that cause major shifts in the state of forest type based indicators reported in Table 1.1. The idea to base forest types delineation on differences in the structural, compositional and functional key-factors affecting forest condition was firstly suggested by the experts of the BEAR project to optimise forest biodiversity assessment in Europe (Larsson *et al.*, 2001; cf. Box 1.1).

The forest types approach, as understood above, enables comparison throughout Europe of forests growing in similar ecological conditions and

Table 1.1 Pan-European criteria and indicators for the sustainable forest management (SFM): forest type based indicators

C 1: Maintenance and appropriate enhancement of forest resources and their contribution to global carbon cycles	1.1 Forest area	Area of forest and other wooded land, classified by forest type and by availability for wood supply, and share of forest and other wooded land in total land area
	1.2 Growing stock	Growing stock on forest and other wooded land, classified by forest type and by availability for wood supply
	1.3 Age structure and/or diameter distribution	Age structure and/or diameter distribution of forest and other wooded land, classified by forest type and by availability for wood supply
C 2: Maintenance of forest ecosystem health and vitality	2.4 Forest damage	Forest and other wooded land with damage, classified by primary damaging agent (abiotic, biotic and human induced) and by forest type
C 4: Maintenance, conservation and appropriate enhancement of biological diversity in forest ecosystems	4.1 Tree species composition	Area of forest and other wooded land, classified by number of tree species occurring and by forest type
	4.3 Naturalness	Area of forest and other wooded land, classified by 'undisturbed by man', by 'semi-natural' or by 'plantations', each by forest type
	4.5 Deadwood	Volume of standing deadwood and of lying deadwood on forest and other wooded land classified by forest type

Source: MCPFE, 2002.

Box 1.1 — The 'key factor' approach

The key factors of forest biodiversity are defined as the factors that have a major influence on or directly reflect the variation in biodiversity within European forests (Larsson *et al.*, 2001). Key factors are classified according to different forest ecosystem components:

structural (physical characteristics);
compositional (the biological component; i.e. tree species);
functional (abiotic/biotic disturbance factors and management).

The key factor concept offers an operational approach to assess forest biodiversity condition in Europe; biodiversity status can be efficiently monitored by a set of key factors (and related indicators to assess them) properly identified according to the scale and scope of the assessment; for national overviews and international reporting the following list of key-factors has been suggested by the BEAR project (Larsson *et al.*, 2001):

Structural key factors	**Compositional key factors**	**Functional key factors**
Total area of forest with respect to:	Native species	Natural disturbance
Legal status/utilisation or protection	Non-native or not 'site original' tree species	Fire
Forest ownership		Wind and snow
Tree species and age		Biological disturbance
Old growth/forest left for free development		Human influence
Afforestation/deforestation		Forestry
		Agriculture and grazing
		Other land-use
		Pollution

Broad relationships can be found between MCPFE indicators of SFM and key factors; key factors can be regarded as a complementary tool to MCPFE biodiversity indicators, in that they offer a wider and structured way for describing the diversity of European forests (Puumalainen, 2001).

Because the relative importance of key factors varies greatly in European forests, due to different natural and anthropogenic determinants, forest biodiversity assessment must consider this variation. For this reason, the BEAR experts recommended to base key factors assessment on forest types for biodiversity assessment (FTBAs). FTBAs are groups of European forests each being reasonably homogeneous as regards the key factors of forest biodiversity. A scheme of 33 FTBAs was presented by BEAR experts as tentative proposal for reporting on the state and trends of forest biodiversity in Europe (see for further reference: Larsson *et al.*, 2001).

levels of anthropogenic modification, independent of national borders; it provides an harmonised classification for pan-European-level assessments of SFM, by offering ecologically meaningful units to reference and report national data on SFM indicators.

The forest types adopted so far for MCPFE reporting are three broad species groups: broadleaved forest, coniferous forest, mixed broadleaved and coniferous forest. Though this is a feasible system to standardise forest information on a global level, it would hardly serve the European requirements for the assessment of SFM indicators. Within the

vast European forest area —1 004 million of ha (MCPFE, 2003) — the values taken by MCPFE indicators show a considerable range of variation, due to variable natural conditions and past and present anthropogenic influences. Given this variability, it is very difficult to grasp the meaning of these indicators and their trends when taken out of their ecological background (see Box 1.2).

To do justice to the state of forests and sustainable forest management in Europe, the variety in European forests should be taken into account (see Chapter 2). This variety is expressed by the values taken by indicators in different localities.

Box 1.2 — The MCPFE indicator 'tree species composition'

Tree species composition (MCPFE indicator 4.1) is considered a proxy variable for the species diversity of the forest community. The tree species composition in a forest is affected both by natural factors (climate, edaphic and hydrological site conditions, stage of stand development) and by present and past human activity (forestry, agro-forestry, grazing). In Europe at high latitudes, altitudes, or under certain ecological limiting conditions (peatland, poor soils) single-species, mainly coniferous, forests naturally dominate. In the boreal forest zone, mixed forests are associated only with the early stages of stand development or to rich soils, whereas they are naturally more frequent in central and southern Europe, in broadleaved deciduous and in mixed evergreen forest zones (Leikola, 1999).

Within a given forest biome the edaphic variation, from poor to rich soils, and hydrological site conditions — from wet to dry soils — are further key factors explaining the variation in tree species composition. The presence of species mixtures alone does not indicate a higher naturalness of a forest, the rationale behind the MCPFE indicator 4.1 is not to assess if the number of tree species is good, bad, adequate or only 70 % of what it should be naturally. Rather, it is to evaluate the progress made by forest management in each country, in improving the quality of managed forests by favouring the natural establishment of tree species mixtures. The success of forest management in creating these transformations depends on careful silvicultural measures and on the location; it can be soundly reported only by a forest type classification more detailed than the simplistic subdivision into broadleaved, coniferous, and mixed broadleaved and coniferous forests.

Accordingly, the MCPFE reporting requires a forest types categorisation more soundly ecologically framed than the three broad species groups adopted so far (see Chapter 4).

The forest type classification covers currently only forest area as defined in MCPFE; much work has yet to be done on the other wooded land forest type categorisation.

2 The diversity of European forests

2.1 Natural determinants

The variety of European forests can not be fully understood without reference to the natural history of the European continent. The diversity of European forest flora and vegetation reflects the stratification of (paleo) climates of the last two million years. The Quaternary glaciations, notably, caused massive regional extinctions of forest communities, with special regard to thermophilous and temperate species, which only survived in locally favourable refuge areas, primarily located in southern and south-eastern Europe (Petit *et al.*, 2002). Geographical barriers like the Mediterranean sea and the west-east oriented European mountain ranges (Alps, Pyrenees) had strongly limited the latitudinal migration of taxa during glaciations, resulting in less and less species recolonising north-west and central Europe during inter-glacial periods. For these reasons the European continent is relatively species-poor when compared with equivalent regions of North America and Asia. The thermophilous species are relatively few and only temperate species (*Betula, Alnus, Pinus, Picea, Ulmus, Quercus, Tilia, Corylus*) took part in the post-glacial recovery of forest species in northern and central Europe (Ozenda, 1994); this process started after the regression of the ice-cap at the end of Holocene, approximately 10 000 years ago, and conditioned by climatic and soil factors.

The location and flora of glacial refugia is a fundamental key for understanding the composition and geographical distribution of present forest communities (Pons, 1984). The highest concentration of plant diversity and endemisms is still found today in refugia like islands and mountain chains with high topographic variations (EEA, 2006). On the whole, the glaciations have left a considerable footprint on northern Europe, central Europe and the mountain regions, leading to a floristic north-south gradient that is still very characteristic today (European Commission, 2003).

Boreal coniferous forests are the youngest European forests, which took shape only some 6 000 BP (Huntley and Prentice, 1993). Southern Europe's forests are much older and much less influenced by the glaciations, some of them retaining even relics of Tertiary flora (e.g. *Juniperus thurifera, Rhododendron ponticum, Pinus peuce,*

Aesculus hippocastanus). The long forest history and the presence of many glacial refugia explain the high species richness and diversity of floristic associations of southern European forests, hosting about 2/3 of the species of European forest flora (Ozenda, 1994). Further floristic variability is to be found in Europe along the west-eastern gradient from oceanic to continental influences, associated with a decrease in species richness and forest vegetation types (European Commission, 2003).

A portrayal of the distribution and diversity of European forests is presented in the Map of Natural Vegetation in Europe (Bohn *et al.*, 2000). Changes in climate zones and ecological site conditions (edaphic and hydrological) across Europe determine different potential natural forest (climax) communities: nine forest-dominated formations and 48 potential forest vegetation types are identified (Maps 2.1 and 2.2). As depicted on the map, without human influence most of Europe would be covered by forest. The historical and present impact of human activity on the distribution and physiognomy of European forest vegetation is not taken into account when elaborating this map.

2.2 The anthropogenic footprint

Anthropogenic disturbances (grazing, burning and forest clearing to conquer space for agriculture) started to interfere with forest ecosystems in Europe during the Neolithic age. The first extensive deforestation and intensive wood exploitation was connected with the introduction of agriculture in Greece, approximately 6 000 BC. From Greece agriculture spread slowly but steadily northwards: as early as 5 000–5 500 BC, cultivation and animal husbandry occurred in a wide zone extending from the Ukraine to France. By 4 000 BC agriculture had reached Scandinavia (Halkka and Lappalainen, 2001).

Since that time the condition of European forests has been strictly tied with the socio-economic development (Perlin, 1991). Human impact on forests varied in intensity, in space and time: historical and paleo-ecological records show periods of increased logging, but also periods of landscape abandonment and forest regrowth, such us the plague years of the 1300s (EEA, 2006).

Map 2.1   Natural vegetation of Europe, Level I — formations

Natural vegetation of Europe, formations

- Glacier
- Polar deserts and subnival vegetation of high mountains
- Tundras and alpine vegetation
- Subarctic boreal and nemoral-montane woodlands and subalpine vegetation
- Mesophytic and hygromesophytic coniferous and broadleaved-coniferous forests
- Atlantic dwarf shrub heaths
- Mesophytic deciduous broadleaved and coniferous-broadleaved forests
- Thermophilous mixed deciduous broad-leaved forests
- Mediterranean sclerophyllous forests and scrub
- Xerophytic coniferous forests and scrub
- Forests steppes
- Steppes
- Oroxerophytic vegetation
- Deserts
- Coastal and inland halophytic vegetation
- Reed and sedge swamps
- Mires
- Swamp and fen forests
- Vegetation of flood-plains and estuaries
- Outside data coverage

Source: Bohn *et al.*, 2000.

Map 2.2   Natural vegetation of Europe, Level II — potential natural vegetation
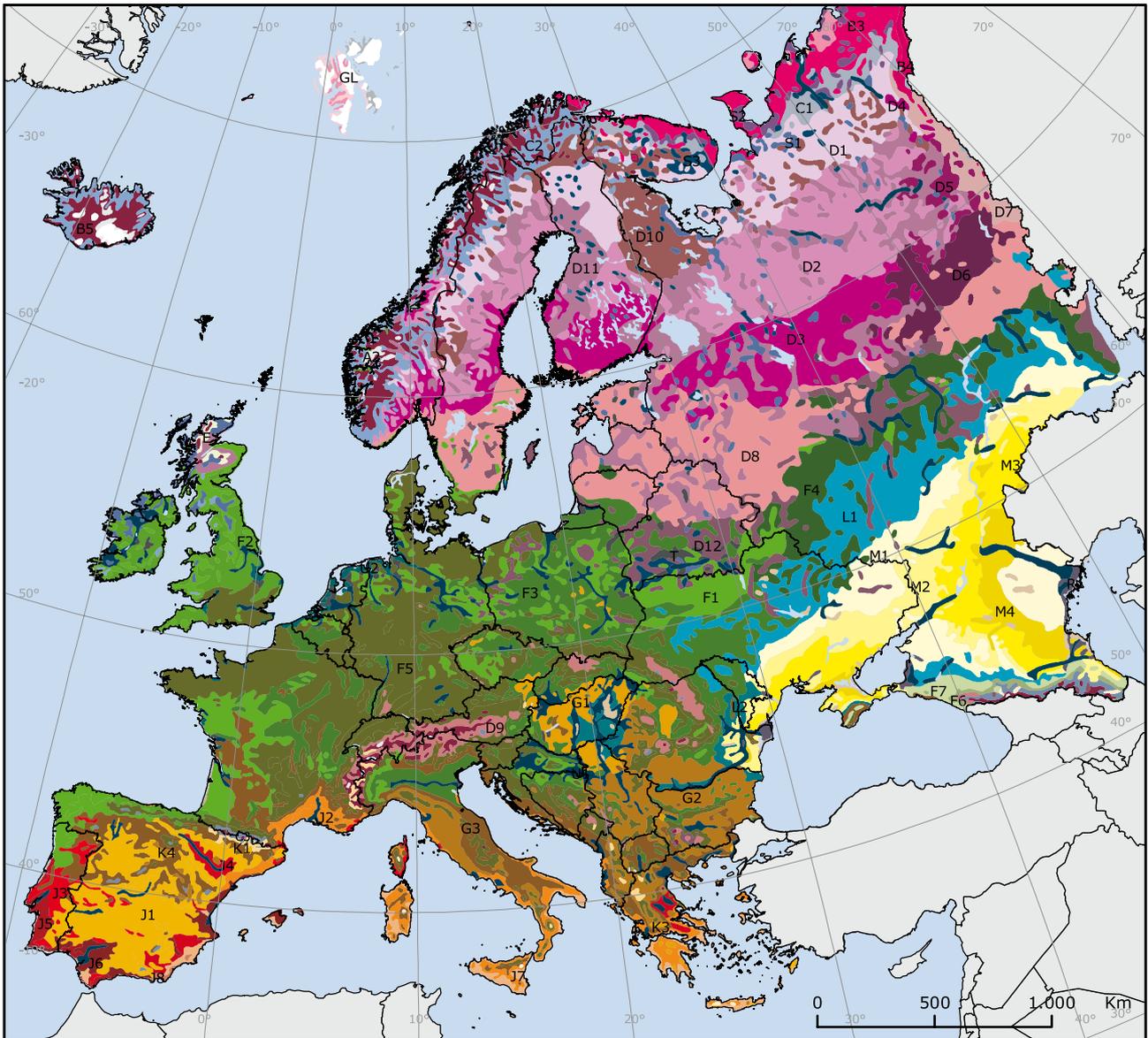
Natural vegetation of Europe, Potential Natural Vegetation types
(labels displayed on the map)

Outside data coverage

Source: Bohn *et al.*, 2000.

Until the late 1700s, European forests were seen as inexhaustible sources of wood, fodder and energy, and thus were logged without basic regards for sustainable yield (European Commission, 2003). In the late 1700s, the imminent threat of a timber shortage created a general concern in many European countries about forest condition. European countries started to issue forestry legislation aimed at the protection and expansion of forest resources. The need to conserve the forest, to halt its exploitation and regulate its use in order to obtain an annual income led to the birth of forestry schools in Europe and of regulated silviculture, based on clear felling or on the uniform shelterwood system (Ciancio and Nocentini, 1997).

The spread of a uniform forest science and related cultivation methods have considerably shaped Europe's forests. Old cultivation practices like coppicing or agro-forestry systems did persist in mountain and rural regions of southern Europe, and can still be found today. However, in central Europe and the lowlands of Alpine Europe much of the 'low quality' broadleaved forests were replaced by large coniferous reforestations during the 1700s and 1800s; on richer soils oak and beech were replaced by spruce, whereas on poor land Scots pine were planted (Ozenda, 1994). Uneven-aged forest structure became even-aged homogeneous and uniform. Other large afforestations were carried out in central Europe on areas that were devastated or that had been logged during or shortly after the First and Second World Wars; in the same period many national reforestation programmes were carried out in southern European countries to recover degraded lands and protect soil from erosion.

Most of the recent afforestations in the European Union have been carried out, often with exotic species, on abandoned agricultural land as part of the set-aside strategy of the EU common agricultural policy (1 million hectares since 1991).

Summarising, the main impacts of human influence on European forests are (European Commission, 2003):

- forest area loss and fragmentation, a phenomenon that is evident when comparing the spatial distribution of potential and current forest vegetation (see Chapter 3);

- harvesting of trees before their physiological maturity and potential age, resulting in a decrease deadwood habitats and of associated species;

- modification of forest stands by silviculture, in term of tree species composition (and selection of provenances), standing volume of forest growing stock, distribution of age classes and rotation periods, regeneration measures, suppression of disturbances like fires or pests;

- establishment of forest structures that do not occur naturally, such as fruit-orchards, coppice and agro-forestry systems, etc., often leading to the development of associated biodiversity linked to continued human interference in natural succession processes;

- establishment of forest plantations with native or not site-native species;

and, as a result (Puumalainen, 2001):

- European forests are dominated by relatively young even-aged stands of few tree species; the largest forest areas are found in age classes 20-40 and 40–60 years.

From the above, it can be concluded that the 'naturalness' and diversity of European forests has been influenced by human activities for a very long time. 'Undisturbed' forests represent today the 27 % of total European forest area (the largest forest area found in eastern and northern Europe, Russia mainly), whereas 'semi-natural' forests account for the 70 % of total European forest area (MCPFE, 2003; see Box 2.1).

During the past 25 years, the conservation and enhancement of biological diversity has become a critical issue of forest management. The so-called nature-oriented silviculture is currently the main trend of European forestry: it is based on somewhat less intensive management methods favouring retention trees and decaying wood, the establishment of natural tree species and species mixtures and the protection of small key biotopes.

In conclusion, if the natural and anthropogenic factors affecting forest composition and structure are put together in a matrix-like grid of crossing influences, depending on level of detail, this analysis could result in an infinite number of possible situations. This explains the complex pattern of variation across Europe in the values reported as regards MCPFE indicators (e.g. tree species composition, tree size distribution, dead wood levels and naturalness). The European forest types presented in Chapters 4–6 are intended to frame this variability within units having similar ecological conditions and levels of anthropogenic modifications.

Box 2.1 — Undisturbed, semi-natural and plantation forest

The degree of forest naturalness is assessed under the MCPFE indicator 4.3 according to three categories :

Undisturbed by man

Forest which shows 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 (MCPFE 2003, from TBFRA 2000).

Semi-natural forest

Forest which is neither 'forest/other wooded land undisturbed by man' nor 'plantation' as defined separately (MCPFE 2003, from TBFRA 2000).

Plantation

Forest stands established by planting or/and seeding in the process of afforestation or reforestation. They are either:

   · of introduced species (all planted stands), or

   · intensively managed stands of indigenous species which meet all the following criteria: one or two species at plantation, even age class, regular spacing.

Excludes: stands which were established as plantations but which have been without intensive management for a significant period of time. These should be considered semi natural (TBFRA 2000).

Due to the above definitions, semi-natural forests include a large share of European forests; the rather imprecise formulation of the term semi-natural, justified mainly by inventory and statistical purposes, covers all forests that are more or less natural or resemble such forests enough to make it difficult to tell the difference (Buchwald, 2005). These are man-modified forest communities of native species shaped by silviculture (or agro-forestry). Accordingly, some stands features are quite different from an undisturbed condition (e.g. even aged structure with low number of decaying trees vs. varied age structure including old growth stands; low deadwood levels vs. considerable amount of dead wood in the form of snags, stumps and logs).

Confusion results also from the interpretation of the term plantation; especially the exclusion of 'stands, which were established as plantation but which have been without intensive management for a significant period of time', had produced different interpretations in European countries.

Box 2.1 — Undisturbed, semi-natural and plantation forest (cont.)

It is important to pinpoint some issues concerning the assessment of plantation forest within MCPFE and the Global Forest Resources Assessment 2005 (FRA2005):

- a plantation forest is a sub-set of planted forest (sensu FAO, 2004); planted forest includes all stands established through planting or seeding, of both native and introduced species;

- there is a difference in the afforestation/reforestation definition between MCPFE/FRA2005 (cf. FAO, 2004) and the Kyoto Protocol:

	MCPFE/FRA2005	**Kyoto Protocol**
Afforestation	Establishment of forest plantations on land that, until then, was not classified as forest. Implies a transformation from non-forest to forest.	Direct human-induced conversion of land that has not been forested for a period of at least 50 years to forested land through planting, seeding and/or the human-induced promotion of natural seed sources.
Reforestation	Establishment of forest plantations on temporarily unstocked lands that are considered as forest.	Direct human-induced conversion of non-forested land to forested land through planting, seeding and/or human-induced promotion of natural seed sources, on land that was forested but that has been converted to non-forest land.
		(For the first commitment period, reforestation activities will be limited to reforestation occurring on those lands that did not contain forest on 31 December 1989).

In the Kyoto Protocol, hence, both afforestation and reforestation imply a transformation from non-forest to forest and the duration of absence of forest cover is specified; this means, for example, an easier monitoring of afforestation/reforestation by remote sensing.

- plantations are planted forests that are under active intensive management; in order to make more clear-cut the distinction of intensively managed stands the MCPFE/FRA2005 definition adopts the three contextual proxy variables: one or two species at plantation, even age class, regular spacing.

Further significant impediments to a correct assessment of plantation forests in Europe are unreliable country data on areas of planted forests by species, purpose, age class distribution and intensity of management.

3 Current and potential forest vegetation in Europe: an assessment

The present chapter will highlight the historical and present effects of the anthropogenic footprint on forest physiognomy, through a cross-analysis of potential and current forest vegetation maps. To this end, detailed statistics on the current extent and physiognomy of European forests by potential forest types by are presented. This will provide updated quantitative information on the major differences between current and potential forest vegetation in Europe.

3.1 Forest cover maps

Forests cover currently ca 30 % of the European land area (EEA, 2006). Maps of the current distribution of European forests are available through different projects like the Corine land cover, the Global land cover 2000 (GLC2000) and 'Forest tree groupings database of the EU-15 and pan-European area derived from NOAA-AVHRR data' (EU-JRC contract No. 17223-2000-12 FISC ISP FI).

For the scope of the present report, the products of the latter two projects have been used for a cross-analysis of current and potential forest vegetation in Europe (see Chapter 3.2).

The GLC 2000 map was produced by the EC-Joint Research Centre Global Vegetation Monitoring Unit in collaboration with a network of partners around the world. The general objective was to provide for the year 2000 a harmonised land cover database over the whole globe, based on FAO Land Cover Classification System (LCCS) and elaborated from 1-km resolution satellite imagery of the SPOT-4 VEGETATION (http://www-gvm.jrc.it/glc2000/ — accessed 08/09/06).

To cover the pan-European forest area a grid has been created based on two GLC2000 windows, namely the 'central and southern European' window and the 'Northern Eurasia'; in the overlapping area of the two windows, the pixels values of the 'central and southern European' window were kept. The

mosaicked raster maps of the actual forest cover in Europe are showed in Maps 3.1 and 3.2.

Raster datasets 1-km resolution of the estimated proportion of land area covered by broadleaf or coniferous forests (Maps 3.3 and 3.4) have been elaborated within the project 'Forest tree groupings database of the EU-15 and pan-European area derived from NOAA-AVHRR data', by a consortium including the University of Joensuu, VTT Information Technology and the European Forest Institute for the Joint Research Centre of the European Commission (http://www2.efi.fi/projects/euromap/phase2/ — accessed 08/09/2006).

In Table 3.1 is reported the mean of the values of estimated coniferous and broadleaved forest proportion of land area (cf. Maps 3.3 and 3.4) for different GLC2000 forest classes (cf. Map 3.2); these figures confirm the differences between northern Europe and central and southern Europe in the character of mixed coniferous and broadleaved forest (cf. Chapter 1.2); for instance, the mixed needleaved and broadleaved forest of central and southern Europe show a relatively even proportion of the mean values of coniferous and broadleaved forest, whereas the mixed forest of northern Eurasia seems richer in coniferous species; in northern Eurasia are found instead conifer forests more or less enriched with broadleaved species (needle-leaf/broadleaf forest, broadleaf/needle-leaf forest); these kind of mixtures is likely due to the presence of the hemi-boreal forest zone; in the boreal coniferous forest zone mix of conifers with broadleaved secondary species (especially birch) originates frequently from silviculture, with the aim of conserving site and stand productivity and its environmental value (Kuusela, 1994).

Surprisingly, even the deciduous broadleaved forest of northern Eurasia is relatively rich in coniferous species, showing mean values similar to the mixed needleaved and broadleaved forest of central and southern Europe.

Map 3.1   Global land cover (GLC) 2000 database

Global land cover 2000

- Forest land
- Shrubland
- Agricultural land
- Grassland
- Steppe
- Bogs; marches; wetland, riparian vegetation
- Tundra
- Bare soil and sparsely vegetated areas
- Urban
- Burnt area
- Water bodies
- Snow and ice
- Outside data coverage
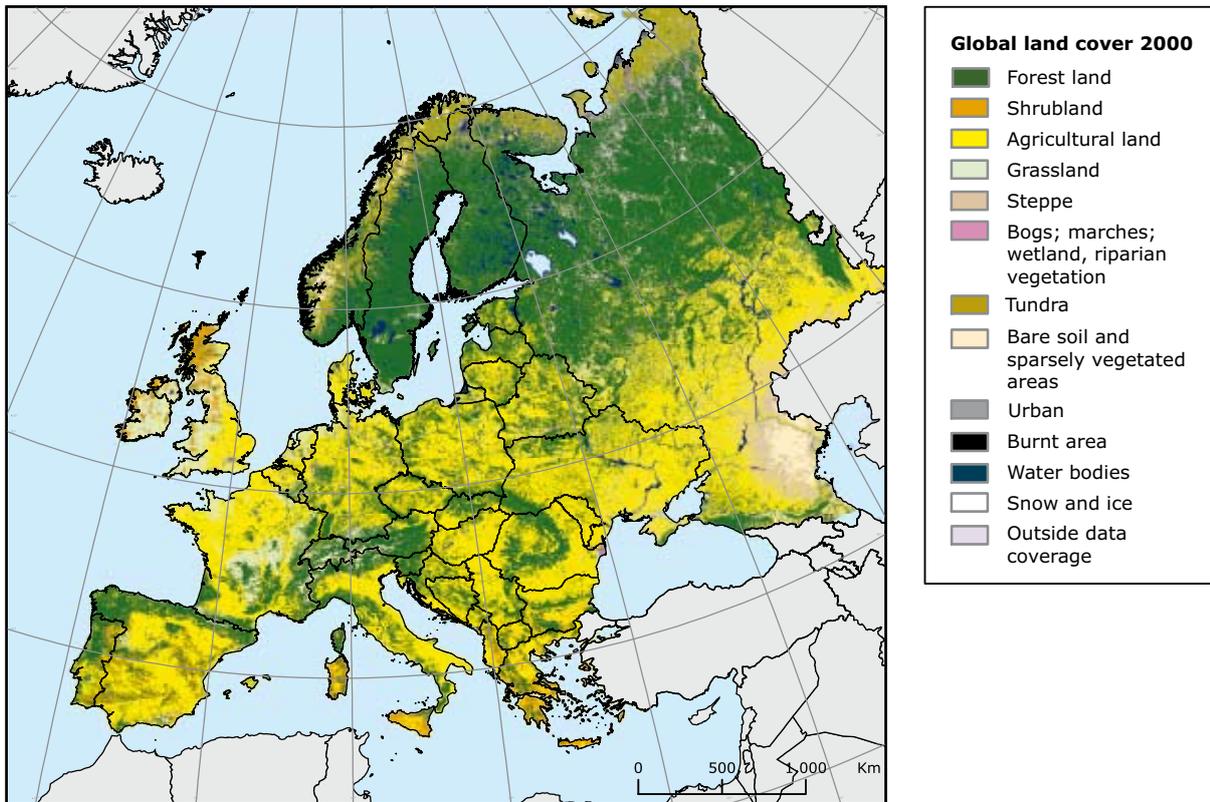
Source: European Commission, Joint Research Centre (JRC), 2003. http://www-gvm.jrc.it/glc2000/. GLC detail by broad land cover categories.

3.2   Cross-analysis of forest vegetation maps

Digital overlays of the GLC2000 dataset and the map of natural vegetation of Europe (Map 2.2) were undertaken and statistics produced to provide relevant information on the current extent and physiognomy of European forests by potential forest types. The results are reported in Appendix I and give a figure of how much forest is left within each zone of potential natural vegetation (PNV) type and whether its physiognomy is 'coherent' to natural vegetation.

The anthropogenic footprint of European forest is clearly reflected by the rate of forest left per natural forest formation. The forest formations that appear to have suffered the greatest proportional loss are those of Mediterranean region (formation codes: G, J, K). In these forest zones — corresponding to

areas with the oldest human settlement — current forest area ranges from the 10–50 %; the highest rates of forest cover are found in boreal forest zones (D1–D7), with values higher that 80 %, while some hemi-boreal forest zones have undergone more intense change (D11b, D12a). In the mesophytic deciduous forest zone of central Europe, types with lowest rate of forest left are mixed oak-ash forest (F2, 10 %), oak-hornbeam forests (F3, 21 %) and acidophylous oakwoods (F1a, 37 %).

Another interesting element emerging from the cross-analysis is the marked change in the natural physiognomy of some forest zones. Several PNVs characterised by a natural dominance of broadleaved species or by mixed forest are currently largely covered by coniferous forests. Most of this 'replacement' forest vegetation likely originates from the historical and present reforestation and afforestation activities mentioned in Chapter 2.2.

Map 3.2   Global land cover (GLC) 2000 database
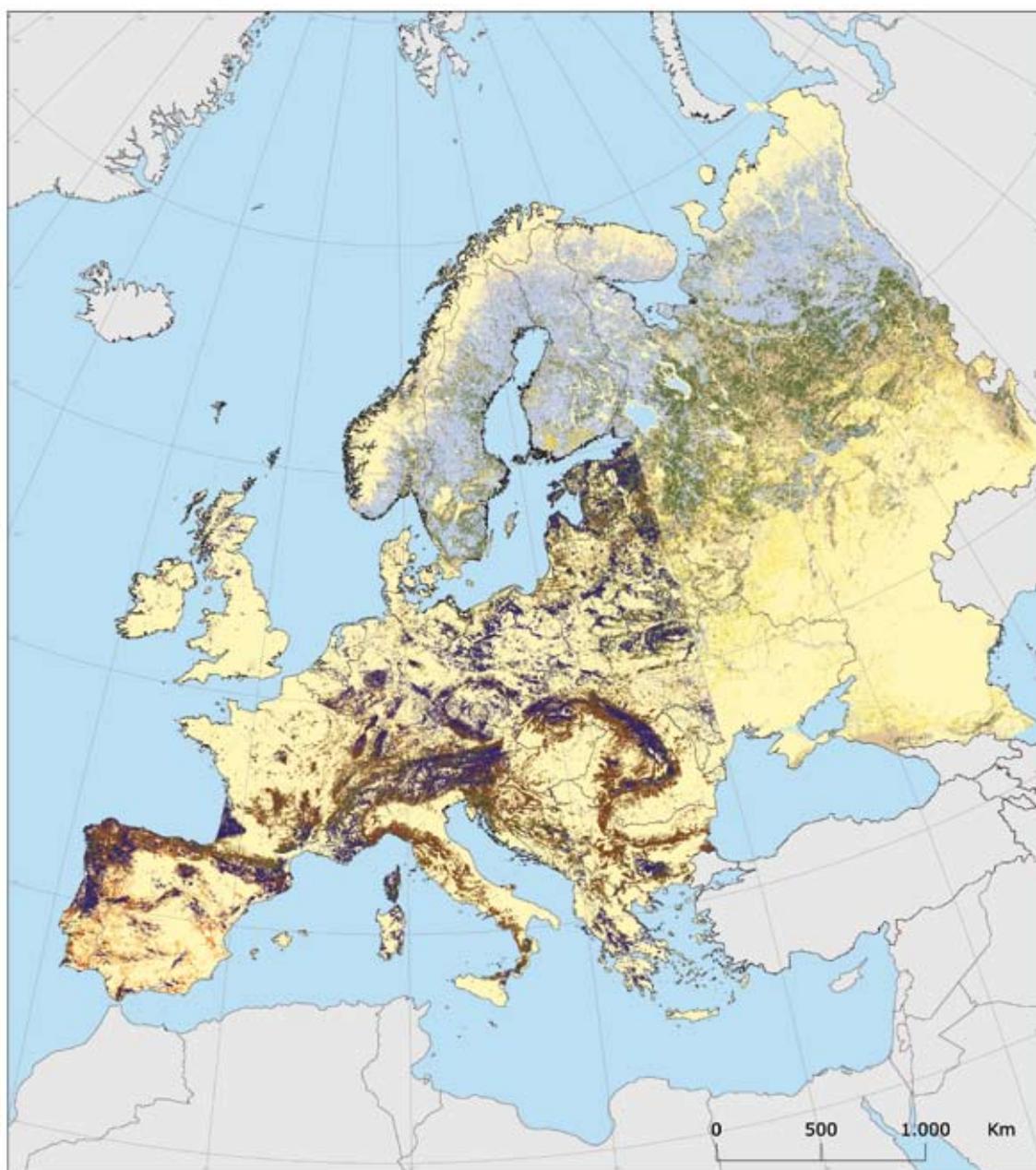
**Global Land Cover 2000
Forest types**

- Open evergreen needleaved forest
- Closed evergreen needleaved forest
- Deciduous needleaved forest
- Closed deciduous broadleaved forest
- Open deciduous broadleaved forest
- Mixed leaf type forest
- Mixed closed forest and shrubland
- Forest-natural vegetation complexes
- Forest-cropland complexes
- Other land uses
- Outside data coverage

Source: European Commission, Joint Research Centre (JRC), 2003. http://www-gvm.jrc.it/glc2000/. GLC detail by forest types.

Map 3.3   Broadleaf forest map of Europe
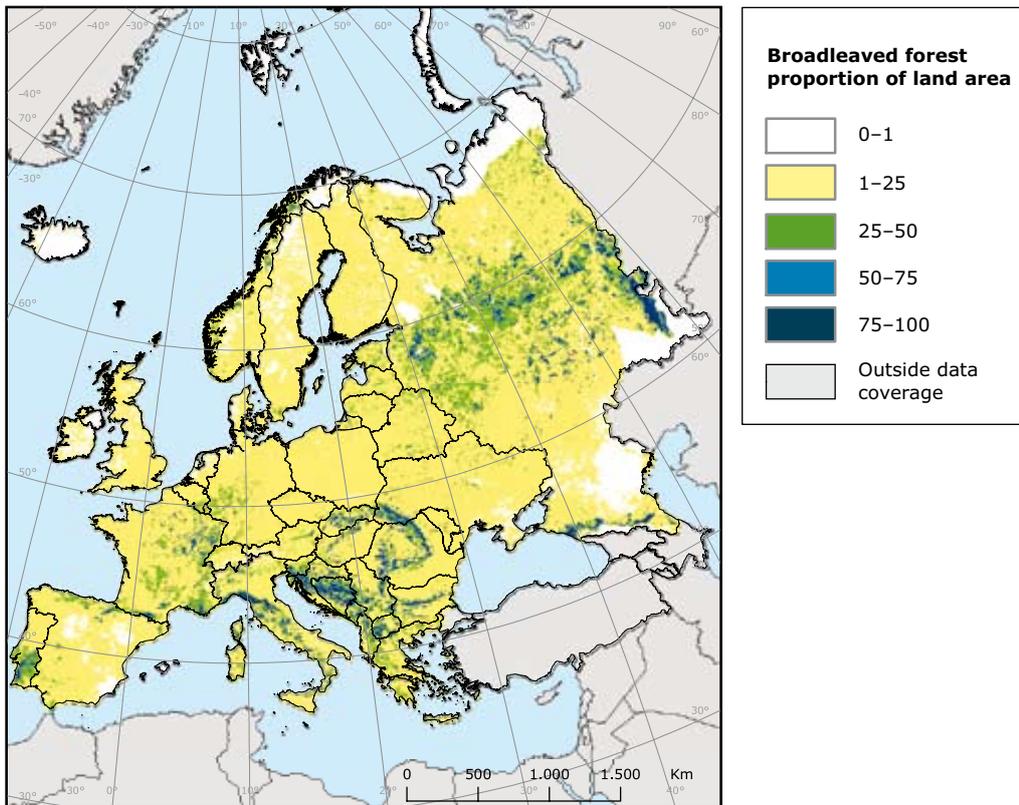
Source: European Forest Institute (EFI), 2005.

Map 3.4   Coniferous forest map of Europe
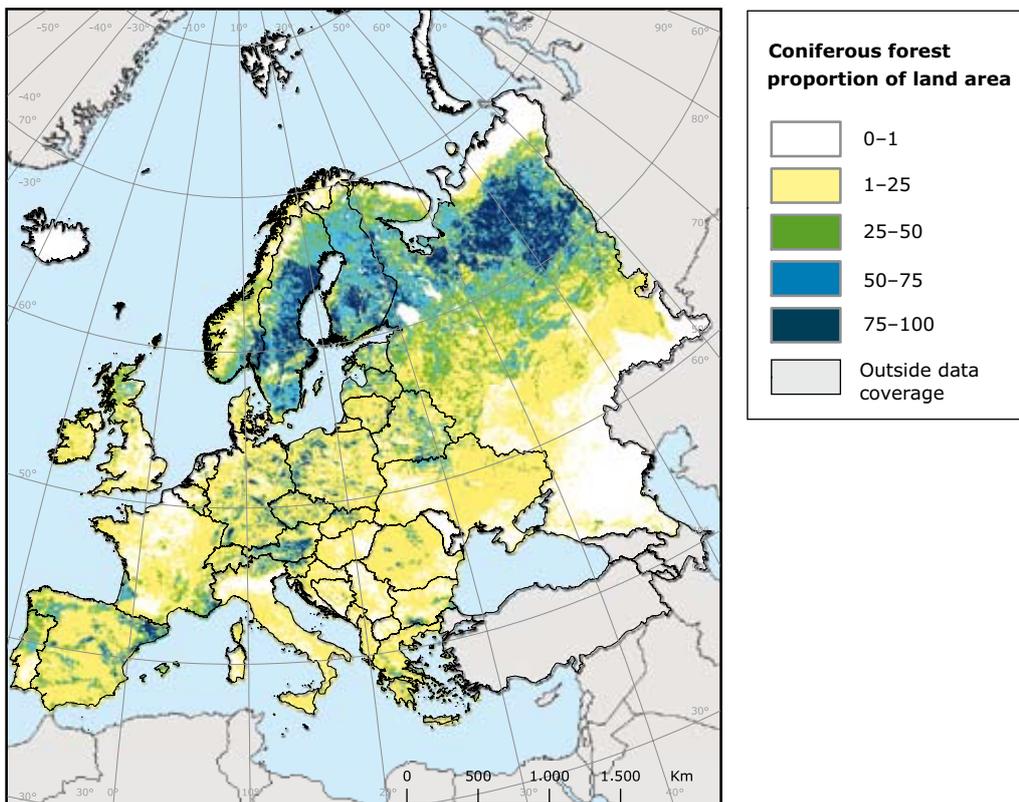
Source: European Forest Institute (EFI), 2005.

Table 3.1   Zonal statistics (mean) of coniferous and broadleaved forest proportion of land area by GLC2000 forest zones

Original GLC 2000 window	GLC2000 forest zone	Ratio of coniferous forest proportion per GLC forest zone (Mean value)	Ratio of broadleaf forest proportion per GLC forest zone (Mean value)
NE	Evergreen needle-leaf forest	48.6	7.3
NE	Deciduous needle-leaf Forest	2.9	0.7
NE	Deciduous broadleaf Forest	21.3	26.2
NE	Broadleaf/needle-leaf Forest	37.5	22.5
NE	Needle-leaf/broadleaf Forest	39.7	11.6
NE	Mixed forest	36.7	12.7
NE	Forest — natural vegetation complexes	20.7	7.5
NE	Forest — cropland complexes	12.8	14.3
CE&SE	Closed evergreen needleaved forest	45.5	13.2
CE&SE	Closed deciduous broadleaved forest	13.6	31.8
CE&SE	Mixed needleaved and broadleaved forest	28.9	24.9
CE&SE	Mixed closed forest and shrubland	22.6	12.1

Note: NE = Northern Eurasia;
CE&SE = Central and southern European;
closed forest > 40 % forest cover;
(Compiled from GLC2000 and broadleaf and coniferous forest maps of Europe, see Maps 3.3 and 3.4).

4 European forest types: the classification system

4.1 Limitations of earlier forest classifications

At present, two schemes allow a systematic identification of ecologically distinct forest communities across Europe: the EUNIS Habitat Classification (Davies *et al.*, 2004) and the Overview of Phytosociological Alliances presented by Rodwell *et al.* (2002). These classifications, though soundly scientifically based and widely accepted, have some evident limitations as regards potential use for the MCPFE reporting.

First, both systems have an unfeasible number of classes for the MCPFE reporting issues. The EUNIS system specifies forest habitats by four (un-informative) classes at the second level of the classification and an unworkable number at the third (52) and fourth (more than 700) levels. These forest habitats correspond to 110 *Alliances* in the overview of Rodwell *et al.* (2002); the Alliances do not cover clearly anthropogenic forests, i.e plantations sensu MCPFE indicator 4.3 (MCPFE, 2006).

Second, the forest vegetation types listed in Rodwell *et al.* (2002) are identified on a phytosociological basis, an approach that not is readily accessible to the community of end-users within MCPFE.

Third and most important limitation: the efficiency of these classifications in meeting the needs of MCPFE reporting is questionable; in order to be useful for assessments, the forest typology should reflect, as much as possible, those changes in the character of the forest ecosystem that are primary determinants of variation in MCPFE indicators on a pan-European scale: e.g. changes of ecological forest zones influencing natural tree-species composition, the length of the growing season (i.e. growing stock), decomposition rate and natural disturbance regimes (i.e deadwood type and amount); changes of management regimes, controlling age and density structure, growing stock and dead and dying wood left in the forest.

4.2 European forest types: the classification scheme

4.2.1 Development of the classification

The European forest types originate from a comprehensive review of a proposal conceived for optimising large scale monitoring of forest biodiversity condition in EU-25 countries (Barbati and Marchetti, 2004), a work grounded on the earlier proposal of Forest Types for Biodiversity Assessment in Europe (Larsson *et al.*, 2001).

The process of revision has been based on a in-depth review of descriptions of actual and potential forest vegetation of Europe (Davies *et al.*, 2004; Ozenda, 1994; Bohn *et al.*, 2000) and of European forest regions (e.g. Mayer, 1984; Nordiska Ministerrådet, 1984; Ellenberg, 1996; Köhl and Paivinen, 1996; Esseen *et al.*, 1997; Quezel and Medail, 2003; Costa-Tenorio *et al.*, 2005). The revision was targeted to the following issues:

- to ensure the European forest types being representative and comprehensive of the variety of forest conditions found in the MCPFE countries;

- to ensure the criteria adopted to separate forest types being consistent with the purposes of MCPFE reporting.

The classification in its present form had been developed by a project consortium including experts drawn from different biogeographic regions. A first release of the classification was circulated in Spring 2006 through the COST Action E43 (http://www.metla.fi/eu/cost/e43/ — accessed 08/09/2006) amongst correspondents of National forest inventories (NFIs) of 20 European Countries. The correspondents were asked to indicate limitations/omissions of the proposed European forest types for the stratification of NFIs ground plots. Amendments were made in response to the comments received.

A further revision of the scheme was made in September 2006, in response to comments to the classification received from the Eionet Primary Contact Points (PCPs) and National Reference Centres (NRCs) for Nature Protection and Biodiversity; comments concerned, in particular, the use of the proposed forest categories and types in assessments and planning at international and national levels related to biodiversity issues.

In addition, two external tests on the operationality of European forest types were carried out in the framework of the Forest Focus projects, Forest Biota (http://www.forestbiota.org/ — accessed 08/09/2006) and Forest BioSoil (http://inforest.jrc.it/activities/ForestFocus/biosoil.html — accessed 08/09/2006), both concerned with the operational assessment of forest biodiversity indicators on ICP-Level I and ICP Level II plots, respectively (ICP — International Co-operative Programme on Assessment and Monitoring of Air Pollution Effects on Forests; http://www.icp-forests.org/ — accessed 08/09/2006). The classification was successfully applied to stratify

ICP plots in order to optimise the reporting of biodiversity indicators.

4.2.2 Classification structure

The European forest types are organised according to a hierarchical classification system (Figure 4.1, Table 4.1) structured into 14 first level classes (categories) and 75 second level classes (types). The classification applies only to forest land as defined in FAO (2004) and growing in MCPFE countries (Figure 1.1). Other wooded lands are not presently covered by the European forest types.

The forest typology is provided with a *classification key* (see Chapter 5) and a nomenclature (see Chapter 6) allowing a systematic identification and characterisation of categories and types throughout Europe. Types are also related to EUNIS III level classes and to the Annex I of the EU Habitats Directive (92/43/EEC).

Figure 4.1 Hierarchical structure of the European forest types classification
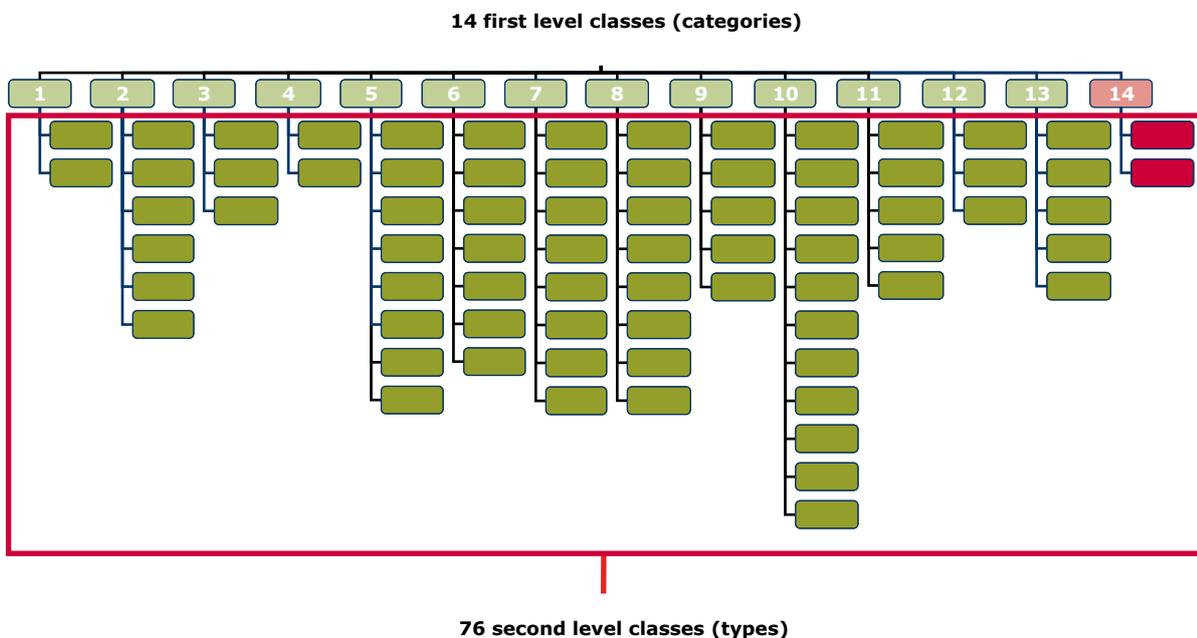
Table 4.1   European forest types classes

Categories	Types
1. Boreal forest	1.1 Spruce and spruce-birch boreal forest 1.2 Pine and pine-birch boreal forest
2. Hemiboreal forest and nemoral coniferous and mixed broadleaved-coniferous forest	2.1 Hemiboreal forest 2.2 Nemoral Scots pine forest 2.3 Nemoral spruce forest 2.4 Nemoral Black pine forest 2.5 Mixed Scots pine-birch forest 2.6 Mixed Scots pine-pedunculate oak forest
3. Alpine coniferous forest	3.1 Subalpine larch-arolla pine and dwarf pine forest 3.2 Subalpine and mountainous spruce and mountainous mixed spruce-silver fir forest 3.3 Alpine Scots pine and Black pine forest
4. Acidophilous oak and oak-birch forest	4.1 Acidophilous oakwood 4.2 Oak-birch forest
5. Mesophytic deciduous forest	5.1 Pedunculate oak–hornbeam forest 5.2 Sessile oak–hornbeam forest 5.3 Ashwood and oak-ash forest 5.4 Maple-oak forest 5.5 Lime-oak forest 5.6 Maple-lime forest 5.7 Lime forest 5.8 Ravine and slope forest 5.9 Other mesophytic deciduous forests
6. Beech forest	6.1 Lowland beech forest of southern Scandinavia and north central Europe 6.2 Atlantic and subatlantic lowland beech forest 6.3 Subatlantic submountainous beech forest 6.4 Central European submountainous beech forest 6.5 Carpathian submountainous beech forest 6.6 Illyrian submountainous beech forest 6.7 Moesian submountainous beech forest
7. Mountainous beech forest	7.1 South western European mountainous beech forest (Cantabrians, Pyrenees, central Massif, south western Alps) 7.2 Central European mountainous beech forest 7.3 Apennine-Corsican mountainous beech forest 7.4 Illyrian mountainous beech forest 7.5 Carpathian mountainous beech forest 7.6 Moesian mountainous beech forest 7.7 Crimean mountainous beech forest 7.8 Oriental beech and hornbeam-oriental beech forest
8. Thermophilous deciduous forest	8.1 Downy oak forest 8.2 Turkey oak, Hungarian oak and Sessile oak forest 8.3 Pyrenean oak forest 8.4 Portuguese oak and Mirbeck's oak Iberian forest 8.5 Macedonian oak forest 8.6 Valonia oak forest 8.7 Chestnut forest 8.8 Other thermophilous deciduous forests
9. Broadleaved evergreen forest	9.1 Mediterranean evergreen oak forest 9.2 Olive-carob forest 9.3 Palm groves 9.4 Macaronesian laurisilva 9.5 Other sclerophlyllous forests
10. Coniferous forests of the Mediterranean, Anatolian and Macaronesian regions	10.1 Mediterranean pine forest 10.2 Mediterranean and Anatolian Black pine forest 10.3 Canarian pine forest 10.4 Mediterranean and Anatolian Scots pine forest 10.5 Alti-Mediterranean pine forest 10.6 Mediterranean and Anatolian fir forest 10.7 Juniper forest 10.8 Cypress forest 10.9 Cedar forest 10.10 *Tetraclinis articulata* stands 10.11 Mediterranean yew stands

Categories	Types
11. Mire and swamp forest	11.1 Conifer dominated or mixed mire forest 11.2 Alder swamp forest 11.3 Birch swamp forest 11.4 Pedunculate oak swamp forest 11.5 Aspen swamp forest
12. Floodplain forest	12.1 Riparian forest 12.2 Fluvial forest 12.3 Mediterranean and Macaronesian riparian forest
13. Non riverine alder, birch, or aspen forest	13.1 Alder forest 13.2 Italian alder forest 13.3 Boreal birch forest 13.4 Southern boreal birch forest 13.5 Aspen forest
14. Plantations and self sown exotic forest	14.1 Plantations of site-native species 14.2 Plantations of not-site-native species and self-sown exotic forest

4.3 Criteria of the classification

The conceptual basis of for the differentiation of the European forest types is the key factor approach (see previous Box 2.1). The arrangement of categories and types within the hierarchy follows the principle of increasing similarity in the natural and anthropogenic conditions affecting the values taken by five selected forest type based MCPFE indicators: naturalness, number of forest occurring species, growing stock, age/diameter distribution, deadwood amount.

The *category* level is conceived to identify and reflect on a pan-European scale the most significant breaking points in the *continuum* of the natural and anthropogenic sources of variation of the indicators above. In other words, *categories* are defined by a unique interplay of forest ecological conditions and anthropogenic influences that 'drive' the MCPFE indicators variation along a characteristic pattern; a pattern that distinguish each category from the others. In such a perspective, categories can be recommended as suitable MCPFE reporting classes.

Below are clarified the most important breaking points behind the differentiation of categories; further details are provided with the nomenclature (Chapter 6, Table 6.1).

A fundamental breaking point is when human action changes the existing/spontaneous vegetation of a site to an artificial stock of trees, by establishing *plantation forests* (see Box 2.1). This sharp change in *naturalness* entails other important features :

- simplification of forest structure, because plantations forest basically consist of even-aged, often monospecific stands, established with regularly spaced trees;

- relevant modification of site genetic variety of the locality, as the genetic variability of the plantation is usually lower and different from that of spontaneous vegetation;

- relevant modification in site species composition, when the native vegetation is replaced by forest stands predominantly consisting of non-native (or *non-indigenous, exotic, introduced*) trees, e.g. *Robinia, Eucalyptus, Picea sitchensis, Pinus contorta, Pseudotsuga menziesii*. Some of these species have become capable of establishing a breeding population without further intervention by humans, spreading at an undesirable scale (*invasive species*); examples are *exotic self-sown forests of Robinia pseudocacia, Ailanthus altissima, Prunus serotina*, that had replaced or seriously suppressed the native forest vegetation in various areas of Europe. Monitoring the spreading of this kind of ecosystems, also termed *novel ecosystems or emerging ecosystems*, is a relevant global ecological issue

From the above, it derives the need to keep separated forests with extremely low degree of naturalness (category 14) from the rest of European forests (categories 1–13). The definition adopted to identify forest plantations is in line with the MCPFE terminology, although to facilitate the assessment of plantation area the Kyoto Protocol definition of afforestation/reforestation could be more appropriate (Box 2.1).

Categories 1–10 and 13 correspond, to groups — of varying breadth — of ecologically distinct forests communities dominated by specific assemblages of native tree species. The forest physiognomy of categories 1–10 is mainly determined by the latitudinal/altitudinal zonation of European vegetation and by inner climatic and edaphic variation therein. Categories 11–12 correspond to azonal forest communities.

Changes in vegetation zones have a significant influence on forest productivity (e.g. different length of the growing season); accordingly, a natural gradient in the average stem volume is found along latitude (MCPFE, 2003). More in general, climatic and edaphic variability can be regarded as the *natural driver* of the pattern of the MCPFE indicators: number of forest occurring species, growing stock, deadwood amount.

In term of naturalness, most of these forests are 'semi-natural' (sensu the MCPFE indicator 4.3). Though for the categories 1–12 can be identified correspondent classes in the map of natural vegetation of Europe (Table 4.2), they may differ significantly on the ground in term of extent, distribution, physiognomy and structure.

Tree species composition, notably, is shaped and maintained by silviculture, which traditionally has favoured species with higher commercial interest; dominant forest trees largely influence the silvicultural systems applied in the forestry (or agro-forestry) tradition of each country (e.g. even/uneven aged high forest, coppice, chestnut orchards, *dehesas* or *montados*). Silvicultural systems strongly affect, in turn, growing stock, tree diameter distribution/age and deadwood levels, as a consequence of wood extraction and rotation length. For instance, typical deadwood volume in European managed forests is 2–50 m^3 ha^{-1} (Humprey *et al.* 2004); the natural levels of deadwood observed in strict forest reserves ('forest undisturbed by man' sensu the MCPFE indicator 4.3) show pronounced differences across different ecological forest zones of Europe, because of site productivity, decomposition rate and disturbance regime (Hahn and Christensen, 2004).

Under category 2 are also included those coniferous 'replacement forests' (cf. Chapter 3.2) of the nemoral zone, that show somewhat natural features: e.g. mixed tree canopy composition,

significant ingrowth of self-sown trees, uneven aged diameter distribution; these kind of structures mostly originate from forest plantations no longer intensively managed for timber and/or of old age and low intensity of forestry. The gradual reconversion of these forests to the originally natural situation is presently regarded a key issue of forest management (conversion forest). The main differences between these semi-natural forests and plantations of native species (category 14) lies mainly on forest management intensity.

The type level is mainly intended to describe and further document the variety and the character of forest communities that each category comprises. Types correspond to a finer level of division of the category in term of tree species composition; in some cases, structural or floristic features vary also significantly amongst forest types.

On the whole, the number of types that each category contains reflects the north-south (boreal to Mediterranean/Anatolian/Macaronesian) and west-east (Atlantic to Continental) gradient in the floristic differentiation of European forests communities (cf. Chapter 2.1). This partially explains why some categories have more types than others and the system might appear unbalanced in this respect.

It could be observed that most European countries have national classification systems that better reflect the variety of forest condition than the types. Nevertheless, these systems are not yet harmonised at European level: waiting for this (unlikely) harmonisation, the types delineated are only indicative and intended as a proposal to bridge the gap between the national level and the pan-European one. Indeed they can be suitably used as an entry-key for the correct assignment of forest stands to the category level.

Considering most compilation of national data on MCPFE indicators uses national forest inventories (NFIs) ground plot information, we recommend the use of types for stratifying NFIs plots and of the fourteen categories for reporting data on MCPFE indicators. In our view, national figures arranged according to the fourteen categories based on the criteria described above will better serve pan-European level MCPFE reporting than any available alternative forest classification.

Table 4.2   Cross-links of the category level with the natural forest vegetation types of Europe

European forest types — category level	Natural vegetation of Europe
1. Boreal forest	C2; D1; D2; D3; D4; D5; D6; D7; D10; D11
2. Hemiboreal forest and nemoral coniferous and mixed broadleaved-coniferous forest	D8; D11; D12
3. Alpine coniferous forest	C3; D9
4. Acidophylous oakwood and oak-birch forest	F1
5. Mesophytic deciduous forest	F2; F3; F4
6. Lowland to submountainous beech forest	F5a
7. Mountainous beech forest	F5b
8. Thermophilous deciduous forest	G1; G2; G3; G4; L1; L2
9. Broadleaved evergreen forest	J1; J2; J3; J4; J5; J6; J7; J8
10. Coniferous forests of the Mediterranean, Anatolian and Macaronesian regions	K1; K2; K3; K4
11. Mire and swamp forest	S3; T1; T2
12. Floodplain forest	U1; U2; U3; U4
13. Non-riverine alder, birch or aspen forest	-
14. Plantations and self-sown exotic forest	-

Source: After Bohn *et al.,* 2000.

5 Key to the classification

Criteria diagrams for categories and types of the European forest types are presented in Appendix II with additional explanatory notes accompanying each 'decision box' (in grey). The notes explain how the decision box is to be applied and form an integral part of the key. The classification key is mainly intended to provide end-users (e.g. MCPFE national correspondents) with classification rules to stratify data sources — mainly ground plots — used to assess MCPFE forest type based indicators according to categories and types. Rules are based on information commonly assessed in a forest inventory, i.e. tree species basal area. In this way, each country can reclassify ground plots according to the European forest types nomenclature and report data on indicators by the categories found in its own territory.

A rough evaluation of the relative frequency of categories for some European countries is available in Table 5.1. The evaluation was carried out testing the classification on ICP-Level I data. The ICP-Level I network consists of approximately 6 000 plots, systematically arranged in nominal grid throughout Europe. On the whole, the ICP Level I plots represent rather well the statistical and spatial distribution of crown canopy trees at European level, but only occasionally at country level (Packalén and Maltamo, 2002). Based on the classification key, the plots were assigned to the European forest types using data on tree species composition and other relevant ecological information on forest site ecological conditions provided by the ICP database. Accordingly, we outlined an overview map of the distribution of European forest types at the category level (Map 5.1). Another possibility to cross-link NFIs data to European forest types is to develop 'label to label' bridging functions; this is applicable and convenient in the European countries having already forest types schemes in place within NFIs to stratify ground plots, provided that such classifications are grounded on same diagnostic criteria as the European forest types (e.g. actual forest vegetation, forest tree species composition, site ecological conditions, etc). In these cases, with the support of European forest nomenclature (see Chapter 6), 'label to label' bridging functions can be established to cross-link national forest types, and associated ground plots, to European level types and categories.

The primary goal of this kind of test is not to provide exact statistics of the relative frequency of the categories at country level. Such information can only be derived from the NFIs data. Rather, it is to give a reasonable idea of the possible increase in the MCPFE reporting burden, which would derive from the application of the proposed categorisation: the number of categories at country level is on average 6 and ranges from 1 to 12. Most European countries included in the test are close to the average.

Table 5.1   Rough estimate of the relative frequency of the categories of the European forest types for some European countries

Country (no of ICP level I plots)	Category (% of the ICP level I plots)														Total Country (%)
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	
Andorra (3)	0	0	100	0	0	0	0	0	0	0	0	0	0	0	100
Austria (136)	0	24	65	0	3	1	6	0	0	0	0	1	0	0	100
Azores (6)	0	0	0	0	0	0	0	0	67	33	0	0	0	0	100
Belarus (405)	8	62	0	0	1	0	0	0	0	0	13	1	14	0	100
Belgium (10)	0	0	0	10	10	0	0	0	0	0	0	0	0	80	100
Bulgaria (103)	0	8	26	0	5	12	7	17	0	17	0	0	0	8	100
Canaries (13)	0	0	0	0	0	0	0	0	38	62	0	0	0	0	100
Croatia (84)	0	1	6	2	15	20	11	14	2	6	0	19	0	2	100
Cyprus (15)	0	0	0	0	0	0	0	0	0	100	0	0	0	0	100
Czech Republic (140)	0	69	1	1	9	4	4	0	0	0	0	1	3	9	100
Denmark (20)	0	0	0	0	10	30	0	0	0	0	0	0	0	60	100
Estonia (92)	7	77	0	0	1	0	0	0	0	0	12	0	3	0	100
Finland (595)	88	3	0	0	0	0	0	0	0	0	4	0	6	0	100
France (511)	0	4	9	6	24	7	5	14	4	10	0	1	2	15	100
Germany (451)	0	51	4	1	8	12	6	0	0	0	0	1	3	14	100
Greece (91)	0	0	0	0	9	2	10	19	16	43	0	0	0	1	100
Hungary (73)	0	5	0	0	21	7	0	19	0	0	0	5	7	36	100
Ireland (19)	0	0	0	0	0	0	0	0	0	0	0	0	0	100	100
Italy (255)	0	0	23	1	2	0	16	40	4	4	0	0	3	6	100
Latvia (95)	19	59	0	0	0	0	0	0	0	0	0	0	22	0	100
Lithuania (63)	5	76	0	0	2	0	0	0	0	0	0	0	17	0	100
Luxembourg (4)	0	25	0	25	25	25	0	0	0	0	0	0	0	0	100
Moldova (10)	0	0	0	0	80	0	0	10	0	0	0	0	0	10	100
Neherlands (11)	0	0	0	9	27	0	0	0	0	0	0	0	0	64	100
Norway (442)	68	4	0	0	0	0	0	0	0	0	0	0	27	0	100
Poland (433)	0	75	5	1	7	2	2	0	0	0	0	1	5	1	100
Portugal (133)	0	0	0	0	1	0	0	4	48	29	0	0	1	18	100
Romania (226)	0	1	16	0	21	22	21	10	0	0	0	0	2	6	100
Russia (134)	20	75	0	0	0	0	0	0	0	0	3	0	1	0	100
Serbia (130)	0	2	1	0	11	23	11	35	0	1	0	5	1	12	100
Slovak Republic (108)	0	5	39	0	16	26	10	1	0	0	0	0	0	4	100
Slovenia (42)	0	12	19	0	2	21	29	5	0	0	0	2	2	7	100
Spain (607)	0	0	3	2	2	0	2	9	26	43	0	0	0	12	100
Sweden (775)	50	39	0	1	1	1	0	0	0	0	0	0	6	1	100
Switzerland (48)	0	15	50	0	8	6	13	6	0	0	0	0	0	2	100
United Kingdom (85)	0	4	0	4	16	14	0	0	0	0	0	1	0	61	100
Total countries (6 368)	**20**	**25**	**6**	**1**	**6**	**5**	**4**	**6**	**4**	**7**	**1**	**1**	**6**	**7**	**100**

Map 5.1   Overview map of the distribution of the European forest types categories, based on ICP level I plot classification

ICP level I plots classification by European forest type, category level

🌲	1	🟢	6	🌲	11
🌲	2	🟢	7	🌸	12
🌲	3	🟡	8	🟠	13
🔴	4	🔴	9	🌲	14
🔵	5	🌲	10	⬜	15
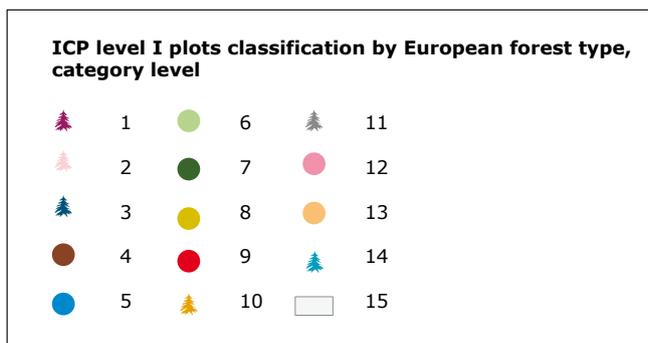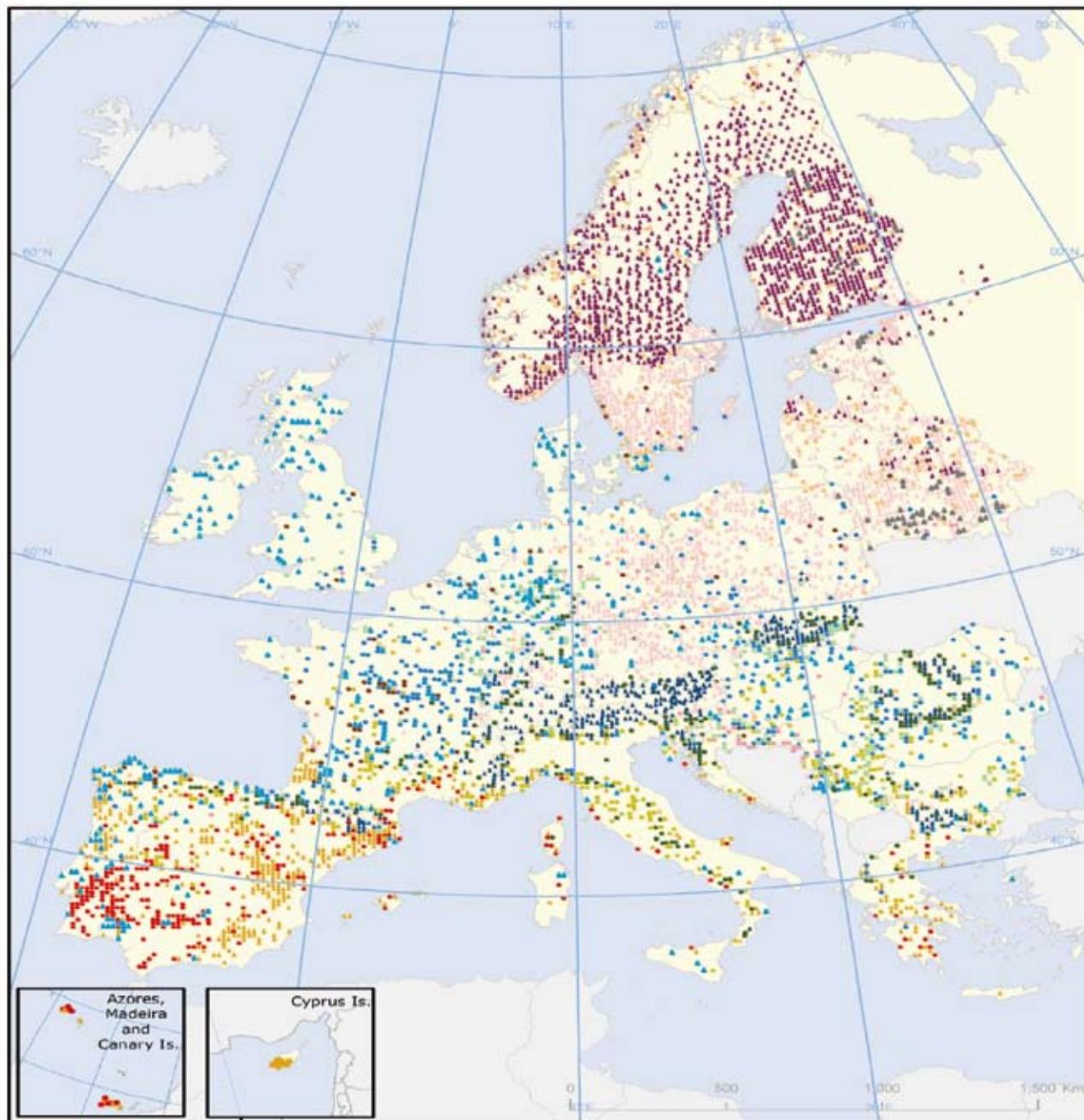
6 European forest types nomenclature: category and types descriptions

The European forest types are provided with a nomenclature, a descriptive frame allowing a comprehensive characterisation of the 14 categories and 76 types.

In the following, the nomenclature is presented, which strictly relates to the classification key (Chapter 5). Categories and types are described and documented using a descriptive frame including:

- **Class definition**: key to the identification of the category; it is a general description of the category in terms of dominant forest species and biogeographical/ecological factors determining its appearance;

- **Geographical distribution**: present distribution of the category in relation to European biogeographical regions or to other relevant environmental references (e.g. soil types, European mountain ranges, bioclimatic zones, etc.);

- **Types**: list and description of the most important forest ecosystems covered by the category;

the descriptions include a delineation of the geographical/ecological distribution of the type, tree species composition and other structural and functional characteristics, including silviculture and past and actual human impact; for selected types (e.g. beech forest types, eastern mesophytic deciduous forest types) type description is more detailed from a floristic point of view, in the case herb layer composition is an additional, but relevant criteria for types discrimination;

- Cross-links with Annex I Habitat Directive and EUNIS Habitat Classification, established at the type level.

Descriptions are integrated with photos to further document the characteristic features of each category.

Table 6.1 below presents a general overview the unique interplay of ecological conditions and anthropogenic influences affecting the variation of the MCPFE forest type based indicators, at the category level.

Table 6.1 Synopsis of the main ecological and anthropogenic determinants of variation of MCPFE forest type based indicators at the category level

1. Boreal forest	The temperature and length of the growing season are the main climatic variables which determine forest productivity in the boreal climate zone. The harsh climatic conditions affect forest composition, dominated by two conifers species (*Picea abies, Pinus sylvestris*) in the late stages of the forest succession; their relative distribution in the boreal climate zone is driven mainly by edaphic conditions. Deciduous trees including birches (*Betula* spp.), aspen (*Populus tremula*), rowan (*Sorbus aucuparia*) and willows (*Salix* spp.) tend to occur as early colonisers of bare ground or in the early stages of forest succession.
	Under natural conditions, forest fires ignited by lightning and repeated with cyclical frequency regulate the dynamic of boreal coniferous forest; nowadays these wildfires have been almost completely prevented by forest management.
	Most of the boreal forest is managed as even-aged forest for commercial forestry; forestry has further increased, during the 20th century, the natural range of conifers in the boreal zone, by favouring conifers over deciduous tree species.
2. Hemiboreal forest and nemoral coniferous and mixed broadleaved-coniferous forest	The category has a double-faced origin: it includes the latitudinal mixed forests located in between the boreal and nemoral forest zones (hemiboreal forest or forest of the boreo-nemoral zone, *sensu* Ozenda, 1994) and anthropogenic coniferous forest in the nemoral zone.
	The light regime and length of the growing season are the main climatic variables controlling forest productivity; these factors differ considerably from the northern to the southern part of the hemiboreal zone.
	Anthropogenic impact has greatly reduced the extent of hemi-boreal forest and altered its original tree species composition. The hemiboreal forest is featured by the coexistence of boreal coniferous species with temperate broadleaved tree species (*Quercus robur, Fraxinus excelsior, Ulmus glabra, Tilia cordata*).
	The structure and composition of hemiboreal forest but also of the nemoral coniferous forests (cf. Chapter 3.2) is affected by a complex interplay of natural and anthropogenic influences.
3. Alpine coniferous forest	This category grows in climatic conditions similar to those of boreal zone, except for the light regime and length of the day. Cold and harsh climate (short growing seasons) characterises the high altitudes of the Alpine region of Europe (cf. Alpine biogeographic region); this determines similar altitudinal vegetation belts, though at differing altitudes, on all alpine mountain ranges. Forest tree species composition vary with the vegetation belts (mountainous/subalpine) and site ecological conditions. In addition to boreal conifers, *Larix deciduas, Pinus cembra, P. nigra* and *P. mugo* are the naturally dominant species. Variation in regeneration patterns and horizontal clustering is also related to vegetation belts.
	Traditional pastoral farming practices, the mainstay of the mountain economy for centuries, have modified the natural distribution of subalpine forests; pasturing, however is now rapidly disappearing under the combined pressure of land abandonment and intensification.
	The management of even-aged stands predominates in the Alpine region; selection cutting management is practised only in small areas of productive forest characterised by mixed forest spruce, fir and beech composition.

Broadleaved deciduous and mixed coniferous-broadleaved forest

Under this heading are included the categories 4–8 growing in the nemoral (or temperate) zone and supra-Mediterranean vegetation belt, covering a large area approximately located between the latitudes 40 °N to 60 °N.

Radiation, light and temperature regimes, oceanic influences (in the west) and continental influences (in the east) determine growing conditions; the temperate climate increases the competitive ability of broadleaved deciduous trees over conifers. The difference between annual precipitation and potential evaporation is, notably, an important factor controlling tree growth. Yields are therefore higher in the western part of the zone, under oceanic influence, than in the south-eastern part where potential evaporation exceeds precipitation.

Soil parent material are varied and richer than in the boreal zone; this larger variability in edaphic conditions and water regimes affect tree species composition and forest growth.

4. Acidophilous oak and oak-birch forest	The category is related to oligotrophic soils of the nemoral forest zone; the tree species composition is poor (1–2 species) and characterised by acidophilous oaks (*Q. robur, Q. petraea*) and birch (*Betula pendula*).
	Oakwoods stocking on poor, acid soils have been managed for a long time for coppice and grazing. Many coppice forests were converted to high forests during the past decades or otherwise abandoned or converted to conifer forest plantations.

Table 6.1   Synopsis of the main ecological and anthropogenic determinants of variation of MCPFE forest type based indicators at the category level (cont.)

5. Mesophytic deciduous forest	The category is related to meso- and eutrophic soils of the nemoral zone; canopy composition is often mixed, and characterised by mixtures of *Carpinus betulus, Quercus petraea, Quercus robur, Fraxinus, Acer* and *Tilia cordata*.
	Due to the association with fertile soils, most of the original mesophytic deciduous forest area has been cleared and soils converted to very productive agricultural land. The management of even-aged stands predominates in the category.
6. Beech forest	The category has a very wide geographic distribution in lowland to submountainous Europe; it is characterised by the dominance of European beech *Fagus sylvatica* or of *Fagus orientalis* in the eastern and southern parts of the Balkan Peninsula. Locally important additional trees, are *Betula pendula* and mesophytic deciduous species.
	The large distribution is due to the wide climatic and edaphic amplitude of beech and to its competitive strength. At its northern and eastern boundaries (and in high altitudes, c.f. category 7) beech is limited by low winter temperatures causing either direct damage (extreme winter cold or late frosts in spring) or too short growing season. To the south and at lower altitudes water deficiency can limit beech distribution.
	Most of beech forests are managed as even-aged forest, although traditional management practices (like wood pastures, coppice with standards) are still in place in especially in rural areas.
7. Mountainous beech forest	The category is related to the mountainous altitudinal belt of the main European mountain ranges. In the mountainous vegetation belt coniferous species (spruce, fir) become competitive as beech; mountainous beech forest is thus characterised by the presence of conifers as important forest building trees; as for the category 6, locally important additional tree species include *Betula pendula* and mesophytic deciduous species.
	Traditionally mountainous beech forest have been intensively managed for fuelwood purposes, in mining areas and in some mountain areas of Apennines and Alps. Beech was coppiced for firewood and charcoal. Most of these stands were turned to high forest in the 20th century.
8. Thermophilous deciduous forest	The deciduous forests under this category mainly occur in the supra-Mediterranean vegetation belt, the altitudinal belt of Mediterranean mountains corresponding to the mountainous level of middle European mountains. Thermophilous deciduous forests are limited to the north (or upslope) by temperature and to the south (or downslope) by drought.
	The mild climatic conditions of the supra-Mediterranean level determine the predominance of mixed deciduous and semi-deciduous forest of thermophilous species, mainly of *Quercus*. *Acer, Ostrya, Fraxinus, Carpinus* species are frequent as associated secondary trees.
	Anthropogenic exploitation has modified the natural mixed composition of thermophilous deciduous forests, leading in most cases to the elimination of natural species without a commercial interest or with poor resprouting capacity or, conversely, the introduction of forest species that would not occur naturally (e.g. chestnut).
	Simplified forest structures shaped by traditional silvicultural systems predominate (coppice, coppice with standards, mixed coppice/high forest); of purely cultural origin are also the chestnut-groves, today largely replaced by coppice-woods or left unmanaged. High forest-like structures developing from the abandonment of forest cultivation are relatively frequent in the category.
9. Broadleaved evergreen forest	Forests under this category are related to the thermo- and meso-Mediterranean vegetation belt and to the warm-temperate humid zones of Macaronesia. These kind of climates determine a forest physiognomy characterised by the dominance of broadleaved sclerophyllous or lauriphyllous evergreen trees.
	Water availability varies considerably between the Macaronesia and thermo- and meso-Mediterranean vegetation belts and it is the main climatic factor limiting tree-growth.
	In the Mediterranean, the structure of broadleaved evergreen forest has been profoundly shaped by traditional agro-forestry (*dehesas, montados*) and coppice cultivation systems. Forest degradation is a very common phenomenon, due to a complex historical interplay of harsh environmental conditions (drought, aridity, soils prone to erosion) and anthropogenic influences (fire, grazing, intensive forest exploitation).

Table 6.1 Synopsis of the main ecological and anthropogenic determinants of variation of MCPFE forest type based indicators at the category level (cont.)

10. Coniferous forests of the Mediterranean, Anatolian and Macaronesian regions	This category includes a large group of coniferous forests, mainly xerophytic forest communities, distributed throughout Europe from coastal regions to high mountain ranges. Forest physiognomy is mainly dominated by species of *Pinus, Abies* and *Juniper*, that are variously distributed according to altitudinal vegetation belts.
	The relation with dry and, often, with poor or poorly developed soils limits tree growth.
	Although some pine forests under this category are adapted to fire (e.g. *P. halepensis, P. canariensis*), in the Mediterranean region repeated forest fires of anthropogenic origin seriously threaten these coniferous forests, by triggering forest degradation.
	From a structural viewpoint, even-aged forest characterise the category.
11. Mire and swamp forest	Waterlogged peaty soils determine these wetland forests mainly distributed in the boreal zone. Changes in forest physiognomy are due to the micro-topographic variability of wetland areas and associated variations in edaphic conditions and water regimes. *Picea abies* and *Pinus sylvestris* build up mire forests; species of *Alnus, Betula, Quercus* and *Populus* dominate the deciduous swamp forest.
	Due to its poor economic value, most of the potential area of swamp forest has been drained and converted to agricultural land or productive coniferous forest plantations. Present management is targeted to the protection and restoration of these wetland forests.
12. Floodplain forest	The riparian or alluvial hydrological regime (high water table subject to occasional flooding) determine the appearance of forests under this category, distributed along the main European river channels. Floodplain forest are species-rich often multi-layered communities characterised by different assemblages of species of *Alnus, Betula, Populus, Salix, Fraxinus, Ulmus*. In the Mediterranean and Macaronesian regions local species are also found (e.g. *Fraxinus angustifolia, Nerium Oleander, Platanus orientalis, Tamarix*).
	Forest composition and structure largely depends on the frequency of flooding.
	Anthropogenic activities like the river damming and canalisation, drainage of riparian areas to provide agricultural land have brought significant changes in the area of floodplain forest during the last century.
	The conservation and restoration of these riparian forests is the main focus of forest management today.
13. Non riverine alder, birch, or aspen forest	The category includes a number of non-riparian, non-marshy often pioneer forest formations dominated by *Alnus, Betula* or *Populus*. These communities are related to specific ecological conditions (mountain birch formations) or occur as pioneer stages of the forest succession and/or are related to traditional land use, e.g. grazing.
14. Plantations and self-sown exotic forest	The category relates to the forests with lowest level of naturalness in Europe, because:
	• the extent of human influence in the establishment and/or management of the forest is higher than in any other category; these are the forest plantations established and intensively managed for production or, otherwise, for the rehabilitation of degraded land (in which case management may be less obvious or intensive);
	• the forest predominantly consists of self-sown non-native, often invasive, tree species.

6.1   Boreal forest

Class definition

Coniferous and mixed broadleaved-coniferous forest of the Boreal (climate) zone of Europe, known also as taiga. Two conifer species, Scots pine (*Pinus sylvestris*) and Norway spruce (*Picea abies*) dominate the boreal forest zone; both of them have quite broad habitat amplitudes and may grow from very dry to wet habitats. Pine generally prevails on drier soils, in areas with a more continental climate and with a high fire frequency. Spruce, on the other hand, prevails on more nutrient-rich, mesic-moist soils, in areas with a more oceanic climate and on sites with a low fire frequency (e.g. Esseen *et al.*, 1997).

Birch species (*B. pubescens, B. pendula*) as well as other deciduous trees, such as aspen, rowan and grey alder can be frequently found growing amongst the conifers. Admixtures of spruce or pine with birch species are also typical of the pioneer stages of the forest succession.

Geographical distribution

The boreal zone covers in Europe most of Fennoscandia and Russia. The zone is often divided into further sub-zones: a northern, a middle and a southern (e.g. du Rietz, 1925; Sjörs, 1963; Ahti *et al.* 1968, Nordiska Ministerrådet, 1984). Further north, the boreal zone is replaced by the hemi arctic zone and to south-west by the hemiboreal zone.

The physiognomy of the boreal forest is not very complicated on a large scale, because the dominant tree species are quite few, and they are, to a large extent, influenced by the north-south temperature gradients and by the elevation. However, at a smaller scale, the situation is more complicated especially towards the western part of the boreal zone; e.g. in Norway the main driver of variation in forest physiognomy are edaphic conditions.

In general, in countries like Sweden, Finland and Russia well over half of the land is covered by forests, while a good third of Norway is wooded (Hallanaro and Pylvänäinen, 2001). Conifer forests naturally dominate over much of the region, but in the 20th century their area further increased, since commercial forest management favoured conifers over deciduous tree species.

For a more detailed description of the zones, see for example Esseen *et al.* (1992). However, in different countries of northern Europe, there are many detailed descriptions of vegetation types within respective country (e.g. Fremstad, 1997).

In the following, a general outline of the main compositional features of later succession stages of the boreal forest is given and of the differences with the hemiboreal forest:

• the middle and northern boreal zones have conifer dominance, with birch *Betula* as the main broad-leaved tree; in the southern boreal zone conifers still dominate but scattered occurrences of the temperate broad-leaved trees of the hemiboreal zone are found;

• the middle and northern boreal zones are separated on floristic criteria, the latter being characterised by the presence of a large number of northern plants, often with an amphi-atlantic distribution (Dahl, 1989); the northern boreal zone deviates also from the middle boreal zone by the addition of a number of northern vascular plants as well as an abundance of willow *Salix* spp. thickets and various tall-herb communities and the absence of low-herb spruce forests and *Vaccinium vitis-idae* forests;

• shrubs play a minor role in Fennoscandian boreal forest compared to other boreal forests; if present, the shrub layer usually consists of tree saplings and small, suppressed trees; most shrubs typical of the hemiboreal forest are absent and those that occur are often reminiscent of post-fire successional stages, e.g. a few willow species such as *Salix starkeana* and *S. xerophila* and juniper (*Juniperus communis*). However, on mesic sites saplings of rowan (*Sorbus aucuparia*) and goat willow (*Salix caprea*) appear regularly. Dwarf shrubs, such as *Ericaceous*-species, play a central role in the northern boreal forests.

Many hemiboreal forests (Section 6.2) are characterised by the dominance of a large number of herbs. Some of these herbs are also common in southern boreal forest like the grass *Calamagrostis arundinacea* and bracken *Pteridium aquilinum*. The main change in the southern boreal forest is a marked decrease among herbs and shrubs, although evergreen herbs still are important (e.g. *Hepatica nobilis* and *Veronia officinalis*). The middle boreal forest is generally characterised

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(¹) The boreal zone is only partially covered by the boreal European biogeographical region, as defined for the purposes of the Habitats Directive, which covers only parts of Finland and Sweden.

by the absence of evergreen herbs, however, evergreen rosette graminoids such as *Luzula pilosa* may still be common. Herbs are mainly restricted to nutrient-rich sites and early succession stages. This situation is still more accentuated in the northern boreal zone where bryophytes and lichens also become increasingly abundant (Esseen *et al.*, 1997).

Types

6.1.1   Spruce-dominated boreal forest
6.1.2   Pine-dominated boreal forest

6.1.1   Spruce-dominated boreal forest

North boreal forest dominated by Norway spruce (*Picea abies*) and Siberian spruce (*Picea obovata*) (earlier regarded as a subspecies of *P. abies*) in the northernmost areas.

It is patchily distributed in northern Norway and as a wide continuous belt in north-western Sweden, almost whole of Finland and further eastwards reaching Ural Mountains.

At high altitudes and latitude the spruce reaches its distribution border and only *Betula pubescens* remains (type 13.1). The spruce forests are found on sites ranging from mesic to the most fertile and moist soils on the north boreal zone of Fennoscandia (Larsson *et al.*, 2001).

In Eastern Europe the northernmost spruce boreal forest has rather poor floristic composition and low productivity. These forests were represented by 'untouched' uneven-aged stands before the start of intensive exploitation in 20th century. On the east end of this zone there is a visible mixture of

Type: 1.1; Spruce boreal forest.
Source: Kjell Sjöberg.

Siberian tree species (*Picea obovata*, *Abies sibirica*, *Pinus cembra var. sibirica*). Southernmost spruce forest bordering the temperate broad-leaved forest has a very rich ground vegetation layer with a great proportion of nemoral species.

Spruce forest in Eastern Europe occupies mostly mesic sites with soils of various productivity: from poor sandy podzols to rather rich loamy luvisols/alfisols (podzolic profile-differentiated, in Russian nomenclature) (Chertov, 1981; Fedorchuk *et al.*, 2006). However the spruce forest can also be found on naturally or artificially drained deep peat.

In the pre-industrial period, the spruce taiga forest was for millenniums under the impact of slush-and-burn (shifting) cultivation, that strongly influenced the recent patterns of this forest with soil degradation in spruce forest in the south part of this zone and corresponding depletion of forest vegetation diversity and stand productivity (Bobrovsky, 2004). However, the rotation of agricultural and forest lands and especially large-scale afforestation of former agricultural lands in 20th century resulted in the appearance of forests with improved site conditions in the central and north taiga (Chertov, 1981). Secondary birch (*Betula pendula*, *B. pubescens*;

type 13.3) forests, in north taiga and on poor soil, and aspen (*Populus tremula*; type 13.5) forests, in more favourable climate and soil conditions, also colonised the broad-scale clear cuts of Soviet times ('concentration cutting' around concentration camps). The proportion of these secondary forests is now exceeding 50 % of the area of spruce forests in Eastern Europe (Smirnova, 2004).

Compared to pine forests, the old growth spruce forests normally have strongly skewed diameter distributions with large numbers of small, suppressed trees. Another typical feature of old-growth spruce forest is the frequent occurrence of snow-breaks. The production of viable conifer seeds at high elevations is strongly dependent on warm summers and, hence, very unpredictable. Years with abundant seed production can often be traced as subsequent peaks in the age structure of the forests.

Relationship to Annex I, Habitat Directive
9010 — Western Taïga
9050 — Fennoscandian herb-rich forests with *Picea abies*
Relationship to EUNIS Habitat Classification
G3.A — Spruce taiga woodland
G4.2 — Mixed taiga woodland with birch

Type: 1.2; Pine-birch boreal forest.
Source: Kjell Sjöberg.

Type: Boreal forest. Left: deadwood, snag; right: *Vaccinium myrtillus*, a keystone species in boreal forest.

Source: Tor-Björn Larsson.

Europe, pine boreal forest located on sandy soils of glacio-fluvial plains, river and lake terraces and on sandy Scandinavian glacial till.

Under normal conditions the main disturbance factor is fire. Pine forests with an high fire frequency are often characterised by bimodal or multiple modal diameter distributions (Engelmark *et al.*, 1984), which is due to a peak in tree regeneration after fire and because the largest pines usually survive fires. Often Scots pine is dominating totally, but deciduous trees like *Betula pubescens* can form a poorly developed understorey. Dwarf shrubs like *Vaccinium vitis-idaea* form the field layer. Also *Betula* nana can exist in the field layer (Larsson *et al.*, 2001).

In Eastern Europe are found pine forests not related to fire regime; these are extra dry edaphic types on shallow fragmented soils on solid rocks (Ural, Karelia) and on shallow carbonate soils (rendsinas) on solid limestone south of Finnish bay. This small group of forests is highly sensitive to anthropogenic disturbances. The secondary mixed birch-pine forest replaces pine stands after clear cutting in absence of fire, whereas pine regeneration appears if clear cut area is burned.

6.1.2   *Pine-dominated boreal forest*

Scots pine (*Pinus sylvestris*) is totally dominating in the pine boreal forest of northern Europe. This forest type is found on nutrient poor and dry sites and its dominance increases to the east. In Finland and in Norway it is the most dominating type of the north boreal region (Larsson *et al.*, 2001). In Eastern

Relationship to Annex I, Habitat Directive
9010 — *Western Taïga
9060 — Coniferous forests on, or connected to, glaciofluvial eskers
Relationship to EUNIS Habitat Classification
G3.B — Pine taiga woodland
G4.2 — Mxed taiga woodland with birch

6.2 Hemiboreal forest and nemoral coniferous and mixed broadleaved-coniferous forest

Class definition

The hemi-boreal zone is a transitional zone between the boreal and temperate forest of nemoral Europe ('boreo-nemoral' zone, sensu Ozenda, 1994); it is characterised by the coexistence of boreal coniferous — on poor soils — and temperate broadleaved tree species (*Fraxinus excelsior, Ulmus glabra, Tilia cordata, Quercus robur*) on the most fertile soils. The structure and composition of hemiboreal forest is maintained by a complex admixture of natural and cultural disturbances.

The category includes four main types of forests growing in the boreo-nemoral and nemoral zones of Europe:

- the hemiboreal forest, a complex mixture of boreal and nemoral forest types;

- the forests dominated by *Pinus sylvestris*, of Scotland, of the lowlands of central Europe, of the east European Nemoral zone and its adjacent wooded steppes;

- the semi-natural, non alpigenous, forests originated from plantations of *Picea abies* or pines of the *Pinus nigra* group (e.g. lowlands of central Europe), located in or near the present or recent natural range of the species;

- the mixed forest with Scots pine and birch or Scots pine and Pedunculate oak in the nemoral zone.

The geographical distribution of the category and its main relevant compositional and structural features are further specified under types descriptions.

Types

6.2.1   Hemiboreal forest
6.2.2   Nemoral Scots pine forest
6.2.3   Nemoral spruce forest
6.2.4   Nemoral Black pine forest
6.2.6   Mixed Scots pine-pedunculate oak forest
6.2.5   Mixed Scots pine-birch forest

6.2.1   Hemiboreal forest

The hemiboreal forest covers the transitional forest zone between the boreal coniferous and temperate deciduous ones. This forest zone covers:

i) Fennoscandia, where it is found mainly in south-central Sweden, south of the distinct biogeographical transition zone called Limes Norrlandicus, which constitutes the southern border of the Eurasian taiga (Fransson, 1965); in Norway and Finland this forest region is represented only as narrow bands in southernmost parts of the countries; ii) most of Estonia, Latvia and north-eastern Poland and northern Belarus, stretching with an eastern wing to Urals across Russian Federation.

The type is characterised by mixtures of *Pinus sylvestris* and *Picea abies* with broadleaves deciduous trees such as *Betula* spp., *Populus tremula*, *Alnus* spp. and *Sorbus aucuparia*. The broadleaved trees generally characterise early-to-mid-successional stages; with age the dominance of coniferous species increases.

On most fertile soils scattered isolated remnants — from a previously wider distribution range — of temperate deciduous trees can be found: *Tilia cordata, Fraxinus excelsior, Ulmus glabra, Quercus robur*. In Fennoscandia some of these are old-growth forest, previously used for grazing or mowing, rich in deadwood habitats, lichens and epiphytes recognised as Habitat of priority importance in the Annex I of Habitat Directive (*9020).

Two main types of hemiboreal forest could be distinguished (Larsson *et al.*, 2001):

- natural hemiboreal forest with large conifers and southern deciduous trees, occurring almost only in forest reserves, like the famous Bialowieza National Park, in eastern Poland;

- culturally originated woodlands i.e. mixed forest originated from abandoned wooded meadows with broadleaved trees (ash, oak, hazel) invaded by conifers, particularly spruce;

An important feature of the hemiboreal forest is that its structural and compositional diversity is shaped by a complicated mixture of natural (fires, windbreaks) and cultural disturbances (grazing, pollarding, lopping), that maintain a continuous presence of large old trees and deadwood.

Relationship to Annex I, Habitat Directive
9020 — *Fennoscandian hemiboreal natural old broad-leaved deciduous forests (*Quercus*, *Tilia*, *Acer*, *Fraxinus* or *Ulmus*) rich in epiphytes
9070 — Fennoscandian wooded pastures
Relationship to EUNIS Habitat Classification
G4.3 — Mixed sub-taiga woodland with acidophilous oak

6.2.2   Nemoral Scots pine forest

Forests dominated by *Pinus sylvestris* ssp. *sylvestris* distributed mainly in the nemoral Europe and further east in the wooded steppe belt of western Eurasia. These forests may originate both from natural regeneration and from artificial planting. Included are, in particular, the forests of Scotland, of dunes of the coasts of the south-eastern Baltic, of the lowlands of central Europe, of the east European Nemoral zone and its adjacent wooded steppes.

In southern Atlantic region and in the lowlands of central Europe (e.g. dry sandy sites) the Scots pine forest has been largely established by afforestation/reforestation in areas where it would not occur naturally. Under this type are included those planted Scots pine forests no longer intensively managed and/or of old age and low intensity of forestry, showing somewhat natural features: e.g. mixed tree canopy composition, significant ingrowth of self-sown trees, uneven aged diameter distribution.

Planted Scots pine forests showing a typical plantation-like structure and intensively managed are included under category 14.

Relationship to Annex I, Habitat Directive
91C0 — *Caledonian forest
91T0 — Central European lichen Scots pine forests
91U0 — Sarmatic steppe pine forest
Relationship to EUNIS Habitat Classification
G3.4 — Scots pine woodland south of the taiga

6.2.3   Nemoral spruce forest

Semi-natural, non-alpigenous forests dominated by *Picea abies* of the nemoral zone. These forests may originate both from natural regeneration and from artificial planting. As for the type 2.2, the nemoral spruce forest covers only those planted spruce forests no longer intensively managed and/or of old age and low intensity of forestry, showing somewhat natural features: e.g. mixed tree canopy composition, significant ingrowth of self-sown trees, uneven aged diameter distribution.

Planted spruce forests showing a typical plantation-like structure and intensively managed are included under category 14.

Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G3.1 — Fir and spruce woodland

6.2.4   Nemoral Black pine forest

Semi-natural, non-alpigenous Black pines forests in the nemoral zone. In the Atlantic Region and in the lowlands of central Europe Black pine is non-native species that has been extensively planted on non-forested dry rocky slopes, on dolomite and limestone hills in Hungary and also in many other parts of the former Austrian-Hungarian Monarchy, where it has replaced former agricultural land. As for the previous types, under this type are included only those planted Black pine forests no longer intensively managed and/or of old age and low intensity of forestry, showing somewhat natural features: e.g. mixed tree canopy composition, significant ingrowth of self-sown trees, uneven aged diameter distribution.

Planted Black pine forests showing a typical plantation-like structure and intensively managed are included under category 14.

Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G3.5 — Black pine (*Pinus nigra*) woodland

6.2.5   Mixed Scots pine-birch forest

Mixed forests of Scots pine and birch most often found in the highlands of Scotland.

Relationship to Annex I, Habitat Directive
91C0 — *Caledonian forest
Relationship to EUNIS Habitat Classification
G4.4 — Mixed Scots pine-birch woodland

6.2.6   Mixed Scots pine-pedunculate oak forest

Mixed forest of Scots pine and pedunculate oak very frequent in western and central Poland and northern Germany.

Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G4.7 — Mixed Scots pine acidophilous oak woodland

Type: 2.2; Nemoral Scots pine forest.
Source: David Woods/Dreamstime.com.

6.3   Alpine coniferous forest

Class definition

Forests occurring in the alpine biogeographical region dominated by coniferous trees, mainly *Picea abies*, *Abies alba*, *Pinus sylvestris* and *P. mugo*. Included in this category is the forest vegetation of high altitudinal vegetation belts of the central European mountain ranges dominated by *Picea abies*, *Abies alba* and, under local microclimatic and edaphic conditions, termophilous pure *Pinus nigra* forests of the southern Alps.

Forests of the Scandinavian Alps are not included under this class, but in the category 1. Not included are also similar coniferous forests of the pontic and caucasian range.

Geographical distribution

The alpine biogeographic region of Europe can be seen as a very inhomogeneous unit, containing several isolated sub-regions corresponding with the main mountain ranges of Europe: the Pyrenees, the Alps, the Apennine, the Carpathians and the Scandinavian Alps.

Types

6.3.1   Subalpine larch-arolla pine and dwarf pine forest
6.3.2   Subalpine and mountainous spruce and mountainous mixed spruce-Silver fir -forest
6.3.3   Alpine Scots pine and Black pine forest

6.3.1 Subalpine larch-arolla pine and dwarf pine forest

These forests show on the European scale a very disjunct and sometimes small scaled distribution due to their occurrence at the highest elevations of European mountain ranges. The natural range of distribution of the type originally covered a larger area; however, due to human activities over thousands of years like pasturing the largest part of its distribution has been converted to alpine meadows.

Three main areas of subalpine coniferous forests exist in Europe:

- pine dominated (*Pinus uncinata* and *Pinus sylvestris* var. *iberica*) open and light flooded forests of the subalpine forest vegetation of the Pyrenees and the oromediterranean altitudinal vegetation belt of the Iberian peninsula (Rivas–Martinez , 1969);

- subalpine coniferous forest of the Alps, covering a narrow altitudinal belt characterised by mixed open-structured *Pinus cembra-Picea abies-Larix decidua*-forests, partly dominated by arolla pine — central Alps — or larch, southern Alps (Mayer, 1974, 1984; Ozenda, 1988, Ott *et al.* 1997);

- in the Carpathian (relicts of *Pinus cembrae* and *Larix decidua*) and Balkan ranges (*Pinus peuce* and *Pinus heldreichii*) in contact with *Pinus mugo*-forests, subordinate in the central European mountain range (Mayer, 1984; Ozenda, 1988).

The following short description focuses on the specific alpine situation (Mayer, 1974, 1984; Ozenda, 1988).

At the upper timberline of the central and eastern parts of the Alps, the *Larix decidua* and/or *Pinus cembra* forests show a smooth transition to shrub vegetation of dwarf pine *Pinus mugo* ssp. *mugo*. More open forests of *P. mugo* ssp. uncinata are mainly found in the western parts of the Alps (France, Italy, Switzerland). In the climatically more atlantic north alpine and in the dinaric regions, subalpine coniferous forest types are replaced by beech. On altitudinal levels above this, forests are replaced by dwarf pine-shrub vegetation.

Larix decidua and *Pinus cembra* are not present in the dinaric region, where spruce and dwarf pine forests cover deep and closed terrain depressions of much lower altitudes, where frequent termal inversion situations occur. In the Carpathian range, especially in the Tatra *Pinus cembra-Larix decidua* forests have remained only fragmentary due to intensive alpine pasturing, in the eastern Carpathians they have been vanished completely (Soó, 1930).

Subalpine larch-arolla pine forests but also subalpine spruce forests are usually open forests, with a distinct shrub layer (*Rhododendron hirsutum*, *R. ferriguneum*, *Juniperus communis* ssp. *nana*, *Vaccinium myrtillus*, *V. vitis-idaea*, *Erica carnea*). Micro-site conditions are very important for forest regeneration and hence affect also the stand structure. When compared to other forest types, tree canopies are uneven and stand density is lower. Horizontal structure is generally clustered and even more significantly at the upper timberline. At lower altitudes clusters are observed mainly in the regeneration phase; horizontal clustering disappears in the later development stages.

Relationship to Annex I, Habitat Directive
9420 — Alpine *Larix decidua* and/or *Pinus cembra* forests
9430 — Subalpine and montane *Pinus uncinata* forests (* if on gypsum or limestone)
Relationship to EUNIS Habitat Classification
G3.2 — Alpine larch-Arolla woodland
G3.3 — Mountain pine (*Pinus uncinata*) woodland

Type: 3.1; Subalpine larch-arolla pine forest.
Source: Georg Frank.

Type: 3.1; Subalpine dwarf pine forest (*Pinus mugo* ssp. *uncinata*).

Source: Georg Frank.

6.3.2 *Subalpine and mountainous spruce and mountainous mixed spruce-silver fir forest*

These forests are present both in the Alpine region and in the mountainous regions of central Europe and in the Carpathian and Balkan ranges. In the Pyrenees but also in the Apennine range and the mountainous altitudinal belt of Corsica spruce is not present for paleoecological reasons. These potential spruce sites are covered by pure silver-fir forests (Mayer, 1984). Also in the central Apennine spruce does not occur and silver fir appears only in mixed beech-silver fir forests (Hofmann,1974).

The type includes:

- Subalpine pure spruce forests of the Alps (Mayer 1974, 1984; Mucina, *et al.* 1993; Ozenda 1988)

- Mountainous pure spruce forests of the central Alps (Mayer 1974, 1984; Mucina *et al.*, 1993; Ozenda, 1988)

- Mountainous mixed spruce–silver fir forests of the transition zone of the Alps and on specific sites the peripheral zone of the Alps (Mayer 1974, 1984; Mucina *et al.*, 1993)

- Subalpine spruce forests of the central European mountain range (Mayer, 1984; Hartmann and Jahn, 1974)

- Subalpine — mountainous Carpathian mountains (Ozenda, 1988)

- Mountainous pure silver fir forests of the Pyrenees (Mayer, 1984; Rivas-Martinez, 1968)

A clear distinction has to be made between the mountainous and subalpine forests, being different in structure and stand development. Subalpine spruce forests can be distinguished clearly from mountainous spruce forests because they are usually open forests with a distinguished shrub layer but also specific regeneration patterns related to harsh micro-site conditions; the horizontal structure is therefore clustered. Mountainous pure spruce forests are closed forests, often with single layer structures, regeneration rich in individuals and show a more homogeneous horizontal structure.

Further differences in stand structure are caused by the proportions of shade tolerant silver fir, occurring partly in the mountainous subtypes, but not in the subalpine ones. In general, the proportion of spruce has increased mainly as a result of silvicultural treatment (clear-cutting and replanting of spruce) and as a result of decreased competitiveness of silver fir resulting from browsing by roe and red deer. In many regions, silver fir dominated types have nearly disappeared and species diversity declined into pure spruce stands. In the Alps, a clear gradient in the proportions of silver fir to spruce exists, due to different species migration patterns and forest history. Spruce dominates in the eastern Alps and silver fir in the western. In the south-western Alps near to the Mediterranean Sea pure fir-forests occur, even close to the upper timberline (Mayer, 1984). Broad-leaved species rarely occur in these forests.

In the mountainous regions of central Europe (Black Forests, Bavarian and Bohemian Forests, Harz, Erzgebirge, Riesengebirge, Altvatergebirge) natural spruce forests on siliceous rocks occur on the highest and most exposed summit-regions of these mountain ranges. Analogous to subalpine pure spruce forests of the Alps is the spruce-habitus adapted to high snow-weight and open stand structure of forests are characteristic (Ozenda, 1988).

In the Carpathians, the subalpine altitudinal belt of pure spruce forests is not continuously interconnected. Only the upper level of the spruce belt is representing the typical subalpine spruce forests analogous to the Alps. In the lower, mountainous parts of this spruce dominated belt *Abies alba* can occur, but not necessarily (Ozenda, 1988).

Type: 3.2; Mountainous undisturbed spruce forest.
Source: Georg Frank.

Type: 3.2; Subalpine spruce forest landscape.
Source: Georg Frank.

Most of the mountainous spruce and mixed spruce-silver fir forests are subject to intensive forest management and used as highly productive forests.

Relationship to Annex I, Habitat Directive
9410 — Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea)
Relationship to EUNIS Habitat Classification
G3.1 — Fire and spruce woodland

6.3.3   Alpine Scots pine and Black pine forest

These are in most cases pure pine forests occurring on sites where climax tree species can not withstand because of specific site conditions (mainly caused by dry and poor limestone, dolomite or serpentine substratum).

The type includes:

- Central alpine pine forests (*Pinus sylvestris* var. *engadinensis*) in complex with dry natural grassland (Mayer, 1974).

Type: 3.2; Mountainous spruce forest.
Source: Georg Frank.

- Pine forests of the peripheral Alps (*Pinus sylvestris*, *P. nigra*) on limestone, dolomite or serpentine sites and on dry fluviatile sites (Mayer, 1974, Mucina *et al.*, 1993).

- Mountainous pine forests (*Pinus sylvestris* var. *pyrenaica*) of the Pyrenees on silicate and calcareous sites (Mayer, 1984; Ozenda, 1988).

Central alpine *Pinus sylvestris* forests cover the driest parts of the Inner Alps (Braun–Blanquet, 1961), most frequently on southern slopes, calcareous soils favoured. These light flooded forests with a pronounced shrub layer (*Juniperis, Berberis, Amelanchier ovalis*) show a characteristic species mixture of xerophytic to mesophytic supra-Mediterrannean species (*Ononis rotundifolia, Astragalus, Onobrychis, Oxytropis, Coronilla*).

Pinus sylvestris-forests of the transition and outer zone of the Alps are located on extreme sites on limestone, dolomite or serpentine primarily on southern slopes. Characteristic species: *Erica herbacea, Polygala chamaebuxus, Orthilia secunda, Epipactis atrorubens, Goodyera repens, Calamagrostios varia, Melampyrum* spp., on dryer sites *Carex humilis, Carex alba*. Shrub layer: *Berberis vulgaris, Amelanchier ovalis, Cotoneaster tomentosa*.

Pinus nigra-forests of the southern and eastern peripheral Alps are the northernmost isolated part-areas of the widespread Black pine range, which is distributed very disjunctly around the mediterranean basin. Natural forests of *Pinus nigra* are located as typical azonal vegetation types strictly on dolomite and/or very dry and exposed limestone sites (Frank, 1991). Characteristic

species: *Euphorbia saxatilis, Carex humilis, Carex alba, Sesleria varia, Polygala amara, Gentiana clusii, Globularia cordifolia, Amelanchier ovalis, Daphne cneorum, Sorbus aria*. In the south-eastern Alps *Pinus nigra* forests are often neighbouring *Ostrya carpinifolia-Fraxinus ornus* forests, the species of which are invading these *Pinus nigra*-forests.

In the Carpathians relict *Pinus sylvestris* forests occur on very specific mountainous, very steep and southern exposed limestone sites. *Pinus sylvestris* dominates this forests, characteristic species are: *Sorbus aria, Acer pseudoplatanus, Juniperus communis, Carduus glaucus, Cotoneaster integerrius, Calamagrostis varia, Inula ensifolia, Anthericum ramosum*.

Relationship to Annex I, Habitat Directive
91Q0 — Western Carpathian calcicolous *Pinus sylvestris* forests
91R0 — Dinaric dolomite Scots pine forests (*Genisto januensis-Pinetum*)

Relationship to EUNIS Habitat Classification
G3.4 — Scots pine woodland south of the taiga

Type: 3.3; Alpine Scots pine forest.
Source: Georg Frank.

Type: 3.3; Alpine Black pine forest.
Source: Georg Frank.

6.4 Acidophilous oak and oak-birch forest

Class definition

Acidophilous oakwoods and mixed oak-birch forest characteristic of oligotrophic soils of the nemoral forest zone.

Pyrenean oak woods, whose sub-mediterranean range may also be described as sub-atlantic have been included under category 8.

Geographical distribution

The main areas of distribution of the class are the Atlantic and Continental biogeographical regions.

Types

6.4.1   Acidophylous oakwood
6.4.2   Oak-birch forest

6.4.1   *Acidophylous oakwood*

Lowland to submountainous forests dominated by acidophilous oaks *Q. petraea* and *Q. robur*. These forests are stocked on poor acid soils.

The area of distribution acidophilous oakwoods is the temperate zone of Europe and extends from the Atlantic coast to western Russia. The range of distribution is similar to a acute-angled triangle, which base runs from the Atlantic coast from northern Portugal (approx. 41 °N) via Ireland to Scotland (approx. 58 °N). The tip of the triangle is located south of Kiew (approx. 53 °N, 34 °E), with isolated outliers near the Wolga (Kasan). The northern boundary runs from Scotland via southern Scandinavia to Lithuania and Belarus, the southern boundary from northern Portugal, northern Spain, southern France, northern Italy, Croatia, Bosnia and Herzegovina, Romania, Ukraine to southern Russia.

Within this range, oakwoods show a pronounced scattered distribution, which is mainly driven by site quality. In the wide natural range of distribution of *F. sylvatica* (categories 6–7) oakwoods are pushed back to areas with poor acid soils, with variable soil moisture or thin soil layers. Therefore the majority of natural stands can be found on relatively small and scattered areas. Larger tracts can be found mainly outside the area of beech in north-western Spain and Portugal, south-western France, Ireland, Great Britain, northern German lowlands, Poland, Belarus and northern Ukraine.

Traditionally oakwoods stocking on poor, acid soils were managed as coppices. However, some small islands of semi-natural stands are left throughout Europe, especially on extreme sites in central Europe. Many coppice forests were converted to high forests during the past decades, or otherwise replaced by plantation pine (*P. sylvestris*) or Douglas fir (*Pseudotsuga menziesii*). In many areas lack of management is also common.

The natural structure of these oakwoods is often not easy to determine, as human influences and grazing show effects until today. Natural stands can show up to five or six layers, i.e. first and second tree layer, bush layer, layer of small bushes, herb layer, and moss layer. In some stands only three layers are present.

The tree layer generally shows a closure of 60 to 90 percent and heights of 15 to 35 m. Pioneers such as birch (*Betula pendula*, *B. pubescens*) are important during the regeneration phase in the western parts of the area of occurrence. In the eastern parts pine and locally spruce can form together with oak the tree layer. In the south-western areas of occurrence some Mediterranean species can participate in the tree layer.

Crataegus monogyna, *Fraxinus excelsior*, *Frangula Alnus*, *Populus tremula*, *Sorbus aucuparia*, and *Vaccinium* spp. *Acer platanoides*, *Fraxinus excelsior*, *Tilia cordata* and *Ulmus glabra* can be found in the southern boreal region.

In the understory — mainly formed by Azidophytes — a well developed shrub and herb layer can be found. However, the forests are poor in species compared to basic or climatic favourable sites.

Relationship to Annex I, Habitat Directive
91A0 — Old oak woods with *Ilex* and *Blechnum* in the British Isles
Relationship to EUNIS Habitat Classification
G1.8 — Acidophilous oak-dominated woodland

6.4.2   *Oak-birch forest*

Acidophilous forests of the Baltic-North Sea plain, composed of *Quercus robur*, *Betula pendula* and *Betula pubescens*, often mixed with *Sorbus aucuparia* and *Populus tremula*, on very oligotrophic, often sandy and podsolised or hydromorphic soils; forests of this type often prevail in the northern European plain, from Jutland to Flanders; they occupy more limited edaphic enclaves in the Ardennes and the middle and upper Rhenish ranges, in north-

Type: 4.2; Oak-birch forest.

Source: Marilyn Barbone/Dreamstime.com.

western France, Normandy, Brittany, the Paris basin, the Morvan and Great Britain. Natural birch-oak dune forests east of the Elbe, installed within Germano-Baltic fluvioglacial inland dune systems are also included.

Relationship to Annex I, Habitat Directive
9190 — Old acidophilous oak woods with *Quercus robur* on sandy plains
Relationship to EUNIS Habitat Classification
G1.8 — Acidophilous oak-dominated woodland

6.5 Mesophytic deciduous forest

Class definition

Forests, typically with mixed canopy composition, on rich and moderately rich soils. The category includes forests dominated by mixtures of *Carpinus betulus*, *Quercus petraea*, *Quercus robur*, *Fraxinus* (*Fraxinus excelsior*, *Fraxinus angustifolia*), *Acer* (*Acer campestre*, *Acer pseudoplatanus*) and *Tilia cordata*.

Five main groups of forest types are separated under this category:

Oak-hornbeam forest
6.5.1 Pedunculate oak-hornbeam forest
6.5.2 Sessile oak-hornbeam forest
6.5.3 Ashwood and oak-ash forest
Eastern European broadleaved forest
6.5.4 Maple-oak forest
6.5.5 Lime-oak forest
6.5.6 Maple-lime forest
6.5.7 Lime forest
6.5.8 Ravine and slope forest
6.5.9 Other mesohpytic deciduous forests

Oak-hornbeam forest: class definition and geographical distribution

Forests dominated by hornbeam *Carpinus betulus* and *Quercus* sp. generally found on clay to lime-clay substrates in plain, colline to submountainous levels, in sub-atlantic to continental climates. Two potentially natural variants exist which are in competition with beech forests: oak-hornbeam forests on wet soil water regimes (predominantly high water tables) or on dry soils (soil water balance dominated by dry phases). On wet soils,

Quercus robur dominates, on dry soils *Quercus petraea* prevails.

The geographical distribution of mixed oak-hornbeam forests is extremely wide from west France to the region of Kiev in Ukraine and from southern Lithuania to the flatlands of the river Po.

Mixed oak-hornbeam forests replace beech forests in areas, where beech can not grow as a result of special local climatic conditions (sites with frequent frost periods in early spring, basins with temperature inversion) as well as macroclimatic areas with too low precipitation rates. Therefore the pattern of geographical distribution shows clearly a main area in central and Eastern Europe. Larger potential areas in western Europe are mainly caused by clay substrate and wet soil water regimes of flood plains (e.g. Loire, Rhone flatlands but also on the river Po).

The potential area in central and western Europe is tied to riverside flatlands with soils not suitable for beech and/or planar-colline lowlands of the great basins. Most of the original oak-hornbeam forests have been cleared and soils converted to very productive agricultural land. In the continental biogeographic region of Europe, oak-hornbeam forests grow in lowlands, out from the competition of beech.

Due to the even more continental climate found at east of the Dnepr basin oak-hornbeam forests are replaced by oak-linden forests, which are geographically and ecologically linked to the south Russian woodland-steppe vegetation belt.

6.5.1   Pedunculate oak-hornbeam forest

The type includes lowland-colline (to submountainous) pedunculate oak-hornbeam forests growing on groundwater influenced or hydromorphic soils.

Typical examples are:

- Central European pedunculate oak (*Quercus robur*) — hornbeam (*Carpinus betulus*) forests on groundwater influenced soils. Dominant and constantly appearing species: *Carpinus betulus, Quercus robur, Fraxinus excelsior, Acer pseudoplatanus, Corylus avellana* (Mucina *et al.*, 1993)

- Pannonian pedunculate oak — (*Quercus robur*)-hornbeam (*Carpinus betulus*) forests on clay

soils with high water-tables but rarely flooded; frequently associated with *Fraxinus angustifolia*. Dominant and constantly appearing species: *Carpinus betulus, Quercus robur, Fraxinus excelsior, Acer campestre, Ulmus minor, Crataegus laevigata*. These forests are geographically determined by the Pannonian plain and their surrounding terraces, in a narrower way, by the lowland part of this region stretching along major rivers and streams. Typically the tree layer is dominated by pedunculate oak, with ample presence of common hornbeam, and partly maple. Hornbeam is found in the understorey layers of more mature and old stands. Small-leaved lime (*Tilia cordata*), silver lime (*Tilia tomentosa*), wild pear (*Pyrus pyraster*), while maple (*Acer campestre*) narrow leaved ash (*Fraxinus angustifolia*) are occasionally present. Hazel, spindle, Guelder-rose and hawthorn are usually found in the shrub layer. A typical forest of pedunculate oak and common hornbeam has always inhabited the terrains out of the reach of flood waters. If a flood does cover some low, wet micro-elevations, it is usually slight, shortlived and rare (Rauš *et al.*, 1996).

Relationship to Annex I, Habitat Directive
9160 — Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli*
Relationship to EUNIS Habitat Classification
G1.A — Meso- and eutrophic oak, hornbeam, ash, sycamore, lime, elm and related woodland

6.5.2   Sessile oak-hornbeam forest

Lowland-colline submountainous oak-hornbeam forests (*Carpinus betulus, Quercus petraea, Tilia cordata*) growing on soils without groundwater or draught extremes. Other common tree species are: *Quercus robur, Fagus sylvatica, Quercus dalechampii, Quercus pubescens, Quercus polycarpa, Tilia tomentosa*.

Typical examples are:

- Central European sessile oak (*Quercus petraea*) — hornbeam (*Carpinus betulus*) forests on average soils, without groundwater or draught extremes. Dominant and constantly appearing species: *Carpinus betulus, Q. petraea*.

- Pannonian field maple (*Acer campestre*)-hornbeam (*Carpinus betulus*) forests on warm soils, mainly loess or tschernosem-soils. Dominant and constantly appearing species: *Acer campestre, Carpinus betulus, Quercus petraea, Euonymus europaea*.

Relationship to Annex I, Habitat Directive
9170 — Galio-Carpinetum oak hornbeam forests
91G0 — *Pannonic woods with *Quercus petraea* and *Carpinus betulus*
91L0 Illyrian oak-hornbeam forests (*Erythronio-Carpinion*)
Relationship to EUNIS Habitat Classification
G1.A — Meso- and eutrophic oak, hornbeam, ash, sycamore, lime, elm and related woodland

The present structure of oak-hornbeam forest has been deeply modified by forest management; presently, only special sites are naturally covered by oak-hornbeam forests.

Typical mixed oak-hornbeam high forests are managed by intensive long-term silviculture and show a characteristic two layered structure. Oak builds up the main layer and hornbeam is used as an auxiliary species in the dominated part of the stand. Most of the silvicultural activities during the rotation period aim to maintain the lead of oak against hornbeam. Strong evidence exists that the structure of naturally developed stands of this type is rather different to stands managed even by close to nature silvicultural practices. According to present knowledge, natural forest are more ore less dominated by hornbeam, with oak as an subdominate tree-species (Mayer and Tichy, 1979).

In the areas where coppicing had a long tradition, especially in the transition zone of beech or hornbeam dominated vegetation belts, the percentage of hornbeam and oak increased due to their ability of sprouting. Through coppicing the tree layer and the understorey have been modified in many cases very effectively, with the short-living shade-tolerant species hornbeam forming an highly organised life community with the long-living light depending oak.

Most stands have been or are being transformed into high forests with the silvicultural aim of valuable oak timber production (Ellenberg, 1988). Regeneration of oak is mostly achieved through planting, as natural regeneration has been suppressed as a result of browsing, grazing and competition from herbaceous vegetation. Silvicultural alternatives are represented by plantation of broadleaved species of high value on moist or well drained fertile soils (e.g. plantations of *Fraxinus excelsior*, *Acer pseudoplatanus*, *Prunus avium*) or Pine or Douglas fir plantations, on dry soils.

In Italy, most of these very small-scaled stands are protected as they represent relics of the original vegetation of the actually most cultivated and industrialised areas of the country. Those stands which are not included in a natural reserve are strongly threatened by the expanding settlements, agriculture and forest plantations.

6.5.3 Ashwood and oak-ash forest

Forests dominated by *Fraxinus excelsior*, characteristic of limestone districts and growing in basic and moist soils in wet, cool and windy climates. Atlantic ashwoods are found mainly on the British islands, on the foothills and in the inner western Pyrenees, and the Cantabrian mountains. Stands of this type are found mainly in areas outside the natural occurrence of oak and mixed oak-hornbeam forest.

Most of the potential area of this type, corresponding to the most rich and fertile soils of Europe, has been converted to agricultural lands. The ashwoods left were managed as coppice or coppice with standards. This management regime is abandoned in most places and the remaining stands convert rapidly into high forests.

In natural stands *Fraxinus excelsior* and *Q. robur* mix up in different proportions in the tree layer. The regular and frequent occurrence of *Hedera helix* together with *Ilex aquifolium* and *Ruscus aculeatus* provides ash-oak woods a semi-evergreen appearance. Trees covered with *Hedera helix* are a typical characteristic of the winter aspect.

As ashwoods grow mostly on neutral or alkaline and often moist soils, they are accompanied by a diversity of flowering plants, including rare herb species.

Sub-types of Atlantic ashwoods are:

- upland type;

- lowland type.

The lowland ashwoods may by sub-divided in ash-beech (species composition: *Fraxinus excelsior*, *Fagus sylvatica*, *Prunus avium*, *Acer campestre*, *Ulmus glabra*, *Q. robur*, *Q. petraea*, and locally by *Tilia platyphillos*) and ash-oak woods (species composition: *Fraxinus excelsior*, *Q. robur*, *Q. petraea*, *Acer campestre*, *Ulmus glabra*, *Prunus avium*, *Salix caprea*, *Betula pendula*, *Carpinus betulus*, *Alnus glutinosa*). The upland subtype includes species such as *Tilia cordata*, *Acer campestre*, *Sorbus aria*, *Ilex aquifolium*, *Sorbus aucuparia*, *Betula*, or *Taxus baccata*.

Eastern European broadleaved forest: class definition and geographical distribution

The east European broad-leaved forest is an eastern wing of the central European beech forest. It grows

Type: Examples of oak-hornbeam forests with different age structure.

Source: Georg Frank.

in continental climate of east European Plain out of the natural range of European beech (Smirnova 1994, 2004). Pedunculate oak (*Quercus robur*) and lime (*Tilia cordata*) play a dominant role in this zone. The other components of plant communities have really the same patterns as in the beech forest. However the pre-Ural broad-leaved forest has a significant proportion of Siberian cold-resistant species in ground cover. This forest grows in the optimal climatic and soil conditions of Eastern Europe: warm summer with a small water deficit, cold winter, and mostly rich loamy and loess grey and chernozem soils (Mollisols); of the east European Plain, it is the forest with highest productivity.

The east European broad-leaved forest represents a wide but rather fragmented belt on the western border near Carpathian Mountains and it becomes narrow and finally lenses out near Volga River. East of Volga River it is totally fragmented and related to so-called 'forest steppe' that is also typical along the south border of all this forest. In Holocene and even in medieval time, the area of this forest had larger extension to north and especially to south perhaps reaching Black sea (Smirnova 1994, 2004). However intensive exploitation and transformation to pasture and then to agricultural lands resulted in a strong fragmentation of this forest and formation of the forest steppe and steppe. One of the factors of conservation of this highly productive forest with a valuable wood in dense populated agricultural area was the development of oak plantations in the 14–16 centuries in Moscow Kingdom as a 'defensive belt' ('zaseki' in Russian) against steppe nomads. Since that time oak is mainly a planted species in this forest. Therefore all pure oak stands here are planted in contrast to more 'natural' mixed broad-leaved forests. Long-term rotation of agricultural and forest lands on the area of broad-leaved forest has led to significant soil degradation (Bobrovsky, 2004), with corresponding depletion of forest vegetation richness and change of stand composition and productivity. Birch and aspen forests with relatively poor species richness and low productivity develop in degraded lands.

6.5.4   Maple-oak forest

This forest is located in the central part of the broad-leaved forest in mostly protected areas. It occupies upper watershed plains and slopes of river valleys on grey forest soils both on loess and alluvial loamy sands. For a long time the forest was under strong anthropogenic impact, but now it is mostly under conservation regime. The diagnostic plant species here are

Type: 5.3; Oak-ash forest.
Source: By courtesy of Coillte.

Acer campestre and *Euonymus europaea*. The stand has mixed composition with *Quercus robur, Fraxinus excelsior, Tilia cordata, Acer platanoides, A. campestre, Ulmus glabra,* and rare *U. laevis.* Ground vegetation represented by *Aegopodium podagraria, Carex pilosa, Mercurialis perennis, Pulmonaria obscura, Galium odoratum* with a large proportion of spring ephemeroids (*Allium ursinum, Dentaria bulbifera,* D. quinquefolia, *Corydalis cava, C. marschalliana, C. solida, Ficaria verna*). In southern part (in forest-steppe) some mesophytic plants disappear from this forest type.

Relationship to Annex I, Habitat Directive
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Relationship to EUNIS Habitat Classification
G1.A — Meso- and eutrophic oak, hornbeam, ash, sycamore, lime, elm and related woodland

6.5.5 Lime-oak forest

This forest is found in the east sector of broad-leaved forests around the Volga River. It occupies various mesophilous sites with loamy grey forest soils. Oak and lime are dominant in the tree layer with a significant proportion of *Ulmus glabra.* The ground vegetation is represented by a sub association of Caricetosum pilosae with *Aegopodium podagraria,* and sometimes with *Aconitum septentrionale* and eastern species *Crepis sibirica.*

Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G1.A — Meso- and eutrophic oak, hornbeam, ash, sycamore, lime, elm and related woodland

6.5.6 Maple-lime forest

This forest characterises the central part of the area of eastern broad-leaved forests. It occupies approximately the same landforms and mesic sites as maple-oak forest but on grey forest soils that probably were eroded and have signs of podzol (lessive) process. It is a multi-species forest of high productivity with *Tilia cordata, Quercus robur, Fraxinus excelsior, Acer platanoides* and *A. campestre, Ulmus glabra,* sometimes *U. laevis* in tree layer. The diagnostic plant species here are also *Acer campestre* and *Euonymus europaea.* In this forest, a constant core of ground vegetation is sometimes represented by *Allium ursinum, Lamium maculatum, Mercurialis perennis, Dentaria bulbifera, Corydalis cava.* The dominant species of the herb layer are *Aegopodium podagraria, Mercurialis perennis, Pulmonaria obscura, Galium odoratum.* There is a lot of spring ephemeroids (*Allium ursinum, Corydalis cava, C. solida, C. marschalliana, C. intermedia, Dentaria bulbifera*). A sparse moss cover on lying deadwood is found, composed by *Brachythecium salebrosum, B. rutabulum, Plagiomnium cuspidatum.* Low proportion of boreal species can be found here especially on eroded steep slopes.

Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G1.A — Meso- and eutrophic oak, hornbeam, ash, sycamore, lime, elm and related woodland

6.5.7 Lime forest

This high productivity forest is typical of the south pre-Ural area and western slopes of low-mountain south Ural at the elevation 300–500 m a.s.l. It develops on mesic or even wet sites with carbonate and grey forest soils in lower parts of slopes on diluvium of limestone, clay schist and sandstone. *Tilia cordata, Quercus robur* and *Acer platanoides* in different proportions characterise the tree layer. Coniferous species are practically absent. The diagnostic herb species are represented by Ural-Siberian plants *Anemonoides altaica, Cacalia hastata, Cicerbita uralensis, Stellaria bungeana* and *Crepis sibirica.* Typical is a high herb layer (*Aconitum septentrionale,*

Type: Eastern European broadleaved forest, autumn aspect.
Source: Maxim Bobrovsky.

Cacalia hastata, Cicerbita uralensis, Senecio nemorensis, Dryopterisfilix-mas) with characteristic species of the broad-leaved forests and dominance of *Aegopodium podagraria*. The number of spring ephemeroids is not too high (*Anemonoides altaica, A. ranunculoides, Chrysosplenium alternifolium, Corydalis solida, Gagea lutea, Ficaria verna*). The moss cover is represented by genera *Rhizomnium* and *Brachythecium* on dead wood and tree butt.

Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G1.A — Meso- and eutrophic oak, hornbeam, ash, sycamore, lime, elm and related woodland

6.5.8   Ravine and slope forest

Cool, moist forests with a multispecific tree layer of variable dominance (*Acer pesudoplatanus, Fraxinus excelsior, Ulmus glabra, Tilia cordata, Tilia platyphyllos*), most often on more or less abrupt slopes. They are of considerable biohistorical and biogeographical importance, as examples of the mixed forests of the Atlantic period, preserved in stations inaccessible to beech domination.

Relationship to Annex I, Habitat Directive
9180 — *Tilio-Acerion* forests of slopes, screes and ravines
Relationship to EUNIS Habitat Classification
G1.A — Meso- and eutrophic oak, hornbeam, ash, sycamore, lime, elm and related woodland

6.5.9   Other mesophytic deciduous forests

Forest of the western Palaearctic region dominated by *Carpinus betulus*, *Ulmus* spp. or *Acer* spp.
Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G1.A — Meso- and eutrophic oak, hornbeam, ash, sycamore, lime, elm and related woodland
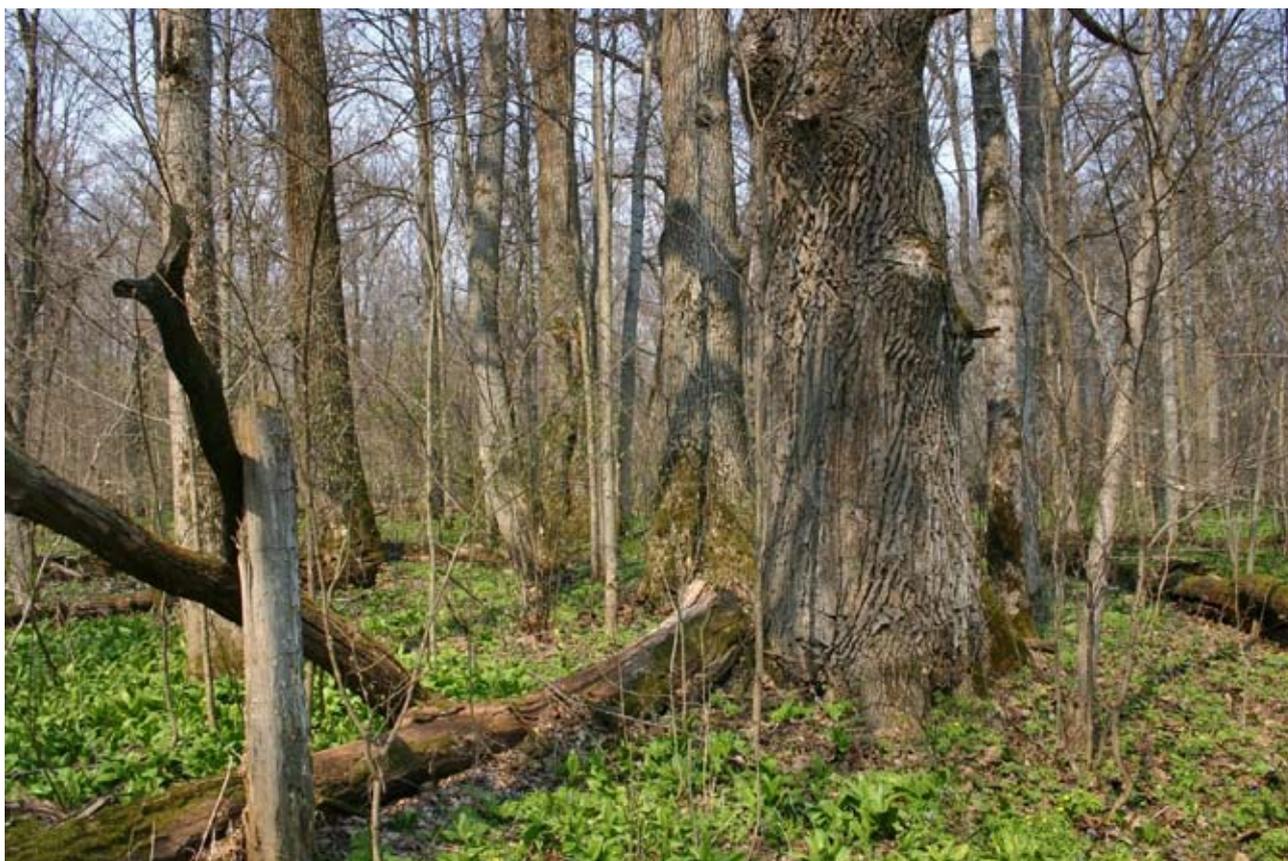
Type: Uneven-aged eastern European broadleaved forest, spring aspect.

Source: Maxim Bobrovsky.

6.6 Beech forest

Class definition

Beech forests are characterised by the dominance of European beech *Fagus sylvatica L.* or its transitional hybrids with *Fagus orientalis* Lipsky in the eastern and southern parts of the Balkan Peninsula, and along the eastern periphery of the Carpathians (Paule, 1995). These latter were described as Balkan beech *Fagus moesiaca Csecz.*, Podolian or Moldovian beech *Fagus podolica* Yap., and Crimean beech *Fagus taurica Popl.*, though some other authors treat them as subspecies of *Fagus sylvatica*. Specific elevation range (from lowlands to submountainous, 0 to 600(–800) meters above see level) and the lack of conifers define this type often referred to as lowland and submountainous beech forest. Important additional tree species include *Acer platanoides*, *Acer pseudoplatanus, Betula pendula, Carpinus betulus, Castanea sativa, Fraxinus excelsior, Populus tremula, Prunus avium, Quercus petraea, Quercus robur, Sorbus aucuparia, Tilia cordata, Tilia platyphyllos, Ulmus glabra*.

Geographical distribution

Beech plays an extraordinary role in European deciduous forests, which is connected to the conspicuous dominance it achieves by competitive vigour throughout the wide geographic range it covers. Competitive strength is explained by its high shade tolerance, the dense shadow it casts and its longevity. Beech has extremely wide climatic and edaphic amplitude, which explains its wide geographic distribution, ranging from southern Norway (Oslo Fjord, 59 °N) to Sicily (Etna, 38 °N) and from Southern England, Brittany in France, and the Cantabrians in Spain (7 °W) to the lowlands in north-eastern Poland, east of the Carpathians in Moldavia (27 °E). More eastern locations are restricted to the mountains of the Crimean peninsula (Jahn, 1991).

At its northern and eastern boundaries (and in high altitudes, c.f. mountainous beech forests) beech is limited by low winter temperatures causing either direct damage (extreme winter cold or late frosts in spring) or too short growing season. To the south

and at lower altitudes water deficiency can limit beech distribution. For characterising the lower limit of beech growth, Ellenberg (1988) developed an index, the so-called Ellenberg quotient (*Q*) for central Europe:

$$Q = \frac{\text{Mean July temperature (°C)}}{\text{Annual precipitation (mm)}} * 100$$

Values below 20 indicate pure beech climate, between 20 and 30 its competitive vigour decreases, and above 30 oak becomes more competitive than beech.

Beech occurs on almost all kinds of soils with the exceptions of extreme acid and waterlogged soils (Ellenberg, 1988; Jahn, 1991).

Types

Since beech-dominated forests are extremely widespread in Europe, their classification at the European scale has been a great challenge for almost a century. An extraordinary number of associations and subunits has been described from all over the range of European beech (for references see Tüxen, 1981). The first attempt to collect available information was made as early as in 1932 (Rübel, 1932). Since then no comprehensive, consistent classification of all European beech associations has been devised, though region level vegetation descriptions and classifications have been published (e.g. Horvat *et al.*, 1974; Mayer, 1984; Ellenberg, 1988; Jahn, 1991; Dierschke, 1990, 1997; Willner 2002 and references therein).

Most classification systems used one or more of the following approaches:

- trophic status (oligotrophic — mesotrophic — eutrophic), often replaced by or mixed with the approach of species poor to species rich;

- altitudinal range (lowland — colline — submountainous — mountainous — altimountainous);

- mesophytic to thermophilous character;

- geographic variants (e.g., local associations, regional suballiances).

The difficulty in applying any strict hierarchy of the above approaches lies in the fact that different parts of Europe can be characterised by different levels of spatial variation in climatic, geologic, soil conditions, and different range sizes of plant species used for distinguishing associations and other syntaxa. Also, the postglacial history is quite different.

However, two major approaches can be distinguished:

1. Grouping of associations based on ecological species groups. This approach results in three major alliances: *Asperulo-* (= *Galio odorati-*), *Cephalanthero-* and *Luzulo-Fagiono*. This approach is most successful in north western Europe, where herbaceous species of beech forests have wide geographical distribution but more or less specific ecological behaviour. Then suballiances and associations can be grouped according to geographical ranges.

2. Definition of alliances is based on geographical types then suballiances and associations are grouped according to ecological behaviour. This approach is best applied in regions where many herb species with restricted distribution characterise beech forests, e.g. in south-eastern Europe.

Another generally accepted subdivision is based on two main altitudinal types: (i) the mixed deciduous beech forests of the lowland and submountainous vegetation zones; and (ii) the beech and mixed beech-conifer forests of the mountainous and (altimountainous) vegetation zones. This approach was adopted by the pan-European project BEAR (Larsson *et al.*, 2001). We follow this approach in distinguishing beech dominated categories (6–7) and the second of the above-mentioned approaches for defining the types.

Under the present category seven types are distinguished:

6.6.1 Lowland beech forest of southern Scandinavia and north central Europe
6.6.2 Atlantic and subatlantic lowland beech forest
6.6.3 Subatlantic to Atlanto-Mediterranean submountainous beech forest
6.6.4 Central European submountainous beech forest
6.6.5 Carpathian submountainous beech forest
6.6.6 Illyrian submountainous beech forest
6.6.7 Moesian submountainous beech forest

Before describing beech forest types in detail, some relevant compositional and structural features of the category are outlined below:

- limited role played by other tree species in building the forest canopy; these are found where soils are too shallow and poor (*Quercus* spp., *Acer pseudoplatanus*), or locally dry or richer in nutrients (*Quercus* spp., *Acer* spp. *Fraxinus excelsior*), and in successional phases (*Acer pseudoplatanus*, *Ulmus glabra*, *Betula* spp., *Fraxinus excelsior*). In the Atlantic region *Ilex aquifolium* and, to a lesser extent, *Taxus baccata*, tend to increase over other woody associates.

- Due to the dense shadow cast by beech, the understorey is sparse and in most types shrub species are absent; ground vegetation varies from very poor (acidic soils) to very rich (fresh, calcareous and base-rich sites).

- In most parts of Europe beech is managed as high forest, with a 120–150 years rotation. In addition, the widely applied management systems (clear-fell or shelterwood with natural or artificial regeneration) use large (compared to natural patch size) compartments. This results in a drastically modified forest landscape with a much coarser patch pattern. Several patch types (the second half of natural forest cycle, early succession phases) are lacking, and new patch types (large uniform tracks of beech regeneration) have been introduced. Forestry practices have decreased (or eliminated) admixing tree species and different forms of dead wood (snags and logs of different sizes and decay phases). Many forest dwelling organisms adapted to these structural features, hence are extremely rare or completely missing from most commercial forests. In many parts of Europe traditional management practices, like wood pastures, coppice with standards, or selection in small farm forests preserved much more of the original forest structures, so they served as refugia for many forest dependent species.

6.6.1 Lowland beech forest of southern Scandinavia and north central Europe

This type includes beech forests on both acid and moderately acid to neutral sites in Denmark, northern Poland and Germany, southern Sweden and Norway. Beech is dominant with *Quercus petraea* and *Q. robur* as possible important associated species. Locally, *Sorbus aucuparia*, *Carpinus betulus*, *Ulmus glabra*, *Tilia cordata* and *Fraxinus excelsior* can also occur. In the sparse shrub layer *Corylus avellana*, *Crataegus laevigata*, *C. monogyna*, *Viburnum opulus*, *Euonymus europaea*, *Frangula Alnus*, *Sorbus aucuparia*, *Corylus avellana*, *Ilex aquifolium* (western Denmark)

are the typical species. On acid brown soils (tending towards podsols) atlantic acidophilous beech forests — *Quercion roboris* alliance and *Ilici-Fagenion* suballiance — develop that are similar to but differing from the Medio-European acidophilous *Fagus* forests with more *Ilex aquifolium* and *Taxus baccata* in the understorey and various ferns and epiphytes. In southern Scandinavia they are characterized by the occurrence of Lonicera periclymenum; *Maianthemum bifolium*, *Luzula pilosa*, *Luzula sylvatica*, *Deschampsia flexuosa*, *Vaccinium myrtillus*, *Trientalis europaea*, *Carex digitata*, *Melicanutans*, *Viola riviniana*. In northern Germany and Poland *Calamagrostis arundinacea*, *Carex pilulifera*, *Holcus mollis*, *Hieracium sabaudum*, *Hieracium laevigatum*, *Lathyrus linifolius*, *Melampyrum pratense*, *Pteridium aquilinum*, *Vaccinium myrtillus*, *Vaccinium* vitis-idaea; Hypnum cupressiforme; or *Carex pilulifera*, *Luzula pilosa*, *Maianthemum bifolium*, *Oxalis acetosella*, *Veronica chamaedrys*, *Veronica officinalis*, *Convallaria majalis*, *Melicanutans*; *Dicranella heteromalla*, *Mnium hornum* communities are characteristic.

On circum-neutral (mesic) soils with mull humus, a richer and more abundant herb layer develops in beech forests of the *Galio odorati-Fagenion* suballiance. Diagnostic herb species include *Galium odoratum*, *Melica uniflora*, *Cardamine bulbifera*, *Festuca altissima*, *Lamium galeobdolon*, *Polygonatum multiflorum*, *Stellaria holostea*, *Hedera helix*, *Anemone nemorosa*, *Carex sylvatica*, *Dryopterisfilix-mas*, *Lathyrus vernus*, *Milium effusum*, *Poa nemoralis*, *Scrophularia nodosa*, *Viola reichenbachiana*, *Hedera helix*.

Relationship to Annex I, Habitat Directive
9120 — Atlantic acidophilous beech forests with *Ilex* and sometimes also *Taxus*
9130 — *Asperulo-Fagetum* beech forests
9150 — Medio-European limestone beech forest of the *Cephalanthero-Fagion*
Relationship to EUNIS Habitat Classification
G1.6 — Beech woodland

6.6.2 Atlantic and subatlantic lowland beech forest

The major distribution of this type is in southern United Kingdom, the Benelux states and north-western France. These forests grow under real atlantic climate. Depending on soil type and trophic status, associate tree species include *Quercus petraea* and *Q. robur* and *Castanea sativa* on more acid sites (*Quercion roboris* alliance), and *Carpinus betulus*,

Tilia cordata and *Fraxinus excelsior* on better sites (*Endymio-Fagion* alliance).

The importance of *Ilex aquifolium* and *Taxus baccata* in the understorey and of various ferns and epiphytes characterise the most atlantic regions. Not mentioning the species listed under the previous type, the most characteristic species of the forest floor include *Hyacinthoides non-scripta*, *Primula acaulis Digitalis purpurea, Ruscus aculeatus*, *Buxus sempervirens, Daphne laureola*; *Arum maculatum*.

Relationship to Annex I, Habitat Directive
9120 — Atlantic acidophilous beech forests with *Ilex* and sometimes also *Taxus*
9130 — *Asperulo-Fagetum* beech forests
Relationships to EUNIS Habitat Classification
G1.6 — Beech woodland

6.6.3 Subatlantic submountainous beech forest

This type spreads from central/western Germany to the foothills of the Pyrenees through southern Belgium, western and central France. The climatic effects of the Atlantic are less pronounced (except from the foothills of the Pyrenees), so these forests represent a transition from the Atlantic to central European province. Species composition in the western part is more similar to the atlantic type, whereas in the north-eastern part species composition is very similar to that of acid or mesotrophic central European beech forests.

Relationship to Annex I, Habitat Directive
9110 — Acidophilous (*Luzulo-Fagetum*) beech forests
9130 — *Asperulo-Fagetum* beech forests
Relationships to EUNIS Habitat Classification
G1.6 — Beech woodland

6.6.4 Central European submountainous beech forest

The major area of this type lies in the central and south-eastern part of Germany and in the Czech Republic. Depending on substrate, acidophilous, mesotrophic and eutrophic stands occur throughout.

On acidic sites *Fagus sylvatica* dominated stands are characterised by *Luzula Luzuloides*, *Polytrichum formosum* and often *Deschampsia flexuosa*, *Calamagrostis villosa, Vaccinium myrtillus*, *Pteridium aquilinum*.

On neutral or near-neutral soils, with mild humus (mull), beech forests are richer in herb species; they are characterised by a strong representation of species belonging to the ecological groups of *Anemone nemorosa*, of *Lamium galeobdolon*, of *Galium odoratum* and *Melica uniflora*.

On calcareous, often shallow soils, small patches of xero-thermophilous *Fagus sylvatica* forests develop usually on steep slopes. In these forests herb and shrub undergrowth is generally abundant, characterised by sedges (*Carex digitata*, *Carex flacca, Carex montana, Carex alba*), grasses (*Sesleria albicans, Brachypodium pinnatum*), orchids (*Cephalanthera* spp., *Neottia nidus-avis*, *Epipactis leptochila, Epipactis microphylla*) and thermophilous species, that show links with forests of warmer sites (*Quercetalia pubescenti-petraeae*). The shrub layer includes several calcicolous species (*Ligustrum vulgare, Berberis vulgaris*) and *Buxus sempervirens* can dominate.

Relationship to Annex I, Habitat Directive
9110 — Acidophilous (*Luzulo-Fagetum*) beech forests
9130 — *Asperulo-Fagetum* beech forests
9150 — Medio-European limestone beech forest of the *Cephalanthero-Fagion*
Relationship to EUNIS Habitat Classification
G1.6 — Beech woodland

6.6.5 Carpathian submountainous beech forest

This type includes beech dominated forest of lower altitudes in the Carpathian region. This means that beech forests under very different biogeographical influences belong to this type. Beech forests occurring west and north of the Carpathians resemble to medio-European beech forests, whereas those east-southeast of the Carpathians (Romanian, Ukrainian Carpathians, east of the Uz and the Stry, and of the west Ukrainian, Moldavian pre-Carpathic hills and plateaux) represent a special type at the eastern limit of distribution of beech. In this latter type tree layer is dominated by *Fagus sylvatica*, or, locally, *Fagus orientalis, Fagus moesiaca, Fagus taurica*. Characteristic species include *Symphytum cordatum*, *Cardamine glanduligera, Hepatica transsilvanica*, *Pulmonaria rubra, Leucanthemum waldsteinii*, *Silene heuffelii, Ranunculus carpaticus*, *Euphorbia carniolica, Aconitum moldavicum*, *Saxifraga rotundifolia* ssp. *heuffelii*, *Primula elatior* ssp. *leucophylla, Hieracium rotundatum*, *Galium kitaibelianum, Moehringia pendula*, *Festuca drymeja*.

Relationship to Annex I, Habitat Directive
9130 — *Asperulo-Fagetum* beech forests
9110 — Acidophilous (*Luzulo-Fagetum*) beech forests
Relationship to EUNIS Habitat Classification
G1.6 — Beech woodland

6.6.6   Illyrian submountainous beech forest

This type includes beech dominated submountainous forests of the Dinarides and of associated ranges and hills, with outliers and irradiations in the south-eastern Alps and in the mid-Pannonic hills. In these areas they are in contact with, or interspersed among, medio-European beech forests. Extremely species rich *Fagus sylvatica* (not *F. moesiaca*) dominated forests grow on better sites in SW Hungary, Slovenia, Croatia and Bosnia-Herzegovina. Associated tree species include *Quercus petraea*, *Q. cerris*, *Tilia tomentosa*, *Sorbus torminalis*. On better sites a rich herb layer develops with many characteristic species, including *Aremonia agrimonoides*, *Vicia oroboides*, *Lamium orvala*, *Primula acaulis*, *Anemone trifolia*, *Cardamine enneaphyllos*, *Leucojum vernum*, *Ruscus hypoglossum*, *Ruscus aculeatus*, *Cyclamen purpurascens*, *Hacquetia epipactis*, *Aposeris foetida*, *Ornithogalum pyrenaicum*, *Lathyrus venetus*, *Tamus communis*.

Relationship to Annex I, Habitat Directive
91K0 — Illyrian Fagus sylvatica forests (Aremonio-Fagion)
Relationship to EUNIS Habitat Classification
G1.6 — Beech woodland

Type: Category 6; two layered beech forest.
Source: Tibor Standovár.

6.6.7   Moesian submountainous beech forest

Fagus sylvatica or *Fagus moesiaca* forests of the Balkan Range, southern Dinarides, Moeso-Macedonian mountains, Rhodopids. They are characterized by a pronounced medio-European character, marked by the frequency of *Acer pseudoplatanus*, *Quercus petraea*, *Fragaria vesca*, and *Oxalis acetosella*. The occurrence of tree species like *Tilia tomentosa*, *Quercus cerris*, *Corylus colurna*, *Acer hyrcanum*, *Acer obtusatum* and *Sorbus torminalis* indicate the Mediterranean effects on flora.

Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G1.6 — Beech woodland

Type: Category 6; examples of even-aged beech forests with different deadwood amounts.
Source: Tibor Standovár.

6.7 Mountainous beech forest

Class definition

Mountainous beech forests are defined by the altitudinal range of distribution, by the dominance of *Fagus* and, in most cases, by the presence of coniferous species (*Abies alba* and/or *Picea abies*) as important components. As in the category 6, locally important additional tree species include *Acer pseudoplatanus, Betula pendula, Carpinus betulus, Castanea sativa, Fraxinus excelsior, Populus tremula, Prunus avium, Quercus petraea, Quercus robur, Sorbus aucuparia, Tilia cordata, Tilia platyphyllos, Ulmus glabra* depending on trophic status and/or successional phase (Ellenberg, 1988; Jahn, 1991).

Geographical distribution

The centre of distribution of mountainous beech forests is in central European mountains, but they also occur in higher mountains in the Pyrenees, Alps, Carpathians and central Balkans, and penetrate via the Apennines as far south as Sicily, where they grow to 2 100 m on Mount Etna. In general, as one moves further south, beech forests occupy a higher and higher mountain zone, their limit is at 1 200 m in the northern Alps, 1 500 m in the Pyrenees, 1 550 m in the Tyrol, and 1 850 m in the Apennines. They also have lower limits ranging from 700 m in the Rhodope mountains Bulgaria to 1 000 m on Mount Olympus, Greece (Polunin and Walters, 1985).

In general, it can be stated that mountainous beech forests have undergone less intensive anthropogenic exploitation by humans, though large geographic variation exists.

In the northern Apennines-southern Alps human use has been intensive for more than a millennium, while in parts of the Dinaric Alps, the Balkans and the Carpathians large tracks of more or less semi-natural forests with smaller natural remnants exist. Intensive forest use for fuelwood purposes was typical of mining areas and in many mountain areas (e.g. in the Apennines and partly in the Alps) beech was used as coppice for firewood and charcoal. Most of these stands were turned to high forest in the 20th century. In other parts of Europe, beech exploitation was severe and large regions became heavily deforested. In some of these areas systematic programmes of reforestation began. Reforestation has changed the composition of natural forest in these areas, supporting the spread of spruce and the fir and pushing back beech.

Types

6.7.1 South-western European mountainous beech forest
6.7.2 Central European mountainous beech forest
6.7.3 Apennine-Corsican mountainous beech forest
6.7.4 Illyrian mountainous beech forest
6.7.5 Carpathian mountainous beech forest
6.7.6 Moesian mountainous beech forest
6.7.7 Crimean beech forest
6.7.8 Oriental beech and hornbeam-oriental beech forest

6.7.1 *South western European mountainous beech forest (Cantabrians, Pyrenees, central Massif, south western Alps)*

This type comprises a wide range of beech- or beech–fir–dominated communities. They are characterised by a mixture of central European, Atlantic and west-Mediterranean effects. The proportion of these depends on location, with increasing Atlantic and west-Mediterranean effects to the southwest. Characteristic species of the Scillo-*Fagion* alliance typical in the Pyrenees, Cantabrians and central Massif include *Betula pubescens* ssp. *celtiberica, Acer monspessulanum, Buxus sempervirens, Erica vagans, Ilex aquifolium, Saxifraga hirsuta, Scilla lilio-hyacinthus*. Forests in the south western Alps contain more species characteristic of the *Geranio nodosi-Fagion* alliance: *Calamintha grandiflora, Ranunculus aduncus, Geranium nodosum, Polygala chamaebuxus*.

Relationship to Annex I, Habitat Directive
9120 — Atlantic acidophilous beech forests with *Ilex* and sometimes also *Taxus*
9130 — *Asperulo-Fagetum* beech forests
9140 — Medio-European subalpine beech forests with *Acer* and *Rumex arifolius*
Relationship to EUNIS Habitat Classification
G1.6 — Beech woodland

6.7.2 *Central European mountainous beech forest*

The beech forests of this type belong to either to the *Luzulo-Fagenion* suballiance on acid substrates or to the *Lonicero alpigenae-Fagion* alliance on richer sites mostly in the Jura Mountains and the northern Alps. The flora has a strong central European character with some subatlantic effects in the northern-northwester part of this area.

Fagus sylvatica-Acer pseudoplatanus forests that grow close to timber line in some central European mountains also belong to this type. They contain *Vaccinium myrtillus, Deschampsia flexuosa,*

Luzula Luzuloides, *Polygonatum verticillatum, Senecio nemorensis, Rumex arifolius, Cicerbita alpina, Athyrium distentifolium,* and *Digitalis purpurea.*

Relationship to Annex I, Habitat Directive
9110 — Acidophilous (*Luzulo-Fagetum*) beech forests
9130 — *Asperulo-Fagetum* beech forests
9140 — Medio-European subalpine beech forests with *Acer* and *Rumex arifolius*
Relationship to EUNIS Habitat Classification
G1.6 — Beech woodland

6.7.3   Apennine-Corsican mountainous beech forest

This type includes mountainous beech forests of the south western Alps, the Apennines and of mountains in Corsica and Sicily.

On acidic sites stands belonging to the *Luzulo pedemontanae-Fagenion* are typical. They are dominated by *Fagus sylvatica* locally mixed with *Abies alba, Quercus petraea, Castanea sativa.* The understorey may contain *Sorbus aucuparia, Rubus idaeus, Ilex aquifolium, Rhododendron ferrugineum,* whereas characteristic herbs include *Luzula pedemontana, Luzula nivea, Deschampsia flexuosa, Vaccinium myrtillus, Hieracium murorum, Blechnum spicant, Oxalis acetosella, Veronica urticifolia, Prenanthes purpurea, Athyrium filix-femina, Dryopteris filix-mas, Gymnocarpium dryopteris, Thelypteris phegopteris.*

On richer sites Apennine beech, beech-fir forests of the *Gerani nodosa-Fagion* occur.

In Corsican mountains beech is mixed with *Abies alba, Pinus nigra* ssp. *laricio.* In the herb layer *Poa balbisii, Luzula nivea, Luzula pedemontana, Neottia nidus-avis, Galium rotundifolium, Crocus corsicus, Cynosurus effusus* are characteristic.

In the northern part of the Apennines beech dominated forests with *Abies alba, Sorbus aucuparia, Acer pseudoplatanus* have *Laburnum alpinum, Rosa pendulina* in the understorey. Characteristic herb species include *Geranium nodosum, Adenostyles australis, Prenanthes purpurea, Galanthus nivalis, Scilla bifolia, Lathyrus venetus, Luzula nivea.*

The tree layer of the small stands of the relict central Apennine beech woods is composed of *Fagus sylvatica, Castanea sativa, Quercus petraea, Quercus cerris, Carpinus betulus,*

Acer pseudoplatanus, Acer obtusatum ssp. *neapolitanum, Acer obtusatum* ssp. *obtusatum.* The occurrence of *Ilex aquifolium, Daphne laureola, Taxus baccata, Laurus nobilis, Buxus sempervirens* is also typical.

Beech-fir forests in the southern part of the Apennines are characterised by the presence of *Ilex aquifolium, Rubus glandulosus* in the shrub layer and of *Geranium versicolor* and *Campanula trichocalycina* in the herb layer.

Relationship to Annex I, Habitat Directive
9210 — *Appenine beech forests with *Taxus* and *Ilex*
9220 — *Appenine beech forests with *Abies alba* and beech forests with *Abies nebrodensis*
Relationship to EUNIS Habitat Classification
G1.6 — Beech woodland

6.7.4   Illyrian mountainous beech forest

This type includes the diverse mountainous beech, beech-fir forests of the south-eastern Alps and the Dinaric Alps.

The thermophilous mountainous beech forest of the *Ostryo-Fagenion* suballiance is composed by a mixture of different tree species (*Fagus sylvatica, Laburnum alpinum, Fraxinus ornus, Ostrya carpinifolia, Sorbus domestica, Sorbus aria, Acer pseudoplatanus*). In the rich shrub layer *Euonymus verrucosa, Rhamnus cathartica, Cornus mas, Ligustrum vulgare, Berberis vulgaris, Viburnum lantana, Ruscus aculeatus, Daphne mezereum, Lonicera alpigena, Rosa arvensis* occur. Characteristic herb species include Sesleria autumnalis, *Lathyrus venetus, Lathyrus vernus* ssp. *gracilis, Cyclamen purpurascens, Helleborus niger* ssp. *niger.*

At sites with more humid climates stands belonging to the *Aremonio-Fagion* alliance occur. At the lower zone within this type *Fagus sylvatica-Fagus moesiaca* forests occur with *Acer pseudoplatanus, Acer platanoides, Fraxinus excelsior, Acer heldreichii* ssp. *macropterum* in the tree layer. At higher elevations *Fagus sylvatica* is mixed with *Abies alba,* (*Picea abies*), *Acer pseudoplatanus, Acer obtusatum.* The shrub layer contains species mixtures made up by *Lonicera formanekiana, Rhamnus alpina* ssp. *fallax, Daphne mezereum, Daphne laureola, Lonicera xylosteum, Lonicera alpigena, Rosa pendulina, Euonymus latifolius, Corylus avellana.* Characteristic herb species include *Anemone trifolia, Aposeris foetida, Helleborus niger, Lamium orvala, Calamintha grandiflora, Homogyne sylvestris, Hacquetia epipactis, Cardamine enneaphyllos, Omphalodes verna, Aremonia agrimonoides, Campanula trichocalycina.*

In the highest mountains of Bosnia-Herzegovina, Macedonia and northern Albania islands of mixed beech-fir stands with stronger moesian character occur.

Relationship to Annex I, Habitat Directive
91K0 — Illyrian *Fagus sylvatica* forests
(*Aremonio-Fagion*)
Relationship to EUNIS Habitat Classification
G1.6 — Beech woodland

6.7.5   Carpathian mountainous beech forest

This type includes beech-dominated forest belonging to the *Symphyto cordatae-Fagion* alliance. These mountainous beech forests have a strong central European character, though in the south/south-eastern Carpathians the effects of the eastern Mediterranean are more pronounced. Important tree species are *Fagus sylvatica, Abies alba, Picea abies, Acer pseudoplatanus, Ulmus glabra*. In this region large tracks of almost pure *Fagus* stands are characteristic. The sparse shrub layer is composed of *Sambucus racemosa, Lonicera xylosteum, Lonicera nigra, Rubus hirtus, Daphne mezereum, Ribes uva-crispa*. Of the many herb species *Cardamine glanduligera, Polystichum braunii, Symphytum cordatum, Pulmonaria rubra, Actaea spicata, Euphorbia carniolica, Hepatica transsilvanica, Aconitum lycoctonum* ssp. *moldavicum* are distinctive for this type.

Relationship to Annex I, Habitat Directive
9110 — Acidophilous (*Luzulo-Fagetum*) beech forests
9130 — *Asperulo-Fagetum* beech forests
Relationship to EUNIS Habitat Classification
G1.6 — Beech woodland

6.7.6   Moesian mountainous beech forest

The forests belonging to this type grow at elevations ranging from 900 to 1 800 meters asl. in Yugoslavia, Macedonia, Bulgaria, southern Albania and Greece. They often occur in isolated small patches in the high mountains. Several associations — belonging to the *Fagion* moesiacum alliance — have been described from this area, but the common characteristic is the presence of transitional *Fagus taxa*, mostly *F. moesiaca*, and the distinctive feature of most associations within this type is the presence of *Abies borisii-regis*. In the tree layer *Fagus sylvatica, Fagus moesiaca, Abies alba, Abies borisii-regis, Picea abies, Acer pseudoplatanus, Sorbus aucuparia, Salix caprea, Betula pendula, Acer heldreichii, Pinus sylvestris,*

Pinus nigra ssp. *Pallasiana* are characteristic. *Acer obtusatum, Lonicera xylosteum, Rubus idaeus, Daphne mezereum, Sambucus racemosa,* are among the locally typical shrub species.

In Greece small areas of special Hellenic beech forests — belonging to the *Doronico orientalis-Fagion moesiacae* alliance with *Silenemulticaulis, Lathyrus alpestris, Orthilia secunda, Festuca drymeja, Doronicum orientale* occur.

Relationship to Annex I, Habitat Directive
9270 — Hellenic beech forests with *Abies borisii-regis*
Relationship to EUNIS Habitat Classification
G1.6 — Beech woodland

6.7.7   Crimean mountainous beech forest

This type occurs on the northern slopes of the southernmost mountain range of the Crimean Peninsula at altitudes between 600 and 1 100 meter asl., where climate is cool with moderate precipitation. *Fagus moesiaca* is in almost pure stands or occasionally mixed with *Carpinus betulus, Fraxinus excelsior, Tilia cordata, Ulmus glabra*. The poorly developed understorey possibly includes *Euonymus latifolius* and *Taxus baccata*. Herb layer is distinct from any above mentioned type (e.g. *Corydalis paczoskii, Cyclamen coum, Nectaroscordum siculum* ssp. *bulgaricum, Lathyrus rotundifolius, Vincetoxicum scandens, Symphytum tauricum*).

Relationship to Annex I, Habitat Directive
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Relationship to EUNIS Habitat Classification
G1.6 — Beech woodland

6.7.8   Oriental beech and hornbeam-oriental beech forest

Oriental beech forests extend from west Euxinian Bulgaria and the European part of Turkey (Istranca Mountains) across northern Anatolia (Pontic Mountains) to the Lesser and Great Caucasus, as well as along the southern coast of the Caspian Sea.

This type consists of mountainous deciduous forests in the area of the Black and Caspian Seas dominated by Oriental beech (*Fagus sylvatica* ssp. *orientalis*). Oriental beech stands may be monodominant, but the tree layer almost always consists of one or several mixed tree species. In addition to hornbeam (*Carpinus betulus*) — which is the

compulsory associate species in the entire range — *Tilia begoniifolia, Acer platanoides, A. cappadocicum, A. pseudoplatanus, Fraxinus excelsior, Castanea sativa, Tilia cordata*, and in the Balkans *Tilia tomentosa* can also occur. Where they are in contact with mountainous coniferous forests, *Abies nordmanniana* and *Picea orientalis* occur, as does *Acer trautvetteri* where the formation borders on subalpine vegetation.

In the extremely humid areas in the southern and eastern regions of the Black Sea, Oriental beech forests are characterised by a more or less dense undergrowth of evergreen shrubs, particularly *Rhododendron ponticum* and *Prunus laurocerasus*. The forest flora displays a range of endemic and ancient species particularly concentrated in the Colchic and Hyrcanian floristic provinces.

Relationship to Annex I, Habitat Directive

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Relationship to EUNIS Habitat Classification
G1.6
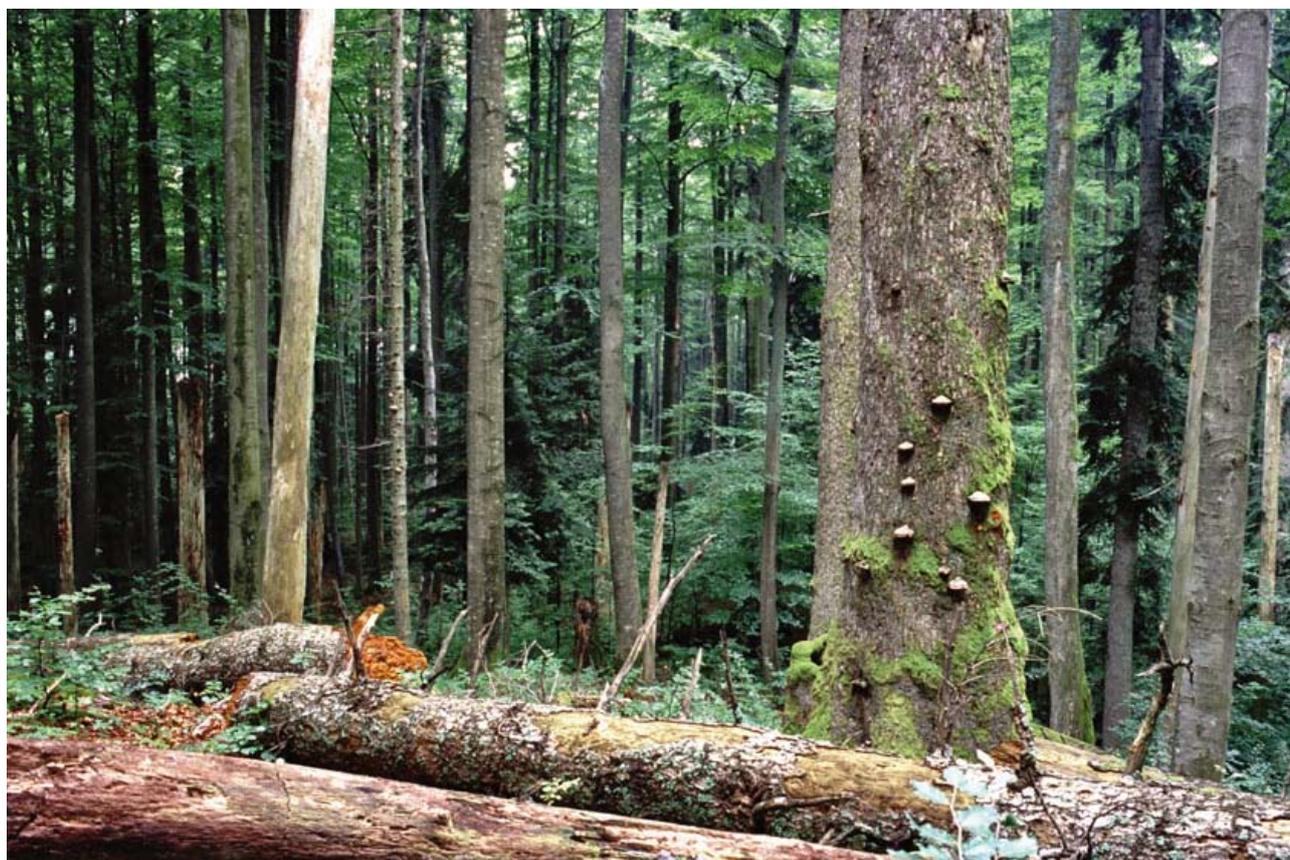
Type: Category 7; Mountainous beech forest with abundant deadwood levels.
Source: Tibor Standovár.

6.8   Thermophilous deciduous forest

Class definition

Forest dominated by deciduous or semideciduous thermophilous species, mainly *Quercus pubescens*; other oaks associate with or replace *Q. pubescens* in submediterranean woods: *Quercus faginea*, *Q. pyrenaica* and *Q. canariensis* (Spain), *Q. cerris* (Italy), *Q. frainetto*, *Q. trojana* (Greece). The species typically associated in these oak woods are maples (*Acer monspessulanus*, *Acer opalus*, *Acer obtusatum*) and, in eastern areas, *Ostrya carpinifolia*, *Fraxinus ornus*, *Carpinus orientalis*. Forest dominated by thermophilous deciduous oaks, under local microclimatic or edaphic conditions, are found also far north in the Atlantic region, Pannonic and Continental regions.

The class includes also:

- other deciduous non-alluvial formations of meso- and supra-Mediterranean zone dominated by *Fraxinus* spp., *Ostrya carpinifolia*, *Carpinus orientalis*, *Acer* spp., *Tilia* spp., *Carpinus betulus*, *Aesculus hippocastanus* and *Juglans regia*;

- *Castanea sativa* dominated forests, represented, for the most part, by old established and naturalised plantations.

Geographical distribution

The main area of distribution of the category is the biogeographical Mediterranean region, namely the climatic zone referred as supra-Mediterranean (see for reference Quézel and Médail, 2003). Forest types under this class are also found in other distinct biogeographical areas, namely: the warmest sector of the Atlantic region (south-western France, north and north-western coast of the Penisula *Iberica*); the Alpine region in the lowest altitudinal levels of Pyrenees, Massif central, Jura, Alps. the periphery and hills surrounding the Pannonic depression; the sub-continental sector of the Continental Region.

Thermophilous deciduous forests are limited to the north (or upslope) by temperature and to the south (or downslope) by drought; at these limits they are replaced by, respectively, coniferous forests and broadleaved sclerophyllous vegetation.

The presence of thermophilous deciduous woods beyond the supra-Mediterranean zone is associated with local favourable climatic or edaphic conditions.

Before describing thermophilous deciduous forest types in detail, we outline in the following some relevant compositional and structural features of the category:

- (residual) richness forest communities as to dominant tree species: most thermophilous deciduous forests are dominated by assemblages of one-two dominant native (or naturalised) tree species accompanied by secondary species and/or an understory. Anthropogenic exploitation has modified the natural composition of thermophilous deciduous forests, leading in most cases to the elimination of natural species without a commercial interest or with poor resprouting capacity or, conversely, the introduction of other forest species that would not occur naturally (chestnut). Some mixed broadleaved and coniferous forest types found under this category derive, for instance, by the 'enrichment' in coniferous forest species (mainly mediterranean *Pinus* species and *Cupressaceae*) of broadleaved deciduous coppices;

- variability of forest cover and physiognomy: tree growth and forest cover range from low-growing and fragmentary woods in most dry sites or degraded sites, to scattered and full-sized trees looking like savanna formations originated by cultivation, to well developed and closed forests;

- differentiation of forest structural types: rather simplified forest structures shaped by traditional silvicultural systems are most common (coppice, coppice with standards, mixed coppice/high forest). Forest structures of purely cultural origin are also chestnut groves, today largely replaced by coppice-woods or left unmanaged. Some chestnut-groves host ancient trees and thus important habitats for species related to the specific qualities of old-growth forest (e.g. hole nesting birds, invertebrates living in thick bark);

- further condition of structural differentiation within the category is the abandonment of forest cultivation: e.g. high forest-like structures develop naturally with the cessation of felling in coppices, process that is under particular circumstances actively managed through the conversion to high forest; a sort of 'infilled' structure can be observed in unmanaged *Castanea sativa* groves with old big tree surrounded and/or overtopped by a crowd of local pioneer forest species.

Types

6.8.1   Downy oak forest
6.8.2   Turkey oak, Hungarian oak and Sessile oak forest
6.8.3   Pyrenean oak forest
6.8.4   Portuguese oak and Mirbeck's oak Iberian forest
6.8.5   Macedonian oak forest
6.8.6   Valonia oak forest
6.8.7   Chestnut forest
6.8.8   Other thermophilous deciduous forests

6.8.1   Downy oak forest

The type is widespread in the meso- and supra-Mediterranean level from the Pyrenees to Caucasus; in Turkey woodlands are dominated by the subspecies *anatolica*, colonising the western and central Anatolian steppes (Quézel and Médail, 2003); the type is also found locally elsewhere in warm, dry or degraded sites in the Atlantic, Continental and Pannonic region; it is frequently associated with warm exposures and limestones.

Quercus pubescens is the dominant forest species, frequently mixed with other thermophilous deciduous species. Coppicing, charcoal burning and grazing are the most relevant anthropogenic factors that influence/ed the present-day physiognomy of *Quercus pubescens* forests. The latter two factors are largely responsible of downy oak woods degradation (Polunin and Walters, 1985).

The trees associated with *Quercus pubescens* vary according to biogeographical, bioclimatic and local site variability; the most relevant association in Europe are listed below:

Western downy oak communities: on southern slopes of Pyrenees and in Catalogne are common mixtures with *Q. faginea* or with the hybrid *Q. cerrioides*; in France, in the thermomediterranean level sclerophyllous species and Aleppo pine are frequent (Provence); in the supra-mediterranean level are often found varied tracts of high forest and coppice and with standards (*Acer monspessulanum. Acer campestre*, *Tilia platyphyllos*, *Sorbus domestica*). In higher elevations (600–900 m) on Pyrenees, Cévennes and Pre-Alps of Provence common associated trees are: *Acer opalus*, *A. platanoides*, *Populus tremula* and *Pinus sylvestris*

Italian downy oak woods: often varied forest of the supra-Mediterranean levels of Italy and Greece; in

the Italian Appennines *Quercus pubescens* is usually associated with other thermophilous deciduous species (*Q. cerris*, *Acer campestre*, *Ostrya carpinifolia*, *Fraxinus ornus*) or *Q. ilex*.

Greek and Anatolian downy oak woods: thermomediterranean communities on deep soils and sub-humid bioclimate are found in Crete, with *Olea* and *Ceratonia* as typical associated trees. Characteristic of meso-Mediterranean greek woodlands is *Q. frainetto* and, locally, *Acer sempervirens* and other trees typical of broadleaved evergreen forests. Low-growing (2–3 m) mostly degraded woodlands of *Q. pubescens* ssp. *anatolica* are found in the semi-arid periphery of the Anatolian plateaux.

Steppe oakwoods: xero-thermophilous oakwoods of the plains of south-eastern Europe, growing under very continental climate, on Chernozem soils. The tree layer is characterised by mixtures of downy oak with by a pedunculate oak (*Quercus robur*) and turkey oak (*Quercus cerris*). The herb layer is rich in continental steppic vegetation elements and geophytes of the *Aceri tatarici-Quercion*. The center of distribution of steppe oakwoods lies in southern Russia and Ukraine and reaches its western distribution in eastern parts of Austria; this vegetation type, which formed the natural vegetation of south-eastern Europe, is today very fragmented and often degraded by invasion of *Robinia*.

Relationship to Annex I, Habitat Directive
91H0 — *Pannonian white oaks woods
91I0 — *Euro-Siberian steppic woods with *Quercus* spp.
93A0 — Woodlands with *Quercus infectoria* (*Anagyro foetidae-Quercetum infectoriae*)
Relationship to EUNIS Habitat Classification
G1.7 — Thermophilous deciduous woodland

6.8.2   Turkey oak, Hungarian oak and Sessile oak forest

Supramediterranean often varied oakwoods characterised by different mixtures of *Quercus* species, mainly *Quercus cerris*, *Q. frainetto*, *Q. petraea*, distributed throughout in the Mediterranean region spreading, locally, in the Pannonic, Continental and Anatolian biogeographical Regions.

The most characteristic assemblages of forest dominant species under this type are:

- *Quercus cerris* and *Q. frainetto* mixed woods on deep soils both on alluvial plains and on the hill and mountain ranges of the Italian Appennine;

- *Quercus cerris*-dominated forest of hill and mountains in Italian Appennines; several structural types can be found under this type; in Italy Turkey oak forests are cultivated both as coppices (coppice, coppice with standards, mixed coppice/high forest) and as high forest. In *Quercus cerris* high forest of central Italy, namely, the silvicultural system traditionally prescribed in forest management is shelterwood with rotation of 80–100 years. Such a model, however, has never been fully applied and selective cuttings, based on commercial criteria, prevailed; this is reflected in the present-day structure of the forest that shows a good degree of stand structure diversity;

- Pannonian *Q. petraea* and *Q. cerris* woods associated with *Tilia cordata*, bordering the pannonic plain;

- forests of the of the Drava and Sava basin and the western Balkan peninsula, dominated by *Quercus cerris* and *Quercus petraea*, usually associated with *Ostrya carpinifolia*, *Carpinus orientalis*, *Carpinus betulus*, *Fraxinus ornus*;

- forests dominated by *Quercus cerris*, *Quercus frainetto*, sometimes *Quercus petraea*, *Quercus pseudocerris*, *Quercus boissieri*, characteristic of the supra-Mediterranean level of the southern part of the eastern Mediterranean peninsulas and of southern Asia Minor;

- xerophytic or xero-mesophytic forests of *Quercus frainetto*, *Quercus cerris*, of *Quercus petraea* and related deciduous oaks, locally of *Quercus pedunculiflora* or *Quercus virgiliana*, of the sub-continental central and eastern Balkan peninsula, of the supra-Mediterranean level of continental Greece, except the extreme south, and of supra-Mediterranean Anatolia. In most of their range they constitute the lowest altitudinal tier of forest vegetation; in Greece and adjacent areas, however, they occur above the forests of the *Ostryo-Carpinion*;

Type: 8.2; Turkey oak high forest originated from coppice conversion.

Source: Anna Barbati.

- *Quercus petraea* ssp. *iberica* forests of northern Anatolia with *Ostrya carpinifolia*, *Abies bornmuelliriana* and *Fagus sylvatica* ssp. *orientalis* as common species;

- *Quercus macranthera* ssp. *syspirensis*-dominated forest of northern Anatolia, where *Q. cerris* may be locally present;

Relationship to Annex I, Habitat Directive
91M0 — Pannonian-Balkanic turkey oak- oak forest
9280 — *Quercus frainetto* woods
Relationship to EUNIS Habitat Classification
G1.7 — Thermophilous deciduous woodland

6.8.3 Pyrenean oak forest

Quercus pyrenaica-dominated forests are endemic to the mountains of Iberian peninsula. The species grows typically on acid siliceous substrates or otherwise on decalcified soils; it is found mostly in the ibero-atlantic zone of Portugal and Spain under humid and sub-humid bioclimate (Rivas-Martínez *et al.*, 2001), in meso- and supra-Mediterranean vegetation belts.

In the Mediterranean region, Pyrenean oakwoods have been intensively coppiced for firewood; as a result it frequently appears as monospecific tracts of low-growing small-diameter trees, originated from shoots or roots (García-Herrera, 2002). In the central-western part of its distribution range Pyrenean oak is occasionally managed as *dehesa*.

Two main groups of Pyrenean oak forests can be distinguished:

1. Cantabric *Q. pyrenaica* forests: the northernmost ones, growing under oceanic influence at mid-mountain levels (600–1 200 m) in areas with precipitation over 1 000 mm/yr; commonly associated species are: *Quercusx andegavensis* (*Q. robur x pyreniaca*), *Acer campestre*, *Fraxinus excelsior*, and less frequently *Q. petraea*;

2. inland *Q. pyrenaica* forests: this group includes most of *Q. pyrenaica* forests. It can be divided into:

   2.1 *Q. pyrenaica* forests of the Iberic and central mountain ranges and foothills, growing under more or less Mediterranean continental conditions (sharp changes of temperature winter–summer and day–night, abundance of frost periods all over the year, except mid summer); in the more continental areas (western part of central Range and Iberic mountains), Pyrenean defines an ecotone with *Pinus sylvestris*, which predominates in higher altitudes and drier soil conditions (type 10.4), and with *Q. ilex* ssp. *ballota* in the lower areas (type 9.1);

   2.2 Southern Plateau low mountains *Q. pyrenaica* forests (Extremadura, Andalucia, Castilla-La Mancha, and the eastern — most Iberic mountain areas close to the Mediterranean coast) growing in absence of continental conditions, in warmer areas with humidity due to oceanic influence. *Q. pyrenaica* is mixed with *Q. suber*, *Q. faginea* ssp. *broteroi*, and *Q. ilex* ssp. *ballota*. *Arbutus unedo* characterises the forest understorey.

Relationship to Annex I, Habitat Directive
9230 — Galicio-Portoguese oak woods with *Q. robur* and *Q. pyrenaica*
Relationship to EUNIS Habitat Classification
G1.7 — Thermophilous deciduous woodland

6.8.4 Portuguese oak and Mirbeck's oak Iberian forest

Portuguese oak (*Quercus faginea*) is typical of the supra-mediterranean level of Penisula iberica (north-eastern and centre) and grows in humid and sub-humid bioclimate. Characteristic associated trees are (Quézel and Médail, 2003;

Type: 8.3; Pyrenean oak forest.
Source: Pedro Regato.

García-Herrera, 2002): i) holm oak and cork oak and Pyrenean oak (Andalusia, Toledo hills and Sierra Morena); ii) *Acer campestre, Acer monspessulanum* and *Fraxinus ornus* in north-eastern mountain ranges; ii) on calcareous baetic mountain ranges *Acer opalus* ssp. *granatense*.

Mirbeck's oak (*Quercus canariensis*) grows in iper-humid and humid warm bioclimate in the thermo-mediterranean ranges of the western Iberian peninsula (Cadiz, Sierra de Huelva, Sierra de Monchique). The most typical associated tree is *Quercus suber*. Mirbeck's oak forest hosts important sub-tropical plant species (Tertiary relics), such as *Rhododendron ponticum* ssp. *baeticum*, *Davallia canariensis*, *Culcita macrocarpa*, *Psilotum nudum*.

Relationship to Annex I, Habitat Directive
9240 — *Quercus faginea* and *Quercus canariensis* Iberian woods
Relationship to EUNIS Habitat Classification
G1.7 — Thermophilous deciduous woodland

Type: 8.4; Portuguese oak forest.
Source: Pedro Regato.

Type: 8.4, Mixed Mirbeck's oak and cork-oak forest.
Source: Pedro Regato.

6.8.5 Macedonian oak forest

Supra-Mediterranean, and occasionally meso-Mediterranean woods dominated by the semi-deciduous *Quercus trojana*. *Quercus trojana*-dominated forests are mainly found in Greece (Thrace and Thessaly) and locally in southern Italy (Apulia, Murge). Greek Trojan oak woods are usually low formations often mixed junipers and maples. Apulian Trojan oak woods are relict woods (few hundred hectares) mixed with *Q. pubescens* and, often, with *Q. ilex* and its associated vegetation.

Relationship to Annex I, Habitat Directive
9250 — *Quercus trojana* woods
Relationship to EUNIS Habitat Classification
G1.7 — Thermophilous deciduous woodland

6.8.6 Valonia oak forest

Quercus ithaburensis ssp. *macrolepis*-dominated woodlands, mainly found in the meso-Mediterranean level in Anatolia; in south-western Anatolia on deep alluvial and colluvial soils and sub-humid bioclimate; it forms open woodlands where *Q. infectoria* ssp. *veneris* and *Q. cerris* are commonly found. In southern Anatolia (Taurus range) and also locally in Cyprus mixtures with *Q. frainetto*, *Q. cerris* and *Q. infectoria* ssp.*xveneris* occur.

Quercus macrolepis formations of continental Greece and its archipelagos range from well developed forest (Ionian Islands, Lesbos) to open forests, grove-like stands (Western Etolia, north-western Peloponnese, Thessaly, Attica, Thrace). In Crete *Quercus macrolepis* is often associated with *Cupressus sempervirens*, *Quercus coccifera* and *Ceratonia siliqua*. Some open *Quercus macrolepis* stands are also found in southern Italy in Salento (Tricase), originated from plantations.

Stands of *Q. brachyphylla*, often associated with *Quercus macrolepis* and *Q. ilex*, are found in Peloponnese and Crete.

Relationship to Annex I, Habitat Directive
9350 — *Quercus macrolepis* forests
9310 — Aegean *Quercus brachyphylla* woods
Relationship to EUNIS Habitat Classification
G1.7 — Thermophilous deciduous woodland

6.8.7 Chestnut forest

Sweet chestnut (*Castanea sativa*) forests are very widespread in Europe and are typically associated to a mild oceanic climate and deep soils, mostly on siliceous substrates. The area covered by chestnut forest in Europe can be estimated in approximately 2 million hectares. Chestnut forest are mainly found in Turkey, Slovenian coastal hinterland, Greece (northern mainland, Peloponnese, Crete and Aegean islands), Italian Alps and southern Switzerland (small historical remnants distributed on warm southern slopes in the eastern peripherical zone of the Alps), Italian Appennines and coastal ranges, Sicily, Sardinia, Corsica, France and Iberian peninsula.

Northern Turkey is an undoubted center of indigenousness of *Castanea sativa*. The species is however regarded as naturalised throughout its wide geographical range.

Regional differences in the composition of chestnut forests are partly related to the wide distributional area covered by the species; associated tree species (e.g. *Quercus, Betula pendula, Acer, Ulmus, Fraxinus, Corylus avellana*) and floristic cortège reflect the differentiation in forest vegetation in this wide geographical range (medio-European acidophilous oakwoods in the Alps, Atlantic oakwoods in Pyrenees and south-western France, several types of thermophilous deciduous forest in Italy and Greece, etc.).

Various structural types of chestnut woodlands are found in Europe. Forest managed for wood production forest are mostly coppices but also high forests, originated from coppice conversion. These types are well represented in Italy and France. Variable rotation periods are applied in coppices depending on the assortments to be yielded (firewood, poles, high quality timber for furniture manifacturing and building construction). Chestnut groves for fruit production are also important types in Italy, Portugal and Spain. A wide spectrum of structural conditions is found as well in chestnut woods left from cultivation: e.g. unused chestnut groves (with big ancient trees) infilled by local native pioneer species, high forests resulting from passive conversion of former coppices.

In recent forest history biological disturbances, mainly *Phyrophthora* and *Cryphonectria*, have been major determinants of change chestnut stands, leading to the conversion of many chestnut groves into coppices or to the abandonment of forest cultivation.

Type: 8.7; Chestnut orchard.

Source: Anna Barbati.

Relationship to Annex I, Habitat Directive
9260 — *Castanea sativa* woods
Relationship to EUNIS Habitat Classification
G1.7 — Thermophilous deciduous woodland

6.8.8   Other thermophilous deciduous forests

The type is very heterogeneous; it includes more or less thermophilous deciduous woods of meso- and supra-Mediterranean levels:

- **thermophilous ash forest**: non alluvial, non-ravine thermophilous formations dominated by *F. angustifolia* often mixed with others oaks (*Q. pubescens, Q. pyrenaica*); typical of the western Mediterranean Region (Sicily, Iberian peninsula);

- *Fraxinus ornus* **and** *Ostrya carpinifolia* **forest**: submediterranean *Fraxinus ornus-Ostrya carpinifolia* low formations of the Alps (southern peripheral zone), Appennines and islands. In the Alps *Fraxinus* and *Ostrya* grow only up to 8–10 m and are marked by a very species rich shrub layer (e.g. *Prunus mahaleb, Cotinus coggygria, Coronilla emerus, Celtis australis*). These woods commonly originate from *Q. pubescens* woods managed as coppices for a long time;

- **hop-hornbeam** (*Ostrya carpinifolia*) **forest**: typical of the higher supra-Mediterranean range of northern Greece (*Ostryo-Carpinion aegeicum*) and of Appennines;

- **Oriental hornbeam** (*Carpinus orientalis*) **forest**: low formations dominated by *Carpinus orientalis*, particularly abundant in Greece, but also found locally in southern Italy;

- **Thermophilous maple** (*Acer* spp.) **forest**: supra-mediterranean forest of southern Iberian peninsula dominated by *A. monspessulanum* and *A. opalus* ssp. *granatense*, associated with oaks (*Q. faginea, Q. pyrenaica*), *Sorbus, Taxus baccata*.

- **Mediterranean lime** (*Tilia* spp.) **forest**: supra- or meso-Mediterranean formations dominated by *Tilia* species (*T. cordata, T. platyphyllos, T. tomentosa*).

- *Celtis australis* **forest**: found both in riparian areas (e.g. western part of central range in Spain, where the Tertiary relic *Prunus lusitanica* frequently appears) and in meso- and supra-Mediterranean rocky slopes and canyons (e.g. southern slopes of central Pyrenees;
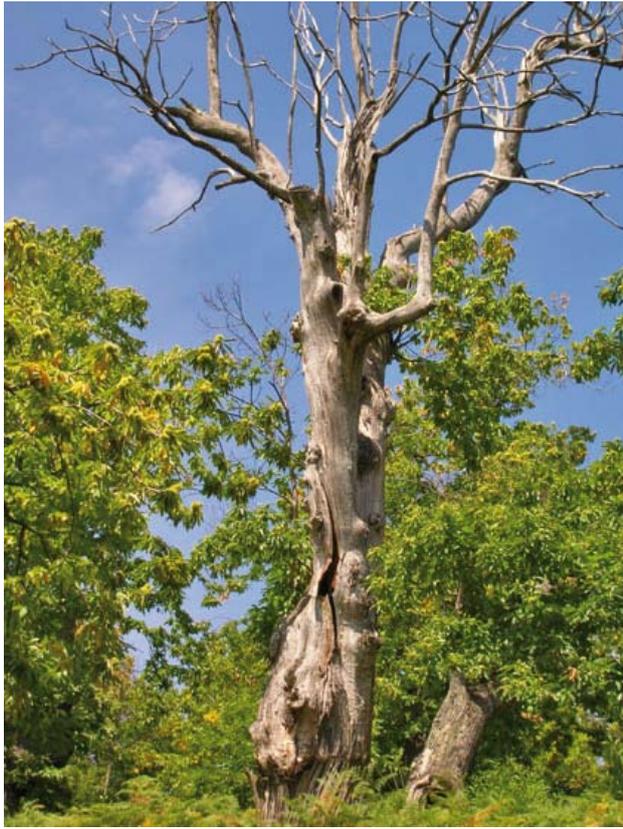
Type: Different types of deadwood habitats found in chestnut orchards. Left: standing dead tree; right: veteran tree.

Source: Anna Barbati.

transfrontier Duero valley between Portugal and Spain; Sierra Morena; Mediterranean coastal ranges) in which warm-Mediterranean floristic elements are found (i.e. *Q. ilex* ssp. *ballota*, *Acer monspessulanum*, *Jasminum fruticans*, *Lonicera implexa*, *Rhamnus alaternus*, etc.);

• **Horse chestnut (*Aesculus ippocastanus*) and walnut (*Juglans regia*) mixed woods**: both species are native of the eastern Mediterranean Region where they form often varied woods restricted to very local sites. The natural range has been widely extended by cultivation and planting and the species have become naturalised in the rest of Mediterranean region

and in central Europe (e.g. open forests or gallery forests of *Aesculus hippocastanus* in parks originally used for hunting purposes etc.). The main native woods are found in eastern Greece in damp mountain ravine and valleys between 350–1 350 m (Polunin and Walters, 1985). Horse chestnut and walnut are associated with *Alnus glutinosa*, *Carpinus betulus*, *Fagus sylvatica*, *Quercus*, *Acer*, *Tilia* and *Fraxinus*.

Relationship to Annex I, Habitat Directive
91B0 — Thermophilous *Fraxinus angustifolia* woods
Relationship to EUNIS Habitat Classification
G1.7 — Thermophilous deciduous woodland

6.9 Broadleaved evergreen forest

Class definition

Forests characteristic of the Mediterranean and warm-temperate humid zones of Macaronesia biogeographical regions, dominated by broadleaved sclerophyllous or lauriphyllous evergreen trees or by palms. The geographical distribution of the category and its main relevant compositional and structural features are specified under types descriptions.

Types

6.9.1 Mediterranean evergreen oak forest
6.9.2 Olive-carob forest
6.9.3 Palm groves
6.9.4 Macaronesian laurisilva
6.9.5 Other sclerophlyllous forest

6.9.1 *Mediterranean evergreen oak forest*

Woodland dominated by the evergreen sclerophyllous *Quercus* species: *Q. suber*, *Q. ilex*, *Q. rotundifolia*, *Q. coccifera*, *Q. alnifolia*. The evergreen oak woodland constitutes the main natural forest formation of the meso-Mediterranean vegetation belt, but today very few fully developed tracts are left in Europe. The present distribution and physiognomy of Mediterranean evergreen oakwoods is the result of an old anthropogenic alteration by clearance, coppicing, fires and overgrazing, resulting in vast areas covered today by the degraded stages of evergreen oakwoods: arborescent matorral, maquis and garrigues.

A characteristic physiognomy of evergreen oak woodlands in the Iberian peninsula, found also locally elsewhere (Balearic islands, Sardinia, Crete), are savanna-like formations — known as montado in Portugal and *dehesa* in Spain — in which crops, pasture land or arborescent matorral are shaded by a fairly closed to very open canopy of native evergreen oaks. The trees are usually lopped or pollarded according to traditional forms to increase the production of acorns or to create dense and low platform of foliage to feed livestock (e.g. 'goat pollard' form in Crete).

In Spain and Portugal under *Q. suber* and *Q. rotundifolia* coverage grow grassland, very rich in species and often different from plant communities in between trees. In east Crete, on limestone mountains in between *Q. coccifera* trees

there is a mosaic of maquis (often of *Q. coccifera* in its ground-oak form), undershrubs and steppe.

The presence of different juxtaposed habitats favours biodiversity development. These cultural woodlands are especially important for the conservation of birds that feed in the open and nest in the trees (e.g. cinereous vultures, *Aegypius monachus*). Due to its uniqueness, this kind of cultural woodland is recognised as habitat of community importance in the Natura 2000 network (6310 — *Dehesa*s with evergreen *Quercus* spp.).

The importance for biodiversity conservation is even increased where ancient trees are present, each single old pollard being an assemblage of deadwood habitats. However, most of these woodlands generally lack ancient trees, which are conversely rather widespread in thermophilous deciduous savanna like formations (e.g. chestnut orchards).

Apart from *dehesa* akin physiognomies, Mediterranean evergreen oak woodlands present inner compositional structural and variability, which major features are outlined in the following based on further stratification of the type into:

- cork oak and holm oak woodland;

- Kermes and alder-leaved oak woodland.

Cork oak and holm oak forest

Geographical distribution

Cork oak and holm oak form the most widespread evergreen woodland in the Mediterranean Region. Forest dominated by *Q. ilex*, are typical of the meso-Mediterranean level, but ingression to the supra-mediterranean level is also common. Holm-oak woodland is often, but not necessary, calcicolous. Two main groups of holm-oak woodlands can be distinguished: *Q. ilex* ssp. *ilex*, that are the moister holm-oak formations; *Q. ilex* ssp. *ballota* (*Q. rotundifolia*) corresponding to drier holm oak formations and restricted to Iberian peninsula.

Q. suber dominated woodland has a west-Mediterranean distribution and is associated to siliceous substrates. It is usually more thermophilous and hygrophilous than holm-oak woodland. In some areas, holm-oak and cork-oak woodland are closely related and the two oaks occur in mixed stands.

Compositional features

Holm-oak and cork-oak woodland share similar floristic train; small trees typically associated in the undergrowth are lauriphyllous and sclerophyllous species. Inner variation in tree species composition depends also on the floristic region and vegetation belt: e.g. in Spain mixed woodland of cork-oak and other deciduous oaks (*Q. robur*, *Q. faginea*) are found; in Greece *Fraxinus ornus*, and *Arbutus andrachne* are associated to holm-oak woodland; in Italy supra-Mediterranean evergreen oak woodland includes thermophilous deciduous trees; also frequent is the mixture of evergreen oaks with mediterranean or Black pines and cypress. Noteworthy are also *dehesa*-like formations of *Q. congesta* and *Q. suber* in Sardinia.

Structural features

Holm-oak woodland

Today, relatively few examples of fully developed holm-oak forest remain in Europe e.g. in the south-western quadrant of the Iberian peninsula (e.g. Portuguese-Extremaduran holm oak woodland) and in Sardinia (Mount Gennargentu, Supramonte forest).

Most *Q. ilex* woodland is under an active coppice management (coppice, coppice with standards), while *Q. rotundifolia* formations are, to a large extent, *dehesa*s.

In both cases forest physiognomy is extremely simplified and generally lacking in deadwood component.

Cork-oak woodland

Cork-oak is one of the forest tree species of greatest commercial interest in the western mediterranean basin, where the survival of reasonably extensive tracts of fully developed forest is currently jeopardized; the best preserved examples are left today in soutwestern Iberian peninsula (e.g. Sierra de Aljibe and Extremadura) and, locally, in Sardinia (Gallura).

Intensive anthropogenic exploitation of cork oak woodland for agriculture, grazing or cork stripping influences cork-oak woodland structure and forest dynamics: crown pruning and pollarding, clearing of the understory, periodical soil ploughing. Natural disturbances (recurrent fires, diseases and attack by leaf-eating insects like *Lymantria dispar*) are additional factors of forest degradation.

The most common physiognomies of cork-oak woodlands are:

- open formations or *'montados'* with scattered cork oaks, never reaching 16 m, and sparse understory; the understory can be periodically cleared for soil tillage for crops (cereals) or bush removal; natural regeneration of cork oak is generally absent;

- two layer forest, formations frequently originated from fire-related processes with an upper layer, where forest cover may be closed, with cork-oak as the main tree, and the lower layer consisting of sclerophyllous or ericoid species; these grow dense and prevent the regeneration by seed of the cork-oak;

- uneven aged high forest originated by recurrent fires, that increase light penetration to the soil and encourage the presence of species, that are a good source of nitrogen for the soil (e.g. *Cytisus*); to maintain the uneven aged structure, especially where the cork is stripped, the tree species considered useless are systematically eliminated.

Relationship to Annex I, Habitat Directive
6310 — *Dehesa*s with evergreen *Quercus* spp.
9330 — *Quercus suber* forests
9340 — *Quercus ilex* and *Quercus rotundifolia* forests
Relationship to EUNIS Habitat Classification
G2.1 — Mediterranean evergreen oak woodland

Type: 9.1; Mediterranean evergreen oak forest, holm-oak dehesa.

Source: Pedro Regato.

Type: 9.1; Mediterranean evergreen oak forest, cork-oak dehesa.

Source: Pedro Regato.

Kermes and alder-leaved oak forest

Arborescent formations dominated by *Quercus coccifera* (*Quercus 'calliprinos'*, *Quercus 'pseudococcifera'*) or *Quercus alnifolia*; occurring in the Iberian peninsula, Greece and eastern Mediterranean (Cyprus, Anatolia).

In the Iberian Peninsula two main types of kermes oak woodlands are found: i) coastal woodlands (Valencia, Alicante, Murcia y Almeria; Arrabida range near Lisbon), occupying areas corresponding to the distributional range of *Chamaerops humilis*. Associated species are *Ceratonia siliqua*, *Pistacia lentiscus*, *Rhamnus alaternus*, *Phillyrea latifolia*; ii) inland woodlands in meso-Mediterranean areas (limestone-gypsum substrates of central Spain) often mixed with *Pinus halepensis*.

Extensive, fully-developed forest stands of kermes oak (*Quercus coccifera*) still remain in several areas of Crete, but in most of its distribution in Greece, *Q. coccifera* appear as degraded stage of thermophilous deciduous woodland (*Q. pubescens*, *Q. frainetto*), due to its resilience to fire, grazing, pressure, and resprouting ability after coppicing.

The Mediterranean and sub-Mediterranean Anatolian *Quercus coccifera* (*Quercus calliprinos*)-dominated forests or steppe-forests are rich communities, with many endemic tree species (*Quercus brachyphylla*, *Quercus infectoria*, *Arbutus andrachne*, *Acer syriacum*).

Endemic arborescent *Quercus alnifolia*-dominated formations are locally abundant in Cyprus on western Troodos range.

Relationship to Annex I, Habitat Directive
9390 — *Scrub and low forest vegetation with *Quercus alnifolia*
Relationship to EUNIS Habitat Classification
G2.1 — Mediterranean evergreen oak woodland

6.9.2 Olive-carob forest

Thermo-Mediterranean woodland dominated by arborescent tree layer, often open, of wild olive (*Olea europaea* ssp. *sylvestris*), carob (*Ceratonia siliqua*) or a mixture of the two; found in southern Spain (Andalucia, Menorca, Maiorca), southern Italy (Puglia, Calabria, Sardinia, Sicilia), Crete, Cyprus and Turkey. In the Macaronesian Region (Canary Islands) formations dominated by *Olea europaea* ssp. *cerasiformis* and *Pistacia atlantica* are found.

Common in some areas (e.g. south-eastern Sicily, Iblei tableland) is the use of these olive-carob woodland as agropastoral system, resulting in a physiognomy akin to *dehesa*.

Type: 9.2; Carob dehesa-like forest.

Source: Anna Barbati.

Relationship to Annex I, Habitat Directive
9320 — *Olea* and *Ceratonia* forests
Relationship to EUNIS Habitat Classification
G2.1 — Mediterranean evergreen oak woodland

6.9.3 Palm groves

Woods, often riparian, formed by palm trees of the Mediterranean and Macaronesian zones, *Phoenix theophrasti* of Crete and western Anatolia, and *Phoenix canariensis* of the Canary Islands.

Type: 9.4; Macaronesian laurisilva.
Source: Joaquim Teodósio.

Relationship to Annex I, Habitat Directive
9370 — * Palm groves of *Phoenix*
Relationship to EUNIS Habitat Classification
G2.5 — Palm groves

6.9.4   Macaronesian laurisilva

Humid to hyper-humid, mist-bound, luxuriant, evergreen, lauriphyllous forests of the cloud belt of the Macaronesian islands (Madeira, Canary islands), extremely rich in floral and faunal species. Rich in springs microhabitats, the shadowy gloom under the foliage favours the development of a diverse community of ferns, lichens and mosses. Many species are endemics to these communities while others, reach in them their maximum development.

Laurel forests are the most complex and remarkable relict of the humid sub-tropical vegetation of the Mioceno-Pliocene late Tertiary of southern Europe. Areas of intact forests have been drastically reduced to a level below which the preservation of their elements could not be sustained.

Relationship to Annex I, Habitat Directive
9360 — * Macaronesian laurel forests (*Laurus*, *Ocotea*)
Relationship to EUNIS Habitat Classification
G2.3 — Macaronesian laurel woodland

6.9.5   Other sclerophlyllous forests

The forest type includes formations, generally relatively small woodlets, of different origin, dominated by sclerophlyllous trees found generally as undergrowth of evergreen oak woodlands 9.1.1. These are, among others:

- arborescent patches of *Ilex aquifolium*; well developed remnants are found in Sicily;

- *Prunus lusitanica* woodlets: small woods of this Tertiary relict of 'lauroid-type' species growing under micro-climate humid conditions (shadow slopes, riparian areas, canyons, etc) in central-Western Iberia. P. lusitanica woods appear in between *Q. faginea* ssp. *broteroi*, *Q. pyrenaica*, *Q. suber* and *Q. ilex* forests. Associated species are: *Frangula Alnus*, *Ilex aquifolium*, *Prunus avium*;

- *Laurus nobilis*-dominated facies of evergreen oak forests found under warm-temperate humid conditions in the southern Atlantic coasts and in humid microclimatic enclaves in the Mediterranean region;

- communities of the Ponto-Caspian warm-temperate humid zone of the southern shores of the Black sea, dominated by lauriphyllous or xero-lauriphyllous evergreen tree species, in particular, *Laurus nobilis*, *Prunus laurocerasus*, *Laurocerasus officinalis* and *Buxus hyrcanica*; anomalous and often limited to exiguous enclaves within a predominantly deciduous forest environment;

- pure tracts of turpentine tree (*Pistacia terebinthus*) occurring in mediterranean Spain generally on limestone substrates, corresponding to degraded facies of evergreen oak woodlands;

- stands of laurels (*Laurus nobilis*), holly (*Ilex aquifolium*), yew (*Taxus baccata*) and strawberry tree (*Arbutus unedo*), occurring as coppices in Atlantic Spain in areas formerly characterised by other land uses e.g. holly groves.

- Canarian, forest-like, very tall formations dominated by *Erica arborea*, *Myrica faya*, *Arbutus canariensis* or *Visnea mocanera*, occurring naturally in the most wind-exposed and the driest stations within the 'monte verde' of the Canary Island cloud belt; they also occur extensively as degradation stages of the laurisilva forest or as secondary colonists.

Relationship to Annex I, Habitat Directive
9380 — * Forests of *Ilex aquifolium*
Relationship to EUNIS Habitat Classification
G2.2 — Eurasian continental sclerophyllous woodland
G2.6 — Holly woods
G2.7 — Canary islands heath woodland

6.10 Coniferous forest of the Mediterranean, Anatolian and Macaronesian regions

Class definition

The category covers a wide range of xerophytic forests dominated by coniferous species (pines, firs, junipers, cypress, cedar) found in the Mediterranean, Anatolian and Macaronesian biogeographical Regions. The geographical distribution of the category and its main relevant compositional and structural features are specified under types descriptions.

Types

6.10.1 Thermophilous pine forest
6.10.2 Mediterranean and Anatolian Black pine forest
6.10.3 Canarian pine forest
6.10.4 Mediterranean and Anatolian Scots pine forest
6.10.5 Alti-Mediterranean pine forest
6.10.6 Mediterranean and Anatolian fir forest
6.10.7 Juniper forest
6.10.8 Cypress sempervirens forest
6.10.9 Cedar forest
6.10.10 *Tetraclinis articulata* stands
6.10.11 Mediterranean yew stands

6.10.1   Thermophilous pine forest

Woodland dominated by thermophilous *Pinus* species: *Pinus pinaster* ssp. *pinaster*, *P. pinea*, *P. halepensis*, *Pinus brutia*. These pinewoods constitute thermo-Mediterranean pioneer formations, largely widespread in the coasts and lowlands of the circumediterranean regions.

Mediterranean pine woodland is in close relation to Mediterranean evergreen broadleaved woodland, most of these are woods appearing as successional stages or plagioclimax replacements of evergreen oaks and carob-olive woodlands.

Fire plays a major role in forest regeneration and dynamics of *Pinus pinaster* and *P. halepensis*

woodland; *P. halepensis* notably, in environment with recurrent forest fires, tends to originate stable 'piro-climax' communities.

The vulnerability of Mediterranean pinewoods to forest fire influences also, indirectly, the conservation deadwood habitats: the removal of coarse woody debris is part of forest fire prevention measures.

Some key structural and compositional features of importance for understanding variation in biodiversity within this type are best listed separately and described in the following.

Pinus pinaster-dominated forest

Western meso-Mediterranean and supra-Mediterranean mesogean pine (*Pinus pinaster* ssp. *pinaster*) dominated forest, mostly on siliceous substrates. Other pines and oak species may be associated to mesogean pine: e.g. in Spain Scots pine and holm oak (Catalonia) or *Pinus nigra* ssp. *salzmannii* (Murcia); in Sardinia holly, holm-oak, arborescent erica.

The undergrowth layer is most often present and is mainly composed of species of the genera *Arbutus*, *Cytisus*, *Genista*, *Ulex*, *Erica*, *Cistus*.

Different regeneration patterns and forest structures may develop from fire-related regeneration processes, including a temporary multi-layered physiognomy, originated by uneven post-fire regeneration underneath the open canopy of residual individual of the former cycle. This structure tends however to evolve — with ageing — to mono-layered.

Pinus pinea-dominated forest

The Iberian peninsula is the main centre of distribution of stone pine forest, which spreads as further east to Greece, Black sea coast and Mediterranean Anatolia. Stone pines mainly occur in coastal areas on stretches of sand, dunes or siliceous coastal ranges, but also in inner lowlands.

The tree layer is usually of pure stone pine; mixtures with *Pinus pinaster*, evergreen or deciduous oaks are however frequent.

Stone pine naturally forms very thick woodland in young stages, lacking of understory. As long as the pines grow in height, light penetrates to the forest floor and different type of undergrowth

may develop (e.g. grass-rich, maquis-like), the composition changing with site conditions (e.g. soil water content, grazing pressure) and floristic region: e.g. in warmest location of Iberian peninsula: lentisk, European fan palm, strawberry tree; in Pontic coastal ranges: *Pistacia palestina*, *Juniperus oxicedrus*.

Cultivation modifies forest physiognomy; in stone pine groves woodland is progressively cleared since the young stages and crowns are pruned in order to develop and expose the greatest crown area to the sun and stimulate cone production.

P. halepensis and *P. brutia*-dominated forest

Aleppo pine (*Pinus halepensis*) dominated woodlands grow along the coasts of the Mediterranean basin, spreading from eastern costs of Iberian peninsula, to Greece and western Aegean Region; eastern vicariant of Aleppo pine forest is Aegean pine (*Pinus brutia*) forest, growing in Calabria, Crete, eastern Aegean islands, Cyprus and Mediterranean Turkey.

Aleppo pine is the most frugal species of the Mediterranean pines; it grows on a wide range of soils, it can survive on very poor soils and withstand severe drought. According to local ecological conditions other trees may occur with Aleppo pine, e.g. holm oak and Mediterranean oak in moister condition; holly oak, carob, European fan palm in thermophilous conditions.

The understory varies as well from maquis- to garrigue-like physiognomies.

Aegean pine woodlands have similar physiognomy, but are somewhat taller, more luxuriant and often extensive, formations.

Type: 10.1; Mixed forest of Aegean pine and Golden oak of Cyprus.

Source: Pedro Regato.

Relationship to Annex I, Habitat Directive
9540 — Mediterranean pine forests with endemic Mesogean pines
Relationship to EUNIS Habitat Classification
G3.7 — Lowland to montane mediterranean pine woodland (excluding Black pine *Pinus nigra*)

Type: 10.1; Thermophilous pine forest dominated by Aleppo pine.

Source: Anna Barbati.

6.10.2 *Mediterranean and Anatolian Black pine forest*

Woods dominated by Black pine sub-species of the *Pinus nigra* group, characteristic of the mountainous level of the Mediterranean and Anatolia regions; these are:

Salzmann's pine forests of Spain and French Causses

Laricio pine forest of Corsica and southern Italy (Sila, Aspromonte and Etna)

Relict Villetta barrea stands of the Italian Appennine

Pallas'pine forest of the Balkan peninsula, Cyprus and Anatolia

Black pines grow on many types of dry and well drained siliceous and calcareous soils of the supra-Mediterranean vegetation belt, in a niche where other tree species of the vegetation belt can not compete.

Reforestations with Black pines of the *Pinus nigra* group, showing a typical forest plantation structure are included under category 14.

Some key structural and compositional features of importance for understanding variation in biodiversity within this type are described in the following.

Salzmann's pine forests

The pinewoods *Pinus nigra* ssp. *salzmannii* usually grow on dolomite and limestone substrates from low elevations (500 m in the Pyrenees foothills) to very high elevations in the southern part of its range (2 200 m in the Baetic ranges); the floristic train varies according to elevation and climate: e.g. undergrowth with species characteristic of holm-oak woodlands at lower elevations and typical of downy oak woodlands at higher ones; in the highest elevation of Baetic ranges, oromediterranean condition, Salzmann pine forms an open tree coverage over a low shrub layer of phanerophytes (*Juniperus sabina*, *J. communis* ssp. *hemisphaerica*, *Astragalus granatensis*); in dry continental Iberian ranges it forms an open woodland physiognomy with a xerophytic undergrowth.

Laricio pine forests

Laricio pine (*Pinus nigra* ssp. *laricio*) forest includes two variants:

- *Corsican laricio* pine (*Pinus nigra* ssp. *laricio var. corsicana*) forests, found mainly on granite mountains of Corsica (900–1 200 m, dry southern and eastern slopes); here Corsican pine forms well developed forest with old-growth tracts; found in pure stands or in mixtures with *Abies alba* and *Betula alba*. The endemic Corsican nuthatch (*Sitta whiteheadi*) habitat is restricted to mature pine trees of this forest;

- Calabrian *laricio* pine (*Pinus nigra* ssp. *laricio var. calabrica*) forests of the Sila, the Aspromonte and Etna; these pioneer woods are found mainly on siliceous and poorly developed soils, with sparse rock outcrops; pinewoods are characterised by a well developed tree layer, where are often found old-growth individuals (up to 50 m and 90 cm of diameter in Sila); in contrast the understory is lacking or very poor in species. As pedogenesis proceeds, mature site native forest species (beech, downy oak) enter the forest, colonising micro-environments with a more developed soil profile.

Relict Villetta Barrea stands

Pinus nigra ssp. *italica* stands, restricted to relict stations mainly in the Abruzzo Region (Costa Camosciara, Villetta Barrea) on rocky limestone-dolomite sites between 1 000–1 300 m; low growing woods, never reaching 15 m.

Pallas's pine forest

Mountainous forests of Pallas's pine (*Pinus nigra* ssp. *pallasiana*), of the southern Carpathians, the Balkan peninsula, Cyprus and Anatolia; similar adaptation of Salzmann pine to cold and continental winter and dry summer, the species is mostly found on limestone-dolomite substrates.

Between Greek Pallas's pine forest are found very rich in species communities: e.g. in Mt. Olimpus canopy tree species are conifers (*Abies borisii-regis*, *Taxus baccata*) and deciduous broadleaved species (*Fagus sylvatica*, *Ostrya carpinifolia*, *Fraxinus ornus*); in the shrub layer *Q. coccifera* and *Juniperus oxicedrus* are common. At lower elevations (below 1 000 m), characteristic maquis-type shrub layer is found dominated by *Quercus ilex*.

Cyprian Pallas's pine forests (above 1 400 m of the Troodos Range) are noteworthy as they host numerous Cyprian endemics or near-endemics plants.

Pallas's pine forest occurs in Anatolia (north-western, south-western and southern interior) between 1 200 and 1 800 m, in areas with moderate to low precipitation and up to six months of summer drought a year. Although it forms some pure stands where climate is more continental, elsewhere it tends to form mixed consortia: e.g. in western Anatolia it is found mixed with *P. brutia*, *Quercus* spp., *Juniperus* spp. and Kazdaği fir (*Abies equi trojana*). On higher mountain slopes around the tree line, Pallas's pine forms sparse mixed forests with *Juniperus* spp.

These forests also contain many species characteristic to steppe vegetation (e.g. *Pyrus eleagnifolia*, *Prunus spinosa*, *Crateagus* spp.) and many herbaceous species in the understorey.

Relationship to Annex I, Habitat Directive
9530 — *(Sub-)Mediterranean pine forests with endemic Black pines
Relationship to EUNIS Habitat Classification
G3.5 — Black pine (*Pinus nigra*) woodland

6.10.3   Canarian pine forest

Forests of endemic *Pinus canariensis*, of the dry mountainous belt of Canary Islands (Tenerife, La Palma, Gran Canaria and Hierro) growing

Type: 10.2; Mediterranean Black pine forest dominated by Salzmann's pine.
Source: Pedro Regato.

above the laurisilva forest between 1 200 and 1 800 m. Different variant exist: pure, with heather undergrowth (*Erica arborea*) and faya (*Myrica faya*), with shrubs (*Chamaecytisus proliferus*), asphodels (*Asphodelus microcarpa*).

These forests, of which well-preserved examples have become rare, are the only habitat of *Fringilla teydea*, *Dendrocopos major canariensis* and *Dendrocopos major thanneri*.

As in the case of mediterranean pines, fire is part of the ecology of Canarian pine woodland, which is adapted, as well as its pyrophilous plants of the undergrowth, to stand up and regenerate in the extreme environmental conditions of the volcanic environments of the Canary islands.

Relationship to Annex I, Habitat Directive
9550 — Canary Island endemic pine forests
Relationship to EUNIS Habitat Classification
G3.8 — Canary island pine (*Pinus canariensis*) woodland

6.10.4 *Mediterranean and Anatolian Scots pine forest*

Scots pine forest in the Mediterranean region have a mountainous and oro-Mediterranean distribution, in the mountain ranges of the Iberian peninsula (Iberian range, Cordillera Central, Baetic ranges) and of northern Greece. The Iberian forests are xerocline, calcicolous or silicicolous, pure forests; in Greek forests the Scots pine is often mixed with *Acer pseudoplatanus*, *Sorbus aucuparia*, and sometimes *Fagus sylvatica* or *Picea abies*.

Forests composed of pines of the *Pinus sylvestris* group, mostly included in *Pinus sylvestris* ssp. *hamata*, are also found in the Pontic Range in northern Anatolia.

Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G3.4 — Scots pine woodland south of the taiga

Type: 10.2; Mediterranean Black pine forest dominated by Laricio pine.
Source: Pedro Regato.

Type: 10.2; Mediterranean Black pine forest dominated by Pallas's pine.

Source: Pedro Regato.

6.10.5 Alti-Mediterranean pine forest

Local treeline formations of Bosnian pine (*Pinus heldreichii* and *Pinus leucodermis*) restricted to the southern Balkans, northern Greece and southern Italy; it is usually an open woodland growing on dry, often stony or rocky soils and stripped grasslands; the shrub layer may be lacking or otherwise includes cushion-shaped plants.

Under this type are also included pure and mixed Macedonian pine (*Pinus peuce*) formations, restricted to the subalpine zone of the high mountains of the Balkan peninsula south to extreme northern Greece (Voras, Varnous, Rhodope).

Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G3.6 — Subalpine Mediterranean pine woodland

Type: 10.3; Canarian pine forest.

Source: Mar Génova.

6.10.6 Mediterranean and Anatolian fir forest

Fir woods dominated by endemic species of Abies distributed along the rim of the southern Mediterranean basin and western Anatolia, outside the range of beech; these are notably:

• Endemic Spanish fir (*Abies pinsapo*) tracts occurring above 1 000 m in the Iberian ranges (Sierra de las Nieves, Sierra del Pinar, Sierra Bermeja); restricted to areas with very high precipitation, north or north-western exposure, rocky places or stony soils not very deep and limestone. Spanish fir forms thick woodland in which other trees may occur (maple, common whitebeam);

• *Abies alba* forests of the Italian Appennine;

• surviving stands of the endemic endangered *Abies nebrodensis* in the Madonie mountains of Sicily;

• Endemic oro-Mediterranean (300–700 m) *Abies cephalonica* or mixed *Abies cephalonica* and *Abies borisii-regis* forests of Greece; the fir forms pure stands in upper mountainous levels and mixed forest with thermophilous deciduous (chestnut, deciduous oaks) species or kermes oak at lower elevations.

• Forests of *Abies equi-trojani* of the higher elevations of the Kaz Dag and of the Mustapha Kemal mountains in extreme western Anatolia. In south-eastern Turkey in the Anti-Taurus mountains (1 200 to 2 000 m) mixed forest of *Abies cilicica* and *Cedrus libani* are found.

Fir forests mixed with beech are included under the category 7.

Reforestations with western Palaearctic firs showing a typical forest plantation structure are included under the category 14.

Relationship to Annex I, Habitat Directive
9520 — *Abies pinsapo* forests
Relationship to EUNIS Habitat Classification
G3.1 — Fir and spruce woodland

Type: 10.5; Alti-Mediterranean pine forest, treeline formations of Bosnian pine.

Source: Pedro Regato.

6.10.7   Juniper forest

Woods dominated by *Juniperus* spp. of the Mediterranean and Anatolian mountains; the more widespread arborescent matorral formations are not included; the most important types are:

- *Spanish juniper* (*Juniperus thurifera*)-dominated woodland, mainly distributed in the Iberian peninsula, but also found in Corsica and in supra-Mediterranean slopes of the Alpine region (Pyrenees, south-western and western Alps). Spanish juniper woodland mainly occur in the north-eastern quadrant of Spain, although relict pure woodlands are found as far as southern Albacete (Murcia). Spanish juniper usually forms a very open woodland, often with holm oak and Portuguese oak. Corsican *Juniperus thurifera* formations are open mountainous woodlands, sometimes mixed with *Pinus laricio* and restricted to a few valleys in the interior of Corsica with extreme temperature ranges (Pinnera, Rudda, Pruniccia);

- *Juniperus oxycedrus* ssp. *badia*-dominated woodland, found on acid substrates in the foothills, plateau and river canyons of the north-western quarter of the Iberian Peninsula (western part of the central Mountain range; plateau, mountains and canyons in the Duero river basin in the border between Spain and Portugal). Associated species is *Q. ilex* ssp. *ballota*;

- pure or mixed Phoenician juniper (*Juniperus phoenicia*)-dominated woodland, found mainly in Spain (continental and dry coastal variants), Canarian islands, Aegean islands, Cyprus and west Turkey;

- Macaronesian juniper wood (*Juniperus cedrus*, *Juniperus brevifolia*)-dominated woodland of Canarian island and Azores;

- Grecian juniper (*Juniperus excelsa*)-dominated woodland of northern Greece mountains, Cyprus (Troodos range) and Anatolia;

- Stinking juniper (*Juniperus foetidissima*)-dominated woodland of the Balkan peninsula, Cyprus, Anatolia;

- Syrian juniper (*Juniperus drupacea*)-dominated woodland of Greece and Asia Minor.

Type: 10.6; Mediterranean fir forest, Spanish fir stand.
Source: Pedro Regato.

Relationship to Annex I, Habitat Directive
9560 — * Endemic forests with *Juniperus* spp.
Relationship to EUNIS Habitat Classification
G3.9 — Coniferous woodland dominated by
Cupressaceae or *Taxaceae*

6.10.8   Cypress forest

Natural woods of *Cupressus sempervirens* are
restricted to Mediterranean islands of Crete, Cyprus
and Rodi. Noteworthy are Cretan formations,
small stands, usually with maquis undergrowth,
occurring mostly between 800–1 500 m; woods
are best developed above 1 000 mwhere also the
semi-evergreen endemic *Acer sempervirens* occur,
which may become locally dominant.

The cypress is elsewhere widely widespread as
cultivated species in coastal Mediterranean areas.

Relationship to Annex I, Habitat Directive
9290 — Cupressus forests (*Acer*o-Cupression)
Relationship to EUNIS Habitat Classification
G3.9 — Coniferous woodland dominated by
Cupressaceae or *Taxaceae*

6.10.9   Cedar forest

Pure or mixed forests of *Cedrus libani* of the southern
Anatolia and locally north-eastern Anatolia
(sub-pontic forests) and endemic endangered
Cedrus brevifolia forest of Cyprus.

Mixed forest are found in western Taurus
between 1 500 and 2 000 metres on limestones and
rendzinas under a cold and snowy climate; the
tree layer is mixed with maples (*Acer sempervirens*,
Acer platanoides), *Ulmus* montana, *Populus tremula*.

Type: 10.6; Mediterranean fir forest, Grecian fir stand.
Source: Pedro Regato.

Cyprus cedar forests of *Cedrus brevifolia* are limited
to the western summits of the Troodos range, in the
900–1 400 metre range.

Relationship to Annex I, Habitat Directive
9590 — *Cedrus brevifolia* forests
(*Cedrosetum brevifoliae*)
Relationship to EUNIS Habitat Classification
G3.9 — Coniferous woodland dominated by
Cupressaceae or *Taxaceae*

Type: 10.7; Juniper forest. Above: Spanish juniper stand;
              below: Grecian juniper.
Source: Pedro Regato.

Type: 10.8; Cypress forest. **Source**: Pedro Regato.

6.10.10 Tetraclinis articulata stands

Woods of *Tetraclinis articulata* restricted to south-eastern Spain (dry coastal region of Cartagena) and the Maltese Islands. These are xero-thermophile formations appearing in scattered stands with a typical maquis understory.

Relationship to Annex I, Habitat Directive
9570 — *Tetraclinis articulata* forests
Relationship to EUNIS Habitat Classification
G3.9 — Coniferous woodland dominated by *Cupressaceae* or *Taxaceae*

Type: 10.9; Cedar forest. Left: Cedar of Lebanon; right: Cyprus Cedar.

Source: Pedro Regato.

6.10.11 Mediterranean yew stands

Woods dominated by *Taxus baccata*, often with *Ilex aquifolium*, of very local occurrence in the mountains of the Mediterranean basin (Corsica, Sardinia, north and central Portugal, Spain). The formation might be dynamically related to the senescent phase of beech or beech-fir woods.

Relationship to Annex I, Habitat Directive
9580 — *Mediterranean *Taxus baccata* woods
Relationship to EUNIS Habitat Classification
G3.9 — Coniferous woodland dominated by *Cupressaceae* or *Taxaceae*

6.11 Mire and swamp forests

Class definition

Coniferous or broadleaved forested wetlands, located mainly in Fennoscandia with scattered occurrences on peaty soils throughout Europe.

Forested wetlands consist of a heterogeneous complex of wet and moist forest types, and they are characterised by a high water table of variable duration. The terminology used to characterise them differs between countries (Sjöberg and Ericson, 1997). In Sweden, for example, swamp forests are classified as forests and not as mires if the annual forest productivity exceeds 1 m3 per ha or if the tree layer has a crown projection exceeding 30 %. In Finland, however, the classification is based on botanical and hydrological criteria. As a consequence, wet and moist forests are assigned to the mire series regardless of forest productivity and tree cover. Therefore, many herb-rich vegetation types are included in this category.

Types

6.11.1 Conifer dominated or mixed mire forest
6.11.2 Alder swamp forest
6.11.3 Birch swamp forest
6.11.4 Pedunculate oak swamp forest
6.11.5 Aspen swamp forest

6.11.1 Conifer dominated or mixed mire forests

These are either spruce-birch swamps or pine bogs. Spruce-birch swamps are mainly restricted to depressions in the terrain and often fringe larger mires. Generally they have a thin peat layer. In the boreal area Norway spruce is the dominant tree, giving rise to a ground flora of shade tolerant plants. Grey birch *Betula pubescens* may also form extensive stands, while alders (*Alnus glutinosa*, *A. incana*) and tall-growing *Salix* spp. are more local. The stands often show marked variations between hummocks and depressions, which at least periodically are inundated at the period of snow melting. Such stands have an extremely rich flora with many tall herbs, particularly in nutrient-rich areas. In more nutrient-poor areas bilberry *Vaccinium myrtillus* forms extensive stands (Sjöberg and Ericson, 1997). Typically for the pristine mire tree stands is that the number of stems is high in small diameter classes and decreases abruptly with increasing diameter. As a consequence, tree stands on pristine mires have a highly uneven-age structure.

Scots pine bogs characteristically exist as a forest fringe at sites where ombrotrophic conditions prevail (i.e. rainwater constitutes the nutrient source). They develop on hummocks, have a thick peat layer and are very poor in species. *Ledum palustre, Vaccinium uliginosum* and a number of other dwarf-shrubs and mosses are commonly found in heath forests. Scots pine bogs may also cover the entire surface of smaller mires in the drier parts of eastern Sweden (Sjöberg and Ericson, 1997).

Relationship to Annex I, Habitat Directive
91D0 — *Bog woodland
Relationship to EUNIS Habitat Classification
G3.D — Boreal bog conifer woodland
G3.E — Nemoral bog conifer woodland
G4.1 — Mixed swamp woodland

6.11.2 Alder swamp forest

Forests dominated by alder have decreased much in area dependent on ditching for agricultural reasons. Typical for such forests is that the ground at the time for snow melting and during rainy periods is covered by water, or that the soils become wet throughout for a period. In old alder forests tussocks are created, where the trees are standing. This is caused as an effect of the growing system of the tree, because new shoots are frequently created from the base of the original stem. Two alder species are dominating in the boreal region, *Alnus glutinosa* and *A. incana*. The former is the more southern one and is distributed up to Nord-Tröndelag in Norway and around the coast of the Bothnian Bay in Fennoscandia, but in the interior part of the Scandinavian Peninsula it is limited to the southern part. In the northern coniferous vegetation zone *A. incana* is the dominant species among the two alder species. This species prefer habitats with lighter soils, and not so wet conditions as *A. glutinosa* (Sjörs, 1956).

The birch is seldom of importance in alder forests, but sometimes *Prunus padus* and the rowan *Sorbus aucuparia* are common there. In older, thin forest and in openings in the forest plants such as *Geranium silvaticum*, *Anthriscus silvestris*, *Melandrium rubrum*, *Geum rivale* and *Filipendula ulmaria* are common (Sjörs, 1956).

Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G1.4 — Broadleaved swamp woodland not on acid peat

6.11.3 Birch swamp forest

On wet forest land at edges of mires, on ditched mires, at ditched lakes and as a natural vegetation succession and in southern Scandinavia also on wet depressions which earlier has been grazed by cattle, *B. pubescens* dominates often mixed with conifer trees, *Salix* species and *Alnus incana* or *A. glutinosa*. *Molinia caerulea* and *Vaccinium uliginosum* are examples of species in the field layer. Such habitats could be found all over the distribution range of the *Betula pubescens*, although most of them nowadays are transformed to conifers after ditching, and the total acreage is small (Nordiska ministerrådet, 1984). A similar type of forests could also be found in forests of *Betula pendula* (*earlier verrucosa*) on wetter ground.

Relationship to Annex I, Habitat Directive
9080 — *Fennoscandian deciduous swamp woods
Relationship to EUNIS Habitat Classification
G1.5 — Broadleaved swamp woodland on acid peat

6.11.4 Pedunculate oak swamp forest

Quercus robur dominated forests of inundatable depressions of the Sarmatic region, west to eastern Poland.

Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G1.4 — Broadleaved swamp woodland not on acid peat

6.11.5 Aspen swamp forest

Populus tremula dominated swamp woods of the eastern European and western Siberian northern steppe zone subject to continental climate conditions, where they occupy pods, inundated endoreic circular depressions.

Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G1.4 — Broadleaved swamp woodland not on acid peat

Type: 11.1; Pine mire forest. **Source**: Dreamstime.com.

6.12 Floodplain forest

Class definition and geographical distribution

Alluvial and riparian woodlands and galleries close to main European river channels. These are species-rich often multi-layered communities characterised by different assemblages of forest dominant trees. Forest composition and structure largely depends on the frequency of flooding.

Included are those forest communities typically associated with alluvial or riparian woodlands that may constitute locally important forest types e.g. in Bulgaria, the dense forests of field elm and ashes associated to alluvial and riparian mixed forests.

Types

6.12.1 Riparian forest
6.12.2 Fluvial forest
6.12.3 Mediterranean and Macaronesian riparian forest

6.12.1   Riparian forest

Riparian forests of the boreal, boreo-nemoral and nemoral zone growing on low-lying areas and organic soils frequently flooded and close to river channels. Characteristically dominated by species of the *Alnus, Betula, Populus* and *Salix*.

Relationship to Annex I, Habitat Directive
9030 — *Natural forests of primary succession stages of landupheaval coast
92A0 — *Salix alba* and *Populus alba* galleries
Relationship to EUNIS Habitat Classification
G1.1 — Riparian and gallery woodland with dominant alder, birch, poplar and willow

6.12.2   Fluvial forest

Mixed forests of the boreal, boreo-nemoral and nemoral zone growing on less frequently flooded mineral soils of floodplains, beside slow- and fast-flowing rivers; sometimes structurally complex and species-rich, the tree layer is characterised by mixtures of *Alnus, Fraxinus, Populus, Quercus, Ulmus* and *Salix*.

Relationship to Annex I, Habitat Directive
91E0 — *Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion*, *Alnion incanae*, *Salicion albae*)
91F0 — Riparian mixed forests of *Quercus robur*, *Ulmus* laevis and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmenion minoris*)
Relationship to EUNIS Habitat Classification
G1.2 — Mixed riparian floodplain and gallery woodland

6.12.3   Mediterranean and Macaronesian riparian forest

Forests of the Mediterranean and Macaronesian regions, similar to 6.12.1–2 with additions of local species e.g. *Fraxinus angustifolia, Platanus orientalis, Alnus orientalis Nerium Oleander, Tamarix, Liquidambar, Flueggea tinctoria*. Included are *B. pendula* ssp. *fontqueri* woods of the Iberian peninsula growing on riparian areas and peat-bogs in between cork oak open woodlands in the southern Plateau metamorphic plains (Montes de Toledo).

Relationship to Annex I, Habitat Directive
92A0 — *Salix alba* and *Populus alba* galleries
92B0 — Riparian formations on intermittent Mediterranean water courses with *Rhododendron ponticum*, *Salix* and others
92C0 — *Platanus orientalis* and *Liquidambar orientalis* woods (Platanion *orientalis*)
92D0 — Southern riparian galleries and thickets (*Nerio-Tamaricetea* and *Securinegion tinctoriae*)
Relationship to EUNIS Habitat Classification
G1.3 — Mediterranean riparian woodland

Type: 12.2; Fluvial forest.
Source: Mirek Hejnicki/Dreamstime.com.

6.13 Non-riverine alder, birch or aspen forest

Class definition

Non-riparian, non-marshy forest formations dominated by alder (*Alnus glutinosa, Alnus incana, Alnus cordata*), birch (*Betula pendula, Betula pubescens, Betula celtiberica, Betula aetnensis*) or aspen (*Populus tremula*).

Types

6.13.1 Alder forest
6.13.2 Italian alder forest
6.13.3 Mountain birch forest
6.13.4 Other birch forest
6.13.5 Aspen forest

6.13.1   Alder forest

Non-riparian, non-marshy formations of the boreal, boreo-nemoral or nemoral zones dominated by *Alnus glutinosa* or *Alnus incana*.

Relationship to Annex I, Habitat Directive
9030 — *Natural forests of primary succession stages of landupheaval coast
Relationship to EUNIS Habitat Classification
G1.9 – Non-riverine woodland with birch, aspen, rowan

6.13.2   Italian alder forest

Alnus cordata dominated forests of slopes with deep, loose, moist soils, endemic to the Campanian, Lucanian and Calabrian Apennines and the Castaniccia and San Petrone ranges of Corsica.

Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G1.9 — Non-riverine woodland with birch, aspen, rowan

6.13.3   Mountain birch forest

Forest dominated by birch species of the boreal zone; along the Scandinavian mountain range, a distinct subalpine belt of birch (*Betula pubescens* spp. *czerepanovii*) creates the border between the alpine zone and the conifer belt at lower elevation.

There is also a more maritime type in the outer archipelagoes of the Baltic Sea, with *Cornus suecica* as a common species in the field layer. The ecological and climatic conditions of the outer part of the large archipelagoes in the north and middle Baltic Sea are quite similar to the mountain area.

The herb-type of birch forests is dominated by *B. pendula* and they are distributed all over Scandinavia. It is growing mainly on older grazed areas which have been abandoned, and there is often rich bush vegetation in these forests. The field layer vegetation is similar to that in Norway spruce forest with low herbs. *Maianthemum bifolium*, *Melampyrum sylvaticum*, and *Oxalis acetosella* are example of dominant species. It is regarded as an unstable forest type which is transformed to conifer forests of low herb type, or to oak or beech in southern areas (Nordiska ministerrådet, 1984).

Relationship to Annex I, Habitat Directive
9040 — Nordic subalpine/subarctic forests with *Betula pubescens* ssp. *czerepanovii*
Relationship to EUNIS Habitat Classification
G1.9 — Non-riverine woodland with birch, aspen, rowan

6.13.4   Other birch forest

Birch forest on non-marshy terrain, dominated by *Betula pendula, Betula pubescens* or other endemic birch species (*Betula celtiberica, Betula aetnensis*). It includes all pioneer and antropogenically promoted birch formations growing from lowlands to mountainous vegetation levels. Lowland birch forest occurs in a large area of Europe.

In northern Europe, there are two main types of birch forests; of bush-grass-type, and herb-type (Nordiska ministerrådet, 1984; Sjörs, 1956; Havas, 1967). The first type is common over most parts of Scandinavia below the subalpine vegetation belt. It is dominated by the birch species *Betula pendula*. These forests have earlier been heavily used as cattle grazed habitats, which nowadays are returning to forest.

In Eastern Europe birch forest is also typical and wide-spread on rather poor or wet soil (Chertov, 1981; Abaturov *et al.*, 1982; Vasilevich, 1996; Fedorchuk *et al.*, 2006).

This type also covers a wide range of birch dominated forest of middle and southern Europe; these are notably:

• pioneer and subclimax *Betula pendula* or *Betula pubescens* formations of the North Sea-Baltic

plains, the lower Hercynian slopes, the periphery of the Paris Basin, south-western France, north-western Iberia, Insubria and Illyria, within the range of Atlantic and sub-Atlantic acidophilous oak woods;

- *Betula pubescens, Betula odorata, Betula carpatica* or *Betula pendula* dominated woods beyond and above the present range of oak woods in Scotland and northern England;

- birch, mostly subclimax, stands of the mountainous and subalpine levels of the Alps, the Carpathians, the Apennines, the Pyrenees, the Jura, the Hercynian ranges and the mountains of the Balkan peninsula;

- *Betula pendula* formations of the upper mountainous level of Corsica, forming extensive subclimax belts on rocky, rapidly eroding soils at the upper forest limit, as well as transition communities in the evolution of laricio pine or beech forests;

- endemic *Betula celtiberica* formations of the upper mountainous and supra-Mediterranean levels of Iberia;

- endemic *Betula aetnensis* formations of Mount Etna lavas, limited to the 1 200–2 000 metres level.

Relationship to Annex I, Habitat Directive
—
Relationship to EUNIS Habitat Classification
G1.9 — Non-riverine woodland with birch, aspen, rowan
9030 — *Natural forests of primary succession stages of landupheaval coast

6.13.5 *Aspen forest*

Forests dominated by *Populus tremula*; very widespread in Eastern Europe as a secondary forest type after clear cutting (Bibikova, 1998; Fedorchuk *et al.,* 2006). Due to extensive clear cuttings of 20th century the area of aspen and birch secondary forests is now exceeding the area of coniferous stands there. Aspen forest grows mostly on relatively rich soils and forms oxalis and *oxalis-myrtillus* types with significant proportion of forest boreal and nemoral herbs. The mixture of birch is also typical for aspen stands. Unexpectedly aspen can live for a rather long time reaching 200 years in spite of heavy stem rot. Therefore the Norway spruce second sub-dominated layer (that is also typical for this forest) can not reach dominant position for a very long time in contrast with the birch forest.

Relationship to Annex I, Habitat Directive
9030 — *Natural forests of primary succession stages of landupheaval coast
Relationship to EUNIS Habitat Classification
G1.9 — Non-riverine woodland with birch, aspen, rowan

Type: 13.3; Boreal birch forest.
Source: Kjell Sjöberg.

Type: 14.1; Plantation of site-native Scots pine.

Source: Dreamstime.com.

6.14 Plantations and self-sown exotic forest

Class definition

The class covers forest plantations (*sensu* MCPFE indicator 4.3) and self-sown stands of exotic species. Forest plantations are stands established by planting or/and seeding in the process of afforestation or reforestation; they are intensively managed stands (e.g. short rotation forestry) that meet all the following criteria: one or two species at plantation, even aged, regular spacing, systematic thinning regimes.

Type: 14.1; Plantation of site-native cherry tree (*Prunus avium*).

Source: Anna Barbati.

Types

6.14.1 Plantations of site-native species
6.14.2 Plantations of not-site-native species and self-sown exotic forest

6.14.1 Plantations of site-native species

The type includes either reforestation with conifers, established for the rehabilitation degraded lands within their natural range, either plantations for timber production, characterised by intensive exploitation for commercial purpose.

Between the species more largely used are: *Pinus* species (*P. nigra, P. sylvestris, P. pinaster, P. halepensis, Pinus brutia, P. pinea*); *Picea abies; Abies alba; Prunus avium; Juglans regia.*

6.14.2 Plantations of not-site-native species and self-sown exotic forest

Plantation and woodlands of forest species non-native to Europe or otherwise not locally site-native; some not-native species like *Robinia pseudoacacia, Ailanthus altissima, Prunus serotina* are able to regenerate and spread naturally competing successfully with autoctonous forest species. These almost pure woodlands are increasingly altering the forest composition of natural communities (invasive species).

Non-site native species plantations include a number of industrial plantations providing the raw material for wood processing (timber, pulp); these are mostly managed by short-rotation forestry. Between the species most commonly used in commercial plantations are: *Eucalyptus* spp.; *Popolus* clones; *Picea sitkensis; Pinus radiata; Pinus contorta; Pseudotsuga menziesii, Tsuga heterophylla.*

Both woodlands of invasive exotic species and industrial plantations are characterised by highly simplified forest structure and composition and low richness of associated fauna, when compared to semi-natural forests (this also because of the time needed for example to invertebrates adjust to the alien species).

Type: 14.2; Plantation of Eucalyptus.
Source: Jose Marques Lopes/Dreamstime.com.

7   Conclusions and perspectives

Sustainable forest management is widely accepted as the overriding objective for current forest policy and practice; this calls for a substantial increase in the amount and sensitivity of information required for the political decision-making process. Good decisions need objective information.

In continental Europe progress towards sustainable forest management is periodically monitored through the set of 35 pan-European indicators endorsed under the MCPFE process. The formulation of seven indicators requires national data to be reported by forest types.

In this context, the present report has discussed the concepts behind and presented a proposal of forest type classification conceived to improve the MCPFE forest type based reporting, which is presently based on the simplistic subdivision into broadleaved, coniferous, and mixed broadleaved and coniferous forests. This is achieved by a not too complicated but still meaningful scheme, reflecting the main (natural and anthropogenic) determinants affecting forest condition throughout Europe.

The category level, which is recommended for the MCPFE reporting, is characterised by a unique interplay of relatively homogeneous forest ecological conditions and anthropogenic influences, that 'drive' the variation of the MCPFE indicators along a characteristic pattern; a pattern that distinguish each category from the others. Categories and types are 'sensitive' to shifts in the levels of naturalness of European forests: undisturbed/seminatural forest of native species, seminatural forest originated from the replacement of nemoral broadleaved native species with coniferous native species, forest plantation of site-native species, forest plantation of not-site native species, self-sown forest of exotic species. This distinction helps also with tracking other emerging issues of importance for understanding the state of forests and trends in their management in Europe, like novel ecosystems or conversion forests.

The increased reporting effort, the adoption of the proposed categories implies, is seemingly moderate: in most European countries the shift will be from 3 to 6 reporting classes; this cost seems well justified by the benefits provided by an improved capability of data interpretation and possibility of cross-comparison at pan-European level.

Obviously, the potential of the European forest types is tied to the available knowledge. A wide range of expertise in fields like geobotanics, forest ecology, forest inventory and forest management will be essential to foster and master any future refinement and improvement of the scheme. In this regard and considering the needs of forest type based MCPFE reporting the enlargement of the classification to Other Wooded Lands would be necessary.

It must be also stressed that national figures on forest area by forest types required by MCPFE reporting are currently largely estimated by statistical data compiled from NFIs information. In the future, a challenging task could be forest types mapping. No map currently exists on the geographical distribution of the categories across Europe: such data would be crucial to fully exploit the potential of the proposed forest type classification.

Acronyms used

C&I — Criteria and indicators

ECOSOC — Economic and Social Council

EEA — European Environment Agency

EFI — European Forest Institute

Eionet — European environmental information observation network

EU — European Union

EU-15 — Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, the Netherlands, Portugal, Spain, Sweden, the United Kingdom

EU-25 — Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, the United Kingdom

EUNIS — European Nature Information System

FAO — United Nations Food and Agriculture Organization

FRA2005 — Global Forest Resources Assessment 2005

FTBAs — Forest Types for Biodiversity Assessment

GLC2000 — Global land cover 2000

ICP — International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests

LCCS — FAO land cover classification system

MCPFE — The Ministerial Conference on the Protection of Forests in Europe

NFIs — National forest inventories

NRCs — Eionet national reference centers

PCPs — Eionet primary contact points

PEBLDS — Pan-European Biological and Landscape Diversity Strategy (Council of Europe)

PNV — Potential natural vegetation

SFM — Sustainable forest management

TBFRA — Temperate and boreal forest resources assessment

UNEP — United Nations Environment Programme

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Appendix I — Cross-analysis of forest vegetation maps — data table

Map of natural vegetation of Europe			Current share of forest area by GLC2000 classes %									
Natural formation		**Potential natural vegetation types (PNV)**	Evergreen needleleaf forest	Closed evergreen needle-leaved forest	Closed deciduous broad-leaved forest	Deciduous broadleaf forest	Mixed evergreen needle-leaf-broadleaved forest	Mixed closed forest and shrubland	Forest — natural vegetation complexes	Forest — cropland complexes	**Total**	Coniferous rate
C	Subarctic boreal and nemoral-montane woodlands and subalpine vegetation	C2	West boreal and nemoral-montane birch forests; partly with pine forests (*Betula czerepanovii; B. pubescens; Pinus sylvestris*)	17	0	0	4	3	0	7	2	**34**	50
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D1	West boreal spruce forests (*Picea abies*; P. obovata); partly with pine; birch (*Pinus sylvestris; Betula czerepanovii*) — north boreal types	71	0	0	3	12	0	3	1	**89**	
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D10	Boreal and hemiboreal pine forests (*Pinus sylvestris*); partly with birch; spruce (*Betula* czerepanovii; *Picea obovata; P. abies*) — northboreal pine forests	64	0	0	2	10	0	4	1	**80**	
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D11a	Boreal and hemiboreal pine forests (*Pinus sylvestris*); partly with birch; spruce (*Betula czerepanovii; Picea obovata; P. abies*) — Middle and south to hemiboreal pine forests — Lowland-colline types	43	7	1	8	24	0	1	3	**86**	
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D11b	Boreal and hemiboreal pine forests (*Pinus sylvestris*); partly with birch; spruce (*Betula czerepanovii; Picea obovata; P. abies*) — Middle and south to hemiboreal pine forests — Montane types	2	15	1	7	6	0	0	0	**31**	
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D12a	Boreal and hemiboreal pine forests (*Pinus sylvestris*); partly with birch; spruce (*Betula czerepanovii; Picea obovata; P. abies*) — Hemiboreal and nemoral pine forests (*Pinus sylvestris; P. peuce; P. heldreichii; P. kochiana*); partly with broad-leaved trees — Lowland (to submontane) types	13	11	1	11	14	0	1	6	**57**	
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D12b	Boreal and hemiboreal pine forests (*Pinus sylvestris*); partly with birch; spruce (*Betula czerepanovii; Picea obovata; P. abies*) — Hemiboreal and nemoral pine forests (*Pinus sylvestris; P. peuce; P. heldreichii; P. kochiana*); partly with broad-leaved trees — Montane types	10	8	1	42	22	0	1	2	**87**	
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D2	West boreal spruce forests (*Picea abies*; P. obovata); partly with pine; birch (*Pinus sylvestris; Betula czerepanovii*) — Middle boreal types	47	0	0	15	30	0	1	1	**95**	
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D3	West boreal spruce forests (*Picea abies*; P. obovata); partly with pine; birch (*Pinus sylvestris; Betula czerepanovii*) — South boreal types	27	1	0	22	29	0	1	7	**87**	

Source: Bohn *et al.*, 2000.

Map of natural vegetation of Europe				Current share of forest area by GLC2000 classes %									
Natural formation		Potential natural vegetation types (PNV)		Evergreen needleleaf forest	Closed evergreen needle-leaved forest	Closed deciduous broad-leaved forest	Deciduous broadleaf forest	Mixed evergreen needle-leaf-broadleaved forest	Mixed closed forest and shrubland	Forest — natural vegetation complexes	Forest — cropland complexes	Total	Coniferous rate
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D4	East boral pine-spruce and fir-spruce forests (Picea obovata; *Pinus sibirica; Abies sibirica*); partly with birch (*Betula czerepanovii*); larch (*Larix sibirica*) — north boreal type	83	0	0	1	12	0	0	0	**96**	
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D5	East boreal pine-spruce and fir-spruce forests (Picea obovata; *Pinus sibirica; Abies sibirica*); partly with birch (*Betula czerepanovii*); larch (*Larix sibirica*) — Middle boreal types	43	0	0	16	38	0	1	1	**98**	
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D6	East boreal pine-spruce and fir-spruce forests (*Picea obovata; Pinus sibirica; Abies sibirica*); partly with birch (*Betula czerepanovii*); larch (*Larix sibirica*) — South boreal type	6	0	0	35	25	0	1	12	**79**	
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D7	East boreal pine-spruce and fir-spruce forests (*Picea obovata; Pinus sibirica; Abies sibirica*); partly with birch (*Betula czerepanovii*); larch (*Larix sibirica*) — Montane (Ural) types	58	0	0	11	24	0	1	0	**93**	
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D8a	Hemiboreal spruce and fir-spruce forests (*Picea abies; P. obovata; Abies sibirica*) with broadleaved trees (*Quercus robur; Tilia cordata; Ulmus glabra; Acer platanoides et al.*) — Lowland-colline to submontane types	12	4	5	17	20	0	0	8	**66**	
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D8b	Hemiboreal spruce and fir-spruce forests (*Picea abies; P. obovata; Abies sibirica*) with broadleaved trees (*Quercus robur; Tilia cordata; Ulmus glabra; Acer platanoides et al.*) — Montane types (Ural)	7	0	0	61	23	0	0	3	**94**	
D	Mesophytic and hygromesophytic coniferous and broad-leaved-coniferous forests	D9	Montane-altimontane; partly submontane fir and spruce forests (*Abies alba; A. nordmanniana; A. borisii-regis; Picea abies; P. omorica; P. orientalis*) in the nemoral zone	0	51	17	4	10	0	0	0	**82**	
F	Mesophytic deciduous broad-leaved and mixed coniferous-broadleaved forests	F1a	Oak and mixed oak forests; poor in species (*Quercus robur; Q. petraea; W. pyrenaica; Pinus sylvestris; Betula pendula; B. pubescens; B. celtiberica*) — Lowland to submontane types	2	16	8	2	7	0	0	1	**37**	49
F	Mesophytic deciduous broad-leaved and mixed coniferous-broadleaved forests	F1b	Oak an dmixed oak forests; poor in species (*Quercus robur; Q. petraea; W. pyrenaica; Pinus sylvestris; Betula pendula; B. pubescens; B. celtiberica*) — Montane to altimontane types; partly without oak	0	30	42	0	8	5	0	0	**85**	35
F	Mesophytic deciduous broad-leaved and mixed coniferous-broadleaved forests	F2	Mixed oak-ash forests (*Fraxinus excelsior; F. angustifolia; Quercus robur; Ulmus glabra; Qercus petraea*)	0	2	6	0	1	0	0	0	**10**	20
F	Mesophytic deciduous broad-leaved and mixed coniferous-broadleaved forests	F3	Mixed oak-hornbeam forests (*Carpinus betulus; Quercus robur; Q. petraea; Tilia cordata; Fraxinus excelsior*)	0	5	12	0	3	0	0	1	**21**	24

Source: Bohn *et al.*, 2000.

Map of natural vegetation of Europe			Current share of forest area by GLC2000 classes %									
Natural formation		Potential natural vegetation types (PNV)	Evergreen needleleaf forest	Closed evergreen needle-leaved forest	Closed deciduous broad-leaved forest	Deciduous broadleaf forest	Mixed evergreen needle-leaf-broadleaved forest	Mixed closed forest and shrubland	Forest — natural vegetation complexes	Forest — cropland complexes	Total	Coniferous rate
F	Mesophytic deciduous broad-leaved and mixed coniferous-broadleaved forests	F4a	Mixed lime-oak forests (*Quercus robur*; *Tilia cordata*) — Lowland and colline types	1	0	0	12	2	0	0	17	**33**	3
F	Mesophytic deciduous broad-leaved and mixed coniferous-broadleaved forests	F4b	Mixed lime-oak forests (*Quercus robur*; *Tilia cordata*) — Submontane-montane types	0	0	0	63	6	0	0	8	**77**	0
F	Mesophytic deciduous broad-leaved and mixed coniferous-broadleaved forests	F5a	Beech and mixed beech forests (*Fagus sylvatica*; partly *F. moesiaca*; *Abies alba*) — lowland to submontane types	0	8	18	0	3	0	0	0	**29**	28
F	Mesophytic deciduous broad-leaved and mixed coniferous-broadleaved forests	F5b	Beech and mixed beech forests (*Fagus sylvatica*; partly *F. moesiaca*; *Abies alba*) — Montane and altimontane types; partly with fir and spruce (*Abies alba*; *Picea abies*)	0	24	34	0	12	0	0	0	**71**	
F	Mesophytic deciduous broad-leaved and mixed coniferous-broadleaved forests	F6	Oriental beech and hornbeam-oriental beech forests (*Fagus orientalis*; *Carpinus betulus*; *C. caucasica*)	1	0	5	50	11	0	0	4	**71**	1
G	Thermophilous mixed deciduous broad-leaved forests	G1	Subcontinental mixed oak and maple-oak forests (*Quercus robur*; *Q. petraea*; *Q. pedunculiflora*; *Q. pubescens*; *Q. virgiliana*; *Q. cerris*; *Acer tataricum*; *A. campestre*)	0	1	13	0	1	0	0	0	**15**	7
G	Thermophilous mixed deciduous broad-leaved forests	G2	Subcontinental-submediterranean and supra-Mediterranean mixed sessile oak; bitter oak and Balkan oak forests (*Quercus petraea*; *Q. dalechampii*; *Q. polycarpa*; *Q. cerris*; *Q. frainetto*)	0	3	23	0	3	0	0	0	**28**	11
G	Thermophilous mixed deciduous broad-leaved forests	G3	Submediterranean and supra-Mediterranean mixed oak forests (*Quercus pubescens*; *Q. faginea*; *Q. Q. faginea ssp. broteroi*; *Q. canariensis*; *Q. pyrenaica*; *Q. brachyphylla*; *Fraxinus ornus*; *Ostrya carpinifolia*; *Carpinus orentalis*; *Castanea sativa*)	0	11	14	1	4	3	0	0	**33**	33
J	Mediterranean sclerophyllous forests and scrub	J1a	Meso- and supra-Mediterranean and relictic sclerophyllous forests — *Quercus rotundifolia* forests — Mesomediterranean types	0	3	3	0	0	11	0	0	**16**	19
J	Mediterranean sclerophyllous forests and scrub	J1b	Meso- and supra-Mediterranean and relictic sclerophyllous forests — *Quercus rotundifolia* forests — Supramediterranean and relictic types	0	8	4	0	0	10	0	0	**23**	35
J	Mediterranean sclerophyllous forests and scrub	J2a	Meso- and supra-Mediterranean and relictic sclerophyllous forests — Holm oak forests (*Quercus ilex*) — Meso-mediterranean types	0	16	6	0	3	0	0	0	**25**	64
J	Mediterranean sclerophyllous forests and scrub	J2b	Meso- and supra-Mediterranean and relictic sclerophyllous forests — Holm oak forests (*Quercus ilex*) — Supramediterranean and relictic types	0	30	7	0	11	0	0	0	**48**	63

Source: Bohn *et al.*, 2000.

Map of natural vegetation of Europe					Current share of forest area by GLC2000 classes %									
Natural formation			Potential natural vegetation types (PNV)		Evergreen needleleaf forest	Closed evergreen needle-leaved forest	Closed deciduous broad-leaved forest	Deciduous broadleaf forest	Mixed evergreen needle-leaf-broadleaved forest	Mixed closed forest and shrubland	Forest — natural vegetation complexes	Forest — cropland complexes	Total	Coniferous rate
J	Mediterranean sclerophyllous forests and scrub	J3	Meso- and supra-Mediterranean and relictic sclerophyllous forests — Cork oak forests (*Quercus suber*)		0	29	10	0	4	15	0	0	**58**	50
J	Mediterranean sclerophyllous forests and scrub	J4	Meso- and supra-Mmediterranean and relictic sclerophyllous forests — Kermes oak forests and scrub (*Quercus coccifera*)		0	1	0	0	0	5	0	0	**8**	13
J	Mediterranean sclerophyllous forests and scrub	J5	Thermomediterranean sclerophyllous forests and xerophytic scrub — Thermomediterranean cork oak forests (*Quercus suber*)		0	12	12	0	2	14	0	0	**39**	31
J	Mediterranean sclerophyllous forests and scrub	J6	Thermomediterranean sclerophyllous forests and xerophytic scrub — Thermomediterranean *Quercus rotundifolia* forests		0	3	2	0	0	16	0	0	**21**	14
J	Mediterranean sclerophyllous forests and scrub	J7	Thermomediterranean sclerophyllous forests and xerophytic scrub — Wild olive-locust tree forests (*Ceratonia siliqua*; *Olea europaea*)		0	8	1	0	1	2	0	0	**11**	73
J	Mediterranean sclerophyllous forests and scrub	J8	Thermomediterranean sclerophyllous forests and xerophytic scrub — Thermomediterranean xerophytic scrub (*Pericploca angustifolia*; *Ziziphus lotus*; *Maytenus europaeus*)		0	0	0	0	0	16	0	0	**16**	0
K	Xerophytic coniferous forests and scrub	K1	Nermoral; sub- and oromediterranean pine forests (*Pinus sylvestris*; *P. nigra*; *P. heldreichii*)		0	44	18	0	8	0	0	0	**70**	
K	Xerophytic coniferous forests and scrub	K2	Meso- to thermomediterranean pine forests (*Pinus pinea*; *P. halepensis*; *P. brutia*; *P. pityusa*)		0	10	1	0	1	0	0	0	**13**	
K	Xerophytic coniferous forests and scrub	K3	Meso- and supra-Mediterranean fir forests (*Abies pinsapo*; *A. cephalonica*)		0	44	0	0	2	0	0	0	**45**	
K	Xerophytic coniferous forests and scrub	K4	Juniper and cypress forests and scrub (*Juniperus thurifera*; *J. excelsa*; *J. foetidissima*; *J. polycarpos*; *Cupressus sempervirens*)		0	9	5	0	0	14	0	0	**28**	
P	Coastal vegetation and inland halophytic vegetation	P1	Vegetation of marine dunes and sea shores; mostly in combination with halophytic vegetation; parlty with vegetation of rocky sea shores		0	25	4	0	3	2	1	0	**35**	
T	Swamp and fen forests (alder; birch)	T	Swamp and fen forests (alder; birch)		1	12	6	5	16	0	0	1	**42**	31
U	Vegetation of flood-plains; estuaries and fresh water polders	U1	Flood-plain vegetation and alluvial forests		4	2	3	3	3	0	0	3	**19**	32

Source: Bohn *et al.*, 2000.

Appendix II — Classification keys

Key A.0 **Criteria for category 14. Plantations and self-sown exotic forest and related forest types**
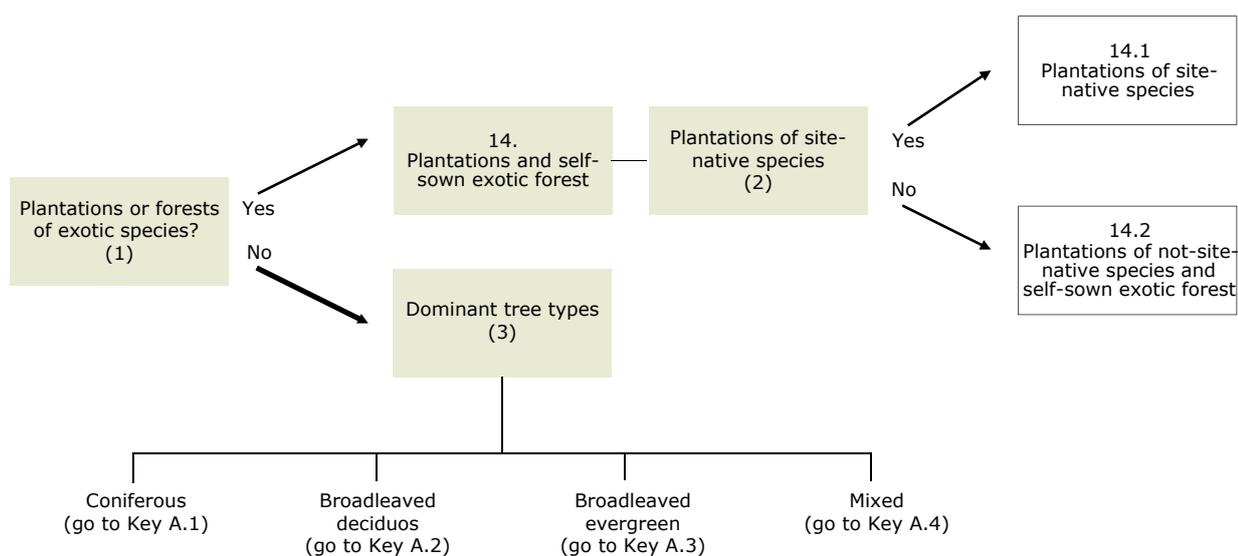
Note: Number(s) refer to explanatory notes, see notes 1–4 at the end of chapter.

Key A.1 **Criteria for coniferous categories and forest types**

Note: Number(s) refer to explanatory notes, see notes 4–5 at the end of chapter.

Key A.1   Criteria for coniferous categories and forest types (cont.)

1. Boreal forest	Dominant species (6)	Norway spruce →	1.1 Spruce and spruce-birch boreal forest
		Scots pine →	1.2 Pine and pine-birch boreal forest

2. Hemiboreal and nemoral coniferous forest	Dominant species (6)	Scots pine →	2.2 Nemoral scots pine forest
		Norway spruce →	2.3 Nemoral spruce forest
		Black pine →	2.4 Nemoral black pine forest

3. Alpine coniferous forest	Dominant species (6)	Larch and/or arolla or dwarf pine →	3.1 Subalpine larch-arolla and dwarf pine forests
		Norway spruce and/or silver fir →	3.2 Subalpine and montane spruce and montane mixed spruce-silver fir forests
		Scots pine or black pine →	3.3 Alpine scots pine and black pine forests

10. Coniferous forest of the Mediterranean, Macaronesian and Anatolian regions	Dominant species (6)	Thermophilous pines →	10.1 Thermophilous pine forest
		Pinus nigra group →	10.2 Mediterranean and Anatolian black pine forest
		Canarian pine →	10.3 Canarian pine forest
		Pinus sylvestris group →	10.4 Mediterranean and Anatolian scots pine forest
		Bosnian pine or Macedonian pine →	10.5 Alti-Mediterranean pine forest
		Abies spp. →	10.6 Mediterranean and Anatolian fir forest
		Juniper spp. →	10.7 Juniper forest
		Italian cypress →	10.8 Cypress forest
		Cedar of Lebanon, Cyprus cedar →	10.9 Cedar forest
		Tetraclinis articulata →	10.10 *Tetraclinis articulata* stands
		Common yew →	10.11 Mediterranean yew stands

Note: Number(s) refer to explanatory notes, see note 6 at the end of chapter.

Key A.2 Criteria for broadleaved deciduous categories and forest types

Broadleaved deciduous

Hydrology (7)

— **Waterlogged** → 11. Mire and swamp forests

Riparian or alluvial → 12. Floodplain forest

Dry or seasonally wet → Dominant species (8)

Beech → Vegetation belt (9)

- Lowland and submontane → 6. Beech forest

- Montane → 7. Montane beech forest

Alder, birch or aspen → 13. Non-riverine alder, birch or aspen forest

2.1 Hemiboreal forest

Boreo-nemoral? (12) — **No** → Oligotrophic? (11)

Yes → 2.1 Hemiboreal forest

No → 5. Mesophytic deciduous forest

Yes → 4. Acidophilous oak and oak-birch forest

No → Thermophilous? (10)

Yes → 8. Thermophilous deciduos forest

Note: Number(s) refer to explanatory notes, see notes 7–12 at the end of chapter.

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4. Acidophilous oak and oak-birch forests

Dominant species (13)

Pedunculate oak and/or sessile oak → 4.1 Acidophilous oakwood

Oak and birch → 4.2 Oak-birch forest

---

5. Mesophytic deciduous forest

Dominant species (13)

Pedunculate oak-hornbeam → 5.1 Pedunculate oak-hornbeam forest

Sessile oak-hornbeam → 5.2 Sessile oak-hornbeam forest

Common ash (or narrow-leaved ash or mixed with Pdunculate oak → 5.3 Ashwood and oak-ash forest

Other mixtures → Nemoral east-european distribution? (14)

Yes → Dominant species (13)

No → Multispecific stands located in ravine or slopes? (15)

Field maple and Pedunculate oak → 5.4 Maple-oak forest

Small-leaved lime and pedunculate oak → 5.5 Lime-oak forest

maples, small-leaved lime, pedunculate oak, common ash, → 5.6 Maple-lime forest

small-leaved lime, pedunculate oak, Norway maple → 5.7 Lime forest

Yes → 5.8 Ravine and slope forest

No → 5.9 Other mesophytic deciduous forests

Note: Number(s) refer to explanatory notes, see notes 13–15 at the end of chapter.

Key A.2   Criteria for broadleaved deciduous categories and forest types (cont.)

```
                                              ┌──────────────────────────┐
                                              │ 6.1 Lowland beech forest │
                                              │ of southern Scandinavia  │
                                              │ and north central Europe │
                                              └──────────────────────────┘
                                              ┌──────────────────────────┐
                                              │ 6.2 Atlantic and         │
                                              │ subatlantic lowland      │
                                              │ beech forest             │
                                              └──────────────────────────┘
                                              ┌──────────────────────────┐
                                              │ 6.3 Subatlantic          │
                                              │ submontane beech forest  │
                                              └──────────────────────────┘
┌──────────────┐   ┌──────────────┐           ┌──────────────────────────┐
│              │   │ Geographical │           │ 6.4 Central European     │
│ 6. Beech     │───│ distribution │───────────│ submontane beech forest  │
│    forest    │   │    (16)      │           └──────────────────────────┘
└──────────────┘   └──────────────┘           ┌──────────────────────────┐
                                              │ 6.5 Carpathian           │
                                              │ submontane beech forest  │
                                              └──────────────────────────┘
                                              ┌──────────────────────────┐
                                              │ 6.6 Illyrian submontane  │
                                              │ beech forest             │
                                              └──────────────────────────┘
                                              ┌──────────────────────────┐
                                              │ 6.7 Moesian submontane   │
                                              │ beech forest             │
                                              └──────────────────────────┘
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                                              ┌──────────────────────────┐
                                              │ 7.1 SW-European montane  │
                                              │ beech forest             │
                                              │ (Cantabrians, Pyrenees,  │
                                              │ Central Massif, SW-Alps) │
                                              └──────────────────────────┘
                                              ┌──────────────────────────┐
                                              │ 7.2 Central European     │
                                              │ montane beech forest     │
                                              └──────────────────────────┘
                                              ┌──────────────────────────┐
                                              │ 7.3 Appennine-Corsican   │
                                              │ montane beech forest     │
                                              └──────────────────────────┘
┌──────────────┐   ┌──────────────┐           ┌──────────────────────────┐
│              │   │ Geographical │           │ 7.4 Illyrian montane     │
│ 7. Montane   │───│ distribution │───────────│ beech forest             │
│  beech forest│   │    (16)      │           └──────────────────────────┘
└──────────────┘   └──────────────┘           ┌──────────────────────────┐
                                              │ 7.5 Carpathian montane   │
                                              │ beech forest             │
                                              └──────────────────────────┘
                                              ┌──────────────────────────┐
                                              │ 7.6 Moesian montane      │
                                              │ beech forest             │
                                              └──────────────────────────┘
                                              ┌──────────────────────────┐
                                              │ 7.7 Crimean montane      │
                                              │ beech forest             │
                                              └──────────────────────────┘
                                              ┌──────────────────────────┐
                                              │ 7.8 Oriental beech and   │
                                              │ hornbeam-oriental        │
                                              │ beech forest             │
                                              └──────────────────────────┘
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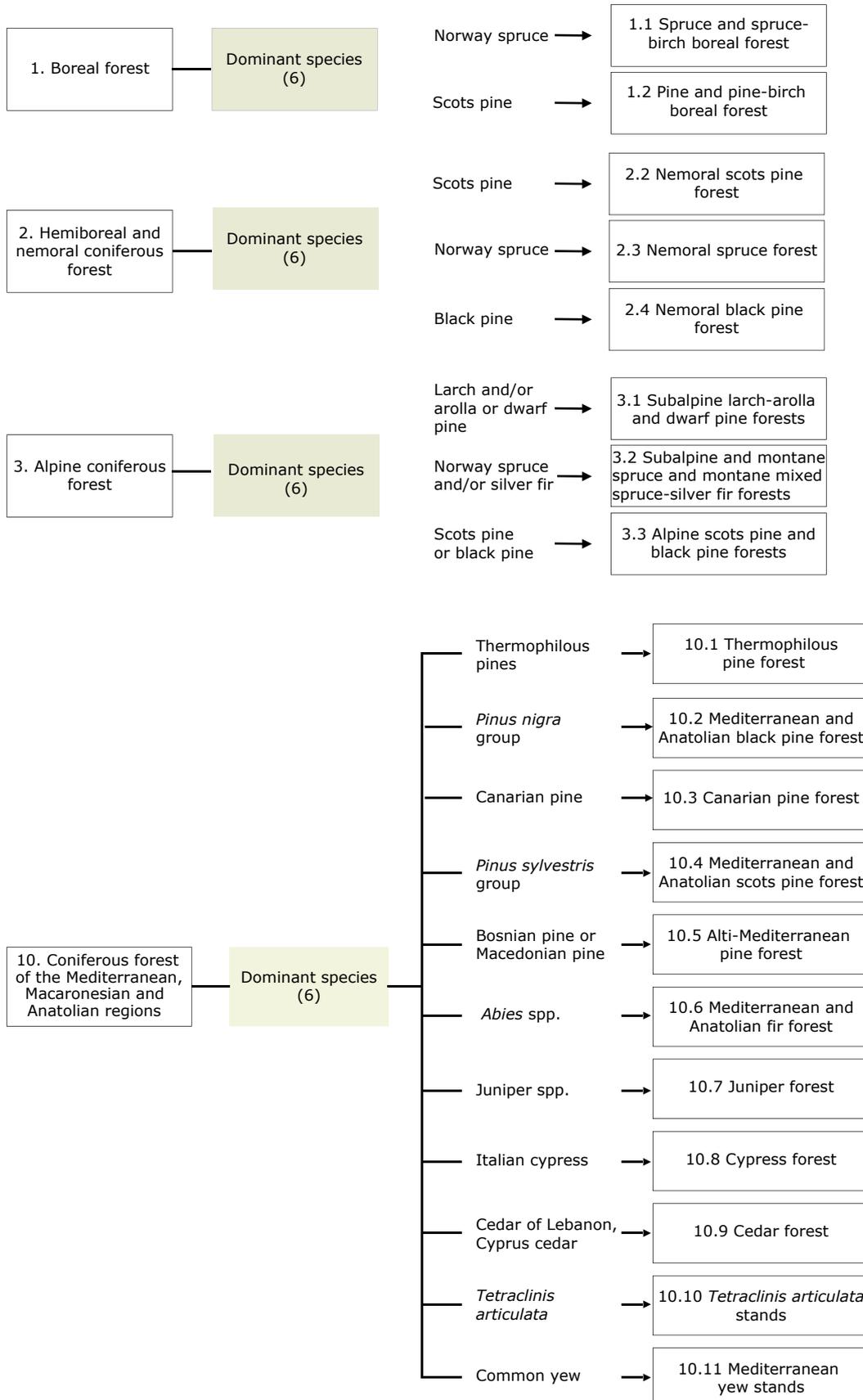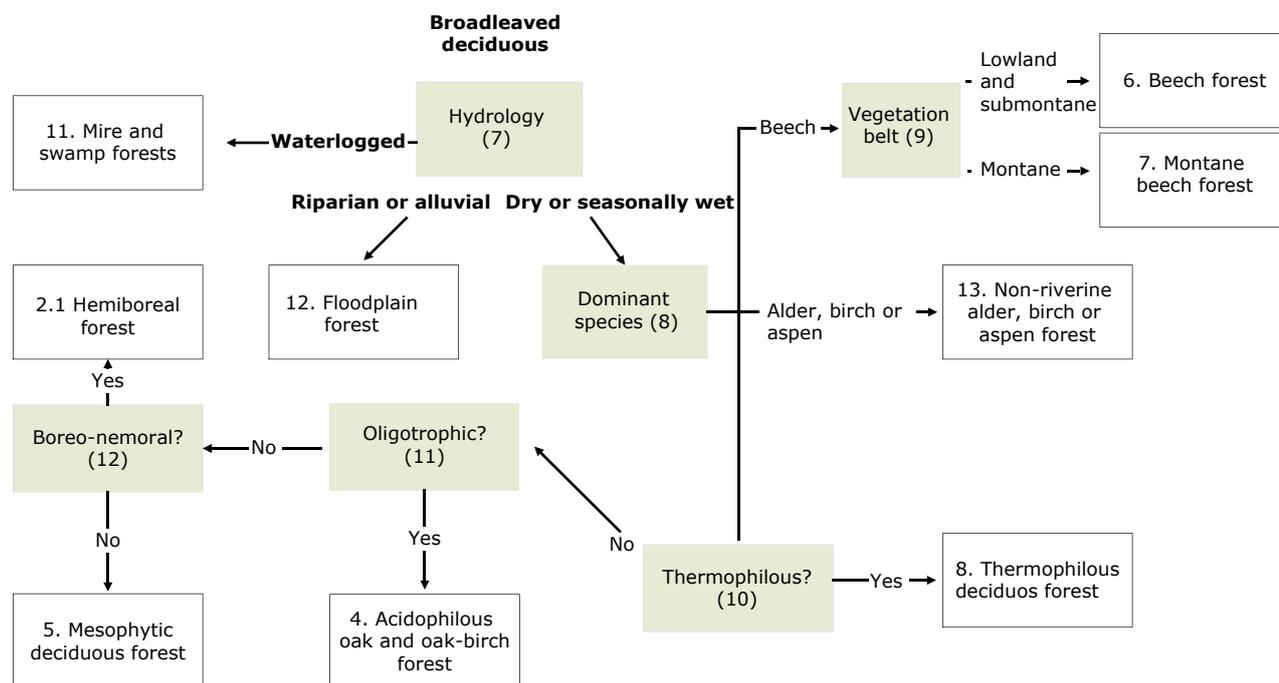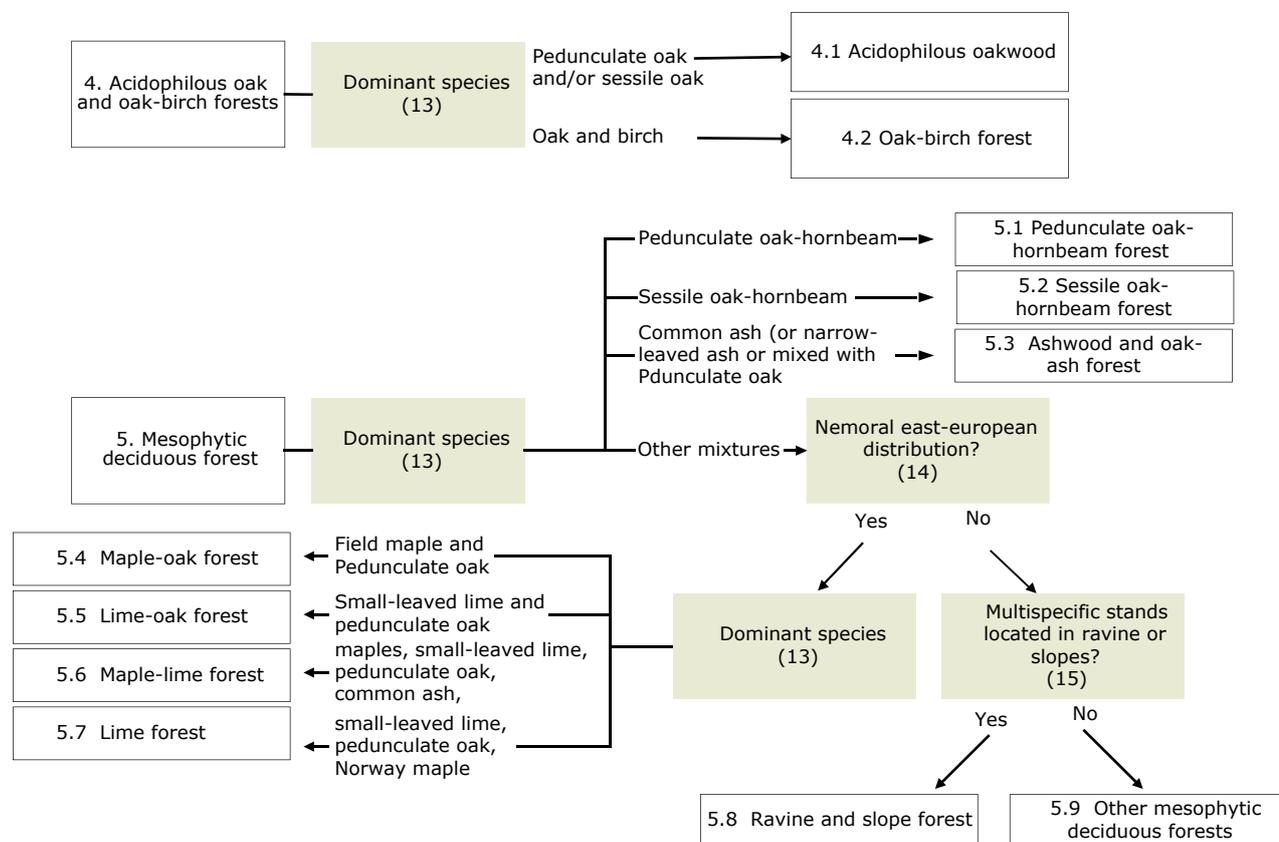
Note: Number(s) refer to explanatory notes, see note 16 at the end of chapter.

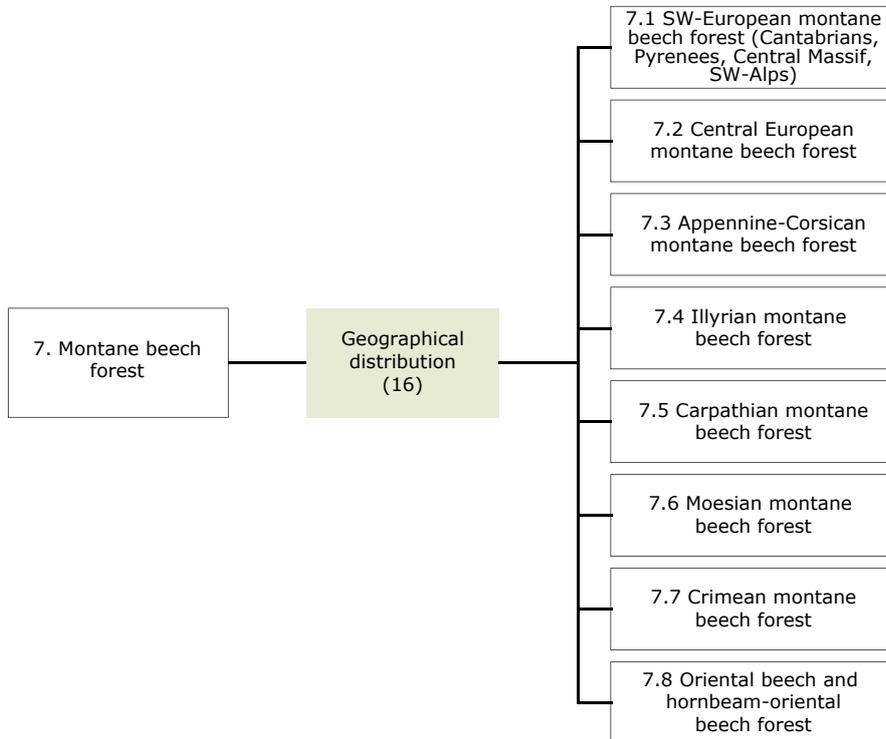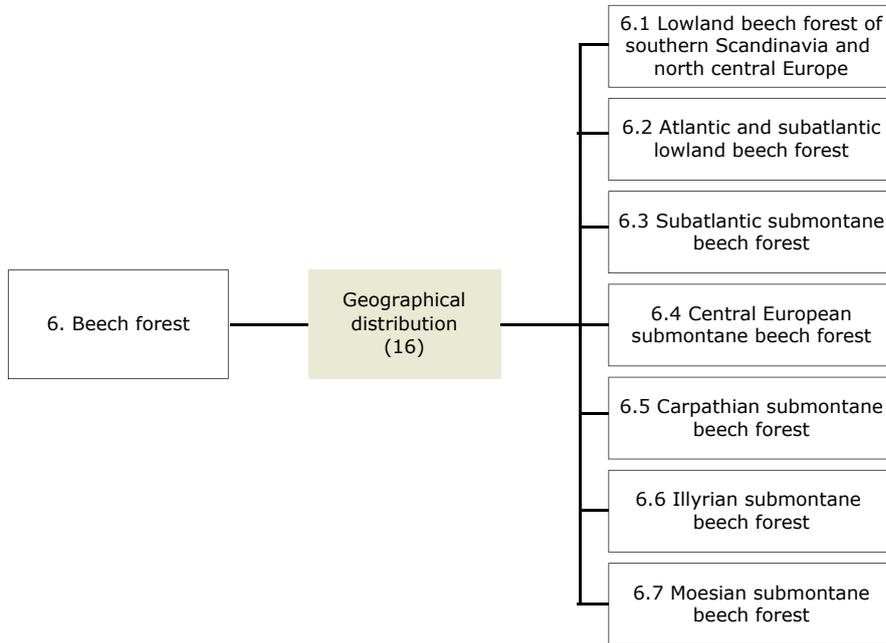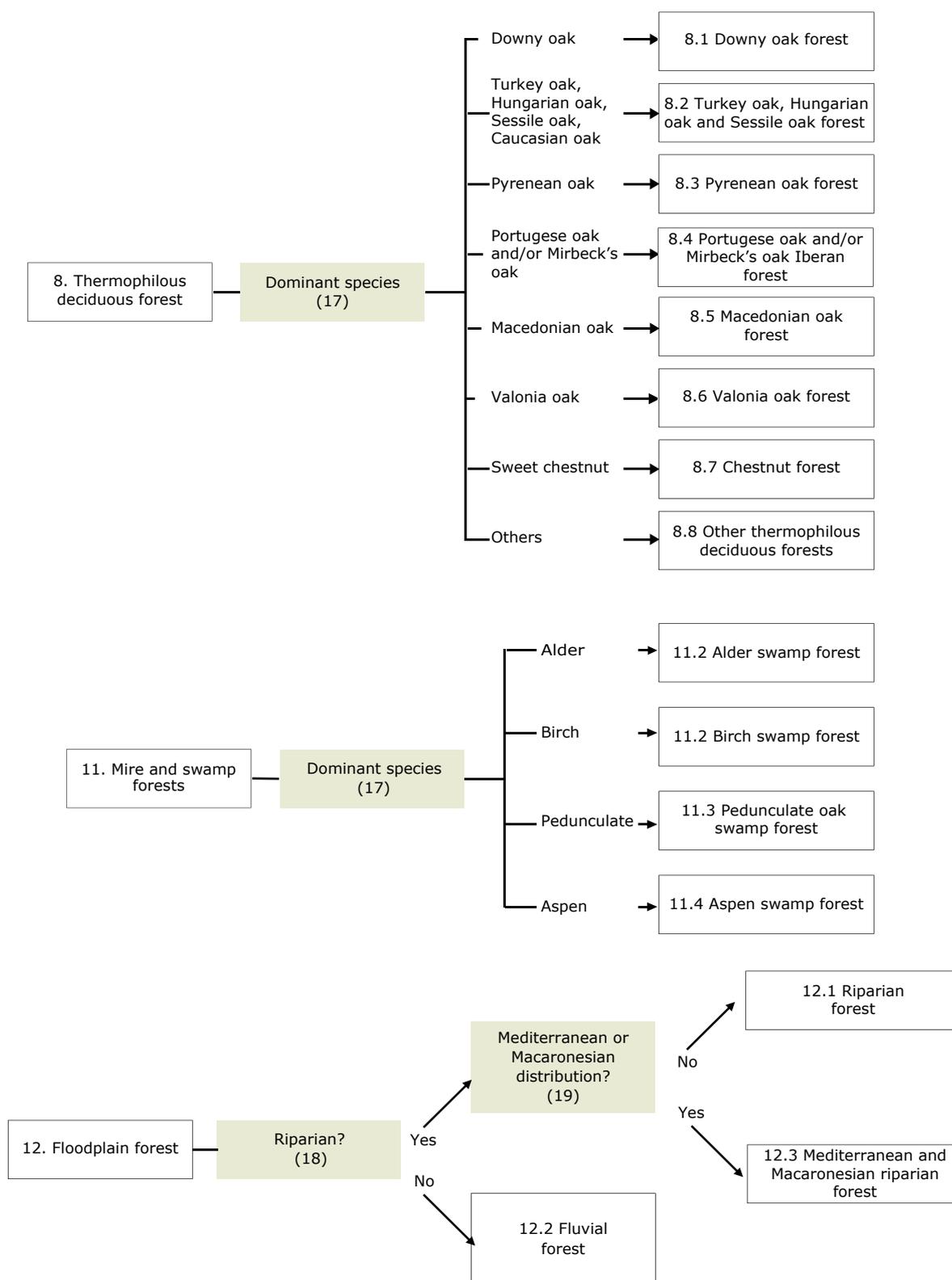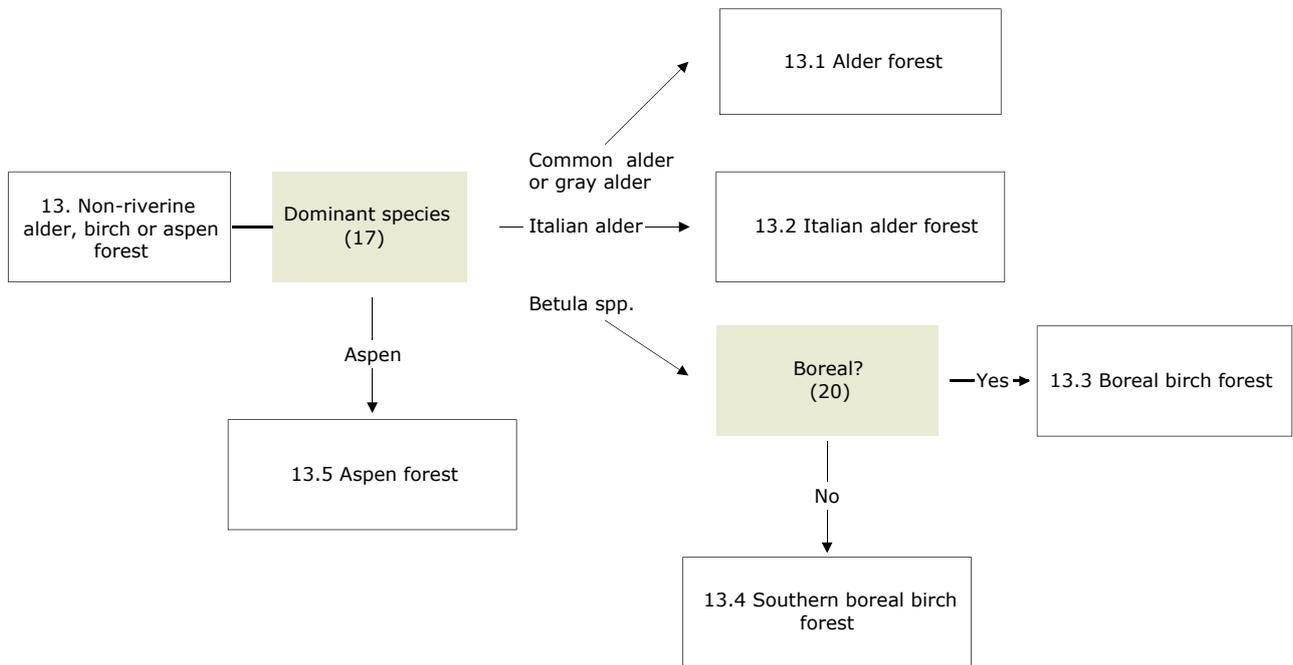## Key A.2   Criteria for broadleaved deciduous categories and forest types (cont.)

	Downy oak	→ 8.1 Downy oak forest
	Turkey oak, Hungarian oak, Sessile oak, Caucasian oak	→ 8.2 Turkey oak, Hungarian oak and Sessile oak forest
	Pyrenean oak	→ 8.3 Pyrenean oak forest
8. Thermophilous deciduous forest — Dominant species (17)	Portugese oak and/or Mirbeck's oak	→ 8.4 Portugese oak and/or Mirbeck's oak Iberan forest
	Macedonian oak	→ 8.5 Macedonian oak forest
	Valonia oak	→ 8.6 Valonia oak forest
	Sweet chestnut	→ 8.7 Chestnut forest
	Others	→ 8.8 Other thermophilous deciduous forests

	Alder	→ 11.2 Alder swamp forest
11. Mire and swamp forests — Dominant species (17)	Birch	→ 11.2 Birch swamp forest
	Pedunculate	→ 11.3 Pedunculate oak swamp forest
	Aspen	→ 11.4 Aspen swamp forest

12. Floodplain forest — Riparian? (18)

Yes → Mediterranean or Macaronesian distribution? (19)
- No → 12.1 Riparian forest
- Yes → 12.3 Mediterranean and Macaronesian riparian forest

No → 12.2 Fluvial forest

Key A.2   Criteria for broadleaved deciduous categories and forest types (cont.)
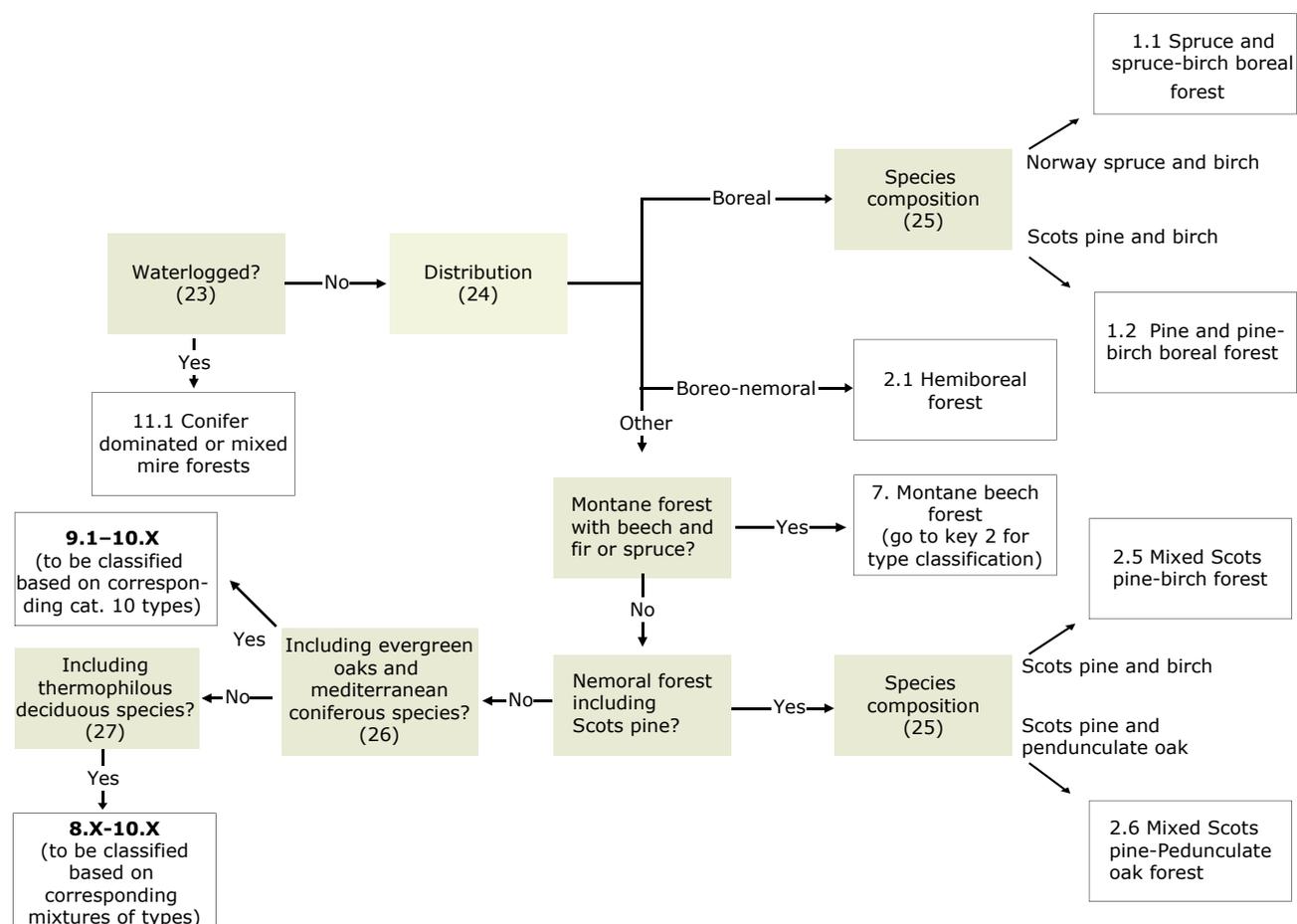

Note: Number(s) refer to explanatory notes, see notes 17–20 at the end of chapter.

Key A.3   Criteria for broadleaved evergreen categories and forest types
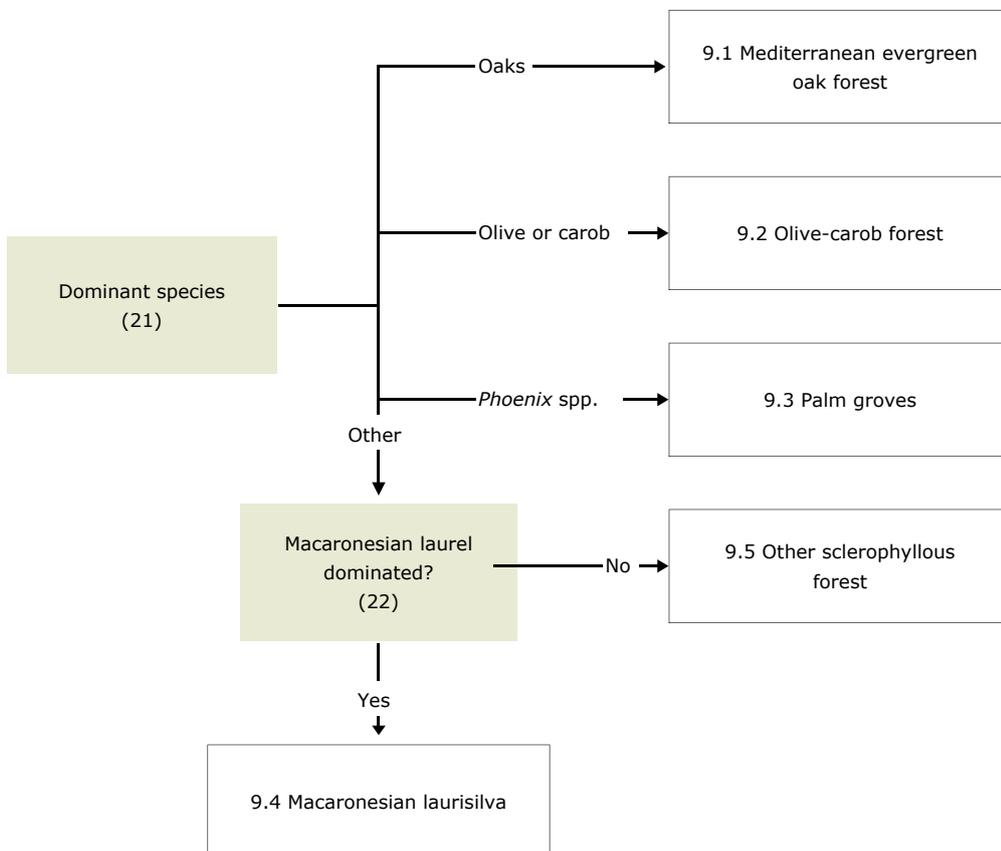
Note: Number(s) refer to explanatory notes, see notes 21–22 at the end of chapter.
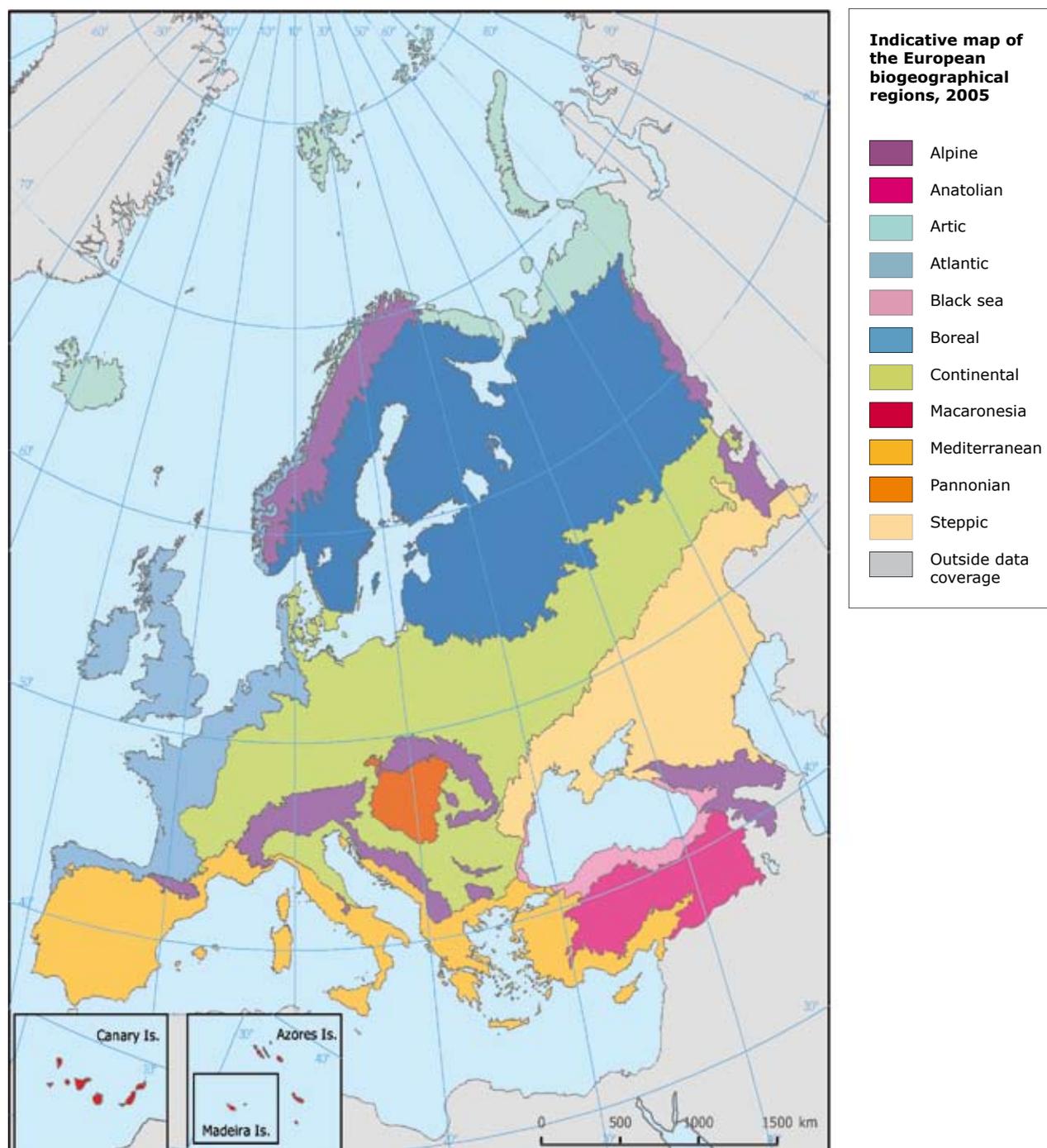
Key A.4   Criteria for mixed categories and forest types

Note: Number(s) refer to explanatory notes, see notes 23–27 at the end of chapter.

Notes to Keys A.1–A.4

1. Highly artificial stocks of trees established by afforestation or reforestation (plantations sensu MCPFE indicator 4.3) or self-sown stands of exotic species (path = Yes) are separated from other from the rest of European forests.

2. Plantations of Palaearctic species established inside their natural vegetation zone in Europe are separated from other plantations and self-sown exotic forest.

3. Forests are assigned to the dominant tree types, based on standing living trees which made up the dominant tree layer. Threshold to include a tree species are > 5 % of basal area by this tree species in the stand or ground sampling plot (e.g. NFIs sampling plots). Dominant tree type is coniferous when > 50 % of the basal area consists of coniferous species; dominant tree type is broadleaved deciduous when > 50 % of the basal area consists of broadleaved deciduous species; dominant tree type is broadleaved evergreen when > 50 % of the basal area consists of broadleaved evergreen species; dominant tree type is mixed woodland when neither coniferous, nor broadleaved species account for more than 50 % of basal area.

4. Two hydrological regimes are distinguished: wet (with the water table at or close to the surface for at least half the year); and mesic or dry.

5. Coniferous-dominated woodlands are separated between the biogeographical regions of Europe as mapped by EEA (see Map A.1 next page): Boreal, Atlantic, Continental, Alpine, Mediterranean, Macaronesian.

6. Dominant species is defined as the coniferous species accounting for > 50 % of the basal area.

7. Three hydrological regimes are distinguished: waterlogged (permanently wet, with the water table at or close to the surface), riparian or alluvial (dependent on flowing water, giving rise to a high water table and subject to occasional flooding) and dry or seasonally wet.

8. Dominant species is defined as the broadleaved deciduous species accounting for >50 % of the basal area.

9. Lowland to submountainous beech forest (pure or with broadleaved deciduous species as associated species) are distinguished from those in the mountainous vegetation belt (with fir and spruce as associated species).

10. Forest dominated by thermophilous deciduous species, mainly oaks (path = Yes), are distinguished. See nomenclature for further reference to species.

11. Forests characteristic of oligotrophic soils, usually with acidophilous oaks, are separated (path = Yes) from those on more meso- to eutrophic substrates.

12. Broadleaved deciduous forest in the boreo-nemoral zone — transition forest zone between the boreal coniferous forest and the nemoral forest — characterised by mixtures of *Q. robur*, *Ulmus* spp., *Fraxinus excelsior*, *Tilia cordata*, or *Acer platanoides* are separated from other mesophytic deciduous forests.

13. Dominant species is defined as the broadleaved deciduous species accounting for >50 % of the basal area.

14. Mixed broadleaved deciduous forest growing under continental climate in east European Plain (eastern wing of the central European beech forest) are distinguished.

15. Cool, moist forests with a multispecific tree layer of variable dominance, most often on more or less abrupt slopes are distinguished from other mesophytic deciduous forests.

16. Beech and mountainous beech forest types are distinguished based on their geographical distribution. See nomenclature (Chapter 6) for further reference.

17. Dominant species is defined as the broadleaved deciduous species accounting for > 50 % of the basal area.

18. Riparian forests with one or few dominant species, typically alder, birch, poplar or willow (path =Yes) are distinguished from mixed flood-plain and river-terrace forests, sometimes structurally complex and species-rich, often including ash, oak or elm.

19. Riparian forests characteristic of the Mediterranean or Macaronesian biogeographical regions dominated by a single species or mixtures of species including *Fraxinus angustifolia*, *Platanus orientalis*, *Nerium Oleander*, *Liquidambar*, *Tamarix* spp., Flueggea tintoria, *Phoenix canariensis* are distinguished (path = Yes).

20. Boreal birch forest (path=Yes) is distinguished from birch forests of other biogeographical regions growing mainly on mountain ranges.

21. Dominant species is defined as the broadleaved evergreen species accounting for >50 % of the basal area.

22. Laurel (*Laurus*)-dominated forests characteristic of the Macaronesian biogeographic region are separated (path = Yes) from other sclerophyllous forests of the Mediterranean and Atlantic regions.

23. Mixed broadleaved and coniferous forests which are waterlogged (permanently wet, with the water table at or close to the surface) are separated (path = Yes) from those with other hydrological regimes.

24. Boreal and boreo-nemoral mixed broadleaved and coniferous forests are separated from other mixed forests (path = Other).

25. The coniferous and broadleaved deciduous species with highest basal area are used to assign the plot to mixed forest types.

26. Mixed broadleaved evergreen and coniferous forests are separated (path = Yes) from mixed broadleaved deciduous and coniferous forests.

27. Forests characterised by mixtures of thermophilous deciduous species and coniferous species related to forest types of the Category 10 (mainly thermophilous pines, cypress and Scots pine) are separated (path = Yes).

Map A.1   The biogeographical regions of Europe

Indicative map of the European biogeographical regions, 2005

- Alpine
- Anatolian
- Artic
- Atlantic
- Black sea
- Boreal
- Continental
- Macaronesia
- Mediterranean
- Pannonian
- Steppic
- Outside data coverage

Note: See note 5 previous page.

Source: EEA.

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