European Environment Agency
European Topic Centre on
Biological Diversity

Technical paper N° 4/2021

Forest & biodiversity in Europe, an overview

Håkan Berglund, Aurélien Carré, Lubos Halada, Robert Kanka, Helmut Kudrnovsky, David Paternoster and Sabine Roscher

28/07/2021

The European Topic Centre on Biological Diversity (ETC/BD) is a consortium of nine organisations under a Framework Partnership Agreement with the European Environment Agency for the period 2019-2022
MNHN EAA (UBA) Ecologic ILE-SAS NATURALIS NCA-CR S4E SLU WENR

Authors' affiliation:

Håkan Berglund, Swedish University of Agricultural Sciences (SE)
Aurélien Carré, Muséum national d'Histoire naturelle (FR)
Lubos Halada, Institute of Landscape Ecology of the Slovak Academy of Sciences (SK)
Robert Kanka, Institute of Landscape Ecology of the Slovak Academy of Sciences (SK)
Helmut Kudrnovsky, Environment Agency Austria/Umweltbundesamt GmbH (AT)
David Paternoster, Environment Agency Austria/Umweltbundesamt GmbH (AT)
Sabine Roscher, Muséum national d'Histoire naturelle (FR)

EEA project manager:

Annemarie Bastrup-Birk, European Environment Agency (DK)

ETC/BD production support:

Muriel Vincent, Muséum national d'Histoire naturelle (FR)

Context:

The Topic Centre has prepared this Technical paper in collaboration with the European Environment Agency (EEA) under its 2021 work programmes as a contribution to the EEA's work on Forest ecosystems.

Citation:

Please cite this report as
Berglund, H., Carré, A., Halada, L., Kanka, R., Kudrnovsky, H., Paternoster, D. and Roscher, S., 2021. Forest & biodiversity in Europe, an overview. ETC/BD report to the EEA.

The withdrawal of the United Kingdom from the European Union did not affect the production of the report.
Data reported by the United Kingdom are included in all analyses and assessments contained herein, unless otherwise indicated.

ETC/BD Technical paper N° 4/2021
European Topic Centre on Biological Diversity
c/o Muséum national d'Histoire naturelle
57 rue Cuvier
75231 Paris cedex, France
Phone: + 33 1 40 79 38 70
E-mail: etc.biodiversity@mnhn.fr
Website: http://bd.eionet.europa.eu

Contents

Introduction

This ETC/BD report on Forest & biodiversity aims to give an overview of all the relevant information on forest ecosystems across the European Union, starting from their definition and description. It reviews how the international and national forest definitions can be dealt with in the European context and what are the relevant sources for estimating the EU forest cover and describing their ecological features, based on the most recent data.

This report also tries to bring a new understanding on how forest ecosystems are protected within the European Union. After showing how forest-related objectives are being stepped up by EU policies from different sectors and how the EU is contributing to implementing sustainable forest management through its different policies and strategies, an in-depth cross analysis of the protected forest habitat types listed under the Habitats Directive within the Natura 2000 network and the nationally designed protected areas was conducted. This gives interesting results on the number and area of Natura 2000 sites including forest habitat types, as well as on the proportion of forest habitat types covered by the Natura 2000 network, but also on the level of protection of the forest cover within the national protected areas, according to their IUCN management category.

After this review of the available knowledge related to the description and the level of protection of the European forests, the report focuses on conducting an alternative analysis of their condition. Indeed, many data already exists at the European level on Forest condition: The State of Nature in the EU (Conservation status of habitat types and species listed under the Habitats Directive), the EU-wide Ecosystem assessment, the Forest Europe review (based on National Forest Inventories) or the Red list of European habitats.

Therefore, the report tries to both synthetize and combine the results of those different assessments, as to investigated the possibilities to compile and review information from both nationwide forest inventories and conservation assessments at larger scales. These two types of biodiversity assessments: conservation status and risk assessments, are indeed the most important indicators to be used to monitor biodiversity, at biogeographic and national scales in Europe. It is therefore important to show if the analysis resulting from their combination can be more useful for biodiversity monitoring than their separate results. This review was done as a pilot study focusing on Northern Europe, as compiling information from different sources is quite labor-intensive and still exploratory.

Finally, and in light of the recent work of the European Commission regarding the drawing of the future Nature Restoration Law, the report ends on a chapter dedicated to restoration potential and progress throughout the world, and in the specific case of Europe.

1 What are European forests?

Defining what is a forest ecosystem seems to be a quite easy task. However, this definition is not only different depending on the region of the world and the type of vegetation, or about the reference landscape scale, but it also depends on its related perspectives and management objectives. Defining what is a forest has also varied over the course of history, and even more quickly over the past decades. In addition, a forest area includes both the forest "land-cover", the area actually covered by the vegetation dominated by trees, and the forest "land-use", adding to the forest land-cover the land without trees but normally forming part of the forest area, temporarily unstocked as a result of human intervention or natural causes, but which are expected to revert to forest.

1.1 From international to national forest definitions

Historically, forest definitions have emerged from prevailing objectives of use and management, where for example the distinction between natural and planted forest was not important[1]. But those objectives and definitions have diversified since the mid-twentieth century, while forest management policies now not only focus on sustainable timber production but incorporate more and more non-timber forest products, such as biodiversity conservation values, ecosystem services delivery and human well-being, landscape approaches, adaptive management or socio-ecological resilience. Forest definitions also shape environmental policies at different scales (global, regional and national) and are therefore different according to their purpose. They are also constrained by feasibility considerations (available data, collection technology, human capacity, budgetary allocations, etc.).

1.1.1 ***The FAO definition and its limitations***

As to set a global framework for forest analysis and in the purpose of international forestry statistics, the Food and Agriculture Organisation of the United Nations (FAO) have defined forest ecosystems as: *"a land with tree crown cover (or equivalent stocking level) of more than 10%, and an area of more than 0.5 hectares. The trees should be able to reach a minimum height of 5 metres at maturity in situ".* The major flaw of this definition is that forest "land-use" prevails over forest "land-cover". It is consistent with the FAO's objective to track and maintain the land area to be used for timber production, but this is for example not appropriate for assessing and monitoring forest degradation, and in particular to monitor the extent and variation of deforestation over time.

According the FAO's definition, deforestation *"specifically excludes areas where the trees have been removed, due, for example, to harvesting or logging, and where the forest is expected to regenerate naturally or with the aid of silvicultural measures within the long-term."* Therefore, the clearing of all trees in an area does not necessarily constitute a case of deforestation, if the forest is expected to regenerate within the long term, even if that FAO acknowledges that *"forests commonly regenerate, although often to a different, secondary condition".*

As a consequence, the large areas of forest clearing done within land that are still classified as forests, and the related huge amount of carbon and biodiversity losses, remain ignored from international statistics. Moreover, new forests resulting of land-use changes, like forests growing on former

[1] Chazdon, R.L., Brancalion, P.H.S., Laestadius, L. et al. When is a forest a forest? Forest concepts and definitions in the era of forest and landscape restoration. Ambio 45, 538–550 (2016). https://doi.org/10.1007/s13280-016-0772-y

agricultural land, as well as restored forests and early stages of spontaneous natural regeneration, will go unnoticed for many years until the forest-cover can satisfy the FAO definition. Another consequence of the prevalence of land-use over land-cover is that tree plantations with the primary purpose of producing wood or wood-derived products, and therefore often cleared, are considered as forests, while permanent planted trees for the production of other goods such as nuts or fruits (coconuts, bananas, etc.) are not, as well as wooded gardens, agroforestry areas and urban forested parks[2].

In addition, forest degradation among open forest formations, often found in tropical areas, is barely considered using this FAO definition. Indeed, this degradation mainly derives from over-grazing, over-exploitation, repeated fires, or attacks by insects, diseases, plant parasites or other natural sources such as cyclones, and in most cases these phenomena do not show as a decrease in the area of woody vegetation but rather a gradual reduction of biomass, changes in species composition and a soil degradation.

1.1.2 *National Forest inventories (NFI) in Europe*

National Forest Inventories (NFIs) of European Member-States have different historical origins but they all were established with the primary aim to cover the information needed at country level. NFI methods then reflect the country-specific conditions of forest types, topographies, climates and interests in forests uses, and a cross-border comparability of their results is not always possible to meet. Indeed, not all EU Member States have the same specific definition of a forest ecosystem within their legislations, and they not all correspond to international definitions. For example, forests inventoried within the Swiss NFI are areas where tree-cover should reach at least 20%, and where every tree must have a diameter larger than 12 cm within a 200 m² circle and larger than 36 cm within a 500 m² circle[3]. In the UK, NFI covers any forest or woodland that have at least 20% tree canopy cover (or the potential to achieve this) and of at least 0.5 hectares, but only for areas with also a minimum width of 20 m[4].

Still, a growing number of target groups from the environmental, wood processing, and energy sectors, as well as international programs, require such comparable information from NFIs as reliable basis in decision-making processes. As a result, the ENFIN[5] (European National Forest Inventory Network) group was established in 2003 and is currently composed of 32 different organisations, from 29 countries. Its objective is to serves as the European network to harmonise forest information across the different European countries, and to support a broad range of European and national forest related policies.

The harmonisation of European NFIs maintains the framework of existing NFI methods and achieves comparability through the development and application of harmonisation procedures for NFI target variables, as to satisfy the various information needs at the international-, country- and sub-country levels.

[2] http://www.fao.org/3/ad665e/ad665e06.htm
[3] https://www.lfi.ch/lfi/methoden1-en.php
[4] https://www.forestresearch.gov.uk/tools-and-resources/national-forest-inventory/about-the-nfi/
[5] http://enfin.info/

1.1.3 *FISE, the Forest Information System for Europe*

The European Commission and the EU Member States have established a Forest Information System for Europe[6] (FISE). Its establishment was at the core of the previous EU Forest Strategy, as to be the instrument to assess progress towards the targets established in the cross-sectorial policies that affect forests and forest resources, and to ensure the sustainable management of forest resources in Europe.

It regroups in a harmonized way all the available European-wide data and information and integrates the diverse database and information systems within a modular array of models. It is now the single entry-point for sharing data and information with the forest community on Europe's forest environment, as well as to support forest-related policies in Europe. It aims to allow clear, easy-to-use, open access and updated information about the state and trends in Europe's forests, through meaningful data and narratives. It has also published several documents, including a synthesis on "What is a Forest"[7].

1.2 Distribution of European forests

1.2.1 *Different data sources to quantify forest cover and land-use in Europe*

- **Corine Land Cover**

The Corine Land Cover (CLC) data represents the European "land cover": the observed biophysical cover on the earth's surface[8]. Land cover should not be confused with "land-use", that shows how people use the landscape (i.e. for development, agriculture, conservation, forestry, etc.). The CLC classification includes 3 classes for forest land cover: broadleaves, conifers and mixed forests. According to CLC, the recently cleared forest resulting from forestry are not represented as forest land cover, contrary to what the EUNIS habitat classification is defining as forest habitat types.

CLC therefore includes a "Transitional woodland/shrub" class, identifying transitional bushy and herbaceous vegetation with occasional scattered trees that can represent woodland degradation, forest regeneration and/or recolonization or natural succession[9]. This transitional woodland class allows to identify areas of natural development of forest formations, consisting of young plants of broad–leaved and coniferous species, with herbaceous vegetation and dispersed solitary adult trees.

Transitional process can be for instance natural succession on abandoned agricultural land, regeneration of forest after damages of various origin (e.g. storm, avalanche), stages of forest degeneration caused by natural or anthropogenic stress factors (e.g. drought, pollution), reforestation after clearcutting, afforestation on formerly non-forested natural or semi-natural areas etc.

- **Copernicus High Resolution Layers**

Copernicus is the European Union's Earth Observation Programme. It offers information services based on satellite Earth observations, among which the Pan-European High-Resolution Layers (HRL) that provide information on specific land cover characteristics. Those HLR are complementary to land

---

[6] https://forest.eea.europa.eu/
[7] https://forest.eea.europa.eu/documents/what_is_a_forest
[8] https://land.copernicus.eu/pan-european/corine-land-cover
[9] https://land.copernicus.eu/user-corner/technical-library/corine-land-cover-nomenclature-guidelines/html/index-clc-324.html

cover / land use mapping such as in the CORINE land cover (CLC) datasets. The Forests HRL consists of 3 types of (status) products and two additional change products, available for 2012, 2015, and 2018 reference years[10]:

- Tree cover density (TCD) (level of tree cover density in a range from 0-100%)
- Dominant leaf type (DLT) (broadleaved or coniferous majority)
- Forest type product (FTY). The forest type product allows to get as close as possible to the FAO forest definition. In its original resolution 10m (2018) / 20m (2012, 2015), it consists of two products: 1) a dominant leaf type product that has a MMU of 0.5 ha, as well as a 10 % tree cover density threshold applied, and 2) a support layer that maps trees under agricultural use and in urban context, based on the dominant leaf type product (derived from CLC and imperviousness 2009 data).

The 10m FTY 2018 product has the agricultural/urban trees removed, as it was previously done for the 100m FTY products.

- **Forest map of Europe**

Statistical data on forest area and its distribution for different forest classes are traditionally available through national forest inventory statistics, as well as from other national and international forest statistical sources. The European Forest Institute then tried to build a global Forest Map of Europe, utilizing both Earth Observation data and recent National forest statistical information (Figure 1).

This work is based on recent National forest inventory (NFI) statistics on forest area, at the sub-national level, for 19 European countries including the European part of the Russian Federation, as well as country-level statistics on forest area published by Forest Europe in 2011. The satellite-based forest cover data was calibrated to sum up to the forest area statistics within a given administrative region, and a European timberline mask was implemented to exclude areas considered above the timberline. A second calibration was done to adjust to the internationally harmonized statistics by Forest Europe 2011 at national level, to allow for comparability between the countries.

[10] https://land.copernicus.eu/pan-european/high-resolution-layers/forests

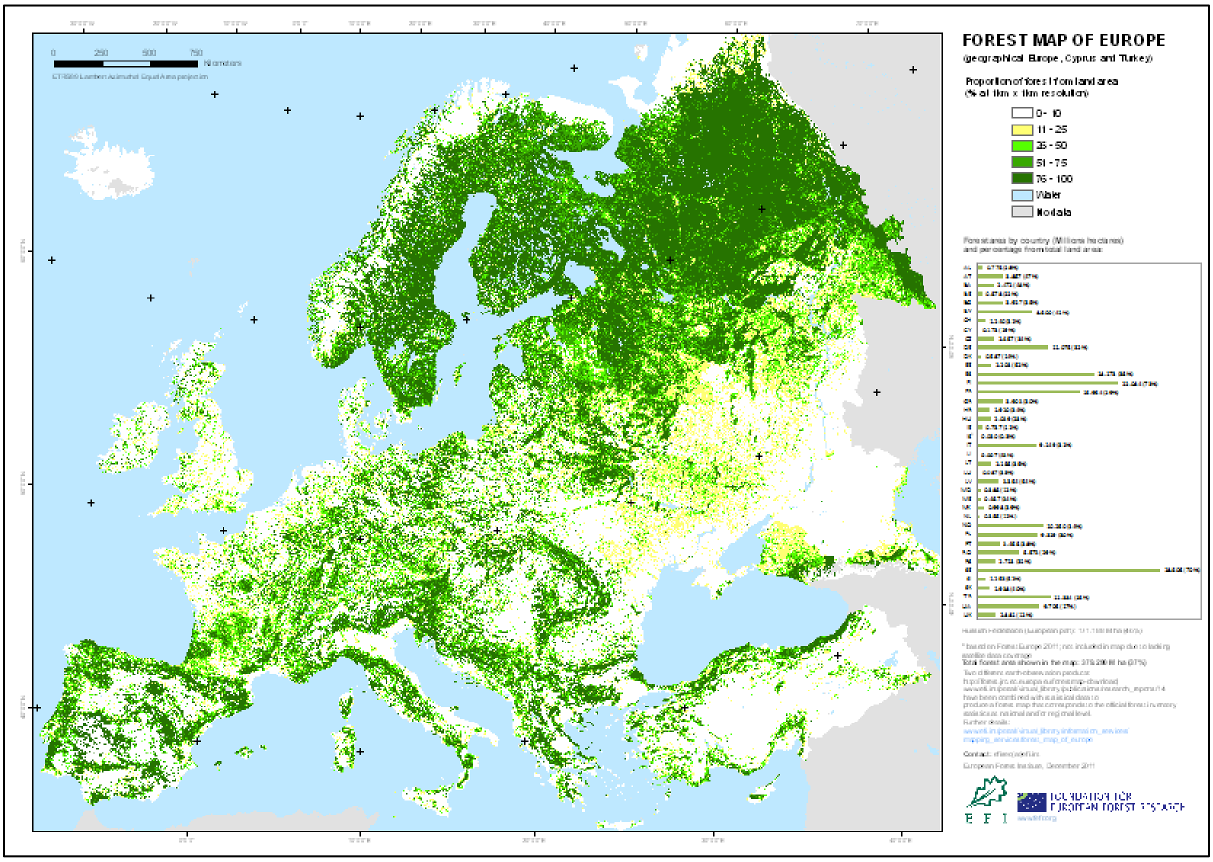


Figure 1: Forest Map of Europe (European Forest Institute, 2011)

1.2.2 *Historical European forest cover dynamics*

It is possible to have a quite specific idea of how the forest cover has evolved in Europe over the past millennials, based on the many scientific studies that have been done in the recent years on pollen-based reconstruction of past European vegetation in quantitative terms[11]. Those studies revealed for example that, over the last 6000 years, the percentage of forest cover has declined more in mid-latitude dominated by broad-leaf trees, than in northern Europe, from about 65 to ~38%.

Much of the mid-latitude European forests have indeed been converted to arable and pasture land, but have also been colonized by late migrating trees such as spruce, fir and beech. However, it appears that the majority of forests in the North and Central Europe remained intact until Early Medieval times, while most forests of the UK and Ireland, France and Belgium had already been cleared in Bronze and Iron Age times. Numerous factors have contributed to vegetation change and forest loss, including climatic changes and long-term ecological dynamics, along with forest conversion to agricultural and grazing lands. But an increase in pasture, arable and disturbed land is evident from 4000 BP (i.e. Bronze Age), which accelerated even more in the most recent 2000 years. It indicates an increase in agricultural land broadly in line with the loss of forests.

---

[11] Woodbridge et al, 2018. European forest cover since the start of Neolithic agriculture: a critical comparison of pollen-based reconstructions

1.2.3 *Current estimates and trends of Forest cover in Europe*

The FAO forest definition is used by the EEA and Eurostat, the statistical office of the European Union, to produce regularly updated assessments and statistics on European forests. According to this broad definition, the European Union contains about 158 million hectares of forest (5% of the world's total) which cover 37.7 % of its land area. When using the CLC geo-spatial data, including the "transitional woodland/shrub" class, forests also appear to be one of the main ecosystems in the EU-28, covering around 1.6 million km² of the land surface, in line with the area provided by National Forest Inventories and Eurostat estimates.

The EU Ecosystem assessment published in 2020, that also used the CLC geo-spatial data to assess forest land-cover, also reported forests as the largest terrestrial ecosystem in the EU-28. This assessment estimated that European forests cover around 16.131 million ha, corresponding to 38% of the EU-28's land area. Still, the data available from Corine Land Cover and from the Ecosystems Map of Europe do not allow a straightforward comparison, mainly due to the nomenclatures used and the spatial resolution of the datasets. A comparison between these data sources, excluding alluvial and riparian forests and the CLC class "transitional woodland/shrub", was made by the EEA in 2021 (Table 1).

Table 1: Forest areas (km²) from different sources for EU 27[12]

Corine Land Cover 2018 (level 3)	
Forests	**1 356 423**
311 – Broad-leaved forest	435 974
312 – Coniferous forest	660 642
313 – Mixed forest	259 807
Ecosystems map (level 3)	
G – Woodland, forest and other wooded land	**1 770 997**
G1 – Broad-leaved deciduous woodland	682 357
G2 – Broad-leaved evergreen woodland	52 200
G3 – Coniferous woodland	707 302
G4 – Mixed deciduous and coniferous woodland	236 096
G5 – Lines of trees, small anthropogenic woodlands, recently felled woodland, early-stage woodland and coppice	93 042

Over the past decades, the area of forests in Europe has strongly increased due to both natural processes (rural land-abandonment and spontaneous recolonization) and to active afforestation (mountain restoration, etc.). According to the National Forest Inventories, European forests (in the EU-28) expanded by nearly 130,000 km² over the 1990-2015 period, from 1.48 to 1.61 million km², an area equivalent to Greece.

[12] EEA, 2021. Background information for potential restoration targets – FORESTS

However, it appears that the annual natural expansion of forests and net area of land converted to forest by man are both falling in the EU over the same period, suggesting a change in trend towards future reductions in extent (Figure 2).

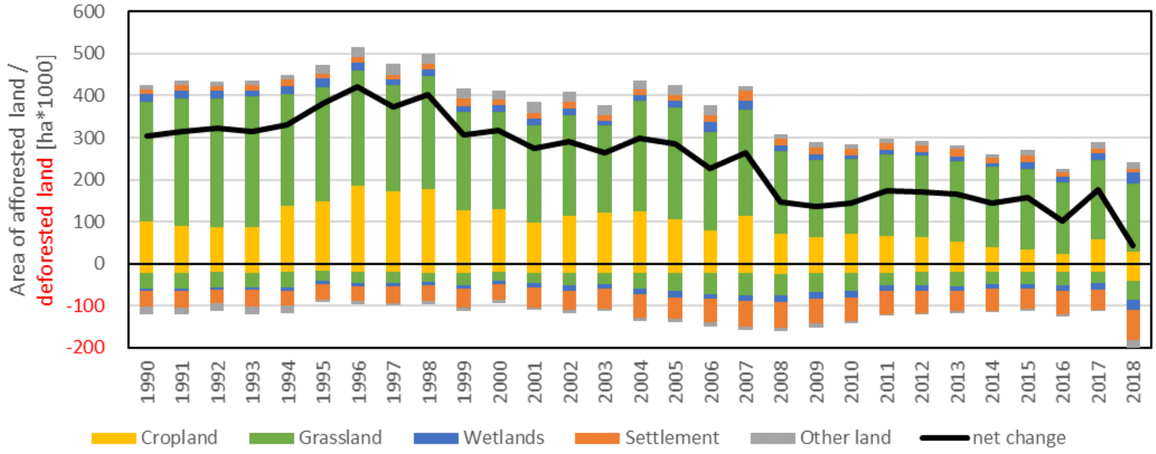


Figure 2: **Area of annually afforested land deforested areas in the EU27 for the period 1990-2018 (EU Member States' GHG inventory submission of 2020)**

EU forests have also experienced strong turnovers (sum of forest cover area loss and forest cover area gain) in ecosystem extent (Figure 3): 5.5%, 8.2% and 6% for the 2000-2006, 2006-2012 and 2012-2018 periods respectively, with respect to the initial forest extent. These turnovers reflect forest cover dynamics in the EU-28 resulting from in particular forest management cycles, felling, regeneration, as well as disturbances due to storms and fires. The total turnover for the period 2000 to 2018 is equivalent to 18% of the extent of European forest ecosystems.

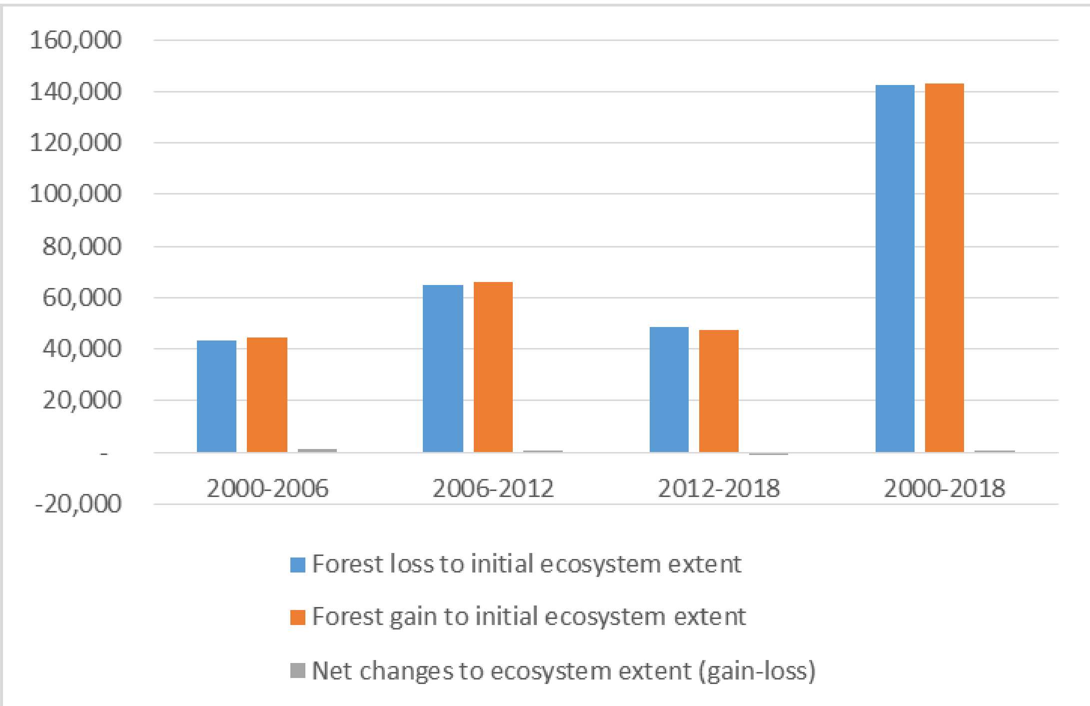


Figure 3: **Trends of forest cover change 2000–2018 in the EU-28 (Data source: Corine Land Cover accounting layers (EEA), figure from Maes et al, 2020)**

In accordance with the First MAES report[13], the definition used for assessing changes in the cover of forest ecosystems in Europe for the EU Ecosystem Assessment corresponds to the three CLC forest categories, together with the "transitional woodland shrub" category. However, as the definition of forests under CLC is not in fully agreement with national or international forest definitions, some discrepancies emerged in comparison to the forest area provided by National Forest Inventories (NFIs) of EU Member States. For example, the pronounced increase of forest area between 1990 and 2015 (nearly 130,000 km² in the EU-28) and between 2000 and 2015 (a net increase of 62,000 km²) indicated by data from NFIs is not reflected by CLC data, which only allowed to report an increase of 572 km² between 2000 and 2018.

1.3 Ecological description of European forests

1.3.1 *European forest ecosystems, a major part of the European terrestrial biodiversity*

European forests and woodlands are home to a very large proportion of the biodiversity observed across Europe, including tens of thousands of invertebrate-species, many fungi and a large number of birds that are dependent on a tree cover. There is also a wide geographic variation among many woodland types, often with a number of sub-types of more restricted distribution. The Red List of European habitats[14] have identified and assessed 42 forest habitats, most of them widely distributed over several biogeographical regions.

The widespread woodland types in Europe with a relatively closed canopy are usually dominated by one or only few tree species. The herb layer is highly dependent on soil, hydrology and climatic conditions, being generally more species-rich in calcareous conditions and in woodland types in dry situations or with a more open canopy. At higher altitudes, specific mountain woodland types constitute the upper limit of tree growth, often with a coniferous canopy but sometimes also with deciduous woodland types. All those higher mountain woodlands can have a diverse herb layer, characterized by species growing only at these higher altitudes and often including a considerable number of striking tall herbs.

Riparian broadleaved deciduous woodlands occur only azonally, in more or less linear form along smaller or bigger river systems, and include different types in temperate, boreal and Mediterranean regions. Bog and swamp woodland types are also azonal forests and closely linked to a special hydrology. They occur patchily and often in small stands, but over a large range, depending on climate and local conditions. A few types have a very restricted distribution, like the South Aegean and Canarian Phoenix groves, Macaronesian laurophyllous woodland or the subendemic *Alnus cordata* woodlands found only in Corsica and Southern Italy.

Woodland habitats also include all developmental phases and, due to natural or anthropogenic modifications, woodland margins and the herb vegetation of canopy gaps. Natural woodland borders, where tree growth is less vigorous, or where patchy mosaics with fringes or grassland vegetation exist, such as thermophilous forest, steppic forests and ravine forests, are especially species-rich.

[13] MAES, An analytical framework for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020, April 2013
[14] https://ec.europa.eu/environment/nature/knowledge/redlist_en.htm

○ Tree diversity across Europe, a "false-friends" indicator?

Tree species are determinants of a forest ecosystem, as they considerably influence forest microclimate (available light, wetness, temperatures), produce litter, humus and deadwood, and provide a whole range of microhabitats. Tree species richness may therefore determine the abundance and diversity of other groups of organisms that could affect ecosystem processes, and especially shape communities of soil invertebrates, key regulators of soil functioning and primary productivity. As such, it is commonly admitted that multi-tree-species forests are more diverse than one-tree-species forests.

However, the direct and indirect mechanisms underlying soil invertebrate responses to tree species diversity and composition remain poorly understood, even in temperate forest ecosystems. A recent study showed the complexity of the direct and indirect mechanisms underlying the relationships between tree species richness and composition and macrofauna communities[15]. The researchers found out that mixed forests supported richer, more diverse and even macrofauna communities, at a broad level of taxonomic resolution. In comparison, pure deciduous stands favored *Lumbricidae* and other macrodetritivore groups, while evergreen forests were dominated by predator taxa. Combined, these two results can suggest that mixed forests offer resource, microhabitat, microclimate, and soil conditions suitable for a wide range of organisms of contrasting lifestyles. But Macrofauna response to tree species richness and functional type was almost only detectable at a very coarse level of taxonomic resolution (deciduous vs evergreen), while it is known that macrofauna species rather responded to microenvironmental variable.

Moreover, as mentioned by the FOREST EUROPE initiative[16], numerous shortcomings and ambiguities make an indicator only related to tree species diversity a not very useful proxy for biological diversity. First, it is disputable on what scale the diversity of tree species should be assessed. The area on which the tree-species diversity is measured can be of various size, from small inventory plots through forest stands to regions. The larger the area, the more tree species there are likely to occur: what is the smallest area on which we would require a full or high diversity of tree species?

And even on a larger scale, there is no answer whether the existence of small one-tree-species forest stands, each with different species, should be considered less favourable for biodiversity than the existence of one large stand of multiple-tree-species. On top of that, some European forest types naturally consist of only one or two tree species. This is the case of natural subalpine Spruce woodlands, of some types of beech forests, or for most of the lowland *Fagus* forests. Additionally, not all tree species are equal from the biodiversity viewpoint.

○ Different degrees of “naturalness”

Many European forests habitat types correspond, according to their description, to the potential “natural” vegetation of their distribution range. It is the case for *Fagus sylvatica* woodlands in central Europe, for different *Quercus* woodlands in the Mediterranean region (mostly *Quercus ilex*), or for

[15] Ganault, P., Nahmani, J., Hättenschwiler, S., Gillespie, L.M., David, J.F., Henneron, L., Iorio, E., Mazzia, C., Muys, B., Pasquet, A., Prada-Salcedo, L.D., Wambsganss, J., & Decaëns, T. (2021). Relative importance of tree species richness, tree functional type, and microenvironment for soil macrofauna communities in European forests. Oecologia, 1-14. https://doi.org/10.1007/s00442-021-04931-w

[16] https://foresteurope.org/diversity-tree-species/

most of the coniferous woodlands in mountain areas or within northern Europe's Taiga (*Picea abies*, *Abies alba*).

However, actual virgin and pristine examples of those potential "natural" forest vegetation only exist in small remnants, and a long history of different use has left its traces on many of these habitats. These cultural modifications of European forests have mostly replaced the natural dynamics of wind throw, fire, and breakdown of senescent trees in the canopy or other natural disturbance regimes, but still allow a substantial proportion of invertebrate species in need of this patchy mosaic for their life cycle, to survive in small relict populations.

The degree of naturalness depicts the distance between the current and the potential natural status of a particular forest type, to describe to what extent it was (or was not) changed by human activities. Forests are usually classed from completely artificial forests through semi-natural to completely natural forests. At present, FOREST EUROPE uses three classes[17]:

- **Forest(s) undisturbed by man**: naturally regenerated stands of native species, with natural dynamics (which requires sufficient area and natural structures). They are always of high nature conservation value. No clearly visible indications of human activities are acceptable.
- **Semi-natural forest(s)**: keep some characteristics of natural forests (e.g. some tree species of original ecosystem, capacity for natural regeneration) whilst other characteristics are changed (e.g. age structure, the presence of non-native species).
- **Plantation(s)**: usually represent ecosystems on their own, with artificial dynamics establishing species communities completely distinct from the original ecosystem.

The vast majority of the European forests fall into the "semi-natural forests" class. The EU Ecosystem assessment[18] gives the estimate that, currently, about 89% of EU-28 forests are semi-natural, while only around 2% to 4% can be described as primary forests. The remaining share is covered by plantations. The Forest Europe also recommend to split the "semi-natural" class into more sub-classes, or to redefine all the existing classes, to narrow the semi-natural class and to broaden the others.

Indicators of biological naturalness are for example the tree maturity (diameter of the largest individuals by species, standing volume, volume and advanced stage of decomposition of dead wood), the proportion of microhabitats, the irregularity of the local or global structure, etc. Naturalness can be used as a proxy for assessing the biological diversity of Forest ecosystems, but it is not necessarily positively correlated with biodiversity. The introduction by human activities of some species in near-natural forests can enhance biodiversity of the forest, while human forestry practices can in some cases encourage the dynamics of forest ecosystems and their regeneration.

The integration of forest naturalness in forest management should therefore be more related to the measure of the impact of each forestry action in terms of ecological resilience. Indeed, the closest the forest is to a "natural" condition, the more it will be able to withstand the hazards (climate change, pathogens, drought, etc.) to which it is subject, and as such to better combine ecological and economic interests[19]. Changes in naturalness can still help to reveal undocumented changes in biodiversity, which makes this indicator useful and worth of further development. Moreover, it is indisputable that

[17] https://foresteurope.org/naturalness/
[18] https://publications.jrc.ec.europa.eu/repository/handle/JRC120383
[19] Bruciamacchie B., 2009. Biodiversité, Naturalité, resilience et plasticité : nouveaux concepts au service de la gestion des arbres, Revue Forestière Française LXII Vol 5, pp 441-446.

the most pristine forests, called “primary” forests, as well as forests defined as “old-growth-forests”, should be a priority focus for Biodiversity conservation.

- **Primary and Old-growth forests in Europe**

Primary and old-growth forest conservation is a priority for the UN’s Convention on Biological Diversity and the EU’s Biodiversity strategy for 2030. Primary forests are defined as forests where signs of human impacts, such as coppicing, burning, partial logging, are absent or blurred due to multiple decades (at least 60–80 years) without forestry operations. An ongoing study at the EU level[20] aims to extend the current knowledge of Europe’s primary forests by identifying which of the 54 forest types in Europe still have primary forest, where secondary forest can be restored in the perspective of reaching the definition of “primary forests”, and define opportunities to expand protected areas to encompass primary forest at risk.

“Old-growth” is a term that indicate that the forest stand is approaching, or has reached, a certain age or successional stage, but can display varying degrees of human impact. This includes old-growth, climax, late-seral, late-successional, and overmature forests. Across Europe and in the international literature, many terms describing high conservation value forests exist and are sometimes used interchangeably with the term old-growth forest. There is no official definition of European old-growth forests yet, but several studies are ensuring a clear progress towards reaching one[21]. Most importantly, the recent development of indices of old-growthless and levels of naturalness represent a favourable option for developing such a definition.

The last EEA Technical report on European Forest condition[22] refers to old forests in Europe, and states that “the importance of old trees for biodiversity is well recognized”. Old forests are indeed vital for forest biota, particularly many rare and threatened species. Ancient forests also have a higher volume of deadwood, which forms microhabitats for many species including fungi, lichens, ferns and invertebrates, as well as woodpeckers and beetles. For example, in the Białowieża Forest, the most recognized ancient forests in Europe, half of the 12.000 species found there are dependent on decaying logs. Old forests are also important for their aesthetic, cultural and nature conservation values”.

Sadly, old growth forests have declined dramatically in Europe in the last centuries. According to EEA (2016), “only a few old forests exist in Europe and these cover a total area of approximately 3 million ha (i.e. less than 2 % of the total forest area)”. Moreover, more than half of Europe’s primary forests are without strict protection status, and the remaining primary and old-growth forests combined represent only around 3 % of the EU’s land area.

Strictly protecting them will not be enough to meet the 10% strict protection of land area target of the EU Biodiversity Strategy. Still, implementing this target will be an opportunity to significantly

[20] https://ec.europa.eu/environment/integration/research/newsalert/pdf/555na3_en_mapping-europes-primary-forests.pdf

[21] O’Brien, L., Schuck, A., Fraccaroli, C., Pötzelsberger, E., Winkel, G. and Lindner, M., 2021: Protecting old-growth forests in Europe - a review of scientific evidence to inform policy implementation. Final report. European Forest Institute. DOI: https://doi.org/10.36333/rs1

[22] Report No 5/16 “European forest ecosystems. State and trends” (EEA, 2016; available at http://www.eea.europa.eu/highlights/is-europe-doing-enough-to)

increase the share of "secondary" primary/old-growth forests in the long run, which would be very beneficial from a conservation perspective.

1.3.2 *International and European vegetation classification, a common reference for the description of forest ecosystems*

- **The IUCN Global Ecosystem typology**

The newly established IUCN Global Ecosystem typology[23] classifies the European forests within the *"Temperate-boreal forests and woodlands biome"* (T2). This unit includes *"moderate to highly productive tree-dominated systems with a wide range of physiognomic and structural expressions, distributed from warm-temperate to boreal latitudes".*

Temperate-boreal forests are generally less diverse than Tropical-subtropical forests (T1) in taxa, such as flowering plants, primates, and birds, but exhibit greater temporal and spatial variability in productivity, biomass, phenology, and leaf traits of trees. Temporal variability is primarily expressed through the seasonal variation in water balance and/or temperature, which regulate the length and timing of growing and breeding seasons. Inter-annual variation is usually less important than in some other biomes, but nonetheless may play significant roles in resource availability and disturbance regimes (e.g. fire and storms).

Gradients in minimum temperatures, soil nutrients, and fire regimes also have strong influences on traits such as leaf form (broadleaf vs. needleleaf) and leaf phenology (evergreen vs. deciduous), morphological traits related to flammability, fire resistance, and recovery, or even on ecophysiological and morphological traits promoting nutrient acquisition and conservation.

- **The EUNIS habitat classification**

EUNIS[24] (the European Nature Information System) was developed over the past decades as the reference system for species, habitat types and protected areas for the whole European region. It is mainly used to assist the N2000 and EMERALD process and to gather information and data on species and habitat types occurring across Europe. Most importantly, EUNIS establishes the EUNIS habitat classification, a *"comprehensive pan-European system to facilitate the harmonized description and collection of data across Europe, through the use of criteria for habitat identification".* This hierarchical classification covers all types of habitats, from natural to artificial and from terrestrial to freshwater and marine.

According to this pan-European classification, Forest habitat types are defined in the same way as the FAO: *"Woodland and recently cleared or burnt land where the dominant vegetation is, or was until very recently, trees with a canopy cover of at least 10%. Trees are defined as woody plants, typically single-stemmed, that can reach a height of 5 m at maturity unless stunted by poor climate or soil.";* but with additional criteria: *"Forest habitat types include lines of trees, coppices, regularly tilled tree nurseries, tree-crop plantations and fruit and nut tree orchards, as well as Alnus and Populus swamp woodland and riverine Salix woodland. Are however excluded Corylus avellana scrub and Salix and Frangula carrs, as well as stands of climatically-limited dwarf trees (krummholz) < 3m high, such as occur at the arctic or alpine tree limit. Are also excluded parkland and dehesa with canopy less than 10%, which are listed under sparsely wooded grasslands E7."*

[23] https://global-ecosystems.org/
[24] https://eunis.eea.europa.eu/about

An extensive review of the EUNIS terrestrial habitat classification was initiated in 2012 for forest and other wooded land, heathland, scrub and tundra, based on European vegetation plot data. The review concerns codes, scientific names and descriptions of the first 3 levels of the hierarchical classification of European habitat types (Table 2). The major change for forests habitats is first that the Level 2 unit "mixt broadleaved/coniferous forests" no longer exists; all its related level 3 units were distributed across the other classes; and secondly that the nature of the substrate (acid or non-acid) is considered from the level 3 for some forest types (e.g Fagus forests), which was not the case before.

Table 2: EUNIS hierarchical classification of European Forest habitats (revised class T: Forest and other wooded land)

T1: Broadleaved deciduous forest

T1-1: Temperate and boreal Salix and Populus riparian forest

T1-2: Riparian Alnus forest

T1-3: Temperate and boreal hardwood riparian forest

T1-4: Mediterranean and Macaronesian riparian forest

T1-5: Broadleaved swamp forest on non-acid peat

T1-6: Broadleaved swamp forest on acid peat

T1-7: Fagus forest on non-acid soils

T1-8: Fagus forest on acid soils

T1-9: Temperate and submediterranean thermophilous deciduous forest

T1-A: Mediterranean thermophilous deciduous forest

T1-B: Acidophilous Quercus forest

T1-C: Boreal-nemoral mountain Betula forest on mineral soils

T1-D: Mediterranean and sub-Mediterranean mountain Betula and Populus tremula forests on mineral soils

T1-E: Carpinus and Quercus mesic deciduous forest

T1-F: Ravine forest

T1-G: Non-riverine Alnus forest

T1-H: Broadleaved deciduous planted forests of non site-native trees

T1-J: Deciduous self-sown forests of non site-native trees

T2: Broadleaved evergreen forest

T2-1: Mediterranean evergreen Quercus forest

T2-2: Mainland laurophyllous forest

T2-3: Macaronesian laurophyllous forest

T2-4: Olea europea -Ceratonia siliqua forest

T2-5: South-Aegean Phoenix groves

T2-6: Canarian Phoenix groves

T2-7: Anatolian Phoenix theophrasti groves

T2-8: Ilex aquifolium forest

T2-9: Macaronesian heathy forest

T2-A: Broadleaved evergreen plantations of non site-native trees

T3: Coniferous forest

T3-1: Temperate mountain Picea forest

T3-2: Temperate mountain Abies forest

T3-3: Mediterranean mountain Abies forest

T3-4: Temperate subalpine Larix, Pinus cembra and Pinus uncinata forests

T3-5: Temperate continental Pinus sylvestris forest

T3-6: Temperate and submediterranean montane Pinus sylvestris-nigra forest

T3-7: Mediterranean montane Pinus sylvestris-nigra forest

T3-8: Mediterranean and Balkan subalpine Pinus heldreichii-peucis forest

T3-9: Mediterranean lowland to submontane Pinus forest

T3-A: Pinus canariensis forest

T3-B: Mediterranean montane Cedrus forest

T3-C: Taxus baccata forest

T3-D: Mediterranean Cupressaceae forest

T3-E: Macaronesian Juniperus forest

T3-F: Picea taiga forest

T3-G: Pinus sylvestris taiga forest

T3-H: Larix taiga forest

T3-J: Pinus bog forest

T3-K: Picea mire forest

T3-L: Coniferous planted forests of non site-native trees

T3-M: Coniferous planted forests of site-native trees

T4: Lines of trees, small anthropogenic forests, recently felled forest, early-stage forest and coppice

T4-1: Lines of trees

T4-2: Small broadleaved deciduous anthropogenic forests

T4-3: Small broadleaved evergreen anthropogenic forests

T4-4: Small coniferous anthropogenic forests

T4-5: Small mixed broadleaved and coniferous anthropogenic forests

T4-6: Early-stage natural and semi-natural forests and regrowth

T4-7: Coppice and early-stage plantations

T4-8: Recently felled areas

- **The European Atlas of forests tree species**

The European Atlas of Forest Tree Species published in 2016[25] provided for the first time a systematic coverage of forest tree taxa distribution and habitat suitability at the continental scale, based on the most comprehensively integrated set of available data and information. The available European-wide data and information have been collected and harmonized within the Forest Information System for Europe (FISE), to integrate diverse database and information systems within a modular array of models.

In Europe, most countries collect information about forest resources by means of National Forest Inventories (NFIs), but additional sources of information are available by supra-national initiatives that collect forest-based field observations for a number of specific purposes. Those sources can provide coarse-resolution estimates on the chorology of vascular plants covering the whole of Europe, or at least a substantial part of the continent, while existing land cover mapping exercises may complement this information by providing high-resolution estimates of forest categories - such as broadleaved and coniferous trees – instead of specific forest tree species.

1.3.3 *Forest genetic intra-species diversity, a neglected third component of biodiversity*

- **Conservation of Forest genetic resources**

Trees species have different ecological traits regarding their tolerance to pests, drought or heat, but so can have different trees or tree population of the same species. The genetic variability of those intra-species ecological traits is therefore a crucial aspect for forest ecosystems to adapt to the ongoing environmental changes, and maintaining forests by ensuring that they can adapt to the future climate and other challenges depends crucially on forest genetic resources (FGR)[26].

[25] https://forest.jrc.ec.europa.eu/en/european-atlas/

[26] Barbara VInceti, Mattia Manica, Nina Luridsen, Peiter Johannes Verkerk, Marcus Lindner, Bruno Fady (2020): Managing forest genetic resources as a strategy to adapt forests to climate change: perceptions of European forest owners and managers

Forest genetic resources are defined as the heritable materials within and among tree species and other woody plants[27]. However, the genetic diversity of forest trees cannot be directly observed, in opposite to the diversity of tree species, and is difficult to "sell" on its own[28]. In addition, unlike many crops, tree seeds do not survive very long and the conservation of FGR must be mainly done *in-situ*[29]. It means that the conservation of forest ecosystems and natural habitats, as well as the maintenance and the recovery of viable populations of tree species in their natural surroundings, are necessary (CBD Art.2).

For the *in-situ* conservation of FGR, countries most often implement networks of forest stands or areas

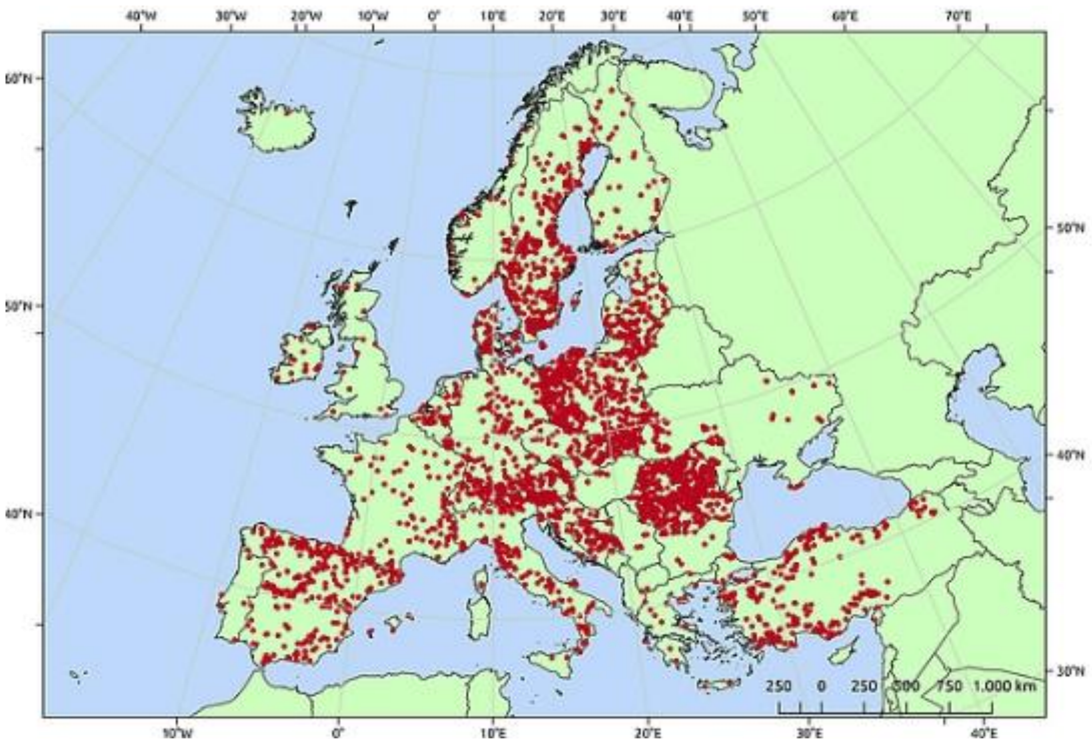


Figure 4: Distribution of Conservatory units of forest genetic resources (EUFGIS)

of tree populations, which have adapted to specific environments or have distinct characteristics. Such genetic conservation units can be located in forests managed for multiple uses, protected areas or seed stands[30]. Via the European Forest Genetic Resources Program (EUFORGEN) and the related European Information System on Forest Genetic Resources (EUFGIS), European countries have organized a core network of dynamic Conservatory units, which are part of a Pan-European strategy for genetic conservation of forest trees (Figure 4).

[27] FAO 2014 a. State of the World's Forest Genetic Resources. Rome.

[28] Geburek Th. and Konrad H., 2008. Why the Conservation of Forest Genetic Resources Has Not Worked. Conservation Biology, Volume 22, No. 2, pp 267–274

[29] http://www.euforgen.org/forest-genetic-resources/conservation/

[30] http://portal.eufgis.org/genetic-conservation-units/

Those units are established and regularly monitored in order to maintain and enhance the long-term evolutionary potential of tree populations. As of today, the EUFGIS database contains information on 3666 units and 111 tree species, in 35 countries. The IUCN voted in 2016 a Recommendation for Forest genetic diversity to be integrated to the environmental objectives of protected areas, while there an ongoing reflection among experts regarding the attribution of an IUCN protected area management category to those conservatory Units.

- **Tree species of interest for genetic resources**

Those conservatory units host a total of 4409 tree populations. Most units are for *Picea abies* (518), followed by *Fagus sylvatica* (462) and *Pinus sylvestris* (421); for 19 species EUFGIS contains only one unit. The map below shows that most units are located in Romania (652), followed by Poland (610) and Sweden (396)[31].

Among the 111 species for which genetic conservation units are documented in EUFGIS, only two are listed in the Annexes of the Habitats Directive (HD) (Table 3). However, Natura 2000 sites have to be designated for the protection of HD Annex II species, while a strict protection regime must be applied across the entire natural range within the EU for all Annex IV species, both within and outside Natura 2000 sites.

Table 3: Habitats Directive's species for which genetic conservation units are documented in EUFGIS

Scientific_name	AnnexII	AnnexIV	AnnexV
Abies nebrodensis	Yes	Yes	No
Phoenix theophrasti	Yes	Yes	No

Phoenix theophrasti is one of the few tertiary relict tree species, endemic to the eastern Mediterranean, with local populations both in Crete (Greece) and in southwest Turkey. Like most of the relict endemics, it has a restricted distribution and it is at risk of extinction[32]. *Abies nebrodensis* is a species endemic to Sicily (elevation about 1500 m) and is the worldwide rarest fir found in the wild. Only a few specimens exist in the Madonie mountains, west of the Monti Nebrodi, which give the tree its name. The reason for its rarity is the exploitation of wood, together with the overgrazing of the mountain slopes, which, over many centuries, has hindered the reforestation of areas once cleared, while strongly encouraging soil erosion[33].

A systematic analysis on how many of the forest genetic conservation units are located within protected areas could not be done in the context of this report, as this would require to get access to the spatial data from EUFORGEN. However, for the two species covered by the Habitats Directive, the location of their related conservation units was compared to the distribution of protected areas – both Natura 2000 sites and nationally designated areas (CDDA).

---

[31] http://portal.eufgis.org/ , accessed 7.7.2021
[32] https://top50.iucn-mpsg.org/species/1
[33] Nilden Vardareli, Taylan Doğaroğlu, Ersin Doğaç,Belgin Göçmen Taşkın (2019): Genetic characterization of tertiary relict endemic Phoenix theophrasti populations in Turkey and phylogenetic relations of the species with other palm species revealed by SSR markers, Oesterreichische Botanische Zeitschrift 305 (suppl 1) DOI: 10.1007/s00606-019-01580-8

The analysis revealed that for *Abies nebrodensis*, three Natura 2000 sites are designated: two in Italy and one in Latvia. The Italian genetic conservation units seem to be located within the perimeter of these Natura 2000 sites (Figure 5), whereas for Latvia, no unit is contained in EUFGIS. For the conservation of *Phoenix theophrasti,* seven Natura 2000 sites are designated in Crete (Greece), whereas the genetic conservation units are only located in Turkey, within nationally designated protected areas (Figure 6).

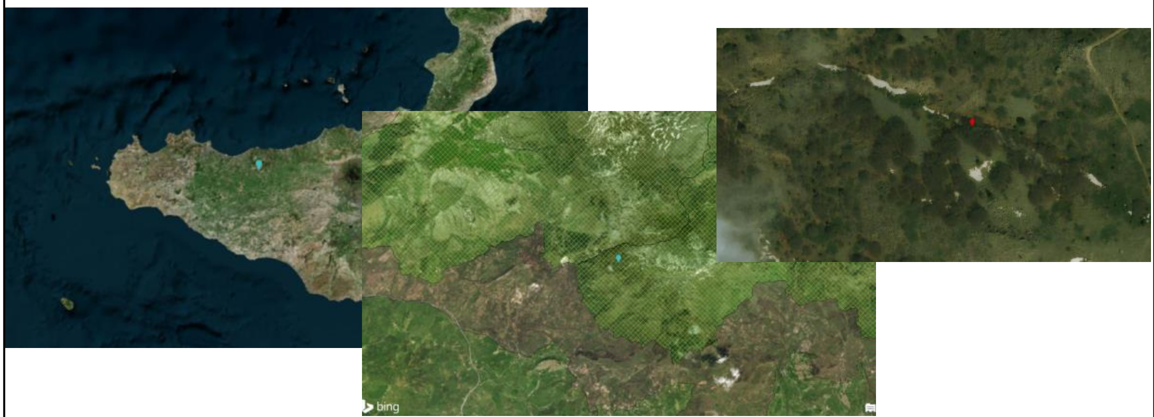
Abies nebrodensis FGR unit ITA00252 located in:

Natura 2000 sites:

- Monte S. Salvatore, Monte Catarineci, Vallone Mandarini, ambienti umidi (ITA020004)
- Parco delle Madonie (ITA020050)

CDDA site

- Parco delle Madonie



Abies nebrodensis FGR unit ITA00241 located in:

Natura 2000 site:

- Alpe della Luna (IT5180010)

CDDA site:

- Riserva naturale dell' Alpe della Luna

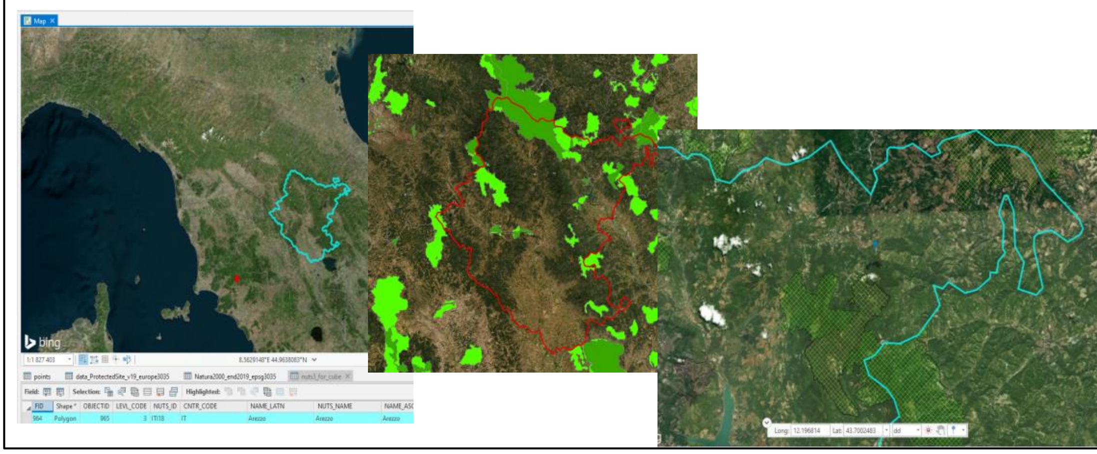


Figure 5: Location of *Abies nebrodensis* FGR units in Natura2000 sites and nationally designated areas (CDDA)

Phoenix theophrasti FGR unit TUR00197 located in

CDDA sites:
- Sit Alanı
- Mugla Marmaris Datca-Datca Hurmasi
- Datca Bozburun

FGR unit TUR00208 located in

CDDA sites:
- Mavikent Sit Alanı
- Antalya Kumluca Adrasan-Datca Hurmasi

Figure 6: Location of *Phoenix theophrasti* FGR units in Natura2000 sites and nationally designated areas (CDDA)

Besides the explicit conservation of HD Annex II and IV tree species, the Habitats Directive is also important for tree species that are typically for HD Annex I habitat types. The conservation status of typical species is, together with the structure and functions of the habitat, one parameter that is used to assess the conservation status of Annex I habitat types, besides range, area and future prospects. Out of the 111 tree-species covered by EUFORGEN, at least 87[34] are considered as typical species of Annex I habitat types. This concerns mainly forest and scrubs (Table 4).

[34] The list of typical species reported under HD Article 17 might not be 100% complete, as this was an optional field in the report format.

Table 4: Top 5 habitat groups for which species covered by EUFORGEN are typical species of HD Annex I habitat types

Annex I Habitat sub-group	Number of species
Forests of Temperate Europe	65
Mediterranean deciduous forests	57
Mediterranean and Macaronesian mountainous coniferous forests	42
Temperate heath and scrub	32
Temperate mountainous coniferous forests	28

For 83 % of the EUFORGEN tree species which are considered as typical species of Annex 1 habitat types, the related habitat type has a poor conservation status (U1 unfavourable-inadequate). For 17 %, the conservation status is bad (U2 unfavourable-bad).

In addition, the European IUCN Red List status[35] is currently known for only 30 species covered by EUFORGEN (Table 5). *Abies nebrodensis* was assessed as Critically endangered (CR) (see also HD Annex species above), while *Fraxinus excelsior* (Ash), which is one of the most important hardwoods in Central Europe after beech and oak, is Near threatened (NT). Surprisingly, the wild apple (*Malus sylvestris*) and also the cherry plum (*Prunus cerasifera*) are Data deficient (DD). The 26 species assessed as Least concern (LC) are of the following genera: *Abies, Betula, Castanea, Crataegus, Frangula, Fraxinus, Ilex, Juniperus, Larix, Pinus, Populus, Prunus, Quercus, Salix, Tilia*.

Table 5: IUCN Red list status of tree species covered by EUFORGEN

IUCN Red List status	Number of species
Critically endangered (CR)	1
Near Threatened (NT)	1
Least concern (LC)	26
Data deficient (DD)	2

[35] IUCN red list species from EEA website https://www.eea.europa.eu/data-and-maps/data/european-red-lists-7

2 How are European forests protected?

2.1 *Forests within EU legislations*

There is no common overall forest policy in the European Union, but forest-related objectives are being stepped up by policymakers from different sectors. The EU has indeed a long history of contributing to implementing sustainable forest management and to Member States' decisions on forests through its different policies and strategies: the Europe 2020 strategy for growth and jobs, the Resource Efficiency Roadmap, Rural Development Policy and Industrial Policy, the 2020 targets of the EU Climate and Energy Package, the Plant Health and Reproductive Materials Strategy, or through the Biodiversity and Bio-economy Strategies. Climate change mitigation related to forest practices is also regulated by the Land use, land use change and forestry (LULUCF) Regulation[36], a binding commitment for each Member State to ensure that accounted emissions from land use and forestry are entirely compensated by an equivalent accounted removal of CO_2 from the atmosphere, through action in the sector.

The EU Member-State are also allowed to fund forestry measures through their national rural development programmes, defined under the Common Agriculture Policy (CAP). These measures are aimed at protecting the forest, making it more resilient to climate change and safeguarding its multiple functions, including the provision of environmental services, as well as supporting investments, innovation and training to the benefit of the rural economy. Through the CAP, Member-States can indeed choose to fund afforestation programmes or new agroforestry systems, prevention of forest damage (fires, natural disasters or catastrophic events) or restoration of damaged forests, as well as forest technologies, valuation of forest products or specific land management contracts for forest-environment-climate services and forest conservation.

Co-financing of forestry measures under the Rural Development Regulation has been and will remain the main means of EU-level funding. As part of the EU commitment to ensure that public money is used effectively, the impact of forestry measures carried out through rural development programmes are regularly assessed[37] and can be used to inform future policy.

2.1.1 *The EU Forest Strategies*

The EU Forest Strategies seek to amend the lack of coordination and coherence between the various forest-related policies within the Union and its Member-States. The first EU Forestry Strategy was established in 1998, as a framework for forest-related actions that support sustainable forest management based on cooperative links between EU and Member States policies and initiatives. After that, the 2007-2011 Forest Action Plan was set to implement the strategy toward four objectives: competitiveness, environment, quality of life and coordination and communication.

The last EU forest strategy (2014-2020) was then developed to provide a coherent framework promoting the concept of sustainable forest management, for both the European policies related to forests and the Member-State's national forestry policies. The aim of this strategy was to safeguard

[36] https://ec.europa.eu/clima/policies/forests/lulucf_en

[37] Evaluation staff working document on forestry measures under rural development, October 2019

and achieve the balanced development of the multiple functions of forests and efficiency use of its resources.

The future Strategy 2021-2030 has been launched on July 14th, 2021[38]. This new strategy will build on the EU Biodiversity Strategy to 2030, as to cover the whole forest cycle and promote the many services that forests provide. It should further help the EU to meet its international commitments, and will form the basis of a consistent and holistic approach on forests, allowing stronger EU leadership internationally in the context of the United Nations' 2030 sustainability agenda, the Paris Agreement, the Convention on Biological Diversity and the Convention to Combat Desertification[39].

2.1.2 *The EU Biodiversity strategy for 2030*

- **EU legislation toward forest restoration**

The EU Biodiversity Strategy for 2020 already formulated the need for an integration of geospatial data. The new EU Biodiversity Strategy for 2030 repeats this need implicitly by requiring improvement of the EU network of protected areas (Trans-European Nature Network), but also in the context of the new ambitious EU Nature Restoration Plan by the intent to put in place a set of legally binding restoration targets and a consistent monitoring and review mechanism, including a clear set of indicators.

The EU Green Deal and the EU Biodiversity Strategy for 2030 also include a roadmap for planting at least 3 billion additional trees in the EU by 2030[40], in full respect of ecological principles. This represents an approach leading to increasing the quantity of forests and improving their health and resilience.

- **The future Nature Restoration Law**

The evaluation of the EU Biodiversity Strategy to 2020 shows that the EU has so far failed in its efforts to halt the loss of biodiversity over the 2011-2020 period, and that the voluntary target to restore by 2020 at least 15 % of degraded ecosystems, delivered insufficient efforts and progress. This target was in line with the global commitment under the Convention on Biological Diversity (Aichi Target 15). The overall picture points to the fact that the current approaches are not delivering favourable results.

The European Green Deal underlined the importance of better protecting and restoring nature and the EU biodiversity strategy for 2030 set out the need to restore degraded ecosystems across land and seas. It states that legally binding EU nature restoration targets to restore degraded ecosystems (i.e. with high importance for biodiversity) should be proposed by the Commission by 2021, in particular for the ecosystems with the most potential to remove and store carbon and to prevent and reduce the impact of natural disasters. This effort, if enacted, would significantly contribute to the strategy's headline ambition to ensure that by 2050 all of the world's ecosystems are restored, resilient, and adequately protected and that Europe's biodiversity is on the path to recovery by 2030.

The European Parliament and the Council have also insisted on stepping up efforts to restore ecosystems, for instance in the Council Conclusions of December 2019 and in the European Parliament's resolution of January 2020 which asked to *"move away from voluntary commitments and to propose an ambitious and inclusive Strategy that sets legally (and, consequently, enforceable)*

---

[38] https://ec.europa.eu/environment/strategy/forest-strategy_en
[39] https://www.eea.europa.eu/policy-documents/the-eu-forest-strategy-com
[40] https://ec.europa.eu/environment/3-billion-trees_fr

binding targets for the EU and its Member States". The European Parliament' Environment Committee repeated its support for an EU Nature Restoration Plan in June 2021.

On this date, the most plausible option for the Nature Restoration Law will be to set an overall binding goal, ensuring that *"By 2050, ecosystems in the EU are restored to and maintained in good status"*, going with additional specific targets for a range of ecosystems, habitats, groups of species of individual species that should be restored by 2050. It would also include the obligation of no deterioration of ecosystems, and Member-States will have to set up national restoration plans to reach those targets.

- **Restoring forest ecosystems**

Three options for forest ecosystem restoration have been developed so far, during the Nature Restoration law's Impact assessment. The first option is to restore all HD Annex I forest area to good condition, and recreate some additional habitat area required to achieve Favourable Conservation Status (FCS) of HD Annex I forest habitats. Two set of targets are proposed: all necessary restoration measures completed on 15 or 30% of degraded areas by 2030, 40 or 60% by 2040 and 90% by 2050, and to recreate 15 or 30% by 2030, 40 or 60% by 2040 and 100% by 2050. This option is constrained by its geographical scope and does not address the condition of forests outside of the scope of HD Annex I habitats. This means that this option has a natural limit in terms of its effectiveness for enhancing biodiversity and climate change mitigation- and adaptation.

The second option is to restore and re-create forest habitats, as necessary to achieve the favourable conservation status of wild birds and species that are listed in Annex II, IV and V of the Habitats Directive and predominantly associated with forests, with 15 or 30% of all necessary actions carried out by 2030, 40 or 60% by 2040 and 100% by 2050. This option overlaps with both the first option and the following one, and is in principle unlimited in terms of forest area covered. This means that its potential in terms of area covered may be the highest across all options. The effectiveness of this option may however depend on the specific actions taken to improve condition of species and their effect on overall ecosystem health, both in- and outside of the Annex I.

The third option is to restore only degraded non-Annex I habitats forest area to a good condition, with all necessary restoration measures completed on 15% of degraded areas by 2030, 40% by 2040 and 100% by 2050. This target would have a wide scope, while covering 72% of the EU forest area. It addresses non-Annex I forests and is mutually exclusive to option 1. This option would be more complex to implement, while indicators and a monitoring and reporting system would need to be established, involving certain costs. However, this option has a high potential considering the poor state of forests outside of the HD Annex I, for biodiversity as well as climate change mitigation- and adaptation.

2.2 The Birds and Habitats Directives: the EU Nature Directives

2.2.1 *Principles*

Nature conservation is undertaken by both Birds and Habitats Directives. The Bird Directive[41] was unanimously adopted by EU Member States in April 1979, making it the oldest piece of EU legislation related to the protection of the environment. It aims to protect all of the 500 wild bird species

[41] https://ec.europa.eu/environment/nature/legislation/birdsdirective/index_en.htm

naturally occurring in the European Union, as identified in its annexes, though different level of protection and measures that Member State need to implement. The Habitats Directive[42] was adopted in 1992 and identifies on its side all non-bird species and habitat types of Community interest within Europe, defined as being those in danger of disappearance in their natural range, rare or endemic, or characteristic of one or more of the EU biogeographical regions. Over 1.000 animal and plant species, as well as 233 habitat types, are therefore protected across the EU in various ways.

Both Directives now constitute the cornerstone of Europe's nature conservation policies and establish the EU wide Natura 2000 ecological network of protected areas[43]. Indeed, the Birds Directives asks Member States to establish a network of Special Protection Areas (SPAs), while the Habitats directive ask them to identify Sites of Community Importance (SCIs), further on designated as Special Areas of Conservation (SACs) within at most six years. SPAs must include all the most suitable territories for the 194 particularly threatened species and all migratory bird species (Annex I), while SACs should ensure the favourable conservation status of each habitat type and species throughout their range, within the EU.

2.2.2 *Forest habitats and species under Nature Directives*

- **Forest habitat types**

Forests are identified and protected across those Directives by a subset of Forest habitat types and forest typical species, as well as by a subset of Forest bird species.

The Forest habitat group (9***) of the Habitats Directive covers 81 habitat types, classified according to the following groups: Forests of Boreal Europe, Forests of temperate Europe, Mediterranean deciduous forests, Mediterranean sclerophyllous forests, Temperate mountainous coniferous forests, Mediterranean and Macaronesian mountainous coniferous forests. The 10 largest forest habitat types are listed in Table 6. They cover mostly zonal forests, apart from the 2nd ranked extrazonal 91D0* Bog woodlands.

It is estimated that this habitat group has an average area of 491 900 km², or about 30 % of all European forests[44].

Table 6: 10 largest Annex I forest habitat types in the EU (Article 17 report 2013-18 for EU 27 excluding Romania)

Rank	Habitat code	Habitat name	Area (km²)
1	9130	*Asperulo-Fagetum* beech forests	**56 043**
2	91D0	*Bog woodland	**44 585**
3	9010	*Western Taïga	**36 315**
4	9340	*Quercus ilex* and *Quercus rotundifolia* forests	**27 784**

[42] https://ec.europa.eu/environment/nature/legislation/habitatsdirective/index_en.htm
[43] https://ec.europa.eu/environment/nature/natura2000/sites/index_en.htm
[44] European Environment Agency, 2020. State of nature in the EU - Results from reporting under the nature directives 2013-2018. 142 pp.

5	91M0	Pannonian-Balkanic turkey oak-sessile oak forests	**22 986**
6	9540	Mediterranean pine forests with endemic Mesogean pines	**21 677**
7	9110	*Luzulo-Fagetum* beech forests	**21 009**
8	9040	Nordic subalpine/subarctic forests with *Betula pubescens* ssp. *czerepanovii*	**19 600**
9	91K0	Illyrian Fagus sylvatica forests (*Aremonio-Fagion*)	**16 339**
10	9120	Atlantic acidophilous beech forests with *Ilex* and sometimes also *Taxus* in the shrublayer (*Quercion robori-petraeae* or *Ilici-Fagenion*)	**15 386**

Table 7 details the largest Annex I forest habitat types per biogeographical regions, reported by the Article 17 report 2013-18. The extrazonal 91D0* Bog woodlands dominates within the Boreal biogeographical region. No forest habitat types are listed for the Steppic region. In all other biogeographical, zonal forest habitat types are top ranked regarded surface area.

Table 7: Largest Annex I forest habitat types per biogeographical regions in the EU per biogeographical regions (Article 17 report 2013-18 for EU 27 excluding Romania)

Biogeographical region	Habitat code	Habitat name	Area (km²)
ALP	9040	Nordic subalpine/subarctic forests with *Betula pubescens* ssp. *czerepanovii*	18 320
ATL	9230	Galicio-Portuguese oak woods with *Quercus robur* and *Quercus pyrenaica*	6 606
BLS	91M0	Pannonian-Balkanic turkey oak-sessile oak forests	1 457
BOR	91D0	*Bog woodland	40 872
CON	9130	*Asperulo-Fagetum* beech forests	34 388
MAC	9550	Canarian endemic pine forests	737
MED	9340	*Quercus ilex* and *Quercus rotundifolia* forests	26 877
PAN	91M0	Pannonian-Balkanic turkey oak-sessile oak forests	1 303
STE	-	-	-

Halada[45] have also proposed that seven additional Annex I habitats types should be considered as forest habitat types, as they meet the main criterion of the definition of forests from the Convention of Biological Diversity (a tree cover greater than 10%):

- 2180 Wooded dunes of the Atlantic, Continental and Boreal region
- 227* Wooded dunes with *Pinus pinea* and/or *Pinus pinaster*
- 3240 Alpine rivers and their ligneous vegetation with *Salix elaeagnos*
- 5220* Arborescent matorral with *Zyziphus*
- 5230* Arborescent matorral with *Laurus nobilis*
- 6310 Dehesas with evergreen *Quercus* spp.
- 6530* Fennoscandian wooded meadows

In opposite, the recent work related to the Nature Restoration Law was an opportunity to redefine groups of Annex I habitats, in relation the EU Ecosystem assessment typology and as to set consistent quantitative restoration targets for Annex I habitat types across the multiple ecosystems of Europe.

As such, the “forests” group for the Nature Restoration Law only include 69 Annex I habitat types, corresponding to all forest habitat types with codes 9xxx with the exception of the wet/alluvial/riparian forests and wooded meadows, which are included in other groups (respectively “River, lake, alluvial & riparian habitats” and “Steppe, heath & scrub habitats”).

EEA estimated the coverage of those 69 habitat types (excluding data from Romania) to be close to 357 952 km² (9.2% of the EU terrestrial area).

- **Species associated with forest ecosystems**

If linking habitat types to broad ecosystems like forest is relatively simple, it is much more complex for species and it can only be partial or indicative, as many species use different ecosystems during their life cycles and can have different ecological requirements across all different biogeographical regions[46]. A specific approach was elaborated for the compilation of a list for the Common Forest Bird Species indicator, and it is assumed that many of these criteria are applicable for the compilation of other species to habitat -linkages as well. Three lists of protected species related to forest ecosystems are available: the List from the “Natura 2000 Nature and forests” guideline[47], the MAES classification (‘Mapping and assessment of ecosystems and their services’), and the List for the ‘State of Nature’ evaluation of target 3b of the Biodiversity Strategy to 2020[48].

---

[45] Halada L., Gajdos P., Gaudillat Z., 2020. Proposals of the ecological grouping of the Habitats Directive habitats and species, ETC/BD Report for the EEA.
[46] Kingberg E.C., 2021. Pilot study for a Common Agricultural Policy impact indicator for ‘Habitats, mammals, plants, arthropods and birds of Community interest associated with forests, with stable or increasing trend’ for Sweden, Denmark, Slovenia and Italy, for the EU reporting period 2013-2018, Bachelor thesis, not published.
[47] Kremer F., van der Stegen J., Gafo Gomez-Zamalloa M., Szedlak T., Olmeda C., Ibero C., García D. & Sundseth K. (2015) Natura 2000 and Forests. Part I-II. European Commission Technical report
[48] Röschel L., Noebel R., Stein U. et al. (2020) State of nature in the EU - Methodological paper. Methodologies under the Nature Directives reporting 2013-2018 and analysis for the State of nature 2020.

2.3 The Natura 2000 network

2.3.1 *Principles*

The Natura 2000 network is composed of 3 types of site:

- A type: Designated Special Protection Area (SPA) according to the Birds Directive;
- B type: The proposed and adopted provisional Sites of Community Importance (pSCIs, SCIs) and their related Special Areas of Conservation (SACs), designated under the Habitats Directive;
- C type: Area of pSCI/SCI/SAC designated under the Habitat Directive, but located within the same area as designated SPA sites.

Although Natura 2000 sites of type A may cover forested areas, there is no obligation to fill information about forest habitat types into their related Standard data forms (SDF), and only the types B and C sites are relevant for the conservation and protection of Annex I forest habitat types. Thus, the analysis in this chapter is based upon sites of type B or C, extracted from the Natura 2000 database[49]. In order to focus on the current implementation of the Habitat Directive in the EU, site data from UK are excluded from the review.

In addition, this study only considers Annex I forest habitat types listed as A - excellent representativity, B - good representativity or C - significant representativity, within the Standard Data Forms (SDF) of each of those N2000 sites. The degree of representativity gives a measure of how typical a habitat type is, as the level "D" (non-significant presence) indicates a form of an Annex I habitat type which is of little conservation value, for example a very degraded occurrence of a woodland with many of the usual species absent.

The first compilation date in the SDF of each N2000 site corresponds to its first submission. Three further obligatory dates can be required and available: the date a site is classified as SPA; the date the site is proposed as SCI; and the date the site was designated nationally as SAC. The date "confirmed as SCI" is optional for Member States to fill in, and the date of confirmation/adoption of relevant union list are documented by DG Environment. As information is not given for all these date characteristics, the "date the site is proposed as SCI" is the most complete information provided in the Natura 2000 database. For 28 missing entries, the first compilation date is used in these cases.

The following analyses consider the 81 Annex I Forest habitat types of the Forest group 9***, as well as the seven additional Annex I habitats types to be considered as forest habitat types proposed by Halada. Numbers and figures are given for both selections: only habitats types from the Forest group 9***, and for those 81 Habitats types + the 7 forest habitat types proposed by Halada.

2.3.2 *Number, area and coverage of N2000 sites including forest habitat types*

- **Number of N2000 reported sites including forest habitat types**

By end of 2019, the Natura 2000 database included 23.532 terrestrial and marine sites of B and C type, across the EU. 595 of them (about 2,5%) are completely marine, and 239 sites (about 1%) have a

[49] https://ec.europa.eu/environment/nature/natura2000/db_gis/index_en.htm

fraction of terrestrial area smaller than 10 %. 16.300 sites of all those marine and terrestrial B or C type (about 69,3%) included at least one forest habitat type, with representativity A, B or C.

Considering only the sites with a fraction of terrestrial area greater than 10 %, the analysis shows that about 71,8 % of all Natura 2000 sites included at least one Annex I forest habitat type, and that 21.836 Natura 2000 sites of type B and C included Annex I forest habitat types with a representativity A, B or C, representing about 77,7 % of all B and C Natura 2000 sites.

In the first implementation years (1995 to ~2000) of the Habitat Directive, the cumulative share of proposed SCIs (site type B and C) with forest habitats per year was about 80 %. Although the total count of proposed SCIs increased over the following years, the cumulative share of proposed SCIs with forest habitats decreased down to about 70 % (Figure 7).

When including the forest like habitat types newly proposed by Halada, the progress is similar, though the cumulative share of proposed SCIs with forest habitat types in the broader sense is calculated slightly above 70% (Figure 8).

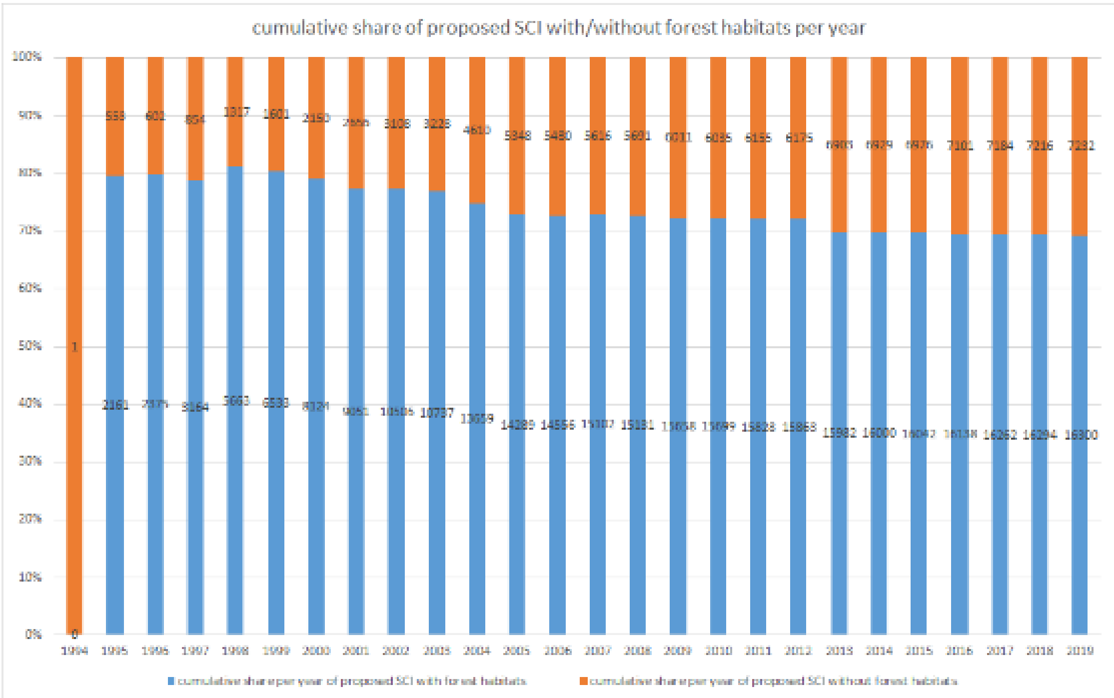


Figure 7: **Cumulative annual share of proposed SCIs with/without Annex I forest habitats types in the period 1994 to 2019**

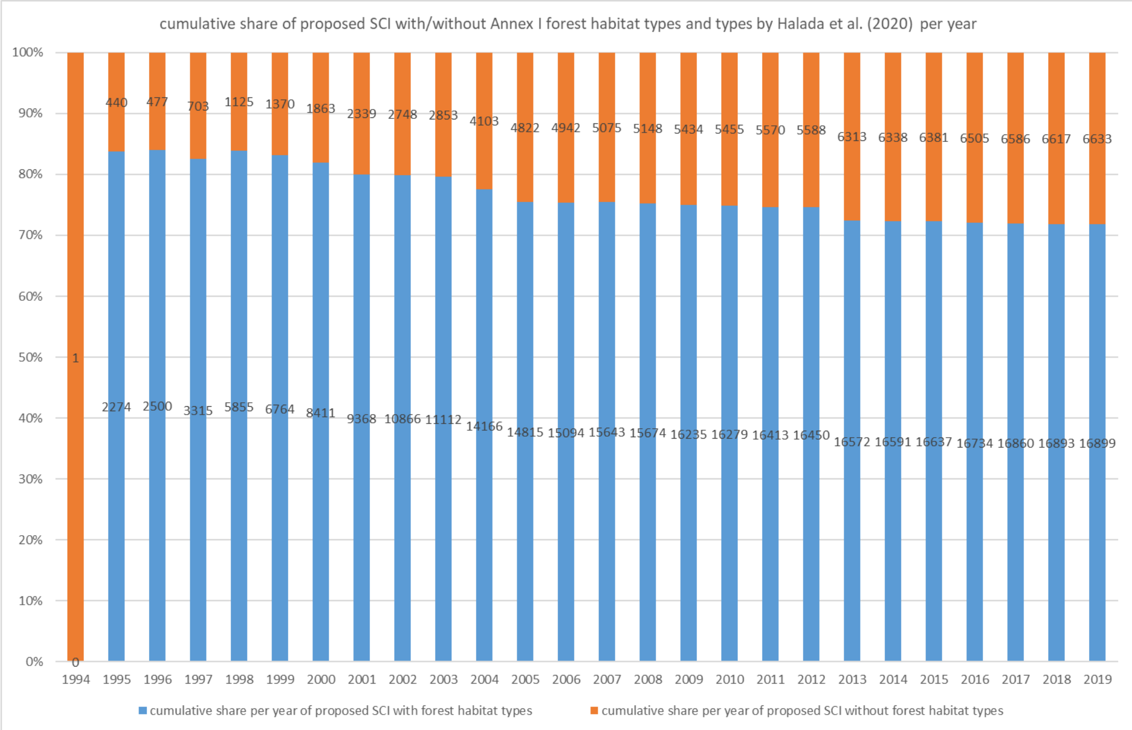


Figure 8: **Cumulative share per year of proposed SCIs with/without Annex I forest habitat types and types by Halada et al (2020) in the period 1994 - 2019**

- **Area of N2000 reported sites including forest habitat types**

Within the N2000 SDFs, Member States have to give the most accurate total surface area available as the site level, in hectares. Similar to the total number of SCIs/SACs sites with and without forest habitat types, the cumulative site area in hectares of proposed SCIs/SACs with or without at least one or more listed forest habitat types decreases from about 90 % in the first directive implementation years, down to about 63%. By end of 2019, the total area of protected sites SCIs/SACs with one or more forest habitats is 59.641.298 ha, versus 33.974.614 ha of such sites without forest habitats (Figure 9).

When including the forest like habitat types newly proposed by Halada into the calculation of the cumulative share of N2000 sites size, the progress over the same period is very similar. Summarized, more Natura 2000 sites with forest habitat types have been included into the network in the beginning of the designation process, whereas more protected areas with other habitat types came in for completion of the network (Figure 10).

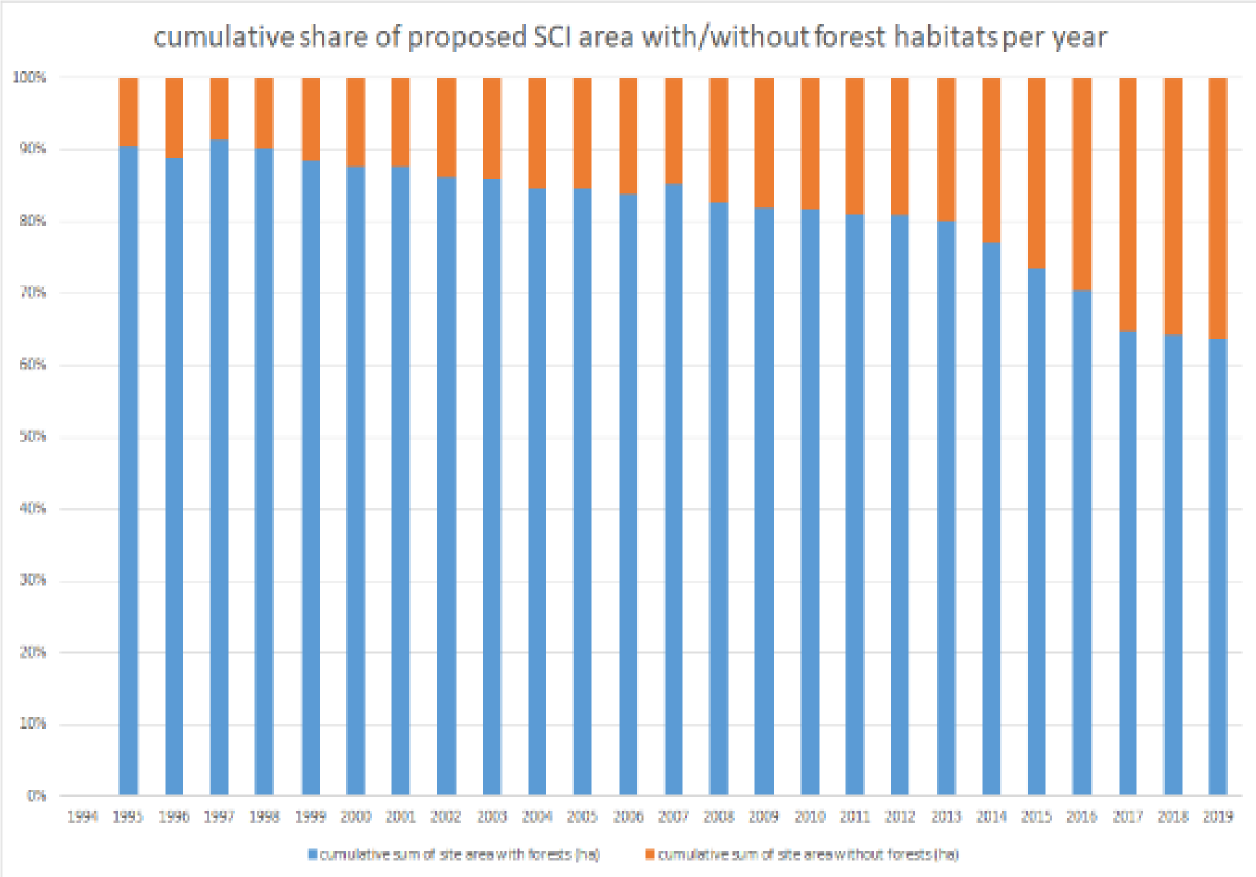


Figure 9: **Cumulative share per year of proposed SCIs/SACs area with/without forest habitats in the period 1994 to 2019**

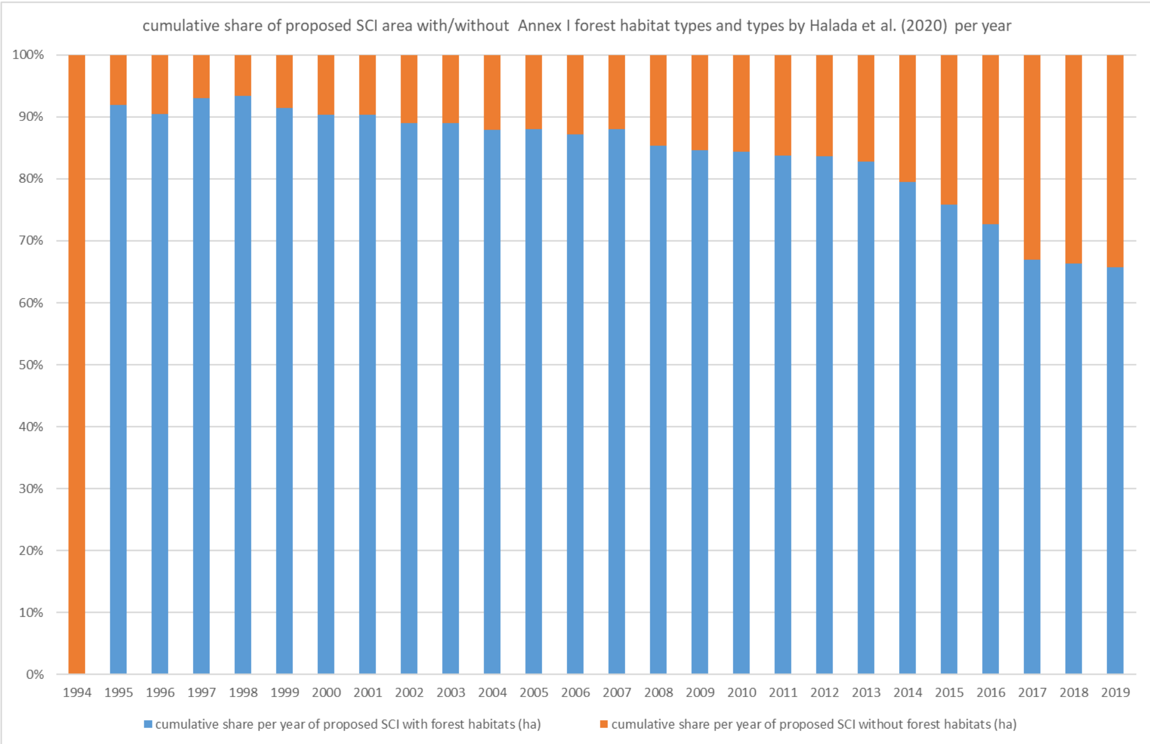


Figure 10: Cumulative share per year of SCIs/SACs area with/without Annex I forest habitat types and types proposed by Halada et al (2020) in the period 1994 - 2019

- **Mean coverage of N2000 sites including forest habitat types**

Protected areas with an ecological complex of a high number of forest habitat types per site are rare within the network. Potapov[50] specified that an intact forest landscapes model should be of a minimum area of 500 km^2, but this can include extensive areas of non-forest ecosystems, on the basis that this area is large enough to include the full suite of natural processes, including disturbance regimes. However, almost all (about 93%) Natura 2000 sites (B or C types) designated for forest habitat types are smaller than 10.000 ha (Figure 11, Figure 12).

[50] https://www.ecologyandsociety.org/vol13/iss2/art51/

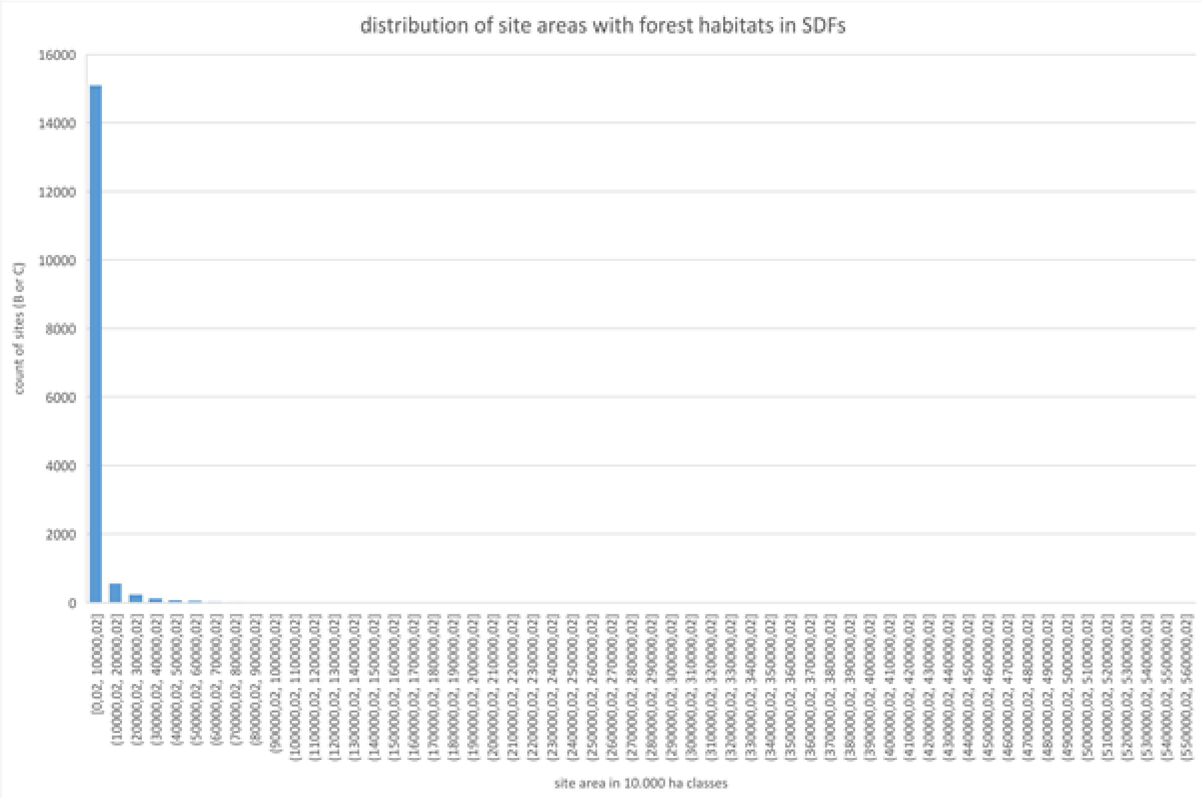


Figure 11: **Distribution of site (B or C) area with Annex I forest habitats habitat types listed in SDFs (n = 16.300)**

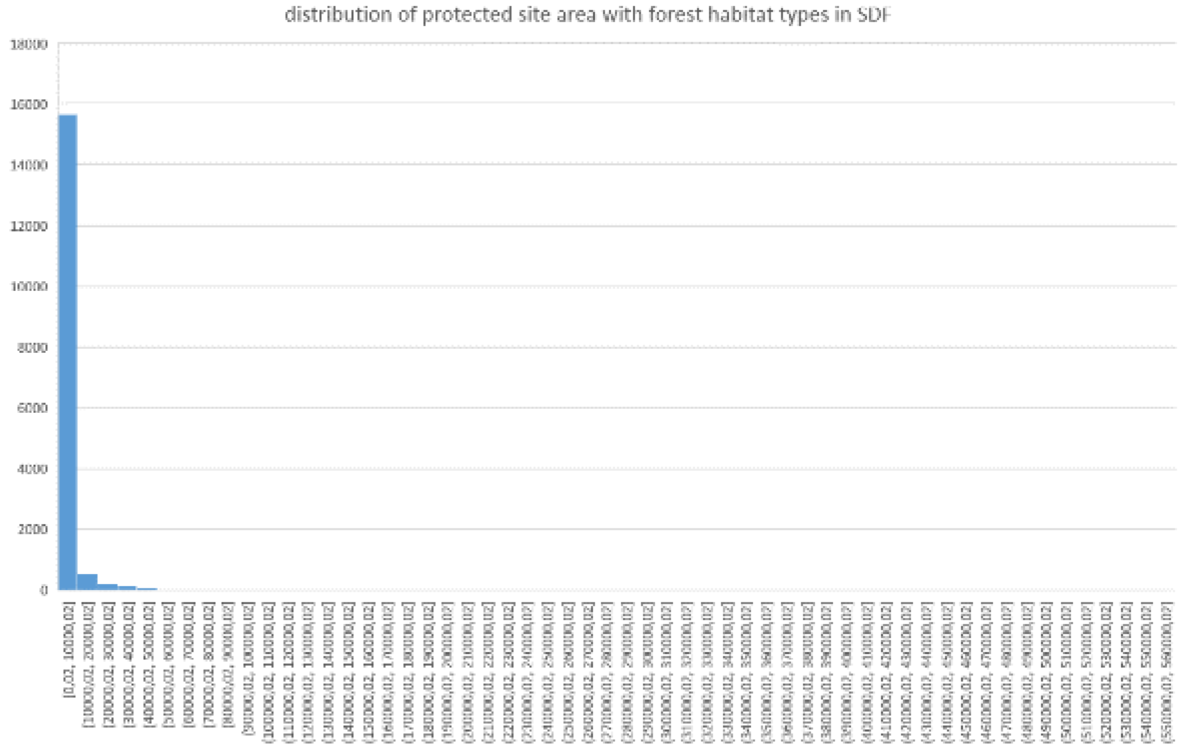


Figure 12: **Distribution of site (B or C) area with forest habitat types of Annex I and Halada et al. (2020) listed in SDFs (n = 16.900)**

The Natura 2000 site BG0001030 Rodopi - Zapadni covers the highest count (20) of forest habitats per site:

- 9110 Luzulo-Fagetum beech forests,
- 9130 Asperulo-Fagetum beech forests,
- 9150 Medio-European limestone beech forests of the Cephalanthero-Fagion,
- 9170 Galio-Carpinetum oak-hornbeam forests,
- 9180 Tilio-Acerion forests of slopes, screes and ravines,
- 91AA Eastern white oak woods,
- 91BA Moesian silver fir forests,
- 91CA Rhodopide and Balkan Range Scots pine forests,
- 91D0 Bog woodland,
- 91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae),
- 91H0 Pannonian woods with *Quercus pubescens*,
- 91M0 Pannonian-Balkanic turkey oak –sessile oak forests,
- 91W0 Moesian beech forests,
- 91Z0 Moesian silver lime woods,
- 9270 Hellenic beech forests with *Abies borisii-regis*,
- 92C0 *Platanus orientalis* and *Liquidambar orientalis* woods (Platanion orientalis),

- 9410 Acidophilous *Picea* forests of the montane to alpine levels (Vaccinio-Piceetea),
- 9530 (Sub-) Mediterranean pine forests with endemic black pines,
- 9560 Endemic forests with *Juniperus* spp.,
- 95A0 High oro-Mediterranean pine forests.

The site is about 272.851 ha and includes large coniferous and mixed forests. It is almost unpopulated and characterized by different climatic conditions.

The Top 5 ranked Natura 2000 sites regarding their area include 4 or 5 different forest habitat types in their SDFs:

- SE0810080 Vindelfjällen (554.732 ha),
- ROSCI0065 Delta Dunării (453.645 ha),
- FI1302002 Kaldoaivin Erämaa (351.349 ha),
- FR2402001 Sologne (346.184ha),
- SE0820282 Torneträsk-Soppero fjällurskog (336.897 ha).

There is however no clear correlation between protected site area and total count of forest habitat types (Figure 13, Figure 14).

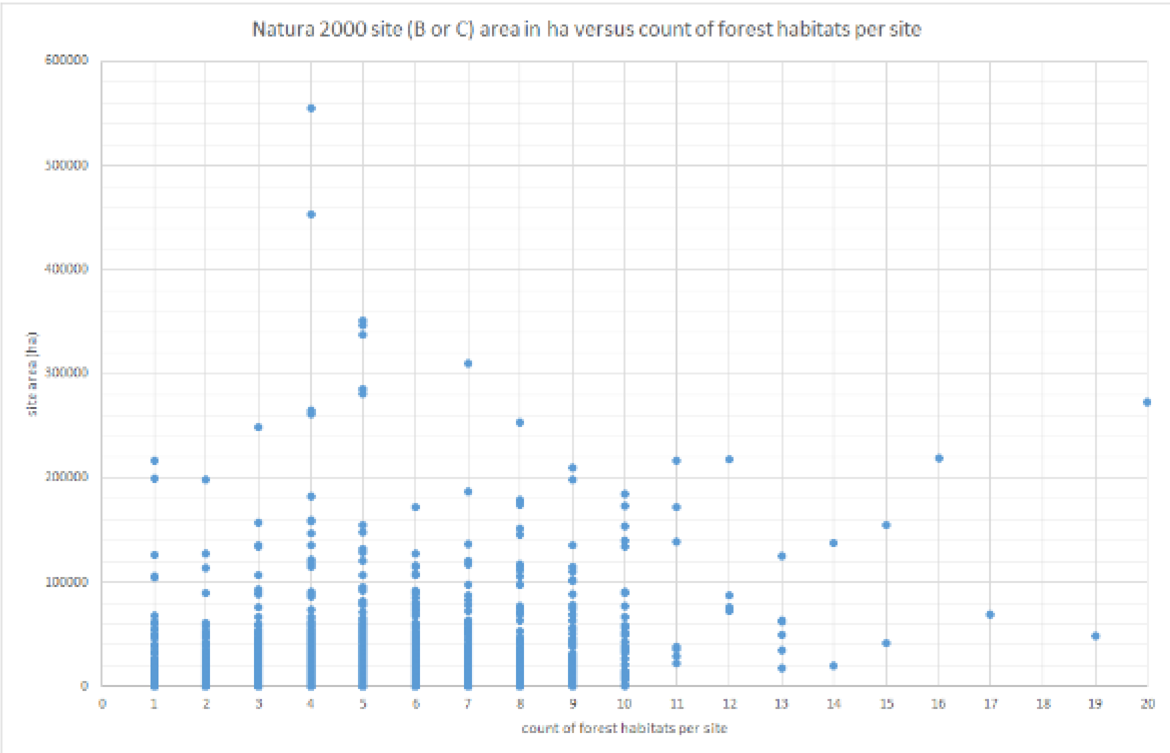


Figure 13: **Natura 2000 sites (B or C) area with Annex I forest habitats type counts versus site area in (ha)**

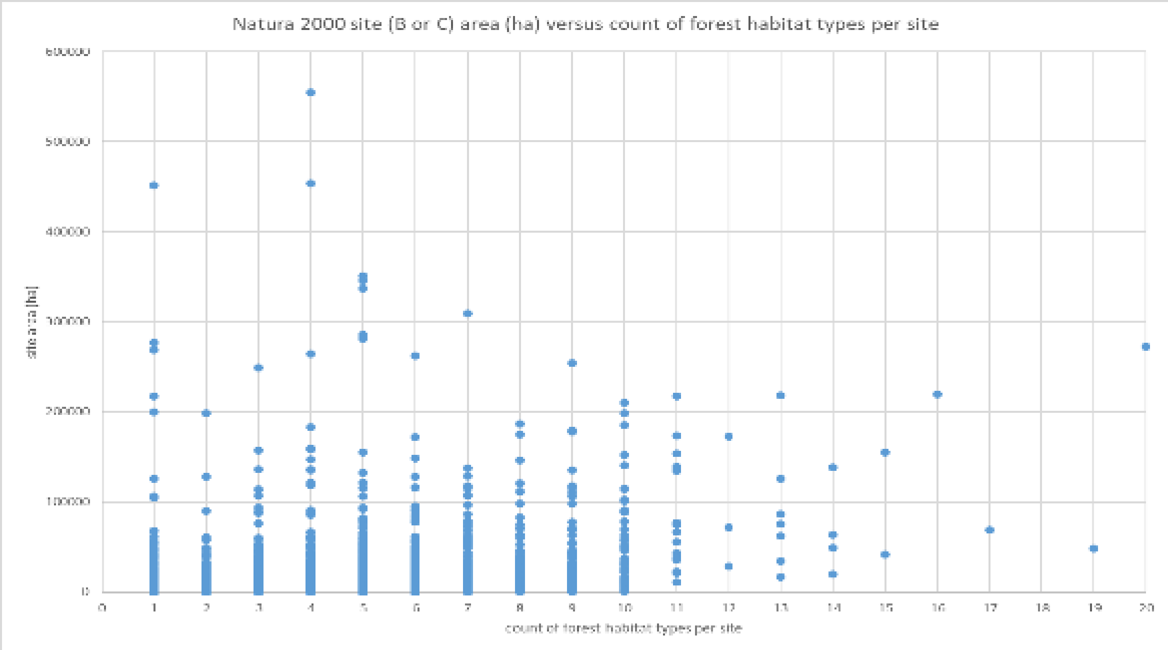


Figure 14: Natura 2000 sites (B or C) with forest habitat types of Annex I and Halada et al. (2020) counts versus site area (ha)

2.3.3 *Area and coverage of Forest habitat types within N2000 sites*

- **Area of forest habitat types within N2000 reported sites**

Member States also have to report the estimate coverage (in ha) of each Annex I habitat types listed in the N2000 site's SDF. In the implementation period (1995 to ~2007) of the Habitat Directive, the forest habitat types area within the Natura 2000 network was characterized by a strong increase. In the following years, the area growth stagnated (Figure 15).

- **Forest habitat types coverage within N2000 sites by Member States**

In Belgium, Finland and Luxembourg, more than 90% of the Natura 2000 sites cover forest habitat types, whereas in Croatia and Ireland only about 15% of the B and C protected sites are listing forest habitat types in their SDFs. The average over all Member States is about 65% of Natura 2000 sites (B or C) listing forest habitats in their SDFs (Figure 16).

Including also the forest like habitat types (Halada et al. 2020), there are small shifts between the two classes, though the overall picture within the Member States does not change (Figure 17).

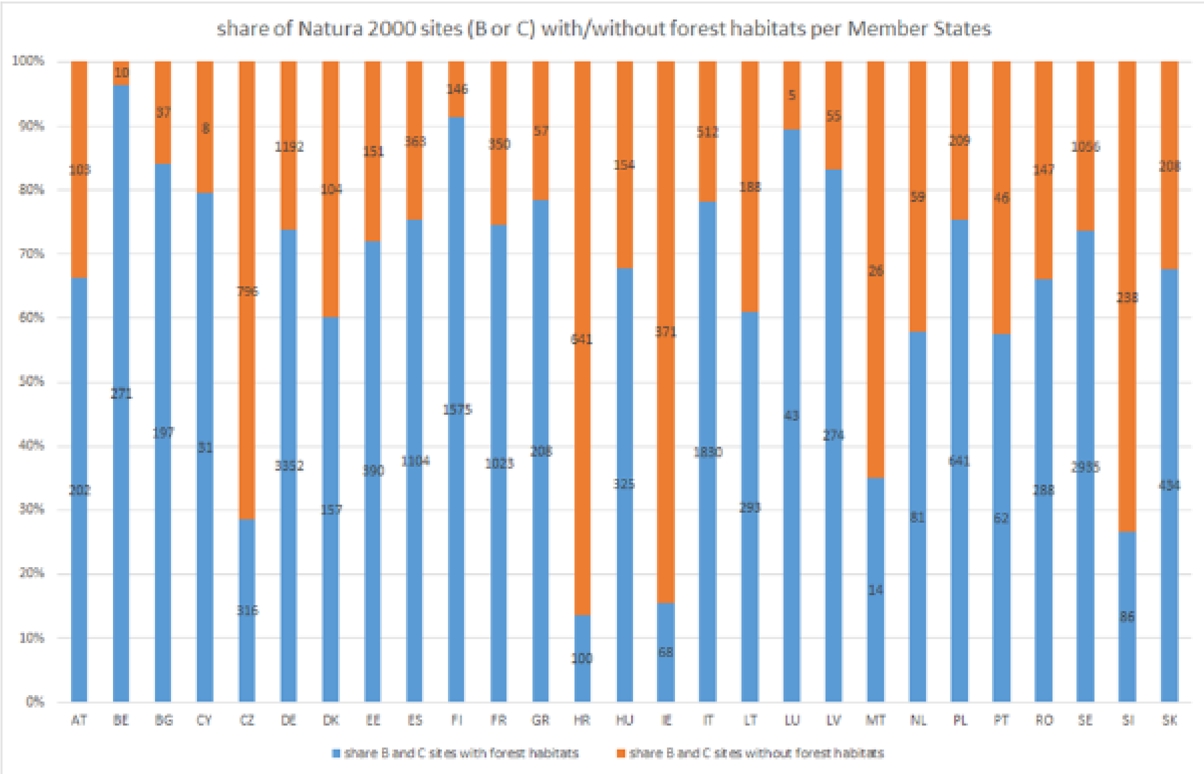


Figure 16: **Share of Natura 2000 sites (B or C) with/without Annex I forest habitats habitat types per Member States**

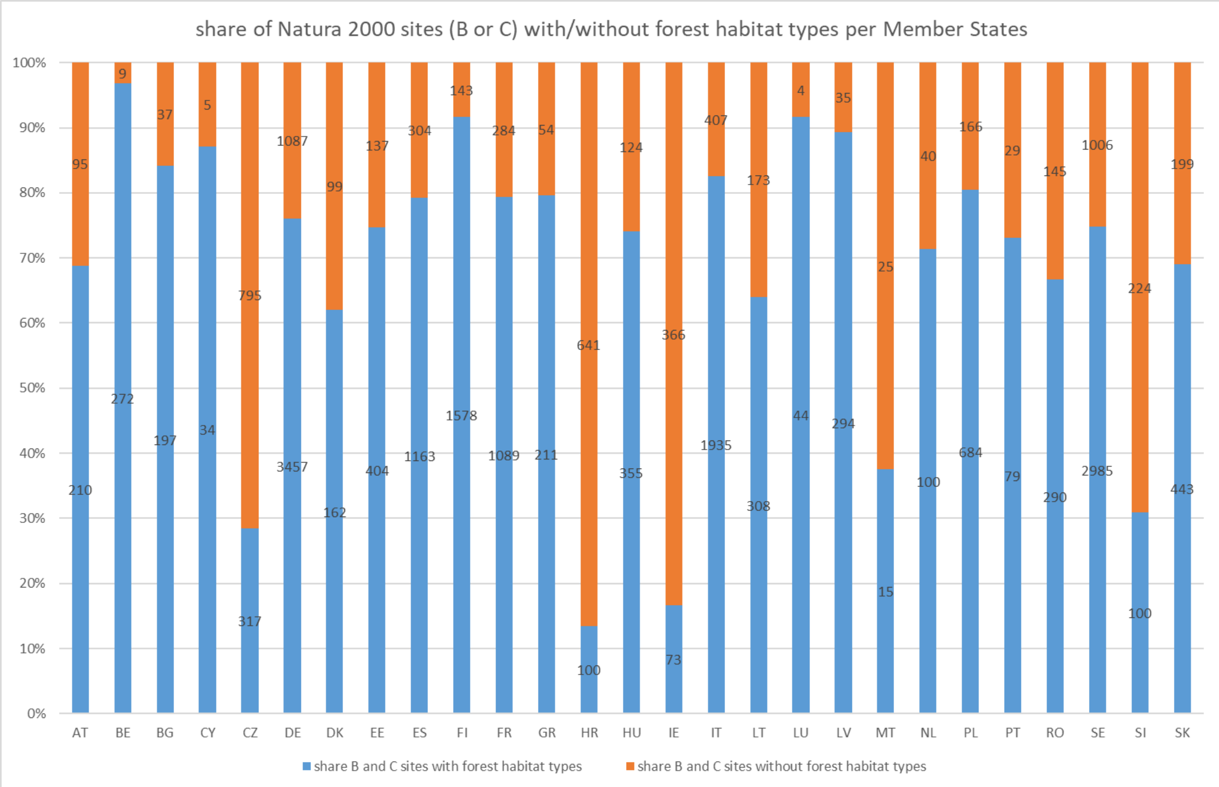


Figure 17: Share of Natura 2000 sites (B or C) with/without forest habitat types in Annex I and proposed by Halada et al. (2020)

- **Number of forest habitat types per N2000 site**

In about 58% of the Natura 2000 sites (B or C) with forest habitat types listed in their SDFs, one or two habitat types are often mentioned; but three or four different forest habitats can be found in about 28% of them. The proportion of higher forest habitat counts per site (=>5) is low (~13%) (Figure 18).

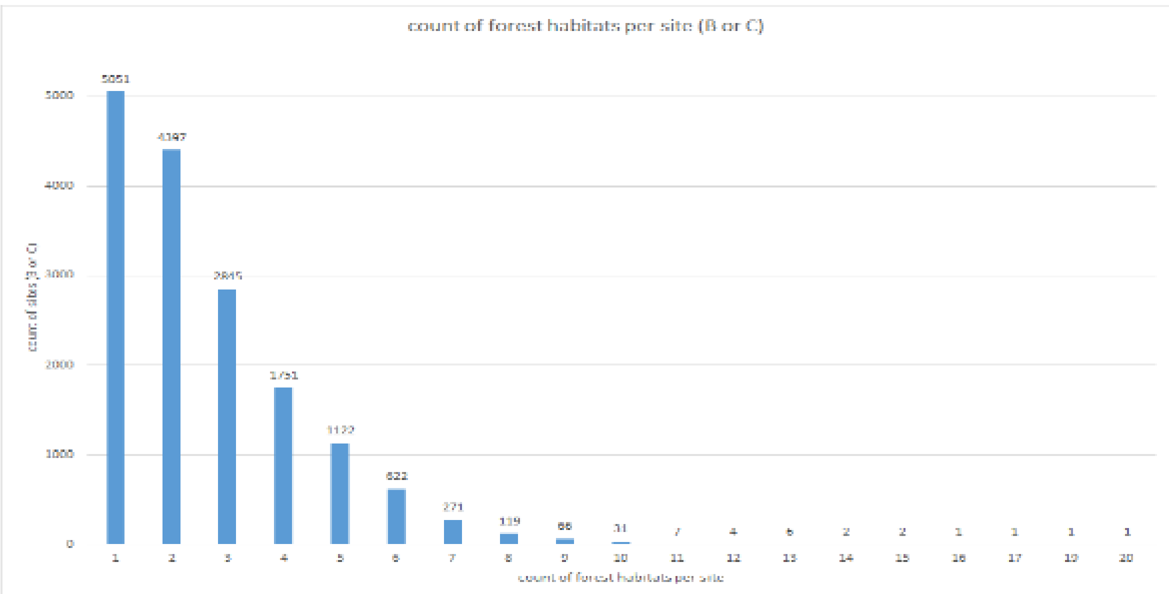


Figure 18: Histogram of Annex I forest habitats habitat types counts per site (B or C)

Considering forest habitat types in the broader sense (Annex I forest group and Halada et al. 2020), the distribution with mainly 1 or 2 forest habitat types listed in Natura 2000 sites is still effective (Figure 19).

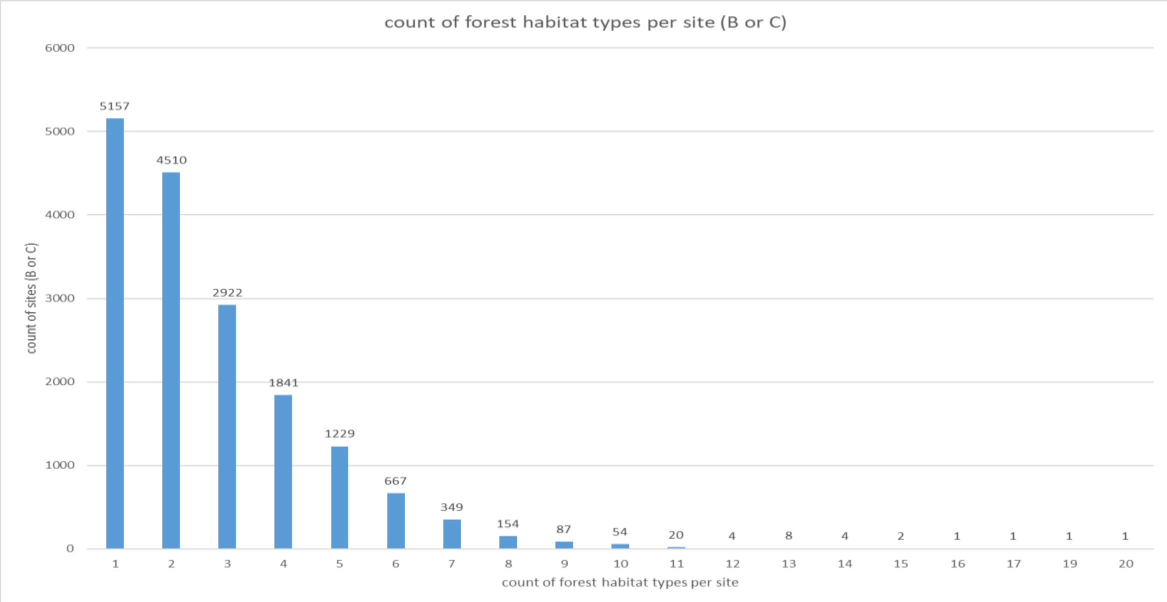


Figure 19: **Histogram of forest habitat types in Annex I and proposed by Halada et al. (2020)**

- **Forest habitat types representativity within the N2000 network**

56 Natura 2000 sites (B or C) in 10 Member States list the equivalent or more than 10 Annex I forest habitat types, with representativity A, B, or C: Bulgaria (19), Spain (16), Romania (9), Austria (3), France (2), Greece (2), Poland (2), Germany (1), Italy (1), Slovakia (1) (Figure 20).

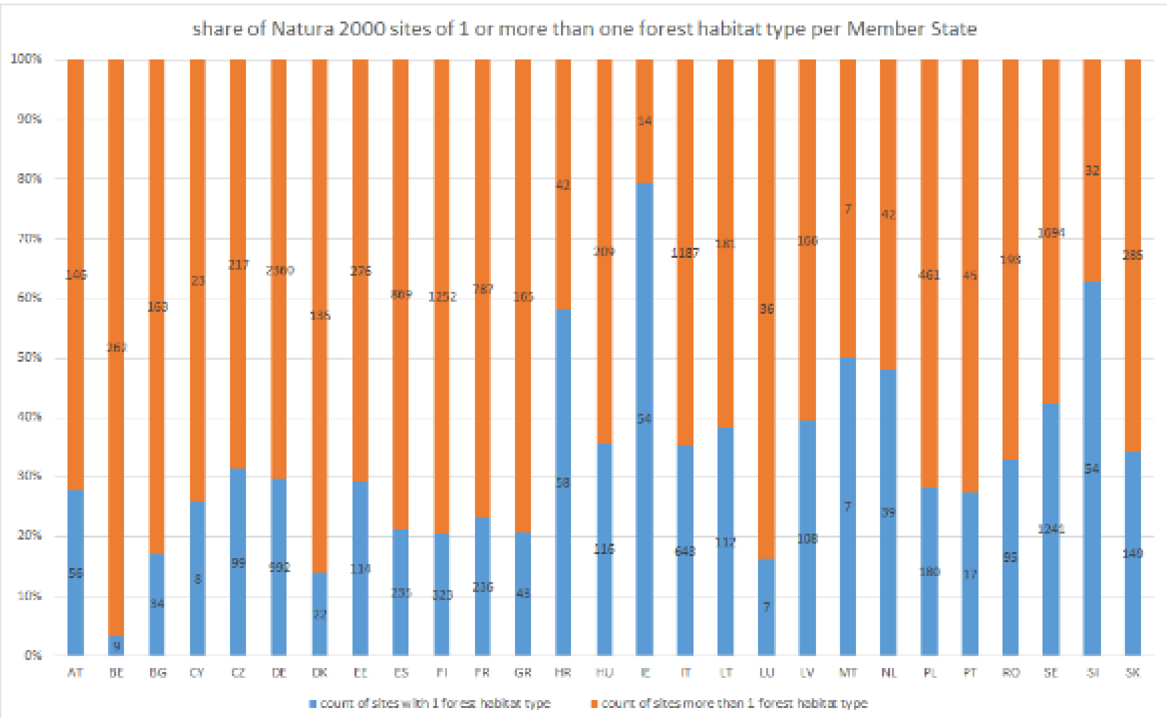


Figure 20: **Share of Natura 2000 sites (B or C) with one or more Annex I forest habitats types**

Including also the additional forest like habitat types proposed by Halada et al. (2020), the figure increases up to 84 sites in 14 Member States (Spain 29; Bulgaria 19; Romania 12; Austria 5; France 4; Greece and Italy 3; Estonia and Poland 2; Germany, Finland, Portugal, Sweden and Slovakia each 2) (Figure 21).

The highest share of Natura 2000 sites with only one Annex I forest habitat type with representativity

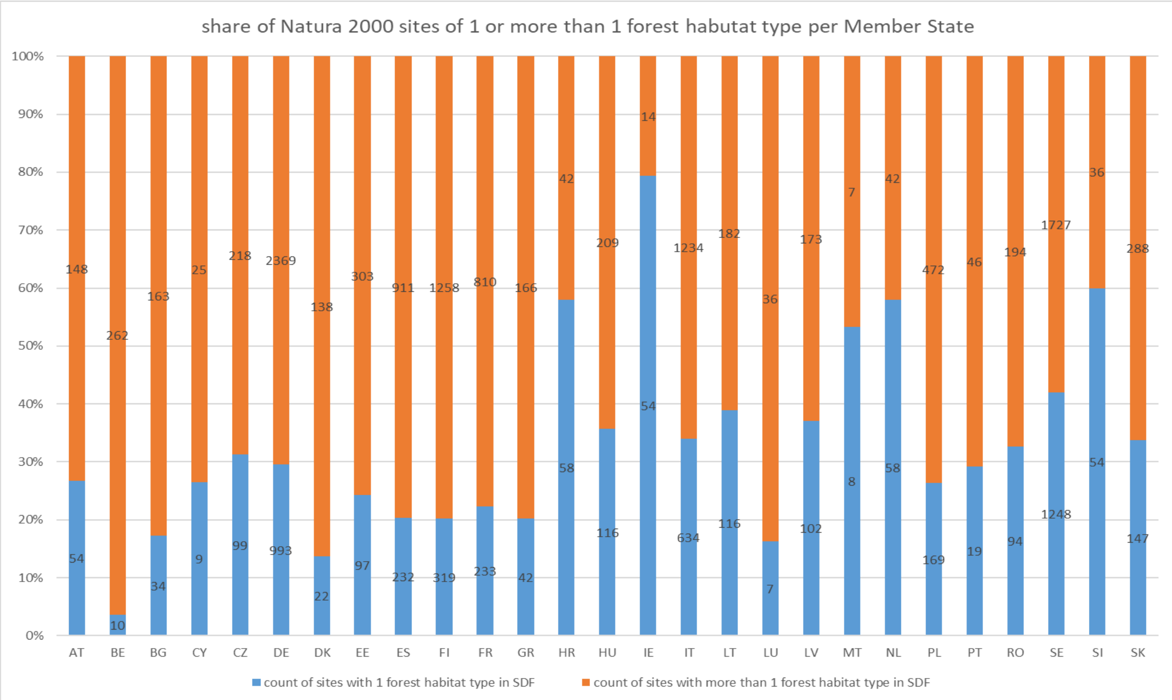


Figure 21: Share of Natura 2000 sites (B or C) with one or more forest habitats types of Annex I and Halada et al. 2020 per site

A, B or C per site is given by the Member States Ireland (~79 %), followed by Slovenia (~63 %) and Croatia (~58 %), whereas Belgium indicates the lowest share (~3%). Considering the additional forest habitat types proposed by Halada et al. (2020), there are small shifts between the two classes, the general view within the Member States remains similar to the one only with Annex I habitats.

The Top Ten ranked Annex I forest habitat types as listed in SDFs are in decreasing order: 91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae), 91D0 Bog woodland, 9010 Western Taïga, 9130 Asperulo-Fagetum beech forests, 9110 Luzulo-Fagetum beech forests, 9180 Tilio-Acerion forests of slopes, screes and ravines, 9160 Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli, 9050 Fennoscandian herb-rich forests with *Picea abies*, 9080 Fennoscandian deciduous swamp woods, 9340 *Quercus ilex* and *Quercus rotundifolia forests*.

The most frequently listed forest habitat in Natura 2000 sites (B or C) is alluvial forest 91E0 (~24,7% of all B and C sites) (Figure 22).

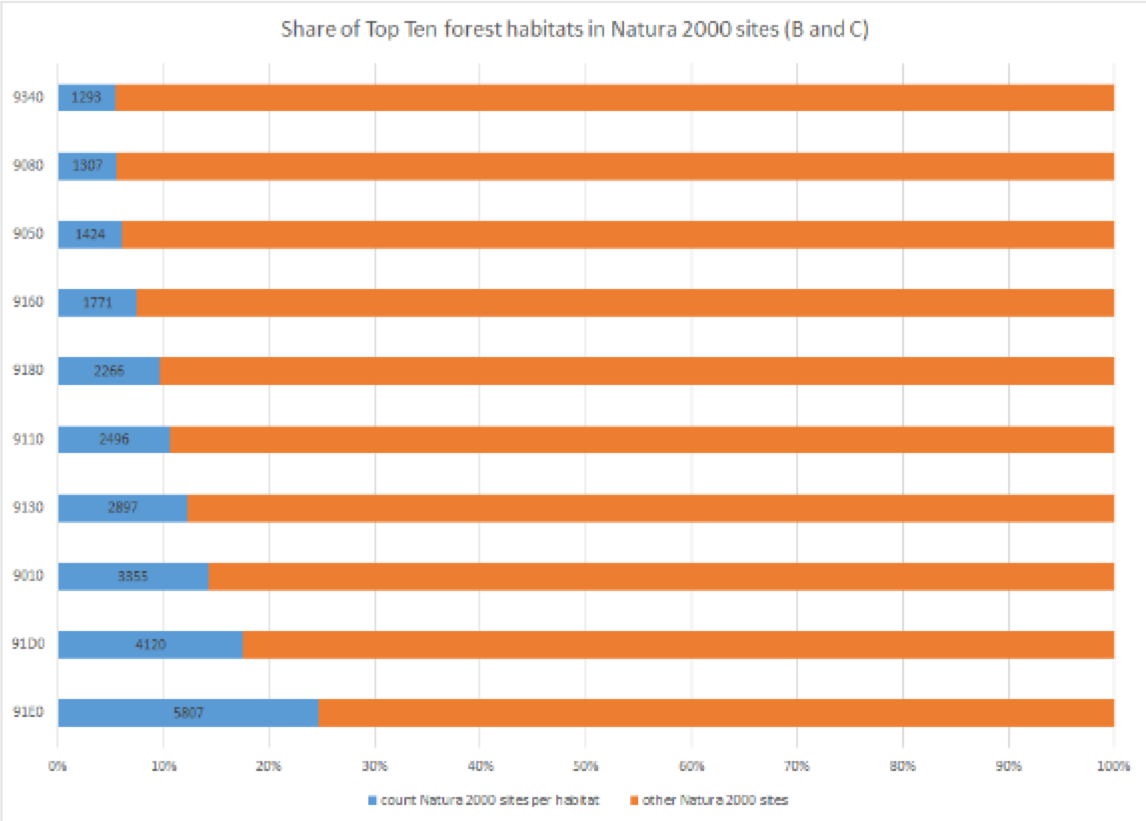


Figure 22: **Share of top ten forest habitats listed in Natura 2000 Standard Data Forms (total count Natura 2000 sites: 23.532)**

There is no change in this ranking when the additional forest like habitat types (Halada et al. 2020) are considered in the calculations.

The endmost Top Ten Annex I forest habitat types listed in SDFs are in decreasing order of Natura 2000 site counts: 91S0 Western Pontic beech forests (12), 93A0 Woodlands with *Quercus infectoria* (Anagyro foetidae-Quercetum infectoriae) (10), 9390 Scrub and low forest vegetation with *Quercus alnifolia* (6), 92B0 Riparian formations on intermittent Mediterranean water courses with *Rhododendron ponticum*, *Salix* and others (6), 9310 Aegean *Quercus brachyphylla* woods (6), 91J0 *Taxus baccata* woods of the British Isles (5), 9520 *Abies pinsapo* forests (5), 9570 *Tetraclinis articulata* forests (4), 91X0 Dobrogean beech forests (2), 9590 *Cedrus brevifolia* forests (Cedrosetum brevifoliae) (1).

Forests of *Cedrus brevifolia*, endemic to the western summits of the Troodos range (9590) is mentioned only in one Natura 2000 site. Most of these habitat types exhibit a very local to regional distribution range or are endemic to certain mountain ranges.

There are 42.812 forest habitat entries (9***) with representativity A, B or C in all Standard Data Forms (SDF) across the EU 27 Member States. All Annex I habitats occurring in the specific site must be noted, with their coverage in hectare. About 0.2% of all forest habitat type entries in SDFs (102) have no cover figures in ha (NULL); the most cases are in SDFs of Austria (69) and Spain (28), followed by the Netherlands (3), France (1) and Greece (1) (Figure 23).

Checking the SDFs for "0 ha" entries for forest habitats, there are 870 cases with "0 ha" (~2%) in 8 Member States (Estonia - 33, France - 46, Germany - 1, Luxembourg - 8, Poland - 5, Portugal - 177, Romania - 583).

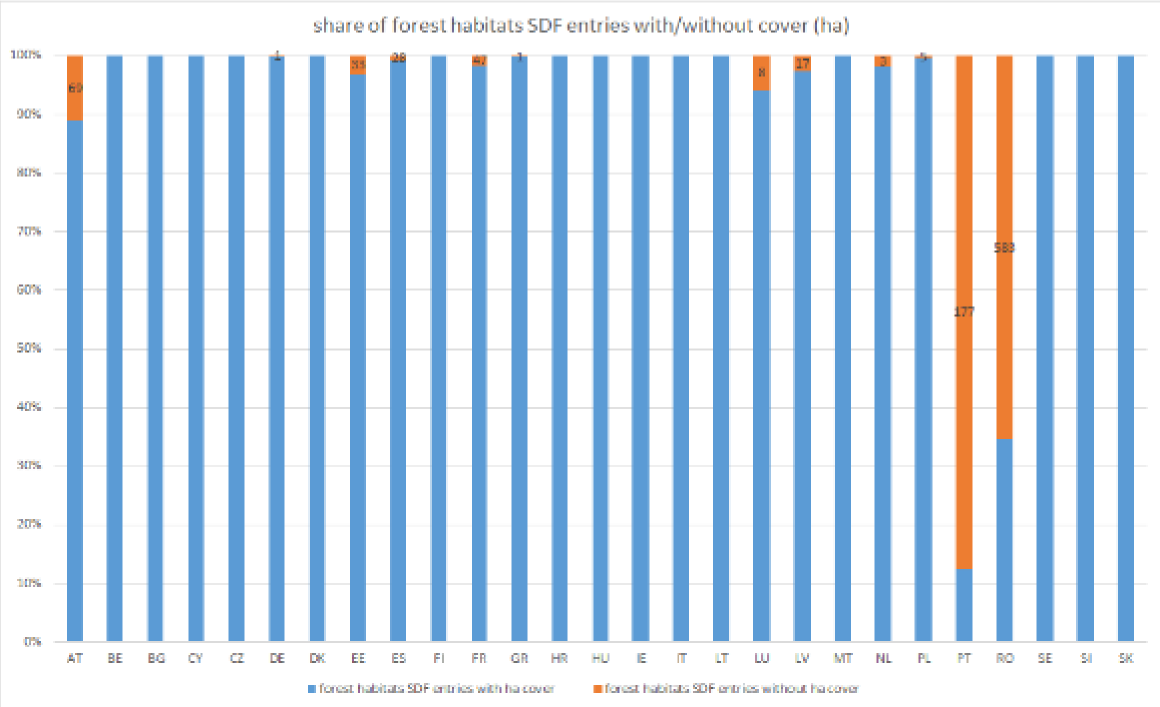


Figure 23: **Share of Annex I forest habitats habitat types SDF entries with/without cover (ha) per EU Member State**

Integrating also the forest habitat types proposed by Halada et al. (2020), there are small shifts between the two classes (with/without surface area information in SDF) in some Member States, though the general view of this compilation is the same (Figure 24).

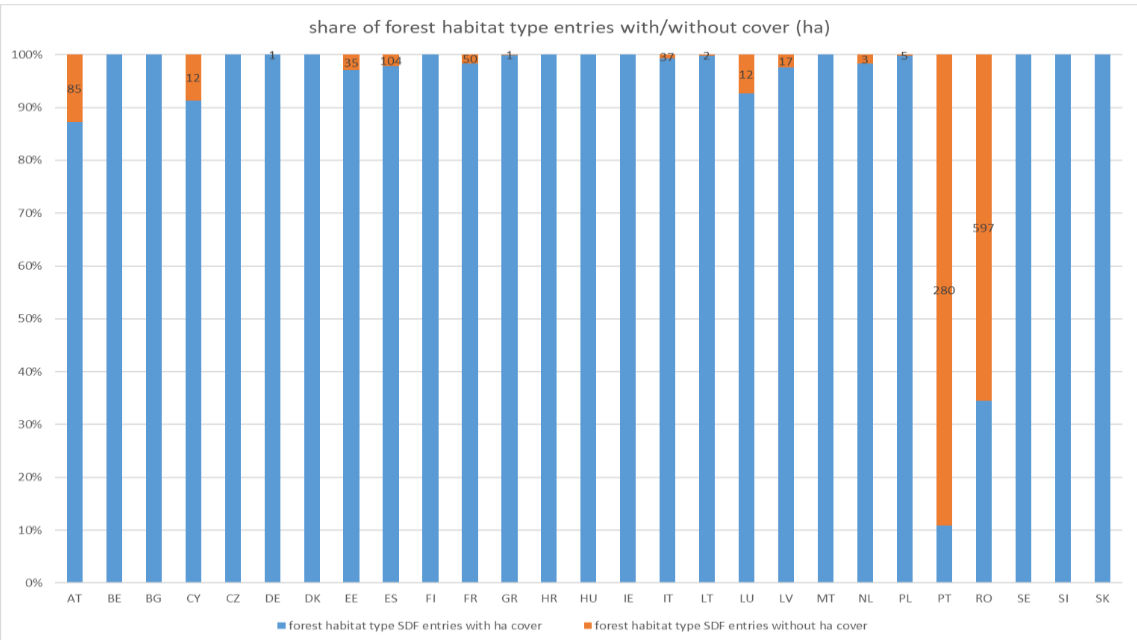


Figure 24: **Share of forest habitat types SDF entries (Annex I and Halada et al. 2020) with/without cover (ha) per EU Member State**

In summary, in 15 Member States, all SDF forest habitat entries (9***) have cover data and can be compared and double checked with the related information given in the Article 17 reports by Member States.

Portugal (~87,6 %) and Romania (~65,4 %) have a very high share of unknown cover of forest habitat types (9***) with representativity A, B or C listed in SDFs. Whereas Austria has about a 11% proportion of unknown cover per SDF forest habitat type cover data, Luxemburg (5,8%), Estonia (3,1%), Latvia (2,6 %), Netherlands (1,8 %), France (1,6 %), Spain (0,8), Poland (0,3 %), Greece (0,1%) indicate only a small share of unknown forest cover data in the SDFs.

2.3.4 *Global forest Annex I habitat types coverage within the N2000 network*

Considering the bias of missing forest habitat cover area mentioned above, the total Annex I forest habitat type cover for protected sites of type B or C registered in the Natura 2000 database by the end of 2019 is 14.680.585 ha (146.805 km^2). This area increases up to 17.693.898 ha (176.939 km^2) while considering Annex I and the newly proposed like forest habitat types by Halada.

The Top Ten ranked Annex I forest habitat types regarding habitat cover (ha) registered within the Natura 2000 database include forest of boreal, temperate, mediterranean sclerophyllous, temperate mountain coniferous and mediterranean and macaronesian mountains coniferous forests according the Interpretation Manual (Table 8). Including also the new forest like habitat types proposed by Halada, the habitat type 6310 Dehesas with evergreen *Quercus* spp. with a coverage of 1.018.794 ha, should be included in the Top Ten group regarding habitat cover within the Natura 2000 network.

Table 8: Top Ten ranked Annex I forest habitats habitat types regarding habitat cover (ha) registered in the Natura 2000 database End 2019 for B and C sites

Habitat code	Description	Total cover ha	%
9010	Western Taïga	2.219.049	15,1
9130	Asperulo-Fagetum beech forests	1.439.928	9,8
9040	Nordic subalpine/subarctic forests with *Betula pubescens ssp. czerepanovii*	1.203.890	8,2
9340	*Quercus ilex* and *Quercus rotundifolia* forests	1.080.157	7,4
91M0	Pannonian-Balkanic turkey oak –sessile oak forests	778.782	5,3
9110	Luzulo-Fagetum beech forests	628.225	4,3
9540	Mediterranean pine forests with endemic Mesogean pines	549.679	3,7
9410	Acidophilous *Picea* forests of the montane to alpine levels (Vaccinio-Piceetea)	508.904	3,5
91D0	Bog woodland	462.668	3,2

91K0	Illyrian *Fagus sylvatica* forests (Aremonio-Fagion)	461.235	3,1

Looking at the endmost Top Ten group, these habitat types are endemic or restricted to a local or regional level within the EU territory (Table 9).

Table 9: Endmost Top Ten ranked forest habitats types regarding habitat cover (ha) registered in the Natura 2000 database End 2019 for B and C sites

Habitat code	Description	Total cover ha	Percent
91Q0	Western Carpathian calcicolous *Pinus sylvestris* forests	2277	0,0
9520	*Abies pinsapo* forests	1325	0,0
9370	Palm groves of *Phoenix*	1006	0,0
91J0	*Taxus baccata* woods of the British Isles	877	0,0
91U0	Sarmatic steppe pine forest	364	0,0
9310	Aegean *Quercus brachyphylla* woods	347	0,0
9590	*Cedrus brevifolia* forests (Cedrosetum brevifoliae)	288	0,0
93A0	Woodlands with *Quercus infectoria* (Anagyro foetidae-Quercetum infectoriae)	205	0,0
9570	*Tetraclinis articulata* forests	67	0,0
91X0	Dobrogean beech forests	3	0,0

The EEA has also recently calculated the share of Annex I forests habitat types included in the N2000 network, according to the selection of habitat types for the Nature Restoration Law. From the estimated 357 952 km² of those 69 forest habitat types, excluding Romania, a least 38 % is part of the Natura 2000 network and included in SCIs and SACs (about 135 596 km²). However, this may be an underestimation, since reports from Member States were not comprehensive on this regard.

The coverage of Annex I forest habitat types by the Natura 2000 network varies according to the sub-groups: from 52 % for “boreal forests” to 31 % for “mountainous forests”. The proportion of habitat types per sub-group and their coverage is detailed in Table 10. Coverage by Natura 2000 also greatly varies according to Member States: from near 85 % in Estonia to about 9 % in France. However, several Member States reported that over 75 % of Annex I forest habitats area were inside Natura 2000 (Croatia, Estonia, Malta and Poland).

Table 10: Area and proportion of HD Annex I forest habitat types (selection for the Nature Restoration Law excluding alluvial forests and wooded meadows) per sub-group, within the Natura 2000 network (EEA "Background information for potential restoration targets – FORESTS")

EU27 excluding Romania	Habitat type area (km^2)	Forest area within N2000 (km^2)	% of Annex I habitat types within N2000
Boreal forests	**68 286**	**35 184**	**52**
9010	36 315	22 199	61
9020	440	196	45
9030	350	139	40
9040	19 600	11 622	59
9050	4 464	560	13
9060	7 116	468	7
Temperate forests	**172 384**	**59 752**	**35**
9110	21 009	6 113	29
9120	15 384	2 530	16
9130	56 043	13 692	24
9140	612	161	26
9150	5 845	2 613	45
9170	8 347	4 320	52
9180	2 472	1 095	44
9190	1 785	879	49
91A0	61	40	65
91AA	6 007	1 193	20
91B0	333	191	57
91BA	245	188	77
91CA	2 440	1 432	59
91G0	3 239	1 760	54
91H0	938	550	59
91I0	1 515	1 200	79

91J0	1	1	100
91K0	16 338	11 475	70
91L0	3 427	1 251	37
91M0	22 986	7 185	31
91P0	185	157	85
91Q0	20	13	63
91R0	85	48	57
91S0	268	222	83
91T0	277	99	36
91U0	9	4	49
91W0	2 124	1 143	54
91Z0	389	197	51
Mediterranean & Macaronesian forests	**66 335**	**24 911**	**38**
9210	3 271	1 916	59
9220	347	280	81
9230	13 154	3 170	24
9240	3 445	1 544	45
9250	457	452	99
9260	8 528	2 034	24
9270	570	570	100
9280	996	221	22
9290	438	175	40
9310	3	3	100
9320	1 966	1 228	62
9330	4 284	2 143	50
9340	27 784	10 545	38
9350	297	79	27
9360	603	398	66

9380	123	121	99
9390	61	31	50
93A0	6	2	34
Mountainous forests	**50 947**	**15 748**	**31**
9410	12 376	3 828	31
9420	4 007	981	24
9430	1 516	901	59
9510	83	75	91
9520	13	13	100
9530	7 896	1 918	24
9540	21 677	5 506	25
9550	737	626	85
9560	2 153	1 571	73
9570	1	1	83
9580	16	17	110
9590	3	3	90
95A0	470	309	31
TOTAL	**357 952**	**135 596**	**38**

2.4 European forests within Nationally designed protected areas

The European inventory of nationally designated protected areas (CDDA) holds information about designated areas and their designation types, which directly or indirectly create protected areas[51].

Natura 2000 protected areas are not included in the CDDA inventory, though nationally designated protected areas and Natura 2000 sites may partial or total spatially overlap. For example, the nationally designated protected area *Naturschutzgebiet Tiroler Lech* share the same spatial borders with the Natura 2000 site *AT3309000 Tiroler Lech*. These spatially overlaps may have historical reasons, for example when already existing nationally designated protected areas have been included

[51] https://www.eea.europa.eu/data-and-maps/data/nationally-designated-areas-national-cdda-16

into the Natura 2000 network, as well as when legal reasons to implement national legal foundations in addition to the European framework of the Habitat Directive, for a stronger protection.

The IUCN management category of the protected sites included in the CDDA database further describes the extent of protection[52]. Following IUCN categories/entries are reported by the CDDA dataset (end 2020):

- Category Ia – Strict Nature Reserve
- Category Ib – Wilderness Area
- Category II – National Park
- Category III – Natural Monument or Feature
- Category IV – Habitat/Species Management Area
- Category V – Protected Landscape/Seascape
- Category VI – Protected Area with sustainable use of natural resources
- NotApplicable - The IUCN management categories are not applicable to a specific designation type
- NotAssigned - A protected area whereby the data provider has chosen not to use the IUCN management categories.
- NotReported - The IUCN management category has not been reported.

Category Ia is a strictly protected area set aside to protect biodiversity, and also possibly geological/geomorphological features, and where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values. Such protected areas can serve as indispensable reference areas for scientific research and monitoring. Category Ib is usually a large unmodified or slightly modified area, retaining its natural character and influence without permanent or significant human habitation, and which is protected and managed as to preserve its natural condition.

The Category II concern large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible spiritual, scientific, educational, recreational and visitor opportunities.

Category III protected areas are set aside to protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value. This category is really intended to protect the unusual rather than to provide logical components in a broad-scale approach to conservation, so that their role in landscape or ecoregional strategies may sometimes be opportunistic rather than planned. In other cases (e.g., cave systems), such sites may play a key ecological role identified within wider conservation plans.

Protected areas of category IV aim to protect particular species or habitats, and their management reflects this priority. Many category IV protected areas will need regular and active interventions to address the requirements of particular species or to maintain specific habitats, but this is not a

[52] https://www.iucn.org/theme/protected-areas/about/protected-area-categories

requirement of the category. Such protected areas frequently play a role in "plugging the gaps" in conservation strategies, by protecting key species or habitats in ecosystems.

Protected areas of category V are selected where the interaction of people and nature over time has produced an area of distinct character with significant ecological, biological, cultural and scenic value, and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values. Generally, category V protected areas play an important role in conservation at the landscape/seascape scale, particularly as part of a mosaic of management patterns, protected area designations and other conservation mechanisms. The main objective is to protect and sustain important landscapes/seascapes and the associated nature conservation and other values created by interactions with humans through traditional management practices.

Category VI protected areas conserve ecosystems and habitats, together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources compatible with nature conservation is seen as one of the main aims of the area.

In summary, the CDDA dataset of nationally designated protected areas (version 18 – 2020) covers information of Albania, Austria, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Kosovo, Latvia, Liechtenstein, Lithuania, Luxembourg, North Macedonia, Malta, Montenegro, the Netherlands, Norway, Poland, Portugal, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

With these IUCN categories assigned to all nationally designated protected areas by every European country, it is possible to draw a European wide overview about protection and management, although there is no concrete information about forests in this data. Still, some forest related analysis can be conducted.

- **Primary and primeval forests within protected areas**

Primary forests have high conservation value but are rare in Europe due to historic land use. A compilation of a comprehensive European-scale map of currently known primary forests was made in 2018[53], covering 261 mapped forests called "primeval forests". The authors found that those primeval forests mostly occur in mountain and boreal areas, and are unevenly distributed across countries, biogeographical regions and forest types. Unmapped primary forests likely occur in the least accessible and least populated areas, where forests cover a greater share of land but wood demand has historically been low.

Only 21 of the total area of those primeval forests are outside of the CDDA area, all located in Ukraine. Considering that the coordinates given by the European-scale map of currently known primary forests are the centroids of these forests, it appears that most of them are already at least partly inside nationally designated protected areas (Figure 25). In total, Italy, Poland and Romania cover each more than 20 primeval forests identified, while Denmark, Hungary or Montenegro have been mapped with only a few ones.

[53] https://doi.org/10.1111/ddi.12778

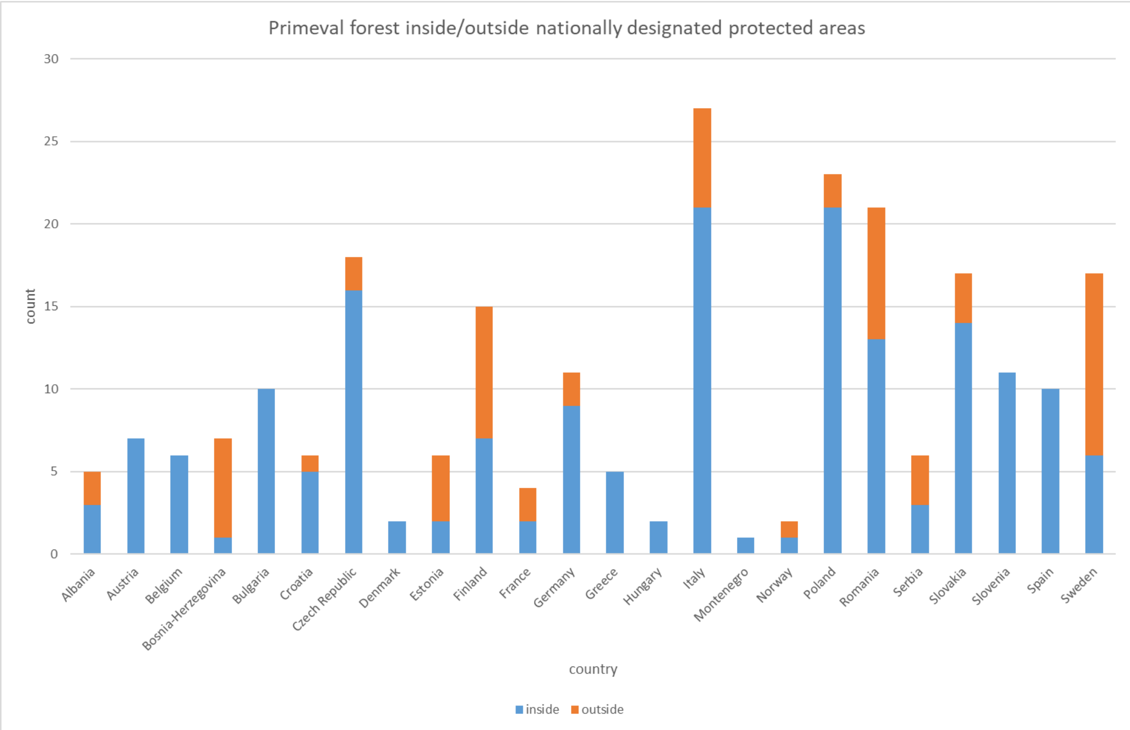


Figure 25: Primeval forest by Sabatini et al. (2018) inside and outside protected areas

About 48% of these nationally designated protected areas containing primeval forests are under high protection, regarding their attributed IUCN management categories: Ia *"Strict nature reserves"* (17,8%), Ib *"Wilderness areas"* (8,6%) and II *"National parks"* (21,3%), whereas only about 18% are under low protection, in category V *"Protected landscapes"* (16,1%) and VI *"Protected areas with sustainable use of natural resources"* (1,7%).

However, about 21% of those nationally designated protected areas have no reported IUCN management category (i.e. not applicable, not assigned, not reported) (Figure 26).

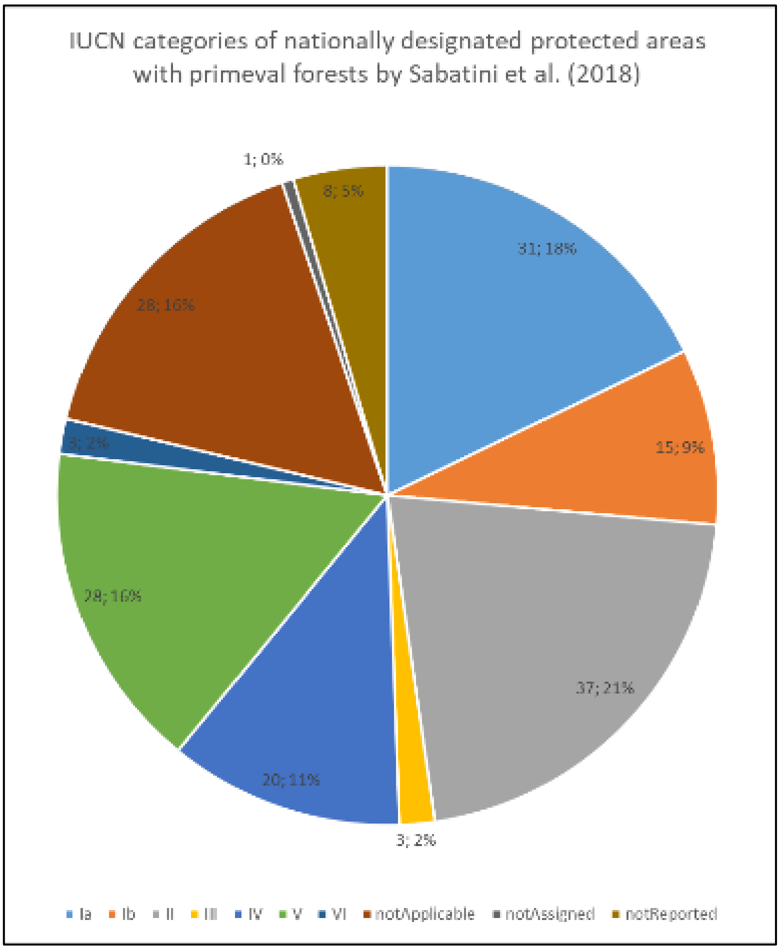


Figure 26: Share of IUCN categories in nationally designated protected areas with primeval forests

- **General overview of protected forests in Europe**

Apart from the focus on primeval forests in Europe, a more general analysis on nationally designated protected areas and forests in Europe covered by the CDDA data set can be outlined. However, about 27,7% of the protected areas listed in the CDDA do not have a IUCN management category attributed (not applicable, not assigned, not reported).

The highest share of nationally designated protected areas are assigned to the IUCN category IV *"Habitat/species management areas"* (~46,4%), while highly protected areas of categories Ia, Ib and II have a share of only ~8,7%. Also, about 13% of those protected sites are low protected areas, in categories V and VI (Figure 27).

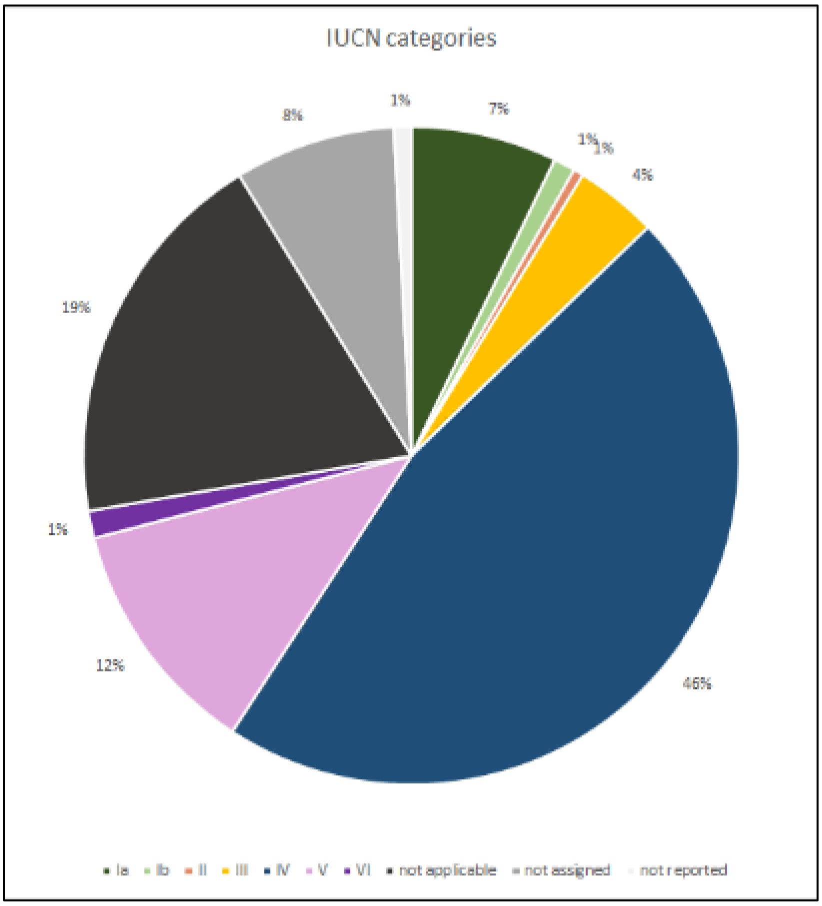


Figure 27: share of IUCN categories of protected sites listed in the CDDA dataset

The total number of nationally designated protected sites with an assigned IUCN category listed in the CDDA dataset is highly varying between the EEA Member-States (Figure 28).

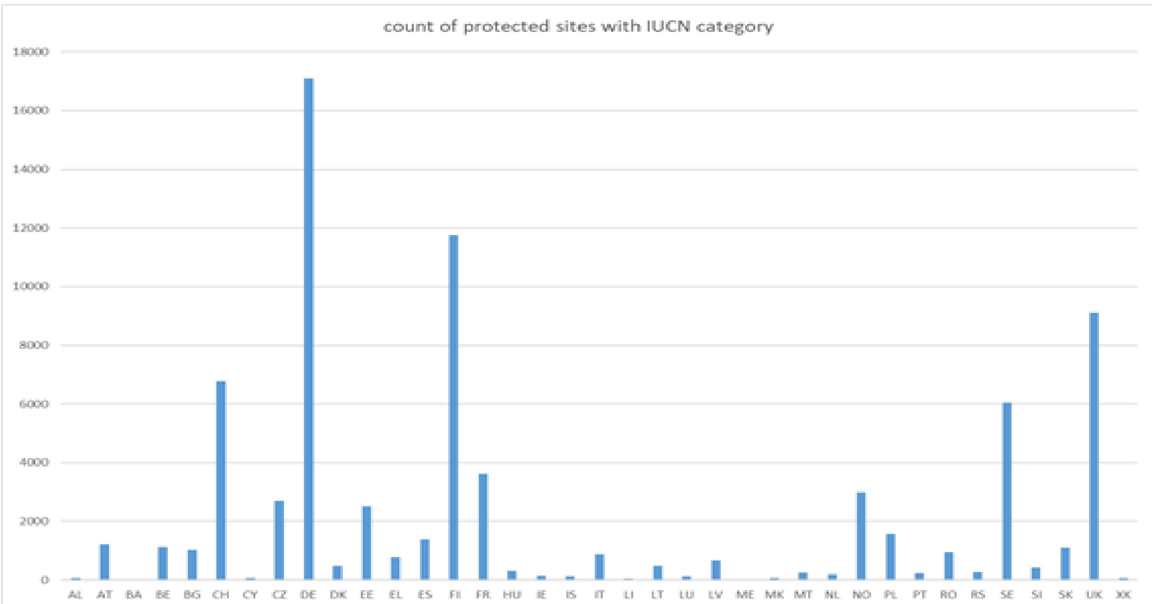


Figure 28: Total count of protected sites with assigned IUCN category per EEA state provided in the CDDA data set

Also, as protected areas with different IUCN categories may overlap, a dissolve of all site polygons in a geographic information system (GIS) is needed in order to get an overall net estimation of the covered area of all protected areas within the CDDA. Furthermore, information about the major ecosystem type (terrestrial, marine, marine and terrestrial) is available for every protected site. Selecting only terrestrial categorized sites, the calculation shows that the overall protected area in Europe is about 852 000 km^2, according to the CDDA. It means that about 16 % of all the European countries area is covered by the CDDA, categorized as a terrestrial protected area.

When crossing this dissolved protected area cover with the Copernicus forest high resolution layer, it appears that about 44,5% of European protected areas are covered by broadleaved (25,4%) and coniferous (19,1%) dominant leave type (DLT). Regarding the tree cover dominant leave type according to the IUCN management categories of those protected areas, some analyzes are outlined below. The Forest High Resolution Layer DLT and TCD products (data 2018) from the Copernicus Land Monitoring Service (CLMS) are used for the following analysis. Those layers provide information about leaf type (broadleaved/coniferous) and the proportional tree cover density at pixel level (TCD in %).

- **Tree cover density within EU protected areas**

The pixels of TCD and DLT can be counted per protected site polygon and IUCN category, when available. Such figures do not give the area of legally defined protected forest, but it can still provide some estimates about forest/woody vegetation within protected sites. By classifying the percentages of Copernicus HRL TCD forested pixel per site in 10 % classes (e.g. 0-10%, 10-20, etc), the variability within and between the IUCN management and protection categories can be analysed.

In a first step, it appears that the percentage of HRL forest pixel per IUCN protected sites categories Ia *"Strict Nature Reserve"* and Ib "*Wilderness Area"* show a very high proportion of sites within the forested pixel class 90-100% (Figure 29). Both categories concern strictly protected and unmodified or slightly modified areas, set aside to protect biodiversity areas. In opposite, the category II *"National Parks"*, large natural or near natural areas set aside to protect large-scale ecological processes, shows an emphasis on sites within the pixel class 0-10% (Figure 29). All other density classes seem to be evenly distributed.

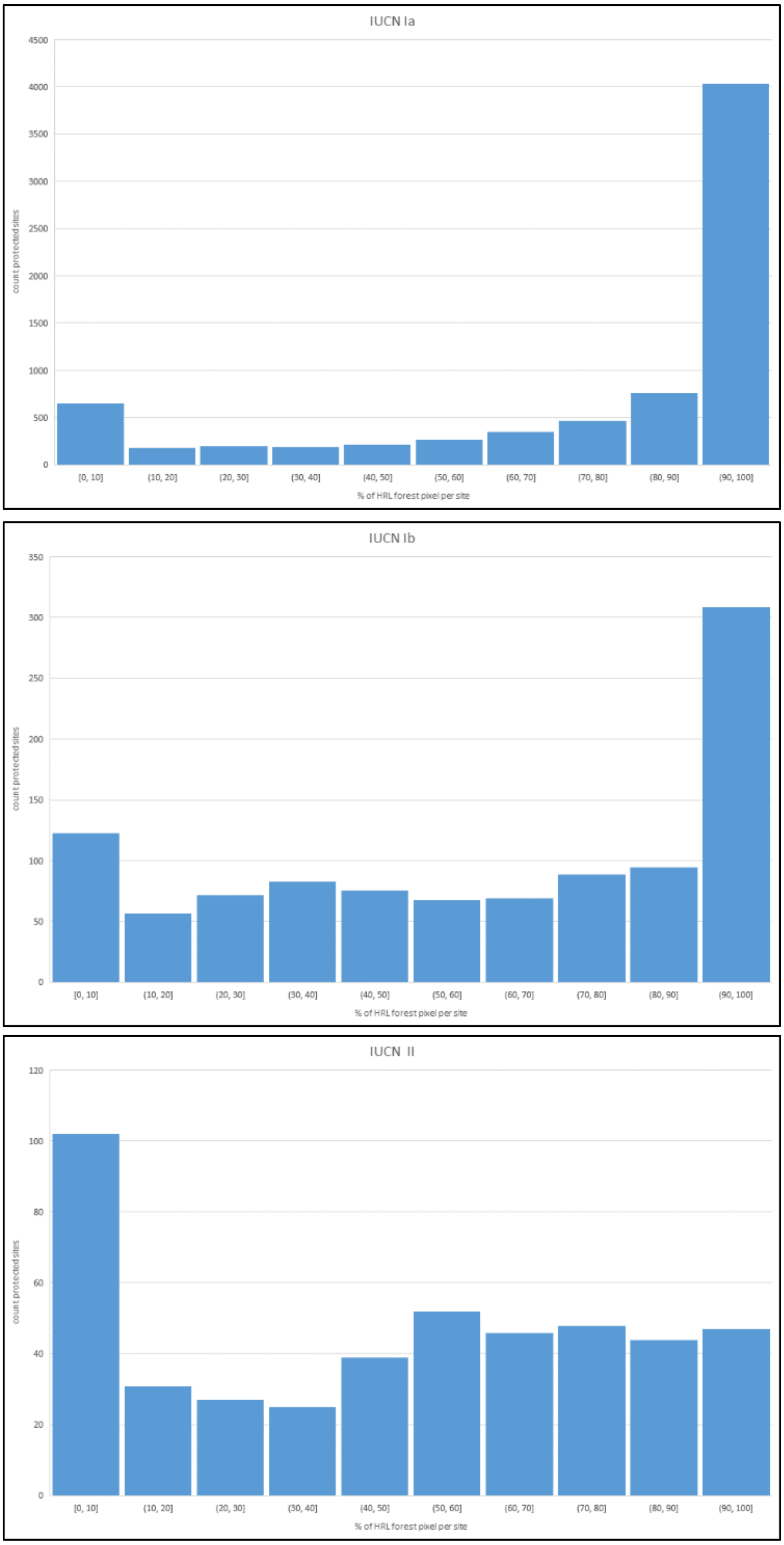


Figure 29: Copernicus HRL forested pixel per protected area, according to IUCN Management and protection categories Ia, Ib and II (CDDA)

Protected areas of category III *"Natural Monument or Feature"*, set aside to protect a specific natural monument, and category IV *"Habitat/Species Management Area"* show two high shares within the classes 0-10% and 90-100%. (Figure 30). It means that either these protected areas are largely forested, or very little. Protected areas of Category V "*Protected Landscape"*, where the interaction of people and nature over time has produced an area of distinct character with significant, ecological, biological, cultural and scenic value, exhibit a more or less evenly distribution in all forested pixel classes.

Finally, protected areas of category VI *"Protected areas with sustainable use of natural resources"*, that conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems, show a high share in sites within the pixel class 90-100%. The sustainable use of forest products might indeed be the main purpose of such protected areas.

In summary, it seems that the protected areas with the highest protection status (Ia and Ib) have a strong focus on woody and densely forested areas, as well as protected areas meant to conserve ecosystems and habitats together traditional natural resource management (Category VI). Protected areas designed for the protection of a natural monument or for the management of specific Habitat/Species (Category III and IV) seems to be either strongly forested, or conversely composed only of open landscapes, while protected landscapes (category V) include a large spectrum of forest tree cover, in reflexion with the diversity of European landscapes. European National parks (Category II) seems to be the type of protected area with the less high-density tree cover areas.

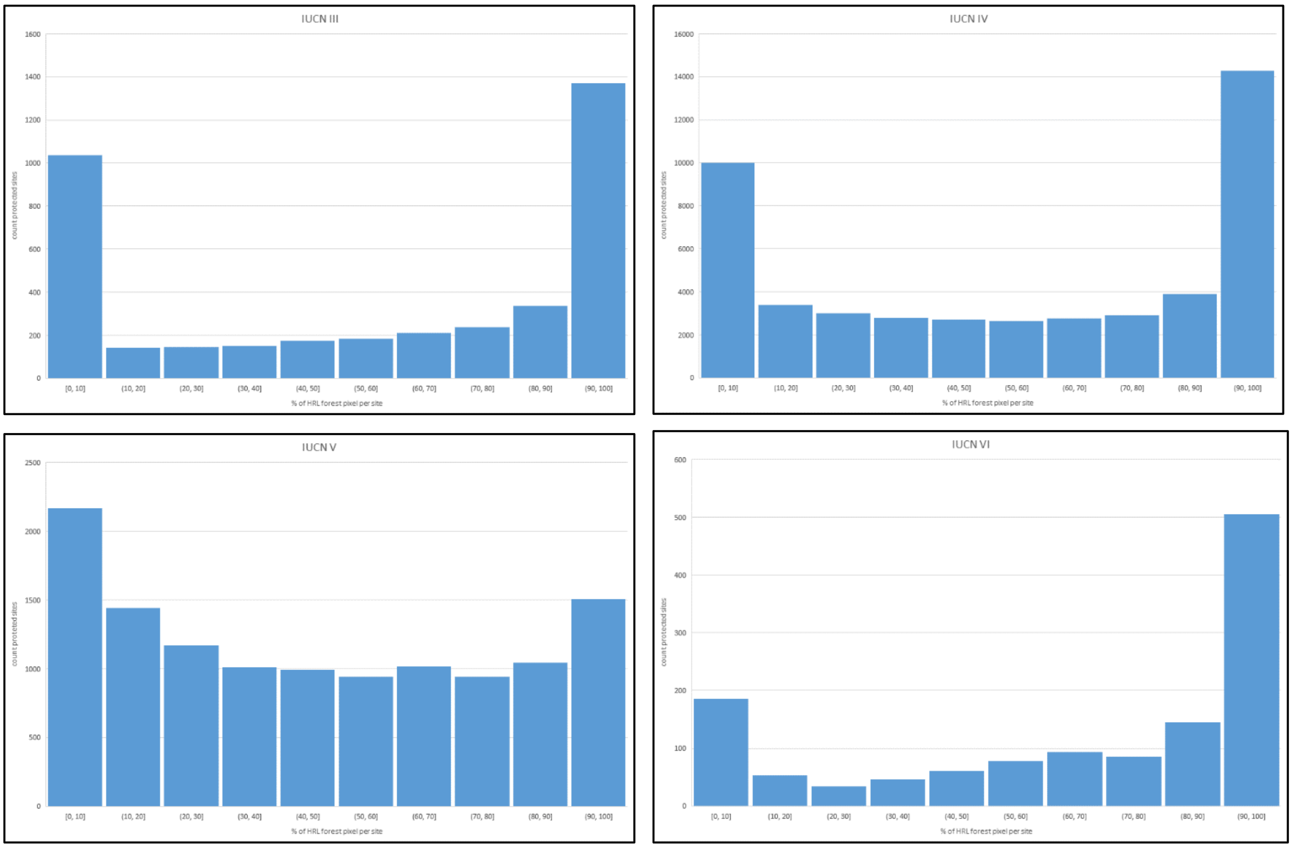


Figure 30: Copernicus HRL forested pixel per protected area, according to IUCN management and protection categories III, IV, V and VI – CDDA

- **Dominant leave type of EU protected forests**

The Copernicus high resolution forest data has also the information about the dominant leave type per pixel (broadleaved vs coniferous). Broadleaved forests are especially important habitats for saproxylic beetles listed in the Annex IV of the Habitat Directive, like *Rosalia alpina*, *Osmoderma eremita, Lucanus cervus* or *Cerambyx cerdo*.

The share of broadleaved pixels classes (e.g. 0-10 %, 10-20 %, etc.) per IUCN categorized site show

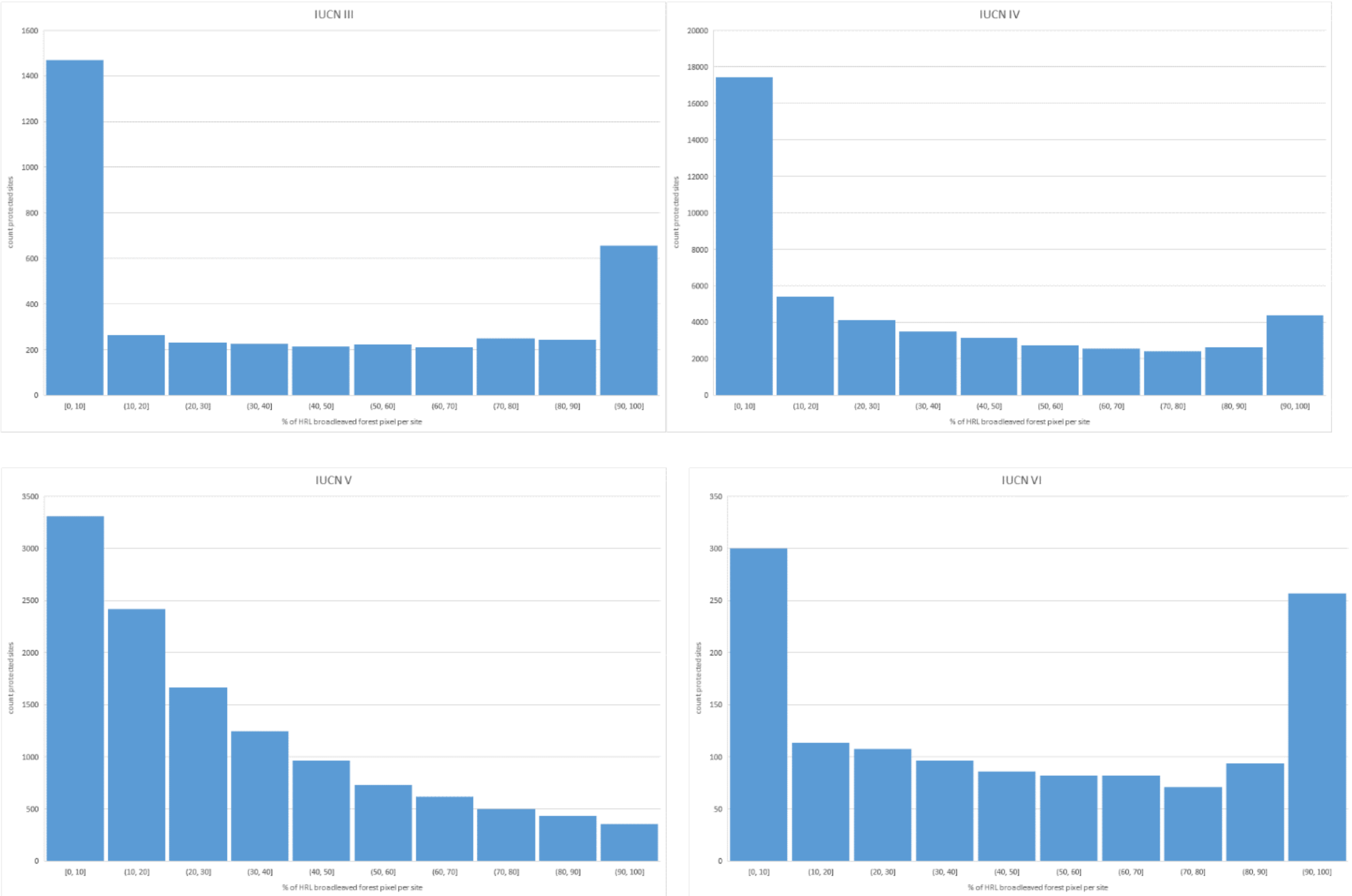


Figure 31: Share of broadleaved pixel class per IUCN protection category (III, IV, V and VI) according to the Copernicus HRL data (CDDA dataset)

that a majority of nationally designated protected areas have a lower proportion of dominant broadleaved pixel type (Figure 31). Conversely, the coniferous leave pixel type is dominant. Only the categories III *"Natural Monument or Feature"* and VI *"protected area with sustainable use of natural resources"* have a second peak within the 90-100% broadleaved pixel class per site.

In summary, very few highly protected sites (in category Ia, Ib and II) exhibit a high share of mainly broadleaved forests, according to the HRL data set (Figure 32).

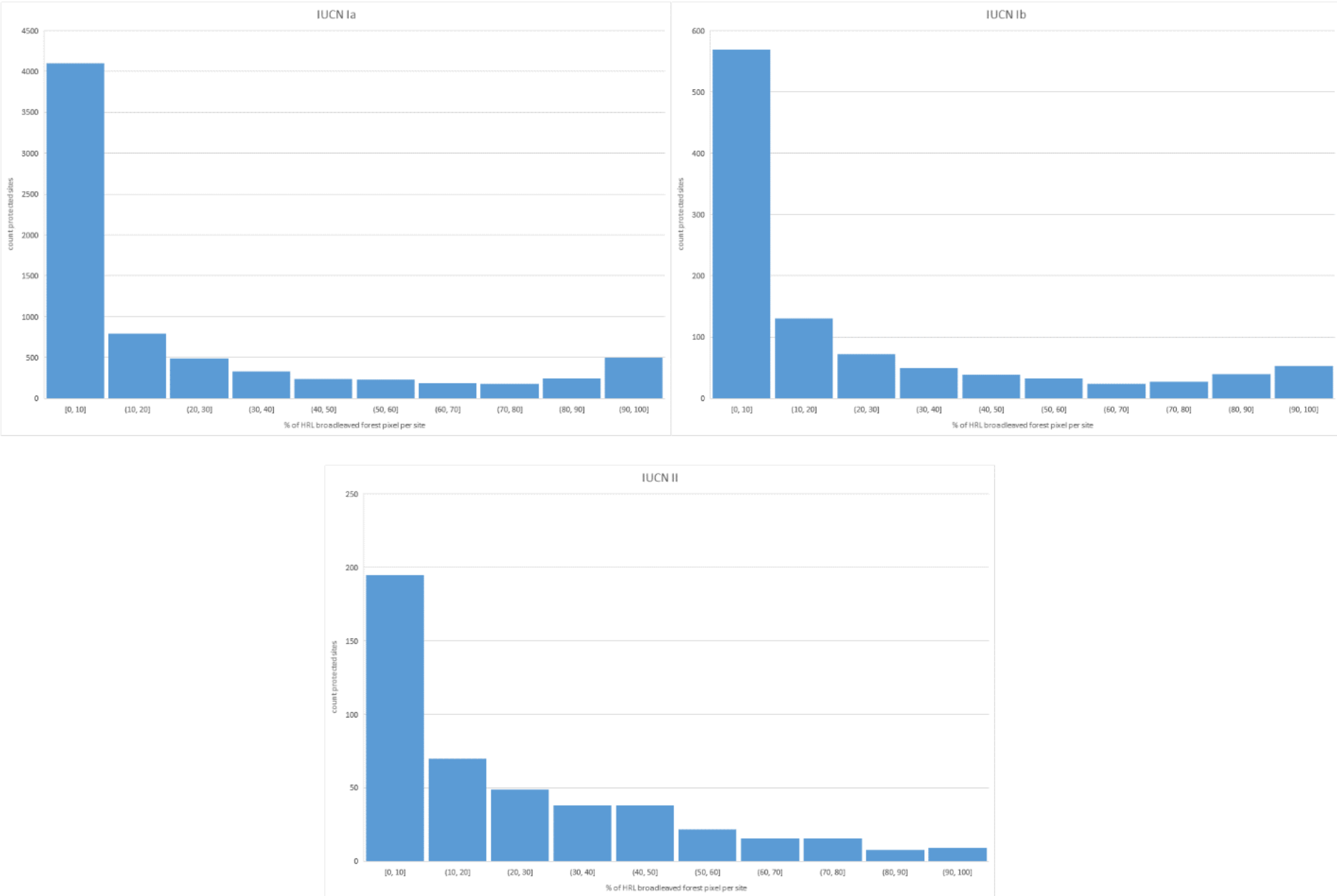


Figure 32: **Share of broadleaved pixel class per IUCN protection category (Ia, Ib and II) according to the Copernicus HRL data (CDDA dataset)**

- **Mean elevation of EU protected forests**

The Copernicus Land Monitoring Service (CLMS) also provides a European wide digital elevation model (DEM). Combining this elevation information with the percentage of HRL forest pixel per protected area gives an estimation of any altitudinal change, regarding the forested area within the nationally designated protected sites.

The analysis shows some slight trends within IUCN categories Ia *"Strict Nature Reserve"*, Ib *"Wilderness Area"* and IV *"Protected area with sustainable use of natural resources",* with a higher proportion of less forested protected areas in low altitudes, and a lower share of more forested protected areas in high altitudes Figure 33).

On the other hand, in category VI *"Protected area with sustainable use of natural resources"* and to a lower extend in category III *"Natural Monument or Feature",* there is a higher share of more forested protected areas in high altitudes than low forested sites in low altitudes (Figure 34).

Figure 33: Copernicus HRL forested pixel percentage and altitude per IUCN protected area categories Ia, Ib and IV (CDDA dataset)

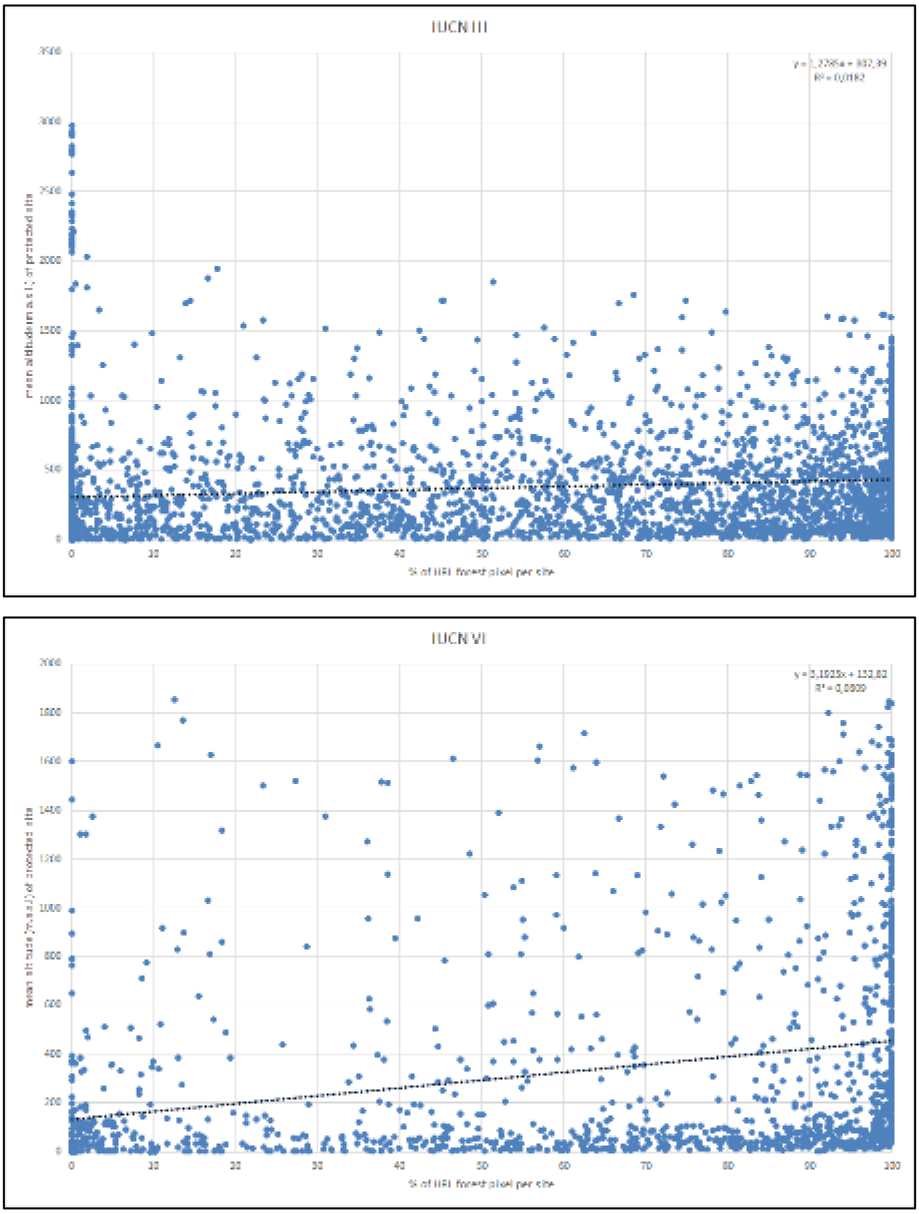


Figure 34: Copernicus HRL forested pixel percentage and altitude per IUCN protected area categories III and VI (CDDA dataset)

In a brief summary, nationally designated protected areas may feature a lower percentage of HRL forest pixel per site in lower altitude, and respectively a higher pixel percentage in higher altitudes, though there is no clear trend within some of the IUCN categories (Figure 35).

Figure 35: Copernicus HRL forested pixel percentage and altitude per IUCN protected area categories II and V (CDDA dataset)

3 European forest ecosystems condition and biodiversity assessments

EU biodiversity policies and strategies should be based on the most relevant and up-to-date information. There is a range of different types of information that can be used to describe the ecological conditions and their changes in Europe's forests. One traditional and often used type of information source is national forest inventories (NFIs). NFI data collected in nationwide sampling designs are used to produce statics on various forest variables (hereafter called 'indicators'). Although NFIs are primarily designed to monitor forest resources (e.g. timber volume and volume increment) and their economic use, they also provide information with environmental relevance. In, for instance, the northern European countries, NFIs have been going on for about 100 years and can thereby also provide information about how forest resources have developed over long periods of time.

Another type of information source is conservation assessments, which are made to systematically determine the conservation status of individual species and habitat types. Conservation assessments can be made at different scales and with different methods, but they all aim to determine the conservation status and the future need for conservation actions to preserve the biodiversity aspects assessed.

In the EU, Member states are also requested to monitor and report biogeographical assessments of the Conservation status of species and habitat types protected under the EU Habitats Directive, using a standard methodology. Likewise, many countries are compiling national Red Lists of threatened species and Red list of habitats and ecosystems, following the International Union for Conservation of Nature's (IUCN) well-established quantitative protocols for assessing the risk of extinction of species and the risk of collapse of ecosystems. These two types of conservation assessments; conservation status and risk assessment, are the most important indicators used to monitor biodiversity at biogeographic and national scales in Europe.

3.1 Results of the reporting to the Nature's Directives: main pressures on forests habitat types and non-bird species

3.1.1 *The Article 17 reporting process*

The Article 17 of the Habitats Directive require that all EU Member States report the Conservation status and the Conservation trends of each habitat type and non-bird species listed under its annexes, according to a specific assessment method, every six years. Three assessment cycles were reported until today: 2000-2006, 2007-2012, and 2013-2018. The last cycle was reported in 2019. Based on those national assessments, the European Environment Agency (EEA) and its European Topic Centre on Biological Diversity (ETC/BD) are publishing an EU wide summary and assessment per biogeographical regions of those habitat types and species, within periodic reports called State of Nature in the EU[54].

[54] https://www.eea.europa.eu/publications/state-of-nature-in-the-eu-2020

The Conservation status and Conservation trends data on Habitat types and non-bird species are an essential source of information on ecosystem condition and biodiversity. This conservation status is determined using 4 different parameters:

- Range, Area, Structure and function and Future prospects for habitat assessments;
- Range, Population, Suitable habitat and Future prospects for species assessments.

Each of these parameters is assessed using four possible outcomes: Good or Favourable conservation status (FV), Poor or Unfavourable inadequate conservation status (U1), Bad or Unfavourable bad conservation status (U2), as well as an unknown conservation status (XX). In addition, it is recommended to estimate for each parameter, except for “Future prospects”, a "short-term trends" over two reporting cycles (i.e. 12 years) or a period as close to this as possible, as this should give a more reliable and comparable estimate of the trend. A “Long-term trends" can also be reported in a series of optional fields, which are likely to be more statistically robust. The recommended period for assessing longer-term trends is four reporting cycles (24 years).

The Member States should then aggregate the results of these four parameters into a single Conservation status conclusion, for all given habitat types and non-bird species, per Member State and per biogeographical region. The aggregation is based on the one out all out principle: good status is reached if all parameters are qualified as good. Moreover, for species and habitat types with an overall conservation status assessment reported as FV, U1 or U2, Member-States must also indicate a Conservation trend (qualifier) as follows: Improving (+), Deteriorating (-), Stable (=) or Unknown (x). This "qualifier" should be based on the trends determined for each of the parameters assessed, and determined over the 6-year reporting period. However, as trends over this short period are often not available, “short-term trends” can be used as a reference, unless there is evidence that the trend during the reporting period is different than a measured short-term trend.

In a final step, for the State of Nature report, all national assessments per biogeographical regions are aggregated into assessments at the level of the overall EU Biogeographical regions, based on an area-weighed aggregation.

Member States should also provide a list of pressures and/or threats (among a predefined hierarchical list), and for each pressure/threat a ranking of its impact on the conservation status of the species or habitat type is also required.

- Pressures should have acted within the current reporting period and should have an impact on the long-term viability of the species, its habitat(s) or on the habitat type;
- Threats are future/foreseeable impacts (within the next two reporting periods) that are likely to affect the long-term viability of the species, its habitat(s) or the habitat type. The threats should not cover theoretical threats, but rather those issues judged to be reasonably likely. This may include continuation of pressures.

In the following analysis, both level 1 (main groups of pressures) and level 2 (individual pressures) are reflected.

3.1.2 ***Main pressures by broad forest types***

For this analysis, Annex I habitat types were classified into four broad forest types based on the type of assimilation organs: Broadleaved deciduous forests, Broadleaved evergreen forests, Coniferous forests and Mixed forests (mixed coniferous and broadleaved).

Not surprisingly, dominant group of pressures reported for forest habitats are pressures related to "forestry". However, their proportion among all reported pressures is higher than 50% (59%) only for mixed forests, and slightly below 50% (48% and 46% respectively) for the broadleaved deciduous and coniferous forest types. These three broad forest types have similar proportion of other important groups of pressures: pressures related to "agriculture" represent between 10 and 12% of all reported pressures, "invasive alien species" between 5 and 10%, followed by "modified water regime" (4 to 7%), "natural processes" 5 to 8%. "Urbanisation" is also quite an important pressure for coniferous forests (7%), less frequently reported for broadleaved deciduous and mixed forest (3% and 5% respectively).

Broadleaved evergreen forests show a very different structure of reported pressures. Pressures related to "forestry" are not the single dominant group but share this position with "agriculture" (both 20%). The "invasive alien species" represent a very important pressure that reach 17% of all reported pressures. Other important groups of pressures belong to "other human intrusions" (10%), "urbanization" (7%), "modification of water regime" (7%), "geological vents" (6%) and "natural processes" (5%).

Broadleaved evergreen forests differ from the other forest types also in the three most frequently reported single pressures. For broadleaved deciduous, coniferous and mixed forest, the three most frequently reported pressures only belong to "forestry": B07 "Removal of dead and dying trees, including debris", B08 "Removal of old trees excluding dead or dying trees", B02 "Conversion to other types of forests including monocultures", and B09 "Clear-cutting, removal of all trees". While the most frequently reported pressure to broadleaved evergreen forest are I02 "Other invasive alien species", followed by A09 "Intensive grazing or overgrazing by livestock" and A01 "Conversion into agricultural land". For further details, see the Figure and the Table below showing number of individual pressures reported by broad forest types (Figure 36, Table 11).

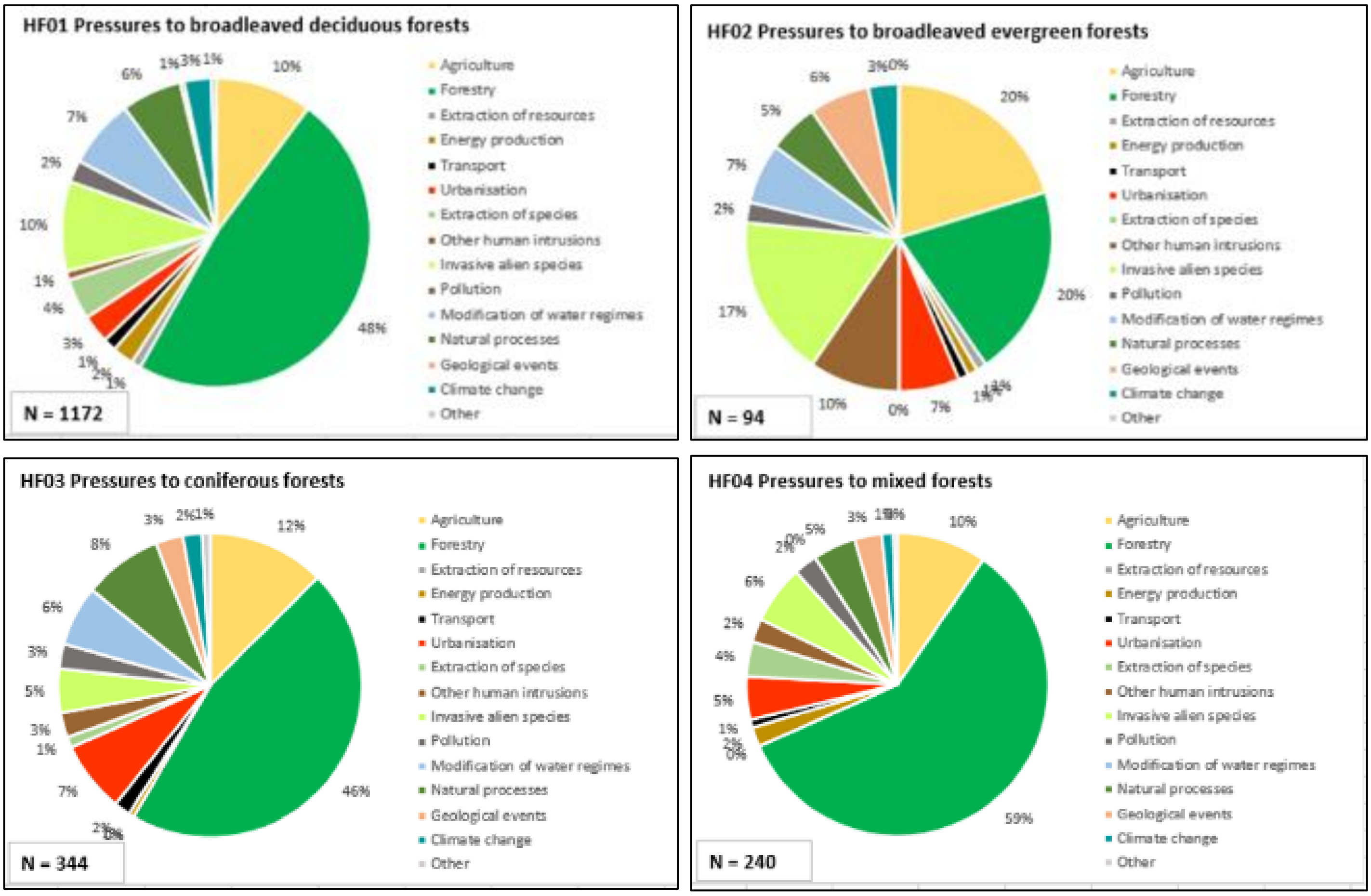


Figure 36: Pressures to broad forest types

Table 11: Most frequently reported pressure per forest type

Code	Pressure name	Broadleaved deciduous	Broadleaved evergreen	Coniferous	Mixed forests
B07	Removal of dead and dying trees, including debris	103		23	27
B08	Removal of old trees (excluding dead or dying trees)	85		19	24
B02	Conversion to other types of forests including monocultures	64		23	18
I02	Other invasive alien species	61	11	10	9
B09	Clear-cutting, removal of all trees	59	3	20	9
G08	Management of fishing stocks and game	45			9
B03	Replanting with or introducing non-native or non-typical species	38	3		9
B06	Logging (excluding clear cutting) of individual trees	38			11
B15	Forest management reducing old growth forests	37		16	9

Code	Pressure name	Broadleaved deciduous	Broadleaved evergreen	Coniferous	Mixed forests
B27	Modification of hydrological conditions, or physical alteration of water bodies and drainage for forestry	31		15	
A09	Intensive grazing or overgrazing by livestock	25	6		
A01	Conversion into agricultural land		5		
M09	Fire (natural)		4		
H04	Vandalism or arson		4		
H08	Other human intrusions and disturbance		4		

3.1.3 *Main pressures to forest habitat types within the different regions of Europe*

Pressures reported to forest habitat types were analysed according to the four main regions of Europe: Boreal region, Mediterranean and sub-Mediterranean region, Macaronesian region and the Temperate zone (all other regions). However, due to the low number of forest habitat types and pressures reported for the Macaronesian region (only 33 pressures classified as having high importance), only Boreal region, Temperate zone and Mediterranean and sub-Mediterranean region can be compared.

The dominant group of pressures in all three regions are pressures related to "forestry". They represent from 33% (Mediterranean) to 51% (Temperate) of all reported pressures in the respective region. Other important groups of pressures are "agriculture" (from 8% in Temperate to 14% in Mediterranean), "invasive alien species" (from 9% in Boreal and Temperate to 13% in Mediterranean), "water regime modifications" (from 7% in Temperate and Mediterranean to 13% in Boreal) and "natural processes" (7% in each region) (Figure 37).

In the Mediterranean region, it is possible to consider "urbanization" and "other human intrusions" as groups of pressures of similar importance (5% each). As for the Macaronesian region, the most frequently reported pressures are related to "agriculture" (37%), followed by "transport" and "natural processes" (both 12%), "forestry", "urbanization" and "invasive alien species" (all 9%). To obtain a more detailed picture of pressures in the Macaronesian region, we also analysed the medium and not ranked pressures. The most frequently reported non-high pressures were related to "agriculture" (28%), followed by "invasive alien species" (13%), "forestry" and "urbanization" (both 12%), "transport" (9%), "natural processes" (7%), and "other human intrusions" (6%). This analysis confirmed that forests in the Macaronesian region are mostly impacted by pressures related to other factors than forestry, and that these pressures are quite diverse. Most of pressures reported were related to the habitat types 9320 "*Olea* and *Ceratonia* forests" and 9560 "Endemic forests with *Juniperus* spp."

The Table 12 summarizes the most frequently reported single pressures for the analysed regions of Europe. The same four pressures were ranked among the first five pressures within the Boreal, Temperate zone and Mediterranean regions, and can be consider as the most important pressures to forest habitat types within the European Union, apart from the Macaronesian region:

- B02 "Conversion to other types of forests including monocultures";
- B07 "Removal of dead and dying trees including debris";
- B08 "Removal of old trees (excluding dead or dying trees)"; and

- B09 “Clear-cutting, removal of all trees”.

The fifth main pressures in both the Temperate zone and the Mediterranean region is I02 “Other invasive alien species”, while K04 “Modification of hydrological flow” is the fifth main pressure for the Boreal region. Invasive alien species were most often reported in the Mediterranean region and seem to be a crucial problem for Mediterranean forest habitat types. As for the Boreal region, the modification of hydrological regime was the second most frequently reported pressure in this region.

Due to the low number of pressures reported for the Macaronesian forests, it is difficult to draw any conclusion about the most important pressures. Still, the most frequent reported pressures were E01 “Roads, paths, railroads and related infrastructure (e.g. bridges, viaducts, tunnels)” and A09 “Intensive grazing or overgrazing by livestock”. If including also the 139 pressures ranked as medium importance or not ranged, the most frequently reported pressures in the Macaronesian region were E01 “Roads, paths, railroads and related infrastructure” (12), I02 “Other invasive alien species” (12), A09 “Intensive grazing or overgrazing by livestock” (11), A10 “Extensive grazing or undergrazing by livestock” (7), F07 “Sports, tourism and leisure activities” (7), A01 “Conversion into agricultural land (excluding drainage and burning)” (5), F01 “Conversion from other land uses to housing, settlement or recreational areas” (5), and M09 “Fire (natural)” (5).

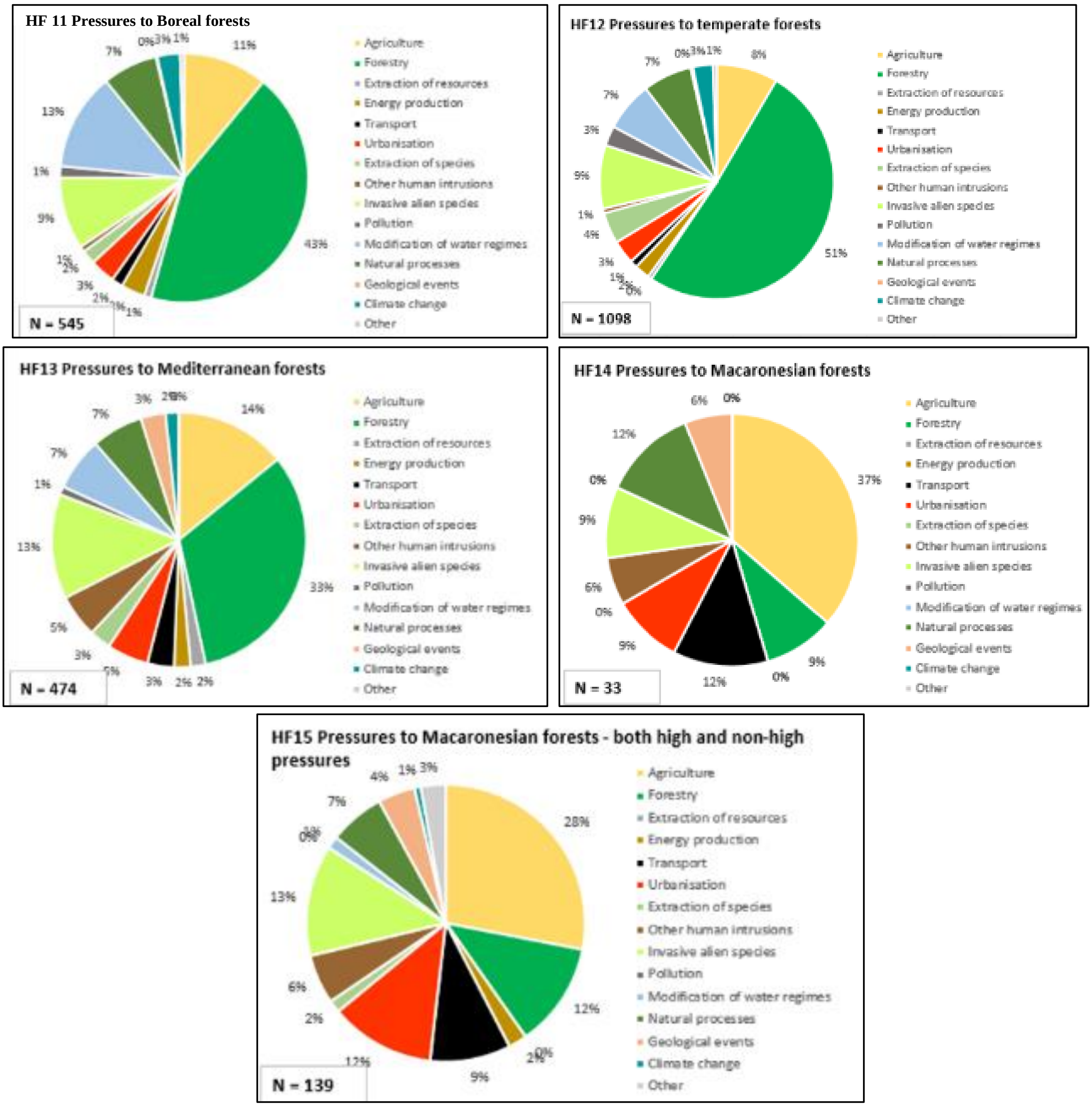


Figure 37: Pressures reported for Boreal, Temperate, Mediterranean and Macaronesian forests

Table 12: Most frequently reported pressures in individual regions of Europe

Order	Boreal		Temperate		Mediterranean		Macaronesian		Macaronesian	
	high		high		high		high		High and non-high	
1	B02	39	B07	103	I02	32	E01	4	E01	12
2	K04	34	B08	88	B07	25	A09	3	I02	12
3	B07	33	B02	59	B02	17	A01	2	A09	11

4	B08	29	B09	59	B08	17	B13	2	A10	7
5	B09	28	I02	56	B09	17	I02	2	F07	7
6	B27	28	G08	46	A09	16	L02	2	A01	5
7	I02	25	B15	40	B03	16	M09	2	F01	5
8	L06	23	B03	39	E01	16			M09	5
9	B15	22	B06	39	I05	16				
10	I05	17	K04	36	H08	15				

3.1.4 *Main pressures to species living on wood*

This analysis is focused to species living on wood, using the number of pressures reported by Member States to individual species. We distinguished two groups of species:

1. Species living on dead wood; and
2. Species living on live, standing trees.

For both species groups, the most important pressures are related to "forestry": measures related to forest management (including dying tree and debris removal), clear-cutting and conversion to other forest types. For species living on live and standing trees, the "construction or modification in existing urban or recreational areas" is also an important pressure (Table 13).

Table 13: Five most frequently reported pressures (level 2) to each of species groups living on wood (number of reports)

Pressure name	Living trees	Dead wood
B07 Removal of dead and dying trees, including debris	174	158
B09 Clear-cutting, removal of all trees	137	80
B08 Removal of old trees (excluding dead or dying trees)	128	107
B15 Forest management reducing old growth forests	91	80
F02 Construction or modification (e.g. of housing and settlements) in existing urban or recreational areas	68	(not reported)
B02 Conversion to other types of forests including monocultures	(50)	30

Results on level 1 show that the dominant pressure groups to both species groups are pressures related to "forestry", but in different degree: while for species living on dead wood 85% of all pressures are related to forestry, for species living on live and standing trees it is only 57% of all pressures (Figure 38).

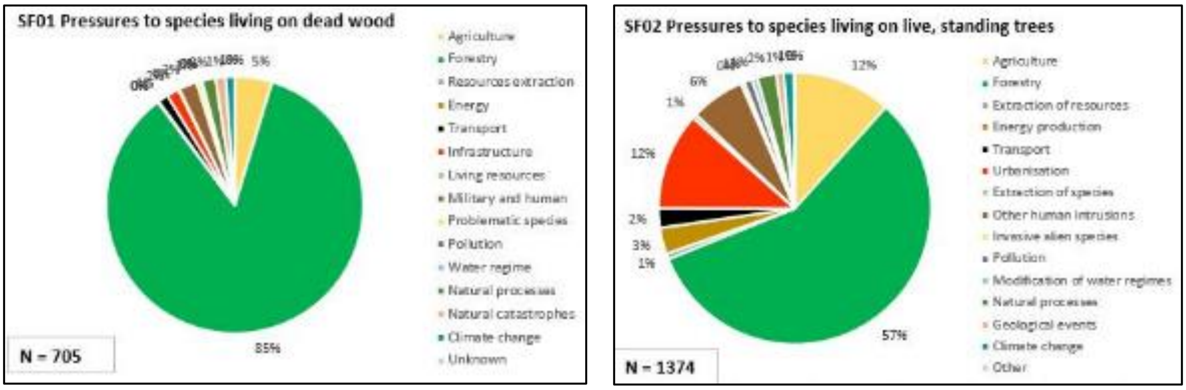


Figure 38: **Dominant pressures to species living on dead wood and species living on live, standing trees**

For species living on dead wood, pressures not related to forestry are marginal, and only pressures linked to "agriculture" reached 5%. As for species living on live and standing trees, some other types of pressures are also important, like pressures related to "agriculture" (12%), "urbanisation" (12%), and "other human intrusions" (6%). The reasons for such difference can provide structure of related species groups.

Species living on dead wood belong to two groups: arthropods (mostly beetles) and non-vascular plants. It seems that these species are strictly linked to old-growth forests with huge amount of dead wood, and that for those species the forestry management practices are the main sources of pressures. In the case of species living on live and standing trees, one additional species group is included: mammals. The majority of mammals in this group are bats (i.e. mobile species), and at least some of them can live also in other types of habitats than forest with old trees. This is probably why a higher number of pressures related to other factors than forestry is reported for Mammals. The differences in pressures to species groups living on live woods is shown in the following graphs (Figure 39).

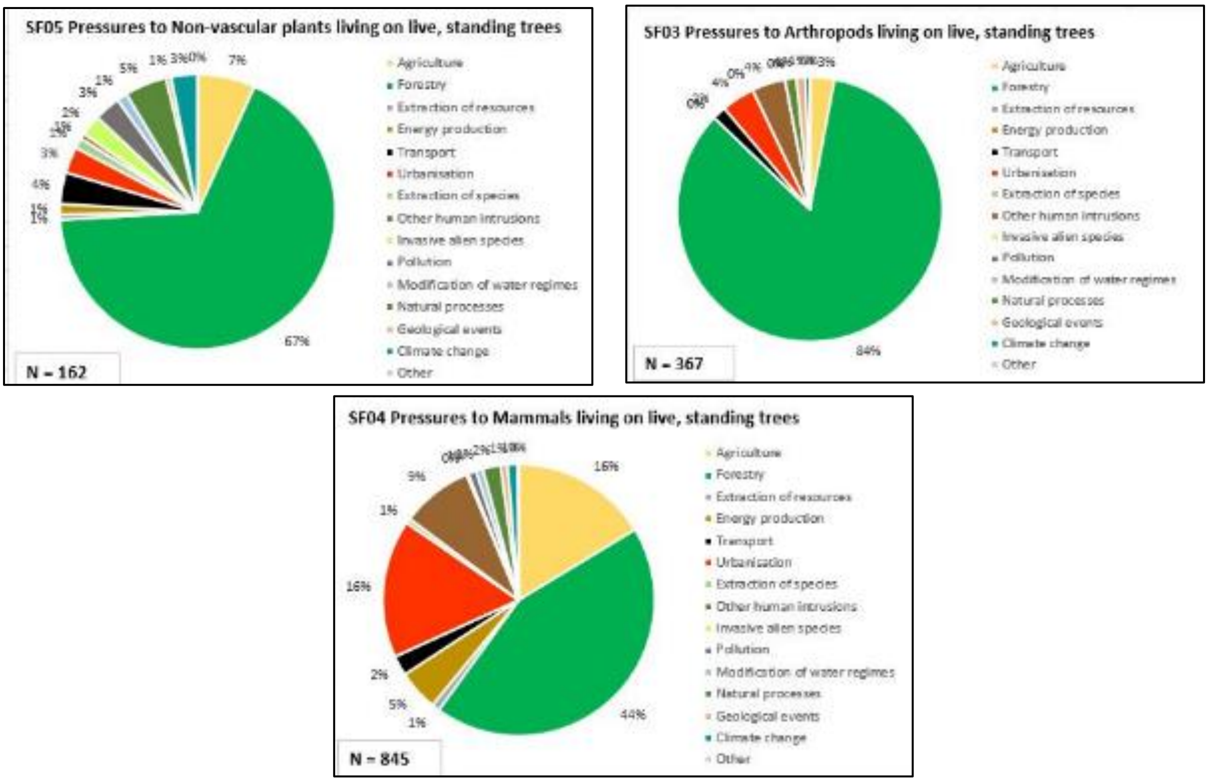


Figure 39: **Differences in pressures to species groups living on live woods**

Pressures related to “forestry” represent more than two thirds of all reported pressures for non-vascular plants and arthropods, while pressures related to “agriculture”, “urbanization” (16 % each), “other human intrusion” (9%) and “energy production” (5%) are also important pressures on mammals. Mammals represent about half of the species living on live and standing trees. Therefore, the pressures reported for them are reflected in the structure of pressures reported for all species living on live and standing trees.

3.1.5 *Climate change as pressure to forest habitat types*

The “climate change” was not reported frequently as a pressure to forest habitat types in the Article 17 reporting (2019): it represented about 2.5% of all reported pressures of high importance to forest habitat types (46 of 1850 reports). “Climate change” is however reported as a pressure of high importance for some habitat types:

- 91F0 “Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (*Ulmenion minoris*) (5 times):
- 9160 “Sub-Atlantic and medio-European oak or oak-hornbeam forests of the *Carpinion betuli*;
- 91D0 “Bog woodland;
- 91E0 “Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (*Alno-Padion, Alnion incanae, Salicion albae*); and
- 9340 *Quercus ilex* and *Quercus rotundifolia* forests (4 times to each).

Three of the mentioned habitat types are riparian and alluvial forests, located in wet sites.

3.2 Annex I Forest habitat types condition and management within the Natura 2000 network

3.2.1 *Degree of conservation of Forest habitat types in N2000 sites*

According to the Habitat Directive requirements (EC 2011), the *Degree of conservation of the structure and functions of the natural habitat type, concerned and restoration possibilities* has to be given for every habitat type listed in the standard data forms. This criterion comprises three sub-criteria:

- **degree of conservation of the structure**: This sub-criterion should be linked to the interpretation manual on Annex I habitats since this manual provides a definition, a list of characteristic species and other relevant elements.

- **degree of conservation of the functions**: It can be difficult to define and measure the functions of a particular habitat type on the defined site and their conservation, and to do this independently of other habitat types. For this reason it is useful to paraphrase ‘the conservation of functions’ by the prospects (capacity and probability) of the habitat type concerned on the site in question to maintain its structure for the future, given on the one hand the possible unfavourable influences and on the other hand all the reasonable conservation effort which is possible.

- **restoration possibility**: This sub-criterion is used to evaluate to what extent the restoration of a habitat type concerned on the site in question could be possible.

The synthesis follows a defined scheme (EC 2011) by applying to the overall grading of the three sub-criteria:

- **A**: excellent conservation
- **B**: good conservation
- **C**: average or reduced conservation

The Degree of Conservation of habitat types reported in the standard data forms (SDF) is the key parameter for Natura 2000 network implementation, protect area selection, impact assessment on protected sites and conservation management and measures.

Summarized across all EU 27 Member States by end 2019, ~51% of the forest habitat types cover within the Natura 2000 network are assessed as B with a good and ~41% as A with an excellent degree of conservation (Figure 40).

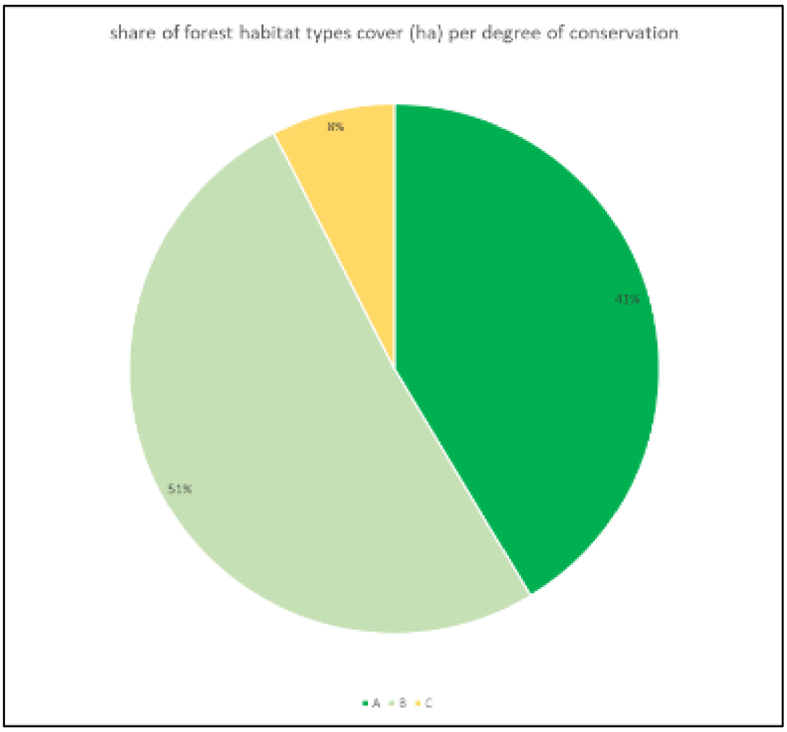


Figure 40: Share of forest habitat types cover (Annex I and Halada et al. 2020) according the Natura 2000 data End 2019

By splitting data at the Member State level, the share of excellent conservation (A), good conservation (B), average or reduced conservation (C) assessments of forest habitat types (Annex I + Halada et al. 2020) varies between the protected sites in the countries (Figure 41). Natura 2000 sites in Sweden and Cyprus cover forest habitat types with a high share (>90%) of an excellent degree of conservation. On the other side in Belgium, Hungary and Malta, protected areas include forest habitat types assessed in the standard data forms (SDF) as C with an average or reduced degree of conservation.

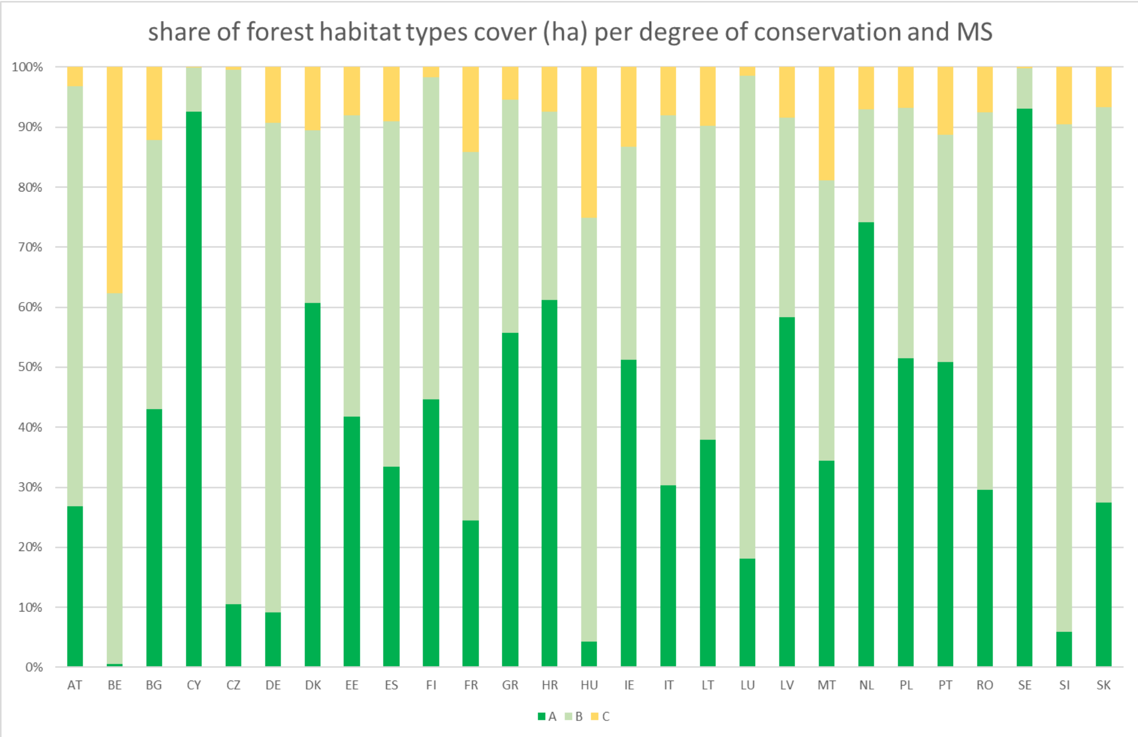


Figure 41: **Share of forest habitat types cover (ha) per degree of conservation and Member State - Annex I and Halada et al. 2020**

3.2.2 *Management of Forest habitat types within N2000 sites*

Article 6 of the Habitats Directive sets out provisions which govern the conservation and management of Natura 2000 sites:

- Article 6(1) makes provision for the establishment of the necessary conservation measures, and is focused on positive and proactive interventions;
- Article 6(2) makes provision for avoidance of habitat deterioration and significant species disturbance. Its emphasis is therefore preventive;
- Article 6(3) and (4) set out a series of procedural and substantive safeguards governing plans and projects likely to have a significant effect on a Natura 2000 site.

The necessary conservation measures can involve appropriate management plans specifically designed for the sites, or integrated into other development plans. Such management plans should address all foreseen activities, unforeseen new activities being dealt with by Article 6(3) and (4).

In the standard data forms (SDF) of each Natura 2000 site, a database entry indicates whether or not a specific and actual management plan exists for the site, or whether one is in preparation. While it is acknowledged that management plans are not a requirement under the Nature Directives, the information is of special interest in order to understand the instruments Member States are using to manage their network, and also to find more specific information.

In Czech Republic, Denmark, Malta, Sweden and Slovenia more than 90% of the Natura 2000 sites including forest habitat types (Annex I + Halada et al. 2020) features existing management plans (Figure 42). 11 Member States exhibit a higher share (>20%) of no given information about management plans (no, in preparation, yes).

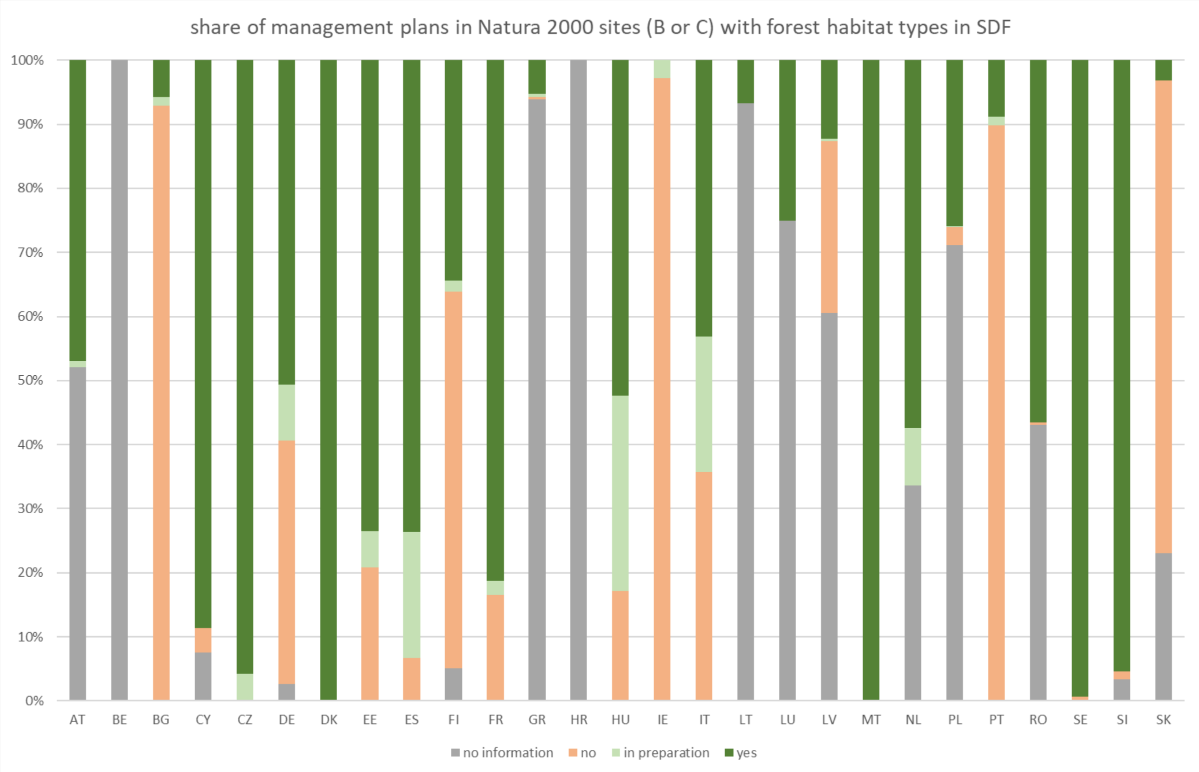


Figure 42: **Share of management plans in Natura 2000 sites with forest habitat types - Annex I and Halada et al. 2020**

In summary, management intensity of Natura 2000 protected areas including forest habitat types via explicit management plans is handled in different ways in the EU Member States.

3.3 European Red lists of species, habitats and ecosystems

3.3.1 *The IUCN European Red list of trees*

The very recent European Red list of trees[55] have identified 454 species of native trees in Europe, found in 45 families. According to this study, the most speciose family is *Rosaceae* which includes 216 tree species, the majority of them being from the genus *Sorbus*. Of those 454 species, 168 were considered to threatened, assessed as Vulnerable (VU), Endangered (EN) or Critically Endangered (CR). Thirteen species (3%) were assessed as Near Threatened (NT), almost meeting the criteria for a threatened category, and a further 216 species (47%) that were considered Least Concern (LC). No tree species were considered Extinct (or Extinct in the Wild, or Regionally Extinct), but 57 species (13%) were considered to be Data Deficient (DD), as insufficient information is available to assign a category of risk. The proportion of threatened species could be between 37.1% (if no DD species are considered threatened) and 49.6% (if all DD species are considered threatened) for Europe.

[55] https://ec.europa.eu/environment/nature/conservation/species/redlist/index_en.htm

3.3.2 *The Red list of European habitats*

The Red List of European habitats[56] was delivered in 2017 and have identified and assessed 42 forest habitats, using an in-between version of the EUNIS habitat classification that was under revision at the time. Twelve woodland habitats (29%) were assessed as Threatened to some degree at the EU28 scale, while 10 types were assessed as Near Threatened, often with some distinctly more threatened subtypes or regional variations.

The two Endangered (EN) habitats are Temperate and boreal hardwood riparian woodland, related to large losses in the majority of the bigger river systems throughout Europe, and Picea mire woodland, due to losses in extent and modifications of hydrology. Ten woodland habitats were assessed as Vulnerable (VU), including the other bog woodland types, all with large recent declines in area, and one other riverine woodland with a recent decline in quality. Most other Vulnerable habitats have a small geographical distribution, being restricted mostly to Macaronesia or to small parts of the Mediterranean region. Three of these woodland types had a large historical reduction in quantity, while a large reduction in quality was the main reason to assess Acidophilous Quercus woodland as Vulnerable.

The Near Threatened habitats include several relatively widespread woodlands such as two montane and alpine woodlands and several lowland, broadleaved woodlands, and one of the most common boreal forest types (Picea taiga woodland), all based on negative recent trends in quality over the past decades. In addition, two more restricted woodland habitats, Mediterranean and Balkan subalpine Pinus heldreichii-Pinus peuce woodland and Ravine woodland, are in this category. Three of all these Near Threatened habitats are Least Concern in the wider range of the EU28+.

The major threats to most woodland habitats are linked with forestry: removal of dead and dying trees, missing deadwood and missing continuity of deadwood and senescent trees, the creation of even-aged stand structure, lack of natural stand dynamics, and removal of undergrowth. In some woodland habitats, at least regionally, clearance as such is also still a threat. Overgrazing by sheep and goats can also be a major threat, especially in several Mediterranean woodland types, for example *Olea europaea-Ceratonia siliqua* woodland, and in Macaronesian types, but also in northern Europe, for example in Fennoscandia or Latvia, overgrazing by reindeer is an important threat to taiga woodlands.

For all woodland types dependent on a special hydrology, such as bog and swamp woodland types, riverine woodlands, and Phoenix palm groves, anthropogenic changes in hydrology are a major threat. For bog woodlands, peat-cutting is also still a danger and, for the riverine woodland types, major threats are canalization and water deviation, lack of flooding, hydropower and weirs and pollution of surface water – many of these connected with intensive agriculture, for example in former alluvial plains.

For many woodland habitats, fragmentation and anthropogenic loss of habitat connectivity is an additional threat in greater or smaller parts of their range or regionally. Airborne nitrogen input and pollution such as acid rain are major threats mainly to naturally nutrient-poor woodlands, and climate change becomes a more and more important threat to many mountain types and Nordic boreal woodlands, but will also induce changes in dry and thermophilous forest habitats. Finally, for several

[56] https://ec.europa.eu/environment/nature/knowledge/redlist_en.htm

woodland habitats, the absence of natural fire dynamics is a threat, for example in northern taiga, while anthropogenic burning with destruction or modification in species composition endangers a number of Mediterranean and Macaronesian woodland types.

3.3.3 *Forest ecosystem assessments using the IUCN Red List of Ecosystems methodology*

The IUCN Red List of Ecosystems is a global framework for monitoring the status of ecosystems. It is part of the growing toolbox for assessing risks to biodiversity and aims to support conservation, resource use, and management decisions by identifying ecosystems most at risk of biodiversity loss[57]. In 2019, 2,821 ecosystem units in over 100 countries have been assessed with the IUCN RLE criteria versions 1 and 2. Systematic assessments are complete or underway in 21 countries and two continental regions (the Americas and Europe), which together represent about 47% of the earth's land surface. While nearly 20% of these are ongoing projects, most have already produced new or revised ecosystem classifications and maps.

Preliminary RLE assessments in Norway have been used as inputs for the country's NBSAP (Norwegian Ministry of Climate and Environment, 2015) and have been adopted as a basic input for a national mapping program on important ecosystem types. In Finland, the RLE serves as important background information for the European Union (EU) Habitats Directive Reporting and is currently being used to assess progress toward the EU Biodiversity Targets for 2020. France is also developing its National Red list of ecosystems and assessing its forest ecosystems, starting with the Mediterranean forests[58].

The systematic application of the RLE criteria at continental and national scales can provide broad-scale information on the status of ecosystems, that can be used in global biodiversity monitoring[59]. RLE indices have high potential to inform global biodiversity reporting, such as for the Aichi Targets of the Convention on Biological Diversity, the United Nations Sustainable Development Goals, the Global Environment Outlook, and the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. For example, RLE indices could inform monitoring toward 12 Targets, in particular those related to the rate of loss natural habitats (Target 5) and the management of fisheries (Target 6), forestry (Target 7), ecosystem services (Target 14), and ecosystem resilience (Target 15).

RLE data could be used to inform progress toward a number of United Nations Sustainable Development Goals (SDGs), especially Goal 6 (sustainable water management), Goal 14 (life below water), and Goal 15 (life on land; Table S3).

3.4 EU Forest condition based on national and EU-wide data, the case of Northern Europe

In this subchapter will be investigated the possibilities to compile and review information from both nationwide forest inventories and conservation assessments, in a specific geographical area of Europe. Indeed, as the work in compiling information from different sources is quite labor-intensive and still exploratory, the investigation is restricted to a pilot study within Northern Europe.

---

[57] https://portals.iucn.org/library/node/45794
[58] https://uicn.fr/wp-content/uploads/2020/05/uicn-france-lre-forets-med-rapport_technique_bd.pdf
[59] Bland LM, Nicholson E, Miller RM et al. Impacts of the IUCN Red List of Ecosystems on conservation policy and practice. Conservation Letters. 2019. https://doi.org/10.1111/conl.12666

In summary, the general forest indicators reported by Forest Europe[60] were reviewed, and the information they provide compared with two types of assessments: The Article-17 reporting of non-bird species and habitat types protected under EU's Habitats Directives for the concerned Member States and biogeographical regions (reporting period 2012-2018) and national Red Lists of species and habitat types implemented in the concerned countries. Many of the indicators reported by Forest Europe are composed of statistics based on NFI data. Conservation assessments are on their side based on data related to their respective species and habitat types concerned. For instance, those protected under EU's Habitats Directives are assessed using data periodically reported by EU Member-States under the Article 17, related to their Conservation status and trends.

This review was done as a pilot study focusing on Northern Europe, which encompasses the entire EU "Boreal" biogeographical region (Figure 43). To enable comparison between Forest Europe and Article-17 reporting data within Northern Europe, the review is further restricted to statistics from EU Member states Denmark, Sweden, Finland, Estonia, Latvia and Lithuania. Additional statistics based on NFI data are publicly available in Sweden[61] and Finland[62]. Hence, when relevant, the review of indicators by Forest Europe were supplemented with NFI's statistics from these two countries, covering the bulk of forests in Northern Europe and EU's "Boreal" biogeographical region.

3.4.1 *Geographic scope: The Northern Europe*

The nature of Northern Europe is characterized by large variation in climate, bedrock and topography. For instance, the climate varies from sub-arctic in the northern part to maritime along the Atlantic west coast and temperate/continental in southern and eastern parts. Hence, the vegetation also exhibits large variation, from sparse tundra and subalpine birch forests in the north and along the Scandinavian mountain range, to boreal coniferous forests in the north-eastern and central parts and temperate/continental broadleaved deciduous forests in the temperate southern, western and eastern parts.

Forest is the dominant land cover and the six EU member states in Northern Europe accounts for about one third of the forest resources available for forestry in EU27, although the forestry sector is of less importance in Lithuania and Denmark than in the other four EU member states reviewed.

According to EU's guiding principles, Northern Europe is divided into four different biogeographical regions: Alpine, Boreal, Continental and Atlantic (Figure 43). However, most of Northern Europe falls within the Boreal region. In fact, the Boreal biogeographical region, as well as a significant number of forest habitat types within it, were included in the Habitats Directive when the Northern European countries (Sweden, Finland, Estonia, Latvia and Lithuania) became members of the EU in 1995. Still, forest composition within the Boreal region varies greatly between the southern and northern parts.

[60] FOREST EUROPE - Ministerial Conference on the Protection of Forests in Europe 2020. State of Europe's Forests 2020. Liaison Unit Bratislava. https://foresteurope.a org/wp-content/uploads/2016/08/SoEF_2020.pdf
[61] SLU Riksskogstaxeringen 2021
[62] LUKE, 2021

The northern-middle parts comprise the boreal coniferous forest zone, but the southern part belongs to the so-called boreo-nemoral zone, the transition zone between the boreal coniferous forest zone and the temperate/continental (nemoral) broadleaved (deciduous) forest zone[63].

The Northern European countries share many similarities in terms of forest composition, ecology and biodiversity, but also on how forests have been used and managed historically.

Current landscapes in Northern Europe are largely a result of a long history of human land use and rational forest management during the 20th century, and today, guiding principles for both forestry and forest biodiversity conservation are fairly similar within Northern Europe.

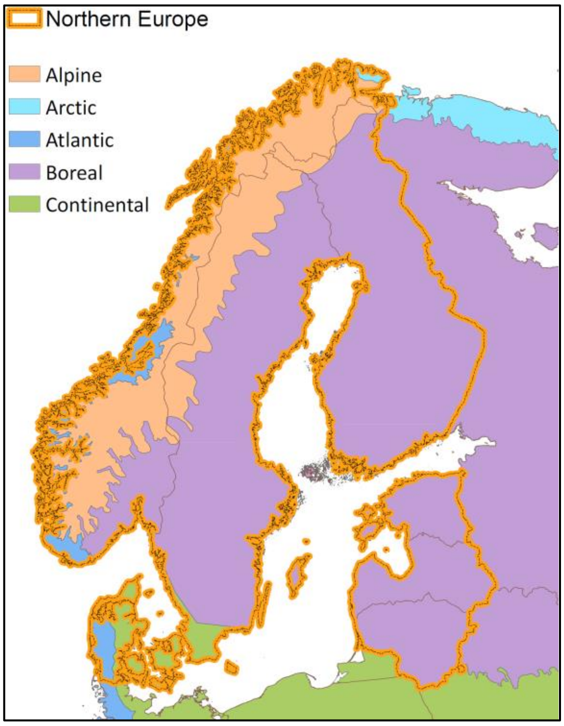


Figure 43: Terrestrial biogeographical regions in Northern Europe according to EEA (2021)

The expansion of the forest industry during the last 200 years has been a major driver of significant landscape changes in terms of forest structure, age class distribution and tree species composition across the entire Northern Europe. Almost all forests have been affected, first by over-exploitation and selective logging of the largest timber trees, and later, during the 20th century, by the introduction of modern forest management in form of short rotation forestry, including clear cutting and planting but also large-scale draining and use herbicides and fertilizers. However, the historical land use varies greatly within Northern Europe[64 65 66].

Some areas among the most inaccessible parts of Northern Europe; i.e. forest areas along the Scandinavian mountain range, in the border area between Finland and northwestern Russia, as well as on the Kola Peninsula, have until now remained fairly unaffected by forestry. In contrast, the landscapes in the boreo-nemoral and continental region, but also forest areas on good, fertile soils and in particular the accessible coastal and riverine areas of the whole boreal region, have generally a relative long and complex history of intensive human land use. Forests in these areas started to be affected by agrarian expansion already thousands of years ago and was successively increasingly used

[63] Ahti, T., Hämet-Ahti, L., Jalas, J. 1968. Vegetation zones and their sections in Northwestern Europe. Annales Botanica Fennici 5: 169–211

[64] Potapov, P., Yaroshenko, A., Turubanova, S., Dubinin, M., Laestadius, L., Thies, C., Aksenov, D., Egorov, A., Yesipova, Y., Glushkov, I., Karpachevskiy, M., Kostikova, A., Manisha, A., Tsybiko-va, E. & Zhuravleva, I. 2008. Mapping the world's intact forest landscapes by remote sensing. Ecology and Society 13: 51.

[65] Kuiters, A.T., van Eupen, M., Carver, S., Fisher, M., Kun, Z. & Vancura, V. 2013. Wilderness regis-ter and indicator for Europe. Final report, October 2013, Contract No: 07.0307/2011/610387/SER/B.3. Alterra Wageningen UR, Wildland research Institute, PanParks.

[66] Watson, J.E.M., Evans, T., Venter, O., Williams, B., Tulloch, A., Stewart, C., Thompson I., Ray, J.C., Murray, K., Salazar, A., McAlpine, C., Potapov, P., Walston, J., Robinson, J.G., Painter, M., Wilkie, D., Filardi, C., Laurance, W.F., Houghton, R.A., Maxwell, S., Grantham, H., Samper, C., Wang, S., Laestadius, L., Runting, R.K., Silva-Chávez, G.A., Ervin, J. & Lindenmayer, D. 2018. The exceptional value of intact forest ecosystems. Nature Ecology & Evolution 2: 599–510.

for livestock grazing and various wood products such as timber, firewood, charcoal and potash. Also, the early mining industry were an important consumer of timber and forests in mining districts were severely overexploited long before the introduction of forestry.

3.4.2 *Forest Europe and National forest inventories for Northern Europe: a selection of indicators*

- **Forest area and forest cover**

Forests cover 59 million hectares of Northern Europe (Table 14) (64% of the total land area), representing about 37% of the total forest area of EU27 (162 million hectares). However, the forest area as well as the proportion of forest cover varies greatly among countries.

Indeed, more than 80% the northern European forests are found in Finland and Sweden (Table 14, Figure 44): they extend over about 50.4 million hectares (70% of the total land area). About 43 million hectares of them are characterized as "productive forests" (annual wood increment ≥1 m^3 per hectare[67]). Forest cover is also relatively important in Estonia and Latvia, where they cover more than 50% of the land area (Figure 44). Denmark has clearly the smallest forested area (0.6 million hectares) and the lowest proportion of forest cover (about 15%) among the Northern European countries.

The forest area has been fairly stable in Finland (22.4 million hectares) and Sweden (28.0 million hectares) while it has increased by 18% percent in Denmark and ca 10% in the three Baltic countries since 1990.

Table 14: A selected set of general forest indicators reported by Forest Europe (2020)

	Denmark	Sweden	Finland	Estonia	Latvia	Lithuania	Northern Europe	EU27
Land area (million hectares)	4.2	40.7	30.4	4.5	6.2	6.3	92.3	352.3
Total forest area (million hectares)	0.6	28.0	22.4	2.4	3.4	2.2	59.1	159.2
Proportion of forest	15%	69%	74%	54%	55%	35%	64%	45%
Forest available for wood supply, i.e. forestry (million hectares)	0.6	19.6	19.7	2.1	3.2	1.9	47.1	134.6
Proportion of forest available for forestry	98%	70%	88%	86%	94%	88%	80%	85%
Area of protected forests by MCPFE Classes 1.1-1.3 (1000 hectares)	55.7	2,166	2,818	553	399	206	6,197	17,760
Proportion of protected forest	8.9%	7.7%	13%	23%	12%	9.4%	10%	11%
Area dominated by introduced tree species (1000 hectares)	279	592	30	2	0	3	906	5,670
Proportion of forest dominated by introduced tree species	44%	2.1%	0.1%	0.1%	0%	0.1%	1.5%	3.6%
Total growing stock (million m^3)	133	3,654	2,449	494	672	559	7,961	25,794
Proportion of coniferous forest	39%	78%	74%	40%	45%	53%	69%	-
Proportion of broadleaved forest	53%	8%	6%	33%	36%	32%	13%	-

[67] SCB 2021

Proportion of mixed forest	8%	15%	20%	27%	19%	14%	17%	-
Growing stock available for forestry (million m^3)	129	2,719	2,203	422	618	474	6,565	22,005
Proportion of growing stock available for forestry	97%	74%	90%	85%	92%	85%	82%	85%
Net annual increment (million m^3) in forest available for forestry	7	95	96	12	-	14	224	556
Felling (million m^3)	4	89	77	10	-	10	191	419
Felling as percent of annual increment	67%	94%	80%	83%	-	70%	85%	75%
Dead wood (m^3/hectare)	4.9	8.4	6.0	14.8	23.6	22.8	9.1	8.0

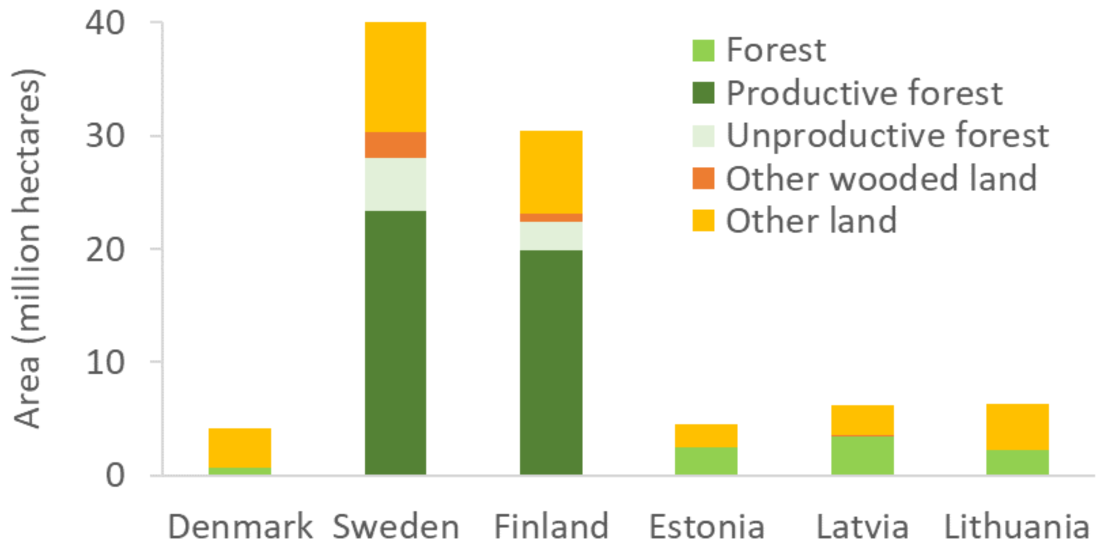


Figure 44: **Distribution of land area in Northern European countries (Forest Europe 2020). National statistics on productive and unproductive forest (annual wood increment ≥1 m^3 and <1 m^3 per hectare) are given for Sweden and Finland (SCB 2021; LUKE 2021)**

- **Growing stock**

The growing stock of forest in Northern Europe is equivalent to 7,960 million m^3, or 31% of the total growing stock in the EU27 (25,794 million m^3) (Table 15). But similar to the forest area, the growing stock also varies greatly among the Northern European countries: The bulk is found in Finland and Sweden (6,103 million m^3 or ca 77%).

Timber stocks have increased in all countries by approximately 1% per year since the 1990s. In fact, the growing stocks in Sweden and Finland has increased by about 100% and 80%, respectively, during the last 100 years[68].

The increase in timber stocks reflects that forests have become denser and that the numbers of medium-coarse to coarse trees of both coniferous and deciduous tree species have increased, as a result of active forest management[69].

Table 15: Growing stock tree-species composition in terms of volume (million m³) in Northern Europe during recent decades according to Forest Europe (2020)

Rank in terms of volume	Scientific name	2005	2010	2015	2020	Share of total growing stock 2020	Increase of growing stock between 2005 and 2020
#1	*Pinus sylvestris*	2,838	2,970	3,118	3,190	40%	12%
#2	*Picea abies*	2,268	2,359	2,493	2,580	32%	14%
#3	*Betula* spp.	1,189	1,250	1,305	1,334	17%	12%
#4	*Populus tremula*	160	211	222	229	3%	43%
#5	*Alnus glutinosa*	102	134	154	166	2%	62%
#6	*Alnus incana*	120	124	126	127	2%	6%
#7	*Quercus robur*	58	67	73	77	1%	32%
#8	*Fagus sylvatica*	51	47	58	59	1%	16%
#9	*Pinus contorta*	22	35	43	45	1%	103%
#10	*Salix* spp.	23	24	26	26	0%	18%
Remaining		103	119	125	123	2%	20%
Total		6,933	7,340	7,743	7,958	100%	15%

- **Tree species composition and diversity**

Forest Europe (2020) uses statistics on the growing stock of forest dominated by different tree species, as an indicator of forest composition. Results indicate that around 69% of the growing stock in Northern Europe is found in coniferous forests (i.e. stands dominated by coniferous trees) (Table 15). The remaining share is found in approximately equal shares in broadleaved (13%) and mixed (18%) forests. The large share of coniferous forests mainly results from a dominance of coniferous forests in

[68] Skogsdata 2021. Aktuella uppgifter om de svenska skogarna från SLU Riksskogstaxeringen. Sveriges lantbruksuniversitet (In Swedish with English table and figure legends).

[69] Henttonen, H.M., Nöjd, P., Suvanto, S., Heikkinen, J., Mäkinen, H. 2019. Large trees have increased greatly in Finland during 1921–2013, but recent observations on old trees tell a different story. Ecological Indicators 99: 118-129.

Finland and Sweden (78% and 74%, respectively), the two countries with the most growing stock in Northern Europe.

Coniferous forests are relatively important also in the other countries (40-50% of the growing stock), but broadleaved forests comprise there a larger share of the growing stock (30-50%) than in Sweden and Finland (6-8%).

The distribution across the three main forest types have remained fairly stable since 2005, i.e. the reported statistics do not reveal any major changes in forest composition as the growing stocks of all three types are increasing. Yet, between 2005 and 2010, the share of broadleaved and mixed forests summed together increased from 29 to 31%, while the share of coniferous forests decreased from 71 to 69%. Particularly, Finland reported a sharp increase in the proportion of mixed forests (from 14 to 19%) between 2005 and 2010.

The 10 most common tree species in Northern Europe are listed in Table 15. The distribution of growing stock across tree species have remained fairly stable since 2005, as all tree species (except ash *Fraxinus excelsior*) have increased in volume during recent decades. As for the relative increase in individual tree species, the largest volume growth (103%) is revealed for the introduced lodgepole pine (*Pinus contorta*). Large relative increases are also observed among some native broadleaved (deciduous) tree species (e.g. *Alnus glutinosa* 62%*, Populus tremulae* 43%, *Quercus robur* 32%).

Stands composed of two or more tree species occupy 77% of the forest area, while 23% of the forests are composed of stands dominated by a single tree species (i.e. either monocultures or naturally homogenous forests). Due to lack of reported statistics from the northern European countries (cf. Forest Europe 2020), it is not possible to detect any clear trends in area of stands with different number of tree species.

Statistics on the area of forest dominated by different tree species may serve as an additional indicator of forest composition. National statistics from Sweden and Finland indicate quite modest composition changes at national scale. In both countries, the bulk of productive forest is dominated by coniferous tree species. Their share (82% and 89%, respectively) has remained fairly stable over recent decades although the share of forests dominated by broadleaved (deciduous) tree species has slightly increased in Sweden (from 6.5 to 7.5%) and remained stable in Finland (about 10%).

National statistics from Sweden and Finland on growing stocks also indicate some composition changes among main tree species at national scale over a longer time period. The proportion of Norway spruce (*Picea abies* L.) has decreased in Finland since the 1970s (from 37 to 30%) while the proportion of Scots pine (*Pinus sylvestris* L.) increased (from 45 to 50%) and that of broadleaved (deciduous) tree species (mainly birch, *Betula* spp. L.) remained around 20%.

Inventories since the 1970s outside protected areas in Sweden also indicate that the proportion of Norway spruce has decreased (from 47 to 41%), while the shares have increased for broadleaved tree species (from 14 to 18%) and remained around 38-39% for Scots pine.

- **Regeneration and forest naturalness**

62% (or 36.7 million hectares) of the total forest area in the Northern Europe has been regenerated naturally or results from natural expansion. The share of these forms of establishment, from 74% in the 1990s, is decreasing (Figure 45) mainly because they are decreasing in Sweden and Finland, the two dominating countries in terms of forest area. In fact, the area of natural regeneration and expansion is slightly increasing in the other countries. Furthermore, a minor share (4%, about 2.6

million hectares) is considered to be forests undisturbed by man ("primary forests" according to FAO 2020's definition[70]) and the area of such forests has remained quite stable over time (Figure 45).

By contrast, the area proportion of afforestation and regeneration by planting and/or seeding is increasing (from 23 to 38% between 1990 and 2015). The area proportion of forest classified as plantations is small (about 1%) and have declined somewhat after 2010, but the proportion of forest dominated by introduced (alien) tree species is nevertheless slightly larger and has increased, from 0.8 to 1.5% between 1990 and 2020 (Figure 45).

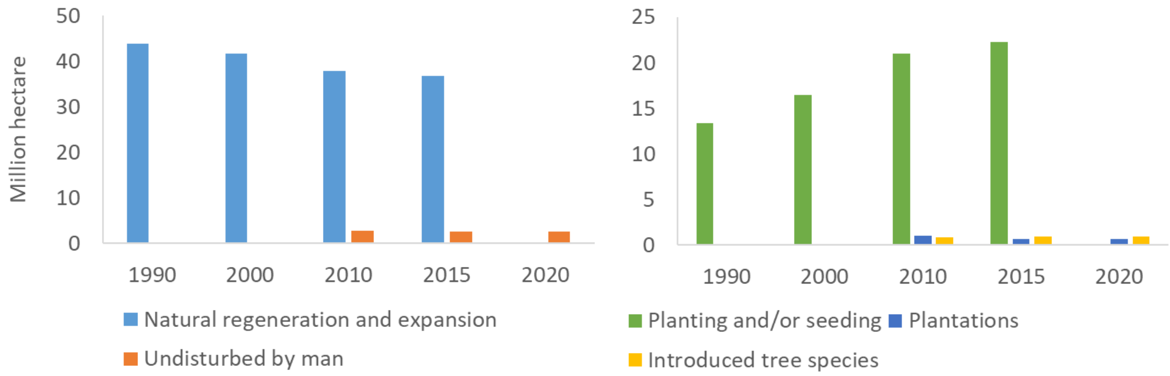


Figure 45: The left diagram shows the area of forest resulting from natural regeneration or expansion (statistics reported from 1990 to 2015) as well as the area undisturbed by man (from 2010 to 2020). The right diagram shows the area of forests afforested and regenerated by planting and/or seeding (from 1990 to 2015) as well as the area of plantations and forests dominated by introduced (alien) tree species (from 2010 to 2020). Statistics reported by Forest Europe (2020).

- **Age structure**

About 85% of forests in Northern Europe are even-aged, of which 61% are in an intermediate development phase (i.e. beyond the regeneration phase and have not yet reached the mature phase). The remaining 15% of forests are uneven-aged. Together with mature even-aged forests (ca 17%), they may serve as indicators of forests that are structurally more complex and older than ordinary managed forests under short rotation even-aged (clear cutting) forestry.

The reported areas of different age classes have remained fairly stable since 2005 (Figure 46; longer times series are lacking). Yet, the area of even-aged forests in general, but those in intermediate development phase in particular, tend to increase at the same time as the area of uneven-aged forest decrease.

[70] FAO (Food and Agriculture Organization of the United Nations) 2020. Terms and definitions. Global Forest Resources Assessment 2020.

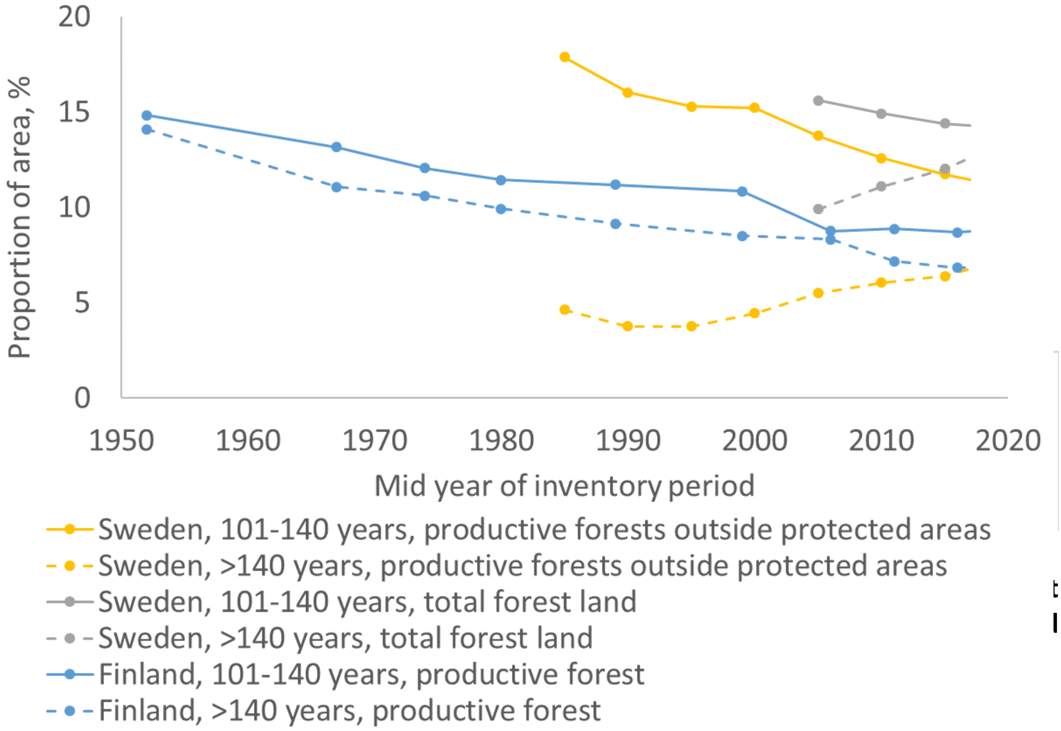


Figure 47: The area proportions of "nearly old" (101-140 years; solid lines) and "old" (>140 years; dashed lines) forests in Sweden and Finland, respectively. The proportion are calculated based on public available statistics (LUKE 2021; SLU Riksskogstaxeringen 2021) for slightly different areas of forest in each country; productive forest in Finland (since the 1950s), but productive forest outside protected areas (since the 1980s) as well total forest land (since the 2000s) in Sweden. Points indicate average estimates based on data collected during inventory periods of several years (e.g. five-year periods in Sweden).

National statistics on the area proportion of "nearly old" (101-140 years) and "old" (>140 years) forests are public available and used as national indicators in Finland[71]. There, the proportion of "old" forest has decreased since the 1980s, from approx. 10% to 7% of productive forest. The proportion of "old" forest decreased also in Sweden until the mid-1990s, but has since then increased from approx. 4% to 7% in productive forest outside protected areas.

On all forest, the proportion has increased from approx. 10% to nearly 13% in the 2000s. The proportion of Finnish "nearly old" forest has also been declining successively since the 1980s, from approx. 11% to 9% in productive forest (Figure 47). Likewise, in Sweden, the share of such forests outside protected areas have fallen from 18% to 11%. Statistics for all forest in Sweden also show a decrease for this age class, to approx. 14%.

[71] biodiversity.fi

Overall, in Finland, the proportion of forest older than 100 years has decreased slightly in the 2000s (from approx. 17% to 16%), while it has increased slightly in Sweden (from approx. 26% to 27%). However, there are significant regional differences in the proportion of forest older than 100 years, with the clearly highest proportions found in northern and mountainous (alpine) regions and low proportions in southern regions where forests have been intensively used for much long time (e.g. totally 13% >100 years of which 3% is >140 years in the boreo-nemoral and continental region Götaland of Sweden.

Both the Forest Europe (2020) indicators of mature even-aged and uneven aged forests, as well as these types of national age-class indicators, may be assumed to correlate with the area of old-growth forest and species habitats of conservation interest. Yet, they include managed forests and are defined from a forestry perspective, based on NFI sample plot data, respectively on the assessed felling (maturity) class and average tree stand age.

Further, it is unclear to what extent managed forests in different maturity and age classes develop into old-growth forest and species habitats. Thus, these indicators mainly reflect that forest landscapes tend to become more divided into managed forests dominated by young to mid-aged forest and already protected and unmanaged areas where forests are ageing and becoming old.

- **Extent and intensity of forestry**

Forestry is the dominant forest land use in all countries. The proportion of forest area and growing stock available for wood supply (hereafter forestry) is about 80% in Northern Europe. However, the reported proportion varies among countries; it is clearly lowest, ca 70%, in Sweden while it varies from about 86% (Estonia) to 98% (Denmark) among the other five countries. The proportion is about 89% when excluding Sweden, which has the largest forest area in Northern Europe.

Areas dominated by introduced (alien) tree species comprise about 1.5% of the Northern European forests. Introduced tree species are most frequently used in Denmark (44% of forests), but are also widespread in Sweden (2.1%), where particularly *Pinus contorta*-forests comprise a fairly large area (0.5 million hectare) concentrated to the country's southern to northern boreal zones[72]. Introduced tree species are use to a limited extent in Finland and the Baltic countries.

Felling as percent of net annual increment on forest area available for forestry is about 85% in Northern Europe. Yet, it also differs among countries and drops to 79% when excluding Sweden, which report a relative high felling proportion (94%) compared to other countries (67 to 83%).

- **Forest protection and forest not available for forestry**

The forest area primarily protected for biodiversity conservation purposes are indicated by the area of protected forests in MCPFE classes 1.1-1.3. It is about 6.2 million hectares, which comprises about 10% of the total forest area in Northern Europe (59.1 million hectares) and about 35% of the protected forests area in EU27 (17.8 million hectares). The proportion of protected forests in these MCPFE classes varies from ca 7.7% (Sweden) to 23% (Estonia).

[72] Ahti, T., Hämet-Ahti, L., Jalas, J. 1968. Vegetation zones and their sections in Northwestern Europe. Annales Botanica Fennici 5: 169–211

Measured in hectares, Sweden and Finland are protecting substantial areas: 2.2 and 2.8 million hectares respectively. These two countries are, together with Germany, Italy and Poland, the only EU27 members that each protect over 2 million hectares of forests (the remaining countries are protecting less than 1 million hectares). In fact, the total protected area (about 5 million hectares) in Sweden and Finland is comparable to the total land area of many individual European countries. Yet, the proportion of protected areas varies greatly within these countries.

The absolute main part of Sweden's and Finland's protected forests are located in the northernmost parts of the countries. In Sweden, for instance, more than half of the forest area in the mountain (alpine) zone is formally protected, but less than 5% is protected in most other regions[73]. Similarly, in Finland, about a quarter of all forest area is currently protected in the northern boreal zone, but less than 3% in most other regions. Hence, the protected forest area is not representatively distributed across biogeographical regions.

According to Forest Europe (2020), the area of protected forest increased during the 1990s and 2000s, but have remained fairly stable since 2010 (Figure 48). The statistics on forest *not* available for forestry may serve as an additional indicator of forest set aside from management and forestry (e.g. protected for biodiversity conservation). As mentioned above, the proportion of forest available for forestry is about 80%, which means that some 20% of the forest area (or growing stock) is not available for forestry.

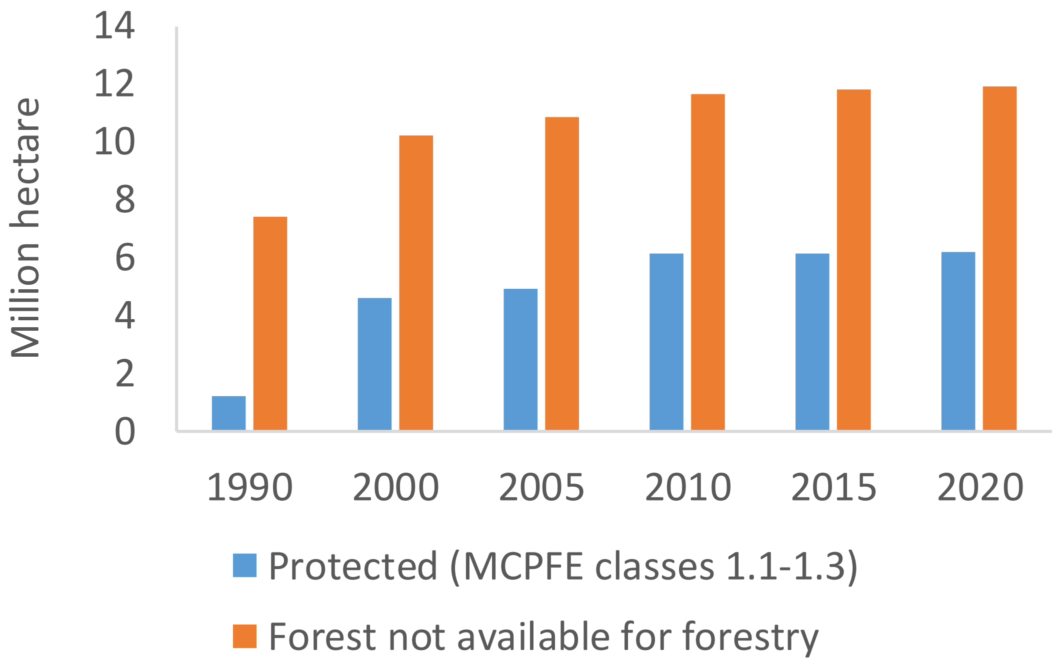


Figure 48: **The area of protected forest in MCPFE classes 1.1-1.3 and the forest area not available for wood supply, i.e. forestry, in Northern Europe (Forest Europe 2020).**

The proportion varies greatly among countries; it is clearly higher (about30%) in Sweden, while ranging from about 2% in Denmark to 14% in Estonia, among the other five countries. In fact, the bulk (71%, or 8.4 of 11.9 million hectares) is reported from Sweden. The proportion of forests not available

[73] Swedish Forest Agency. 2019. Statistik om formellt skyddad skogsmark, frivilliga avsättningar, hänsynsytor samt improduktiv skogsmark. Redovisning av regeringsuppdrag. Report 2019/18 – DNR 2018/4167. (In Swedish)

for forestry is almost halved, drops to 11%, when excluding Sweden from calculations. It then becomes comparable with the proportion of forest area protected in MCPFE classes 1.1-1.3, which is about 13% when excluding Sweden.

The differences among countries are probably related to somewhat different definitions of what types of forests that are protected and what types that are available or not available for forestry. Sweden reports a fairly low proportion of protected forests in MCPFE classes 1.1-1.3 (7.7%), but simultaneously the clearly highest proportion of forest not available for forestry (30%) among Northern European countries. One explanation is that Sweden has an extensive area (4.5 million hectares) of legally called “unproductive forest” (annual wood increment <1 m^3 per hectare), which, together with formally protected areas (National parks, natural reserves etc.; about 2.4 million hectares) and voluntarily not exploited forest areas (1.2 million hectare), as well as tree retention in forestry (about 0.45 million hectare[74]), are included in the area considered to be not available for forestry[75].

- **Dead wood**

As timber stock has increased, so has the volume of dead wood (Figure 49). The current average volume of deadwood (9 m^3 / ha) corresponds to about 7% of the average growing stock (135 m^3 / ha) in Northern Europe (Table 15).

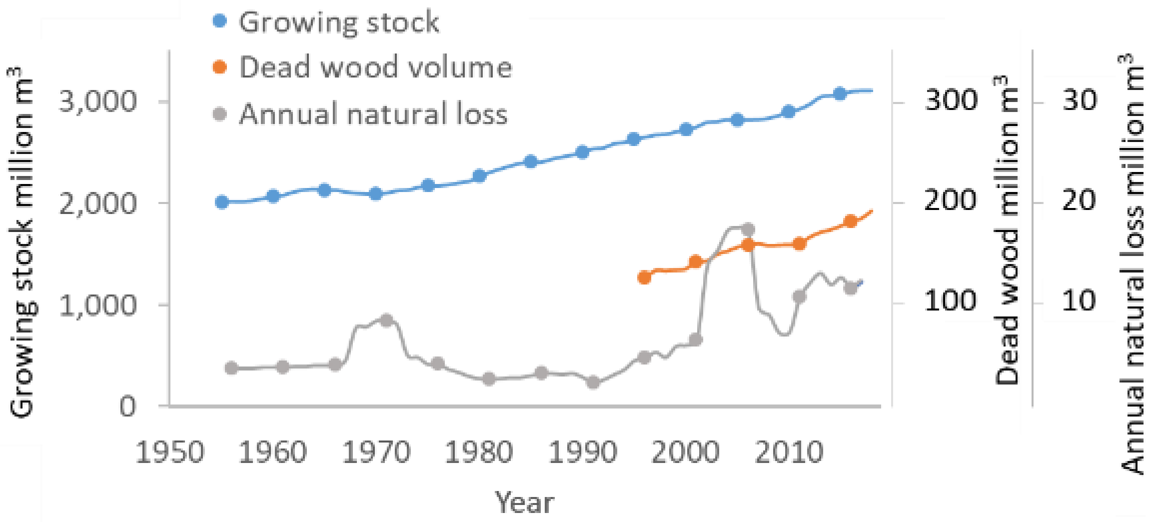


Figure 49: **Trends with increasing timber stock, annual natural loss and dead-wood volume illustrated with Sweden as an example. The variation in annual natural loss is most likely due to large losses during years with cyclones (e.g. in 2005 and 2007). The diagram is based on public available statistics on productive forest outside protected areas (SLU Riksskogstaxeringen 2021). Points indicate independent five-year averages. Lines show moving five-year averages**

[74] This area (0.45 million hectare) of tree retention is currently used in official statistics on protected forest in Sweden (Swedish Forest Agency 2019; SCB 2021). In the report by Forest Europe (2020), the area (ca 1.6 million hectare) is overestimated.

[75] Swedish Forest Agency. 2019. Statistik om formellt skyddad skogsmark, frivilliga avsättningar, hänsynsytor samt improduktiv skogsmark. Redovisning av regeringsuppdrag. Report 2019/18 – DNR 2018/4167. (In Swedish)

NFI measurements of average dead wood volumes in forest started in Sweden and Finland in the 1990s. National statistics show that volumes have increased, from low levels, and now amounts to nearly 9 m^3 / ha in Sweden. In Finland, the volume of dead wood has been approx. 6 m^3 / ha since measurements started in the 1990s.

In the Baltic countries, the volume of dead wood varies between 15 and 24 m^3 / ha. Increasing trends since the 1990s are reported from Estonia and Latvia. Denmark reports relative low average volumes; about 5 m^3 / ha.

3.4.3 *Article-17 reporting under EU's Habitats Directive for Northern Europe*

73 forest species and 20 forest habitat types are reported from Northern Europe and its 6 Member-States[76] (Table 16). 29 species, or 15% of all 73 forests species, are expected to have wood (living or dead trees) as their main habitat[77].

Table 16: Total number of species (excluding fishes) along with numbers of forest and wood-living species as well as total number of habitat types and number of forest habitat types reported from EU's terrestrial biogeographical regions (alpine, boreal, continental and atlantic) by the EU Member states in Northern Europe. Forest and wood-living species are expected to have forests and wood (living or dead trees) as their main habitat, respectively. Forest habitat types are defined according to applicable interpretation manual (DG Environment 2013)

	Species			**Habitat types**	
	Total number	**Forest species**	**Wood-living species**	**Total number**	**Forest types**
Alpine	54	21	1	44	8
Boreal	166	69	28	82	17
Continental	89	38	11	70	15
Atlantic	39	19	2	46	7
Total	**189**	**73**	**29**	**95**	**20**
Denmark	65	29	8	53	9
Sweden	154	65	26	81	16

[76] DG Environment 2013. The Interpretation Manual of European Union Habitat types - EUR28. European Commission, DG Environment, Nature ENV B.3.
[77] Halada, L., Gajdos, P., Gaudillat, Z. 2020. Proposals of the ecological grouping of the Habitats Directive habitats and species. Report version 1.0. European Environment Agency. European Topic Centre on Biological Diversity

Finland	127	56	20	63	12
Estonia	87	37	11	55	10
Latvia	98	40	15	59	12
Lithuania	84	32	12	52	13

- **Habitat types of Community interest**

The reported forest habitat types amount to approximately 11.6 million hectares, or nearly 20% of the total forest area (59 million hectare) in Denmark, Finland, Sweden, Estonia, Latvia and Lithuania. For the forest habitat types in these countries, 101 assessments of conservation status were made for the period 2012-2018. The overall impression is that the conservation status is inadequate or bad. About 7% of the assessments result in favourable conservation status, 92% of the assessments show unfavourable inadequate or unfavourable bad conservation status.

The proportion of assessments that show favourable conservation status is the highest in the Alpine region (36%), while it is only 5% in the Boreal region and 0% in both the Continental and the Atlantic region. The proportion of favourable conservation status varies between countries from 0% (Denmark and Latvia) to 20% (Estonia).

The reason why the conservation status was assessed as unfavourable inadequate or unfavourable bad is primarily due to the fact that the structures and functions (quality) are deficient (nearly 90% of all assessments); e.g. that the proportion of area in good condition is too small and/or in decline, but unfavourable inadequate or unfavourable bad conservation status may also occur because the area of the habitat types is too small (compared with the reference level) or decreases (40% of all assessments).

The trend in conservation status is more favourable; it is classified as stable or positive in almost 31% and negative for approx. 27%, but unknown for 43% of the assessments. The proportion of assessments that show a stable or positive trend is higher, 73%, in the Alpine region, while it is 29%, 24% and 0% in the Boreal, Continental and Atlantic region, respectively. Among the countries, the proportion with a stable or positive trend varies from ca 8% (Lithuania) to 52% (Finland). The results for forest habitat types are summarized in Table 17 and Figure 50**.**

Table 17: **Codes, names and area (km2) of the forest habitat types included in EU Habitats Directive and reported from EU's terrestrial biogeographical regions, alpine, boreal, continental and atlantic, in Northern Europe (Denmark, Sweden, Finland, Estonia, Latvia and Lithuania). Colors indicate habitats with favorable (green), inadequate (yellow) or bad (red) conservation status (nature-art17.eionet.europa.eu)**

Name	Finland	Sweden	Finland	Sweden	Estonia	Latvia	Lithuania	Denmark	Sweden	Denmark	Total
9010 - Western Taig	990	7,400	12,000	14,000	700	623	572		30		**36,315**
9020 - Fennoscandi			8	60	71	128	163		10		**440**
9030 - Natural fores			180	170							**350**
9040 - Nordic subal	3,320	15,000	1,280								**19,600**
9050 - Fennoscandi	9	650	2,550	750	89	115	301				**4,464**
9060 - Coniferous fo	-		7,000	60	32	16	8				**7,116**
9070 - Fennoscandi		33	34	650	30	2.015	4.38		65		**818**
9080 - Fennoscandi	-		-	230	375	237	520		60		**1,422**
9110 - Luzulo-Faget				20				176	50	2	**247**
9120 - Atlantic acido								32		3	**35**
9130 - Asperulo-Fag				10				378	40	2	**430**
9150 - Medio-Europ								7			**7**
9160 - Sub-Atlantic				120		36	147	90	30	10	**434**
9170 - Galio-Carpin								1			**1**
9180 - Tilio-Acerion			0.3	20	5	61	86		1.4		**173**
9190 - Old acidophi			0.6	40			3	31	20	13	**107**
91D0 - Bog woodlar	170	2,000	19,000	20,000	470	901	501	45	150	8	**43,245**
91E0 - Alluvial fores	2	10	10	40	38	105	287	185	10	8	**694**
91F0 - Riparian mixed forest of Querc				8	7	5	3		0.4		**24**
91T0 - Central Euro						25.405	71.86				**97**
Total	**4,491**	**25,093**	**42,063**	**36,178**	**1,817**	**2,254**	**2,666**	**944**	**467**	**46**	**116,019**

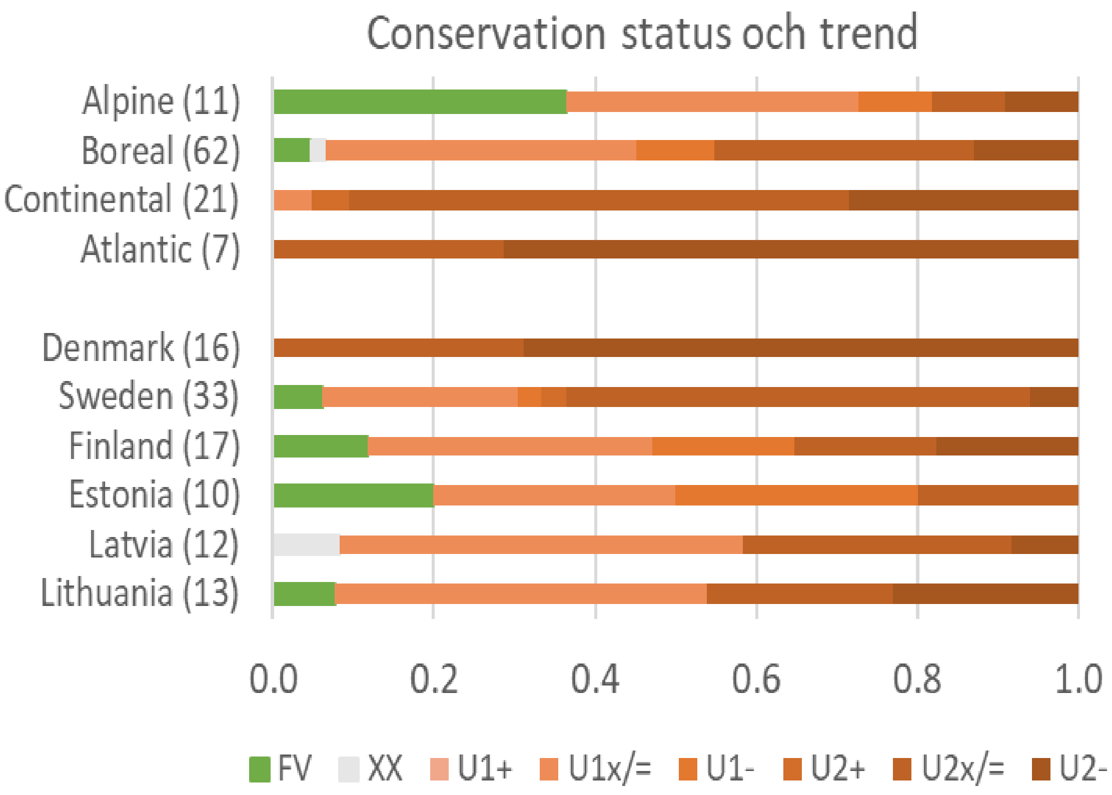


Figure 50: **Number of assessments of conservation status and trend for forest habitat types in different biogeographical regions and countries in Northern Europe. The number of assessments is given in parentheses. Colors indicate different results on conservation status and trend: FV favorable, XX unknown, U1+ inadequate, positive trend, U1x / = inadequate, unknown / stable trend, U1- inadequate, negative trend, U2+ bad, positive trend, U2x / = bad, unknown / stable trend, U2-**

- **Species of Community interest**

A total of 326 conservation status assessments have been carried out for these species. The results show a more favourable conservation status than for habitat types. Nearly 44% of the assessments show favourable conservation status, while 46% show unfavourable inadequate or unfavourable bad conservation status. The highest proportion of favourable conservation is found in the Alpine region (77%), while this proportion fall to 43%, 44% and 21% in the Boreal, Continental and Atlantic region, respectively. The proportion of favourable conservation status assessments varies from 23% in Denmark to 60% in Estonia.

The reasons why the conservation status is classified as unfavourable inadequate or unfavourable bad are primarily due to the species' populations being too small (compared with the reference level) and/or declining (about 46% of all assessments), but also because the quantity of suitable habitat is too small and/or declining (33% of all assessments) as well as because the range is too small and/or declining (22% of all assessments).

The trend in conservation status is also more favourable for species than habitat types; stable or positive trends are reported for 61% of all assessments, negative in about 18% of them and as unknown for 22%. The proportion of assessments that indicate a stable or positive trend is highest in the Alpine region (90%), and is around 62%, 53% and 37% in the Boreal, Continental and Atlantic region. Among countries, the proportion with a stable or positive trend varies from 37% in Denmark to 78% in Estonia.

The proportion of species having unfavourable inadequate or unfavourable bad conservation status is higher among wood-living species than among forest species as a group (Figure 51). About 22% of the assessments show favorable conservation status, while 64% show unfavourable inadequate or unfavourable bad conservation status. The trend in conservation status is also less favorable among the subgroup of wood-living species. It is classified as stable or positive for 42% (compared to 61% for forest species), negative for 24% and as unknown in 34% of the assessments. The results for forest-dwelling species are summarized in Figure 51.

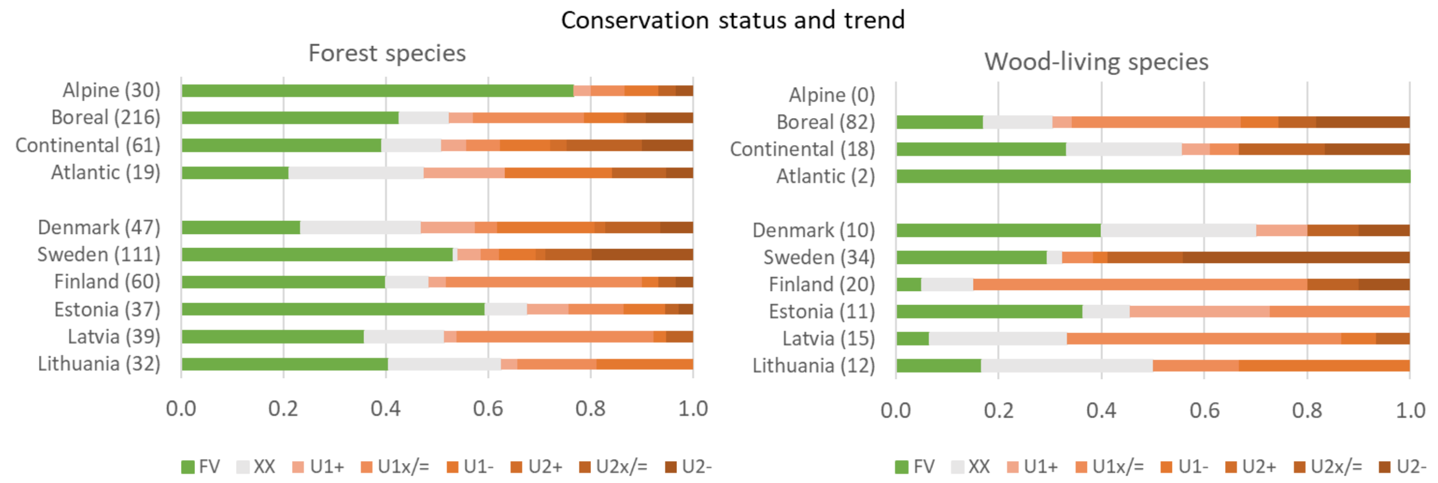


Figure 51: Number of assessments of conservation status and trend for forest species in general (left diagram) and wood-living species (right diagram) in different biogeographic regions and countries in Northern Europe. The number of assessments is given in parentheses. Colors indicate different results on conservation status and trend: FV favorable, XX unknown, U1+ inadequate, positive trend, U1x / = inadequate, unknown / stable trend, U1- inadequate, negative trend, U2+ bad, positive trend, U2x / = bad, unknown / stable trend, U2- bad, negative trend

- **Pressures**

Forestry is the most often reported high-ranked pressure (approximately 41% of all reported types) (Figure 52). Impact from natural processes, such as succession due to lack of disturbance from forest fires, grazing or floods is another high-ranked pressure that is frequently reported (approx. 13%). In several cases, influences from natural processes are related to other types of pressures that are also reported relatively often: energy production (11%), agriculture (7%) and changes in hydrology (5%).

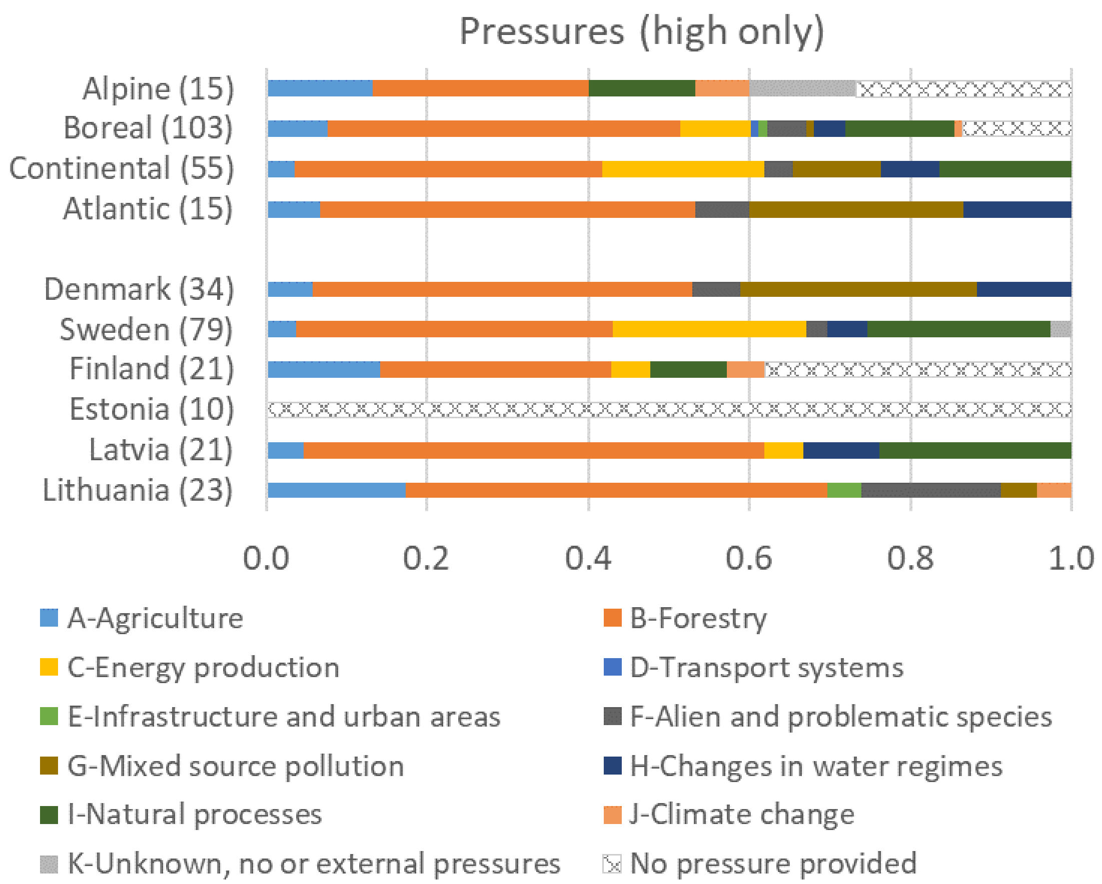


Figure 52: **Proportion of reported pressures on forest habitat types in different regions and countries. Numbers in parentheses indicate the number of assessments for each region and country, respectively.**

3.4.4 *National Red lists using IUCN methodologies in Northern Europe countries*

- **Red list of threatened species**

Forest Europe reported a large number of threatened forest species classified according to the IUCN Red List categories, for different organism groups (Table 18). Nearly 1,000 threatened forest species were reported from Denmark, Sweden and Finland.

The majority of threatened forest species in these countries include invertebrates and various cryptogams including fungi (Table 18). In all countries, various activities related to forestry, but also the lack of natural disturbances such as forest fire, flooding, etc. and traditional forest grazing are emphasized as the most important reason for the species to become threatened.

Table 18: **Numbers of threatened forest species (vulnerable, endangered or critically endangered) per country and their distribution in percent across organism groups (according to numbers reported by Forest Europe 2020). In parenthesis, the year(s) in which respective Red Lists were confirmed or published. Information is missing for Lithuania**

Country	Total number	Birds	Mammals	Other vertebrates	Invertebrates	Vascular plants including tree species	Cryptogams and fungi
Denmark (2010)	881	0.7%	0.8%	0%	29%	3.3%	66%
Sweden (2015)	919	1.6%	1.3%	0.3%	33%	6.2%	58%
Finland (2010, 2015)	1053	2.1%	0.5%	0.2%	50%	4.6%	43%
Estonia (-)	93	12%	1.1%	1.1%	5.4%	42%	39%
Latvia (-)	183	10%	4.9%	1.1%	25%	43%	15%

Threatened forest species make up for about 30 to 45% of the total number of threatened species on the red lists, in each country[78] [79] [80]. Smaller numbers of threatened forest species are reported from Estonia and Latvia. However, Estonia reported only the legally protected species, although about 1,000 forest species are considered to be qualified for the national Red List. Latvia also refer to legislation, in relation to the threatened species numbers reported to Forest Europe. Denmark, Sweden and Finland have all published new Red Lists, but those new red lists do not provide numbers of forest-living species in different organism groups. Therefore, we stick to the numbers reported by Forest Europe in 2020, which is based on previous Red Lists.

- **Red lists of habitats & ecosystems**

Finland is the only EU member state in Northern Europe that presents a national red list of habitat types, made according to the IUCN Red list of Ecosystems methodology[81]. Among the 34 forest habitat types assessed at national level, 76% are assessed as threatened, 21% as near threatened and 3% as

[78] Hyvärinen, E., Juslén, A., Kemppainen, E., Uddström, A. & Liukko, U.-M. (eds.) 2019. The 2019 Red List of Finnish Species. Ympäristöministeriö & Suomen ympäristökeskus. Helsinki

[79] Eide, W., Ahrné, K., Bjelke, B., Nordström, S., Ottosson, E., Sandström, J. & Sundberg, S. (red.) 2020. Tillstånd och trender för arter och deras livsmiljöer – rödlistade arter i Sverige 2020. SLU Artdatabanken rapporterar 24. SLU Artdatabanken, Uppsala.

[80] Moeslund, J.E., Nygaard, B., Ejrnæs, R., Bell, N., Bruun, L.D., Bygebjerg, R., Carl, H., Damgaard, J., Dylmer, E., Elmeros, M., Flensted, K., Fog, K., Goldberg, I., Gønget, H., Helsing, F., Holmen, M., Jørum, P., Lissner, J., Læssøe, T., Madsen, H.B., Misser, J., Møller, P.R., Nielsen, O.F., Olsen, K., Sterup, J., Søchting, U., Wiberg-Larsen, P. og Wind, P. 2019. Den danske Rødliste. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi. www.redlist.au.dk.

[81] Kontula, T. and Raunio, A. (eds.) 2019. Threatened habitat types in Finland 2018. Red List of habitats – Results and basis for assessment. Finnish Environment Institute and Ministry of the Environment, Helsinki. The Finnish Environment 2/2019.

data deficient. The share of habitat types assessed as threatened is much higher in southern (79%) than in northern (56%) Finland. Habitat types are red-listed mainly due to a reduction in coarse deadwood, reduction in old-growth forests and individual old trees as well as changes in tree species composition.

3.4.5 *Discussion*

Forest Europe report comprehensive statistics on a very large number of internationally agreed Criteria and Indicators for the European forests and their management at national scale. For instance, the main annex of their report comprises statistics on some 60 different quantitative and qualitative indicators, of which many are covering specifically forest biodiversity. Together with additional data from the several countries that published forest inventory and monitoring programs, i.e. NFIs, which can provide additional statistics on forest conditions at national scale, the compilation of national Red Lists of species (as well as of Red List of habitat types for Finland), and the reporting data on the conservation status of species and habitat types under the EU Habitats Directive, these various sources of information form a well-developed basis for assessing the forest conditions in Northern Europe, as follow.

The main part of forest in Northern Europe is characterized by a very long history of intensive human land use and rational forest management during the 20th century. Hence, the ecological conditions of forests have been significantly altered compared to reference conditions of natural, unmanaged forests. For instance, according to Forest Europe indicators, the average share of forest undisturbed by man ("primary forests" *sensu* FAO 2020's definition) is very low (4%) in Northern Europe. Swedish and Finnish statistics also show that both protected forest and old forest (average stand age >140 years) are disproportionately, and thereby not representatively distributed across Northern Europe. Clearly, the largest areas and highest proportions of primary and old-growth forests are found in northern and mountainous (alpine) regions, which have the shortest and least intensive forest-use history. In fact, the few intact forest landscapes and wilderness areas of Northern Europe are found along the Scandinavian mountain range as well as the Finnish-Russian border.

In contrast, the lowest proportion of primary and old-growth forests are found in southern regions, where forests have been intensively used and managed for a very long time. Research also show that old forests with long tree continuity are being clear cut, and that the remaining old forest are becoming increasingly fragmented[82]. Hence, analyses show that most of the current landscapes comprise insufficient habitat networks and functional connectivity to maintain forest-dwelling species, that cannot cope with intensive forest management [83].

Still, some general indicators reported by Forest Europe and NFIs indicate that the forest conditions in Northern Europe is somehow improving. For instance, the overall growing stock, including the numbers of medium-coarse to coarse trees, as well as growing stocks of broadleaved (deciduous) tree species, are increasing. The average volume of dead wood is also increasing in most countries, even if it started from very low levels since the 1990s. Nationally, the area of old forest (average stand age >140 years) is increasing in Sweden. Likewise, NFI statistics reveal an increase of forests dominated by

[82] Svensson, J., Andersson, J., Sandström, P., Mikusinski, G., Jonsson, B-G. 2018. Landscape trajectory of natural boreal forest loss as an impediment to green infrastructure. Conservation Biology 33, 152–163.
[83] Angelstam, P., Manton, M., Green, M., Jonsson, B.G., Mikusinski, G., Svensson, J., Sabatini, F.M. 2020. Sweden does not meet agreed national and international forest biodiversity targets: A call for adaptive landscape planning. Landscape and Urban Planning 202: 103838.

temperate broadleaved tree species (*Q. robur*, *Fagus sylvatica*, etc.) in southern Sweden[84] and Forest Europe indicators show that northern European forests are generally modestly affected by air pollution and nitrogen deposition (indicators not described in detail here).

Yet, some deviating trends are also visible among some general forest indicators. For instance, the dead-wood volume remains low and the area of old forest declines in Finland. Furthermore, the current average levels of dead-wood volume and old natural forests represents about one tenth of what is expected to characterize Northern Europe's forests under natural conditions[85] [86] [87].

Another example is that the coverage of blueberry (*Vaccinum myrtillus* L.), reindeer lichens (*Cladonia* spp.) and a number of other common and functionally important field- and bottom-layer species is declining as the growing stock is increasing, because forests are getting denser, especially in Sweden. Likewise, NFI statistics indicate that some specific forests types, such as swamp forests and reindeer-lichen rich Scots pine forests, are declining in Sweden since the 1990s (statistics not described in detail).

The relevance of the observed increases of some indicators; for instance, growing stocks and dead wood volumes, for forest biodiversity is also to some extent ambiguous. One obvious shortcoming of the national indicators reported by Forest Europe and NFIs is that they are too unspecific. They represent fairly general phenomena and characteristics (e.g. total forest area) with coarse spatial resolution (national scale). Their information value is therefore quite limited with regard to the status and trends of biodiversity aspects of conservation interest, such as species and forest habitat types with specific ecological requirements and/or restricted biogeographical distribution ranges.

For instance, some species are restricted to some specific substrates (giant hollow oak trees, charred and fire-scarred dead wood, etc.) mainly found in certain habitats (old, dead-wood rich broadleaved forests, fire areas and successions, etc.). Or, those are found in some part of a country which cannot be monitored, based on the type of broad, general indicators reviewed here. Another problem is that reporting countries probably make somewhat different interpretations of how certain indicators are to be defined and quantified. This inconsistency complicates comparisons of indicators' status and trend between countries.

The fact that countries interpret various aspects in slightly different ways also affects the conservation assessments made for the reporting under EU Habitats Directives, as well as the national Red Lists. Yet, the assessments are more specific as they are based on the best available information about the respective species and habitat types concerned, and use a common assessment methodology. Thus, when the assessments from several countries are weighed together, they provide comprehensive and relevant information on important biodiversity aspects and their needs of conservation measures.

---

[84] Skogsdata 2014. Aktuella uppgifter om de svenska skogarna från SLU Riksskogstaxeringen. Sveriges lantbruksuniversitet (In Swedish with English table and figure legends).

[85] Siitonen, J., 2001. Forest management, coarse woody debris and saproxylic organisms: Fennoscandian boreal forests as an example. Ecological Bullitins 49: 11–41.

[86] Ranius, T., Kruys, N., Jonsson, B.G., 2004. Estimation of woody debris quantity in European natural boreal forests – a modeling approach. Canadian Journal of Forest Research 34: 1025–1034.

[87] Berglund, H. and Kuuluvainen, T. 2021. Representative boreal forest habitats in northern Europe, and a revised model for ecosystem management and biodiversity conservation. Ambio 50: 1003–1017.

The Red Lists show that many forest species and habitat types are threatened under the prevailing forest conditions. For instance, about 1,000 forest species are threatened in each of the respective countries Denmark, Sweden and Finland. It implies that 30 to 45% of the total number of threatened species in each country are using forests as their habitat[88 89 90]. Various activities related to forestry, but also the lack of natural disturbances such as forest fire, flooding, etc. and traditional forest grazing are emphasized as the most important reason for the species' becoming threatened. Thus, to improve the situation, measures are needed to protect, manage and restore habitats of red-listed species.

Likewise, the reporting under EU’s Nature Directives show that forest habitat types, as well as a wide range of forest-dwelling species, are under pressure and have an inadequate or bad conservation status. A general feature is that the proportion of assessments with favourable conservation status for habitat types is low (about 7%), while the proportion of assessments with favourable conservation status for forest-dwelling species is significantly higher (44%). One possible explanation is that habitat types include specific and natural forest environments whose status is negatively affected by past and current pressures from intensive human land use, while the group of forest-dwelling species includes several species that are adapted and subsist in today's managed landscapes.

However, the proportion of species having favourable conservation status is lower (22%) among wood-living species than among the overall forest species as a group. The pattern of more favourable conservation status among forest species than among wood-living species is likely explained by the composition of species within each group. Among the forest species, there are generalist species that can live in different types of forest environments. Hence, they may be well adapted to survive in current managed landscapes. The wood-dwelling species, however, are by definition restricted to substrates and habitats linked to living and dead trees. Some are clearly specialized and require certain qualities of living or dead trees that develops only in naturally dynamic forests, but are rare and/or decreasing in today´s landscapes (giant hollow oak trees, forest fire areas, etc.).

For both habitat types and species, the proportion of assessments that indicate a favourable conservation status as well as a stable or positive trend is highest in the Alpine region, and is gradually decreasing in the Boreal, Continental and Atlantic region. Again, such results are expected due to the regional gradients in land-use history and a disproportionate distribution of, for instance, protected forests as well as old and natural forests in Northern Europe.

The impact from forestry as well as the lack of natural disturbances due to various other pressures (fire suppression, river regulation, etc.) are most often considered as important reasons to why the conservation status is bad. To improve the conservation status, measures are needed to counteract pressures and create suitable conditions for species as well habitat types.

---

[88] Hyvärinen, E., Juslén, A., Kemppainen, E., Uddström, A. & Liukko, U.-M. (eds.) 2019. The 2019 Red List of Finnish Species. Ympäristöministeriö & Suomen ympäristökeskus. Helsinki.

[89] Eide, W., Ahrné, K., Bjelke, B., Nordström, S., Ottosson, E., Sandström, J. & Sundberg, S. (red.) 2020. Tillstånd och trender för arter och deras livsmiljöer – rödlistade arter i Sverige 2020. SLU Artdatabanken rapporterar 24. SLU Artdatabanken, Uppsala.

[90] Moeslund, J.E., Nygaard, B., Ejrnæs, R., Bell, N., Bruun, L.D., Bygebjerg, R., Carl, H., Damgaard, J., Dylmer, E., Elmeros, M., Flensted, K., Fog, K., Goldberg, I., Gønget, H., Helsing, F., Holmen, M., Jørum, P., Lissner, J., Læssøe, T., Madsen, H.B., Misser, J., Møller, P.R., Nielsen, O.F., Olsen, K., Sterup, J., Søchting, U., Wiberg-Larsen, P. og Wind, P. 2019. Den danske Rødliste. Aarhus Universitet, DCE – Nationalt Center for Miljø og Energi. www.redlist.au.dk.

In summary, different aspects of forest conditions are monitored by the type of general indicators reported by Forest Europe, on one side, and the conservation assessments made for Red Lists and the Article-17 reporting under the EU Habitats Directive on the other side. The general forest indicators provide information about forest conditions in broad sense. Some changes since the 1990s are positive from a biodiversity perspective, such as the general increase in timber stocks, including the amount of medium-coarse to coarse trees and dead wood, as well as shares of broadleaved trees and forest. Still, increases occur from low levels and deviating, less positive trends are also found among some indicators reviewed.

By contrast, the conservation assessments made for Red Lists and the Article-17 reporting are more specific as they are based on relevant information about the individual biodiversity aspects concerned. The assessments involve considering a range of important variables; for instance, the distribution, population size and habitat of species and the area, structure and functions of habitat types, in order to systematically determine the conservation status. Overall, the assessments show that a large share of the species and habitat types assessed are far from being in a favorable conservation status. Thus, the conservation assessments highlight the need of conservation actions at biogeographic scale in different countries, which are not revealed by general forest indicators.

4 Forest restoration potential and progress

Biodiversity provides important ecosystem services, such as pollination (e.g. by bats, birds and insects), decomposition (e.g. by soil arthropods, fungi and micro-organisms), seed dispersal (e.g. by insects, birds, mammals and fish), resilience and disease reduction[91]. But biodiversity is being lost and ecosystems are degrading at an alarming rate. Pressures on biodiversity are increasing at a faster rate than the efforts to protect it[92].

4.1 Addressing forest degradation through restoration initiatives

4.1.1 *Defining forest degradation and deforestation*

The FAO defines forest degradation as *"changes within the forest which negatively affect the structure or function of the stand or site, and thereby lower the capacity to supply products and/or services".* It is assumed to be indicated by the reduction of canopy cover and/or stocking of the forest through logging, fire, wind-felling or other events, provided that the canopy cover stays above 10%. Forest degradation is the long-term reduction of the overall supply of benefits from forest, which includes wood, biodiversity and other products or service. Forest degradation can therefore be considered as both a state and a process.

Deforestation is, on its side, defined as *"the conversion of forest to another land use or the long-term reduction of the tree canopy cover below the minimum 10 percent threshold*", and implies the long-term or permanent loss of forest cover, and the transformation into another land use. Deforestation can only be caused and maintained by a continued human-induced or natural perturbation. Degradation can be, but is not necessarily, a precursor to deforestation. Forests may indeed remain degraded for a long time but never become completely deforested (forest cover <10%). Deforestation and forest degradation are major causes of biodiversity loss and can significantly reduce the productivity of the natural assets, upon which the well-being of humanity relies.

There are multiple ways to measure and describe forest degradation worldwide, using two opposite data collection methods: remote sensing data and ground-based indicators (Figure 53).

[91] FAO, 2011 Assessing forest degradation. Towards the development of globally applicable guidelines, Rome.109p.
[92] IPBES, 2019. Global Assessment Report on Biodiversity and Ecosystem Services

Data collection method	Indicator	Measurement method	Relevant case studies or data source	Scale of measurement
Remote sensing	Ecosystem state (resilience)	Satellite or aerial photographs: expected forest type for climate elevation, soil and moisture condition	Surrounding area, protected areas, etc.	Stand or landscape
	Fragmentation/ intactness and road density	Satellite or aerial photos: area deforested, roads per km^2	United Nations Environment Programme-World Conservation Monitoring Centre, World Resources Institute	Landscape
	Ecosystem diversity	Satellite or aerial photography: extent of each ecosystem type	National forest inventories	Landscape (stand)
Ground-based (species-based) indicators	Expected community composition by forest tree species for the ecosystem type	Ground plots: species composition	Individual research, government survey, expert opinion, IUCN red list of threatened species	Stand and landscape
	Key indicator species, including threatened species, old-growth forest species, and hunted species*	Surveys for change in population size (relative or absolute)	IUCN red list of threatened species, local data on populations, expert opinion	Stand, landscape
	Invasive alien species	Remote sensing or ground-based surveys: area of forest affected	Local data	Stand, landscape
	Functional species	Surveys for change in population size, surveys for expected function products (e.g. fruit production)	Local data	Stand

Figure 53: Possible biodiversity indicators of forest degradation

4.1.2 *The Forest Landscape restoration principles*

The Forest landscape restoration (FLR) is the ongoing process of regaining ecological functionality and enhancing human well-being across deforested or degraded forest landscapes, supported by IUCN[93]. FLR is about restoring the landscape as a whole, as to meet present and future needs and offer multiple benefits and land uses over time. FLR aims at helping expand the world's stock of agricultural, agroforestry and forested land, by integrating both the improvement of food security and climate change mitigation and adaptation. Indeed, the urgent need for better food and water security and more secure livelihoods among forest communities, and the growing demand for forest products and bioenergy, underscore the need to massively scale-up current restoration efforts. And meeting these needs while also increasing carbon stocks, improving adaptive capacity and addressing the decline in biodiversity, cannot be achieved solely by efforts to tackle deforestation.

93 https://infoflr.org/what-flr

Restoration based on FLR principles can help take the pressure off existing forest land, provide alternative sources of forest products, improve soil fertility and reduce erosion, and generally contribute to carbon-intensive land stewardship. It complements other approaches, including climate-smart agriculture and REDD+ (Reducing Emissions from Deforestation and Forest Degradation). Forest landscape restoration can take many forms, such as new tree plantings, managed natural regeneration, agroforestry, or improved land management to accommodate a mosaic of land uses, including agriculture. Those initiatives are typically categorised in three ways, each incorporating different types of restoration:

- Forest land: This is land where forests are or are meant to become the dominant land feature. It can include both protected and productive forests. If the land is without trees, it can be restored either through planting or natural regeneration. Degraded forests can be restored through rehabilitation and silvicultural treatments.
- Agricultural land: This is land that is being managed to produce food. If the land is under permanent management, it can be restored through agroforestry. If it is under intermittent management, it can be restored through improved fallow.
- Protective lands and buffers: This is land that is either susceptible to, or critical in safeguarding against, climatic or other events. While the land may be used for agricultural or forest production it also has a very special value in safeguarding lives, property and ecosystem services. It is typically – but not always – closely associated with marine and freshwater ecosystems. FLR interventions can involve mangrove restoration or watershed protection and erosion control, protected wildlife reserves, managed plantations, riverside plantings and more.

4.1.3 *Distinct levels of restoration intensity*

Forest restoration can have a variety of objectives, relating to reversing land degradation or loss of productivity of ecosystem goods and services such as food, biodiversity and water. The intensity for the restoration measures will also depend on the level of degradation of the ecosystem (Figure 54).

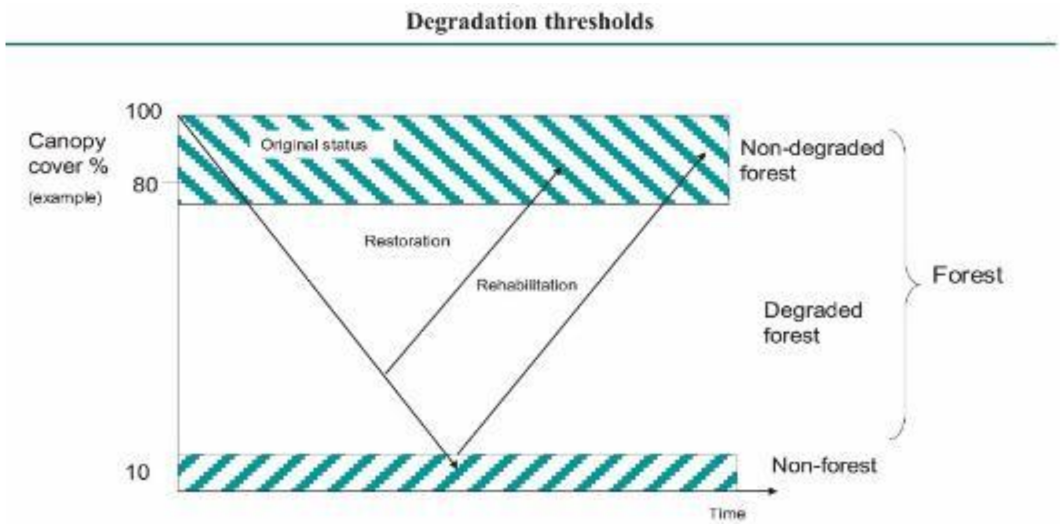


Figure 54: Degradation threasholds for restoration activities

Restoration activities therefore vary from [94]:

a) Rehabilitation: an action to restore specific desired species, structures or processes within an existing ecosystem;

b) Reconstruction: an action to restore native plants and structures within areas that are used for other purposes;

c) Reclamation: the restoration of severely degraded land devoid of vegetation; to

d) Replacement: the most radical form of restoration, in which species or provenances maladapted for a given location and unable to migrate are replaced with new vegetation, as climates change rapidly.

Following the concepts and definitions of FAO and WOCAT[95], these restoration activities can be subdivided into prevention, mitigation and rehabilitation:

✓ Prevention implies the use of conservation measures that maintain natural resources and their environmental and productive properties;

✓ Mitigation stands for intervention intended to reduce ongoing degradation;

✓ Rehabilitation is required when the land is already degraded to such an extent that the original use is no longer possible and the land has become practically unproductive.

Agroforestry: a specific approach for forest restoration

Agroforestry is one of a wide range approaches for restoring degraded forests and agricultural lands in which forests and trees are combined with other land uses, thereby contributing to landscape restoration. The area of land potentially available for landscape restoration has been estimated at 2.2 billion hectares, of which 1.5 billion hectares are best suited to mosaic restoration. Agroforestry systems have the potential to restore degraded lands, support livelihoods, improve food and nutrition security and reduce poverty, but constraints limit the adoption of these land-use systems in landscape restoration initiatives.

Agroforestry is part of traditional land use systems across Europe, which often have high nature and cultural values. Such systems are unique as land management practices that simultaneously offer biophysical, ecological and socio-economic services, including climate-smart solutions. Traditional examples include systems in which trees are integrated into arable systems on the field boundaries (e.g. windbreaks, hedgerows) and where intercropping and grazing is combined with high-value tree crops such as olives and apples. Contemporary agroforestry is however not so widespread in Europe[96].

[94] Stanturf, J.A., Palik, B.J., Dumroese, R.K., 2014. Contemporary forest restoration: A review emphasizing function. Forest Ecology and Management 331, p. 292–323

[95] Hillbrand A., Borelli S., Conigliaro M., Olivier A., Agroforestry for landscape restoration. Exploring the potential of agroforestry to enhance the sustainability and resilience of degraded landscapes. Food and Agriculture Organization of the United Nations Rome, 2017, 28p.

[96] EEA, 2021. Nature-based solutions in Europe: Policy, knowledge and practice for climate change adaptation and disaster risk reduction, 159p. doi: 10.2800/919315

4.2 *Challenges of implementing forest restoration initiative*

The SDG report indicates that 20 percent of the Earth's surface was in a degraded state, between 2000 and 2015[97], while the Global Partnership on Forest Landscape Restoration[98] suggested that more than one billion hectares of deforested and degraded forest land worldwide are suitable and available for restoration. The FAO report[99] also presents the large-scale forest restoration as the one of the most important approaches to prevent, halt and reverse the loss of biodiversity. A comprehensive scientific assessment of land degradation and restoration potential was also delivered by the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES) in 2018[100].

In the meantime, 61 countries have, together, pledged to restore 170 million hectares of degraded forest lands under the Bonn Challenge since 2011. Still, progress to date is slow. The United Nations Decade on Ecosystem Restoration 2021–2030[101], announced in March 2019, aims to accelerate ecosystem restoration action worldwide. Forest restoration, when implemented appropriately, helps restore habitats and ecosystems, create jobs and income and is an effective nature-based solution able to meet many societal challenges, including climate change adaptation and mitigation[102].

4.2.1 *Global commitments for restoring forest ecosystems*

Dozens of national governments have already made commitments for forest and other ecosystem restoration as part of global and regional initiatives, including the New York Declaration on Forests, the Bonn Challenge, Initiative 20x20, AFR100, or ECCA30. Below are some of the most important strategic documents in which the forest restoration has been included:

- **The Bonn Challenge (2011)**

The Bonn Challenge, launched in 2011 by IUCN and the Federal German Ministry for the Environment, aims at restoring 150 million hectares of degraded landscapes and forest by 2020[103], and significantly increase the rate of global restoration thereafter which would restore at least an additional 350 million hectares by 2030.

Underlying the Bonn Challenge is the "Forest Landscape Restoration" approach[104], which aims to restore ecological integrity while improving human well-being through multifunctional landscapes. Since its launch in 2011, 61 nations, 8 states and 5 associations have taken up the Bonn Challenge –

[97] UN. 2019. The Sustainable Development Goals Report 2019. New York, USA.64p.
[98] https://www.forestlandscaperestoration.org/
[99] FAO and UNEP, 2020. The State of the World's Forests 2020. Forests, biodiversity and people. Rome. 214p. https://doi.org/10.4060/ca8642en
[100] IPBES, 2018. Summary for policymakers of the assessment report on land degradation and restoration of the Intergovernmental Science Policy Platform on Biodiversity and Ecosystem Services. R. Scholes, L. Montanarella, A. Brainich, N. Barger, B. ten Brink, M. Cantele, B. Erasmus, J. Fisher, T. Gardner, T. G. Holland, F. Kohler, J. S. Kotiaho, G. Von Maltitz, G. Nangendo, R. Pandit, J. Parrotta, M. D. Potts, S. Prince, M. Sankaran and L. Willemen (eds.). IPBES secretariat, Bonn, Germany. 44p.
[101] https://www.decadeonrestoration.org/
[102] Mansourian, S. and Parrotta, J., 2018. Forest Landscape Restoration: Integrated approaches to support effective implementation. Earthscan Forest Library, Routledge. 266p.
[103] https://www.bonnchallenge.org/
[104] https://infoflr.org/what-flr

committing more than 210 million hectares to the world's largest forest landscape restoration (FLR) initiative and forging ahead with restoration planning and implementation.

For the 2020-2030 period, the Bonn Challenge is promoted to be a considerable mean for countries to strengthen most of their international commitments, and especially their Nationally Determined Contributions (NDCs, efforts by countries to reduce national emissions and adapt to the impacts of climate change under the United Nations Framework Convention on Climate Change), their post-2020 Biodiversity plans and their Land Degradation Neutrality targets (LDNs, targets and measures by countries to stabilise or increase the amount and quality of land resources necessary to support ecosystem functions and services and enhance food security under the United Nations Convention to Combat Desertification).

Building on the region's first high-level roundtable meeting in 2018, Europe, the Caucasus and Central Asia launched the ECCA30 initiative in 2019. Aiming to serve as a regional initiative to secure additional commitments and accelerate the implementation of the Bonn Challenge, its objective is to bring 30 million hectares of degraded and deforested land into restoration by 2030. ECCA30 aims to accelerate progress on national goals and priorities, attract domestic, regional and global funding, provide access to technical support, and facilitate regional and international learning exchanges.

- **The New York Declaration on Forests (NYDF, 2014)**

Launched during the Climate Summit in 2014, the New York declaration on Forests[105] commits its signatories to achieving 10 goals, including halting natural forest loss by 2030, restoring 350 million hectares of degraded landscapes and forestlands, improving governance, increasing forest finance, and reducing emissions from deforestation and forest degradation as part of a post-2020 global climate agreement. There are currently over 200 endorsers of this declaration: national governments, sub-national governments, multi-national companies, Indigenous Peoples and local community organizations, non-government organizations, and financial institutions.

The NYDF is supported by two initiatives: The NYDF Global Platform, and the NYDF Progress Assessment led by a coalition of 28 research organizations and civil society groups, which releases an in-depth report looking at progress on a selected goal (or set of goals) and a brief updates on all ten of the goals every year.

- **The Convention on Biological Diversity (CBD, 2011-2020)**

Restoration was already a key part of the CBD's Strategic Plan for Biodiversity for the 2011-2020 period and the Aichi Targets:

- Aichi Biodiversity Target 5: by 2020, the rate of loss of all natural habitats, including forests, is at least halved and where feasible brought close to zero, and degradation and fragmentation is significantly reduced;
- Aichi Biodiversity Target 15: By 2020, ecosystem resilience and the contribution of biodiversity to carbon stocks has been enhanced, through conservation and restoration, including restoration of at least 15 percent of degraded ecosystems, thereby contributing to climate change mitigation and adaptation and to combating desertification.

[105] https://forestdeclaration.org/

- Forest landscape restoration was also recognized as a mean by which to achieve Aichi Targets 5, 7, 11, 13 and 15;

It is now through to the Sustainable Development Goals (SDGs), to be achieved by the year 2030, and the future post-2020 Strategic Plan for Biodiversity, that forest restoration will be carried out.

- **The United Nations Strategic Plan for Forests (UN SPF, 2017-2030)**

The agreement on the first-ever UN Strategic Plan for Forests was defined during a special session of the UN Forum on Forests, held in January. Adopted by the UN Economic and Social Council on 20 April 2017 and subsequently adopted by the UN General Assembly on 27 April 2017, it provides an ambitious vision for global forests in 2030. This Strategic Plan features a set of six Global Forest Goals and a subset of 26 associated targets to be reached by 2030, which are voluntary and universal.

Its main goal is to reverse the loss of forest cover worldwide through sustainable forest management, including protection, restoration, afforestation and reforestation, as well as to increase efforts to prevent forest degradation and contribute to the global effort of addressing climate change. It includes a target to increase forest area by 3% worldwide by 2030, signifying an increase of 120 million hectares[106].

- **The United Nations Decade on Ecosystem Restoration (UN Decade 2021-2030)**

In an effort to mainstream ecosystem restoration into policies and plans to address current national development priorities and challenges, the upcoming UN Decade on Ecosystem Restoration is calling for the large-scale conservation and restoration of all ecosystems, to ensure the SDGs will be attained by 2030. It follows a strategy to foster a global restoration culture, through the empowerment of a global movement, political will and technical capacity for restoration[107]. The three main goals of the strategy are:

1. Prevent, halt and reverse the degradation of ecosystems worldwide;
2. Increase understanding of the multiple benefits of ecosystem restoration (Figure 55);
3. Apply knowledge of ecosystem restoration in education systems and within all public and private sector decision-making.

[106] https://www.un.org/esa/forests/documents/un-strategic-plan-for-forests-2030/index.html
[107] FAO, 2019. The Road to Restoration. A Guide to Identifying Priorities and Indicators for Monitoring Forest and Landscape Restoration 78p.

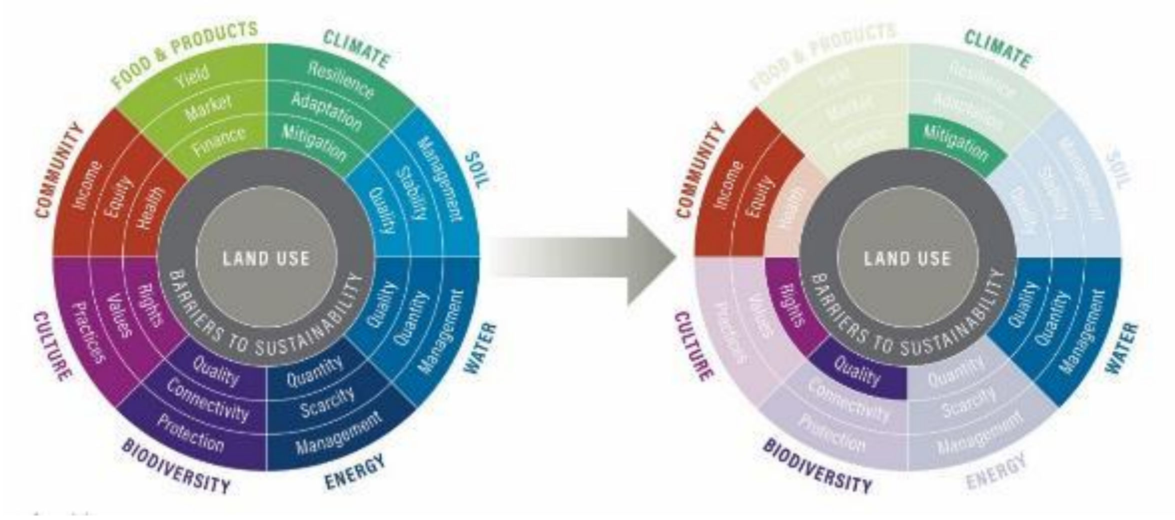


Figure 55: Determining Goal and sub-themes using the Restoration Monitoring Wheel

4.2.2 *Assessing and monitoring forest restoration*

- **Overview of worldwide forest restoration initiatives**

A forthcoming study by researchers from the University of Virginia analysed all reforestation and afforestation activities made for the Global forest landscape restoration implementation, since the year 2000. They evaluated over 3 500 peer-reviewed studies, grey literature and databases published since 2010, as to show the increase of forest cover by region and type of restoration over the period 2000–2019 (Figure 56).

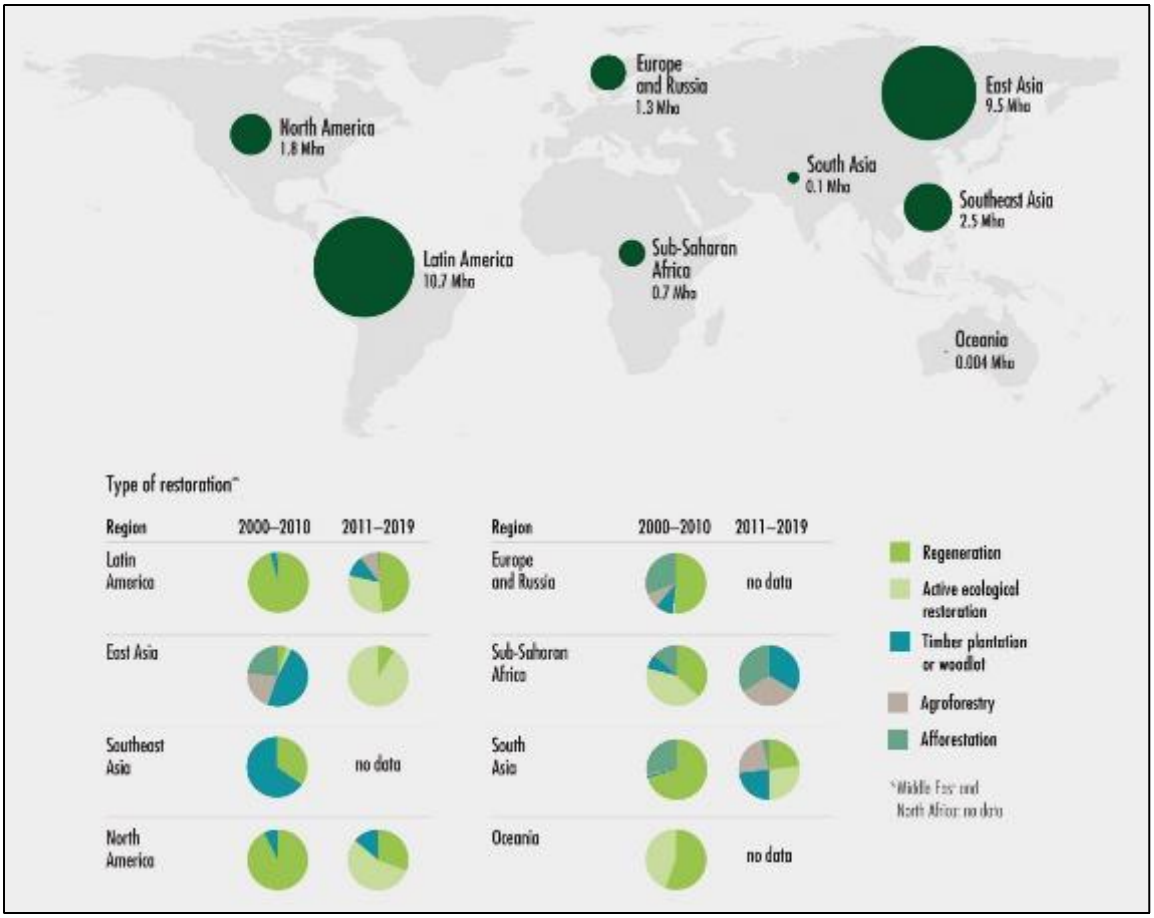


Figure 56: **Reforestation and afforestation activities since 2000, per regions and type of restoration**

The results show that, if the majority of forest restoration is due to natural regeneration, the share of restoration initiative based on natural regeneration has fallen sharply between the 2000-2010 and 2011-2019 periods, for the benefit of Timber plantation and woodlot. This is mostly the case for Latin America, Sub-Saharan Africa and South Asia. However, Active ecological restoration was only marginally observed in the Oceania and Sub-Saharan Africa regions for the 2000-2010 period but implemented in almost all regions during the next decade, especially in East Asia where it replaced all plantation initiatives. The total amount of restoration reported from 2000–2010 was 23.6 million hectares (Mha), and 3.1 Mha for the 2011–2019 period.

- **Assisting monitoring of tree-based restoration initiatives**

Forest and landscape restoration monitoring is an important component of a well-rounded restoration implementation strategy and an important next step is to monitor restoration activities to assess progress toward intended goals. The FAO produced a specific guide that serves to assist stakeholders in monitoring tree-based restoration, with a focus on trees outside forests, such as trees on agricultural and pastoral landscapes and within cities and towns, using a Collect Earth mapathon approach[108].

Planning, conducting, and processing the data from a Collect Earth mapathon involves eight key steps:

1. Developing a data use plan and influence strategy;
2. Defining the survey indicators and area of interest;
3. Designing the survey;
4. Designing the sampling scheme;
5. Organizing the mapathon;
6. Conducting the mapathon;
7. Assessing the data quality;
8. Analyzing data and presenting results.

The mapathon approach presents an opportunity to involve local stakeholders and people familiar with the landscape as data collectors and interpreters, which increases accuracy and creates a sense of ownership among end users of the findings and products produced.

4.3 Benefits from Forest restoration in Europe

4.3.1 *Priorities for reaching good condition of forest ecosystems*

The results of the 2015 Global Forest Resources Assessment of the FAO[109] indicated that the total world forest area declined by 3% between 1990 and 2015, from 4128 M ha to 3999 M ha. However, the annual rate of net forest loss halved from 7.3 M ha/y in the 1990s to 3.3 M ha/y between 2010 and 2015. Moreover, this decline is largely happening in the tropics (from 1966 M ha in 1990 to 1770 M ha in 2015), while temperate forest expanded from 618 M ha to 684 M ha over the same period.

Indeed, Europe (including the Russian Federation) figures among the sub-regions where forest cover is expanding, together with North America, the Caribbean, East Asia, and West and Central Asia, and has more forest than any other geographical sub-region (25%). Still, and even if certain structural condition indicators have improved (e.g., biomass volume and deadwood), the condition of EU forests is considered to be poor, in general. Several indicators point to a degrading trend, like defoliation levels, and some positive trends are not sufficient to reach a good condition, like the fact that the amount of deadwood is still below the desirable threshold levels for biodiversity in various forest habitat types.

Therefore, if halting forest loss or re-creating forest habitats does not seem to be the key answers to improve the condition of the European forest ecosystems, apart for some restricted and specific habitat types (still, it is estimated that a strict minimum of 3 500 km² would need to be re-created to achieve a 'favourable area" for the Annex I habitat types), efforts should be strongly pushed on

---

[108] Reytar K., Martin O., Landsberg F., Ray S., Gallo Granizo C., Zamora Cristales R., Duraisami M., Kanchana C.B., Woldemariam T., Stolle F., Arakwiye B., Courtois A.M., d'Annunzio R., Finegold Y., 2021. Mapping Together. A Guide to Monitoring Forest and Landscape Restoration Using Collect Earth Mapathons. FAO, 98p.
[109] Rodney J. Keenan, Gregory A. Reams, Frédéric Achard, Joberto V. de Freitas, Alan Grainger, Erik Lindquist, 2015. Dynamics of global forest area: Results from the FAO Global Forest Resources Assessment 2015, Forest Ecology and Management, Volume 352, pp 9-20, ISSN 0378-1127, https://doi.org/10.1016/j.foreco.2015.06.014

ecosystem restoration. EEA estimated the area of Annex I forest habitats that would need to be restored (i.e., improved in condition) is at least 79 210 km², representing 22 % of the total area reported for the forest habitat group, while an 'unknown' condition the condition is reported (or not reported) for over 116 444 km² of additional forest habitat types.

4.3.2 *Forest and Climate change mitigation*

Forests have the potential to mitigate climate change by functioning as carbon stocks and sinks. To realize this potential, it is essential to halt deforestation and forest degradation, as to optimise their ability to capture and store carbon from the atmosphere. This can be done through sustainable forest management, forest conservation and forest ecosystem restoration[110].

The REDD+ initiative is a good example of restoration initiative for climate change mitigation purposes. It consists of three phases: (i) the readiness phase, including the development of national strategies, action plans, safeguards information systems and a national reference emission level; (ii) the implementation of policies and measures; and (iii) the results-based payments (RBPs). RBPs provide financial incentives to developing countries able to prove that they have halted deforestation or degradation over a specific period. The payments are funded by financing mechanisms such as the Green Climate Fund (GCF) Pilot Programme for RBPs.

Countries that have received REDD+ payments commit to reinvesting the proceeds to address key drivers of deforestation and forest degradation, as well as barriers to improved forest protection, restoration and SFM. Reinvestments that yield further REDD+ results receive corresponding payments, which are again reinvested to suppress deforestation and forest degradation and enhance forest restoration. The successful projects realized from Europe are from the United Kingdom of Great Britain and Northern Ireland, Norway, France, Switzerland, Germany and Poland.

4.3.3 *Forest and Pollinators*

Pollinators are essential for the reproduction of foundational tree species in a range of ecosystems[111]. However, some recent studies have found that pollinators were less diverse and abundant, and that their functional interactions were lower in restoration plantings than in primary forests. The species with the largest bees, as well as above-ground bee species, are the most diminished pollinator populations in these restoration plantings, suggesting that those pollinating insects are highly dependent on mature forest features, such as pre-existing cavities in trees. Trees in restoration sites (plantings) may therefore be dependent on pollinators in nearby primary forests to ensure reproductive success. Still, forest restored sites were more favourable to bee-community recovery than the other disturbed habitats studied (anthropogenic wetlands and sugarcane fields).

[110] FAO, 2020. Moving forward – Selected achievements of the FAO Forestry Programme in 2018–2019. Rome. https://doi.org/10.4060/cb1275en

[111] Krishnan, S., Wiederkehr Guerra, G., Bertrand, D., Wertz-Kanounnikoff, S. and Kettle, C.J. 2020. The pollination services of forests – A review of forest and landscape Interventions to enhance their cross-sectoral benefits. Forestry Working Paper No. 15. Rome, FAO & Bioversity International. https://doi.org/10.4060/ca9433en

Restoration efforts should consider the nesting needs of bees, and address the management and conservation of primary-forest remnants that are sources of habitat. For example, restoration areas may be best sited close to functional habitat areas, or it may be possible to re-create habitat elements with plantings or by improving existing spaces. Restoration plantings should also aim to establish tree species at densities sufficient to enable their effective pollination.

Few studies exist, however, of the long-term implications of initial restoration plantings on pollination, but the study of pollination services of forests highlighted the presence of wild honeybee (*Apis mellifera*) colonies in European forests, and the importance of tree cavities as nest sites. Conserving cavity-bearing trees in managed European forest and maintaining a proportion of unmanaged forest areas (that generally host far more tree cavities than their managed counterparts) could contribute to safeguarding and sustaining wild native honeybee populations.

The European Topic Center on Biological Diversity published in 2020 a report, identifying the most important Annex I habitats for pollinating insects[112]. This report concluded that forest habitats show a medium species richness, but with a high proportion of plant species classified as important for pollinators. The Top 5 ranked Forest habitat types (91E0, 9180, 91F0, 9150 and 9170) have a high number of entomophilous plant species, comparable to some of the grassland habitats, but those value of plant species richness are in most cases restricted to forest edges, glades and clearings. Dense forest areas are indeed of less species richness.

Furthermore, several forest habitat types include a high number of sub-types. For example, 91E0 Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* covers Ash-alder woods of springs and their rivers, Ash-alder woods of fast-flowing rivers, Ash-alder woods of slow-flowing rivers, Montane grey alder galleries, Sub-montane grey alder galleries or White willow gallery forests. Therefore, the high number of characteristic species (404) reflects some kind of an aggregated species pool over all subtypes. The same situation can be assumed with 9180 *Tilio-Acerion* forests of slopes, screes and ravines, as well as with 91F0 Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia* along the great rivers. The latter habitat type forms often mosaic vegetation with pioneer or stable forests of soft wood trees.

Some scientific papers focusing on the Mediterranean regions also identified Pine forests, oak woodlands and managed olive groves as habitats of great value for plant-pollinator communities, and the provision of pollination service. The highest bee species richness in oak woodlands and managed olive groves fits to the high floral diversity recorded (flower species richness as well as flower abundance) in these habitats. There, the abundance of common bee species is strongly associated with the overall abundance of flowers and of energy availability in the form of nectar.

4.3.4 *Impact assessment of the EU Nature Restoration Law, cost-benefits estimates of forest restoration*

Forest and landscape restoration is a process to regain ecological functionality and enhance human well-being across degraded landscapes. Restoring degraded land generates numerous benefits for people, nature, and business. Indeed, forests provide a wide range of ecosystem services, including timber provisions, non-wood goods, carbon sequestration, flood control, water purification and nature-based recreation. At the European level, all these forest services are estimated at a total

[112] https://www.eionet.europa.eu/etcs/etc-bd/products/etc-bd-reports/etc-bd-technical-paper-1-2020-report-for-a-list-of-annex-i-habitat-types-important-for-pollinators

economic value 81.413 million euros, where wood production representing only 18%. Forestry and logging still employs almost 500.000 people in the EU27, and the wider sector around 4.5 million people. Forests currently sequester around 10 % of the EU's annual emissions.

Continuous pressures are expected to negatively affect various ecosystem services that forests provide, including wood production, biodiversity protection as well as the role forest have for climate change mitigation, while forests' ability to sequester carbon from the atmosphere is projected to decline further towards 2030 and beyond. A recent policy analysis suggested that, even considering ongoing policy reviews and new initiatives, in the absence of additional action to establish legally binding targets, there will likely be a continuous policy gap to adequately address the need to restore forest ecosystems and protect them from further deterioration.

The impact of restoration activities can involve certain costs for forest owners and forest managers, while it may impact their own use of forests or the related value of marketable goods and services (i.e., the opportunity cost of reduced harvesting levels). On the other hand, restoration activities might improve the resilience of forests and ensure a certain economic value of marketable products and services in the future (e.g. due to a reduced risk of damage).

These dynamics could also have an indirect impact on the forest-based industries which are dependent on forest biomass resources. Across the options, the 'opportunity costs' of options 2 and 3 are assumed to be the highest, because those would involve restoration of forests that are more intensely managed for wood production. In addition, more 'nature-based' or 'climate smart' forest management would to some degree depend on the willingness, know-how and adaptability of foresters.

Forest restoration actions will benefit society, as well as specific sectors and groups benefiting from particular forest ecosystem services:

- Healthy forest ecosystems can generate additional income to society and ensure employment in the forest-based sectors;
- Recreational users and the tourism and recreation sector will benefit from enhanced recreational use of forests;
- Conservation organisations and contractors will benefit from investments in restoration, which will enhance revenues and employment in restoration actions;
- Local communities could benefit from positive effects of restoration, e.g., by helping them adapt to climate change, and because of enhanced biodiversity values, water -and soil quality;
- All EU citizens and economic sectors will benefit from mitigation of climate change and the reversal of biodiversity loss.

Despite the fact that a robust cost-benefit analysis for forest restoration in the EU is complicated because of the variety of forests across the EU, the lack of comprehensive and reliable data at EU level and uncertainties regarding baselines and future developments, the available valuation evidence suggests that even without carbon benefits included, the benefits from restoration would far exceed the costs in all possible options for implementing restoration of forest ecosystems.

5 Conclusion

European forest cover is estimated to be around 16.131 million ha, corresponding to 38% of the EU-28's land area. The area of forests in Europe has strongly increased over the past decades due to both natural processes (rural land-abandonment and spontaneous recolonization) and to active afforestation (mountain restoration, etc.). However, it appears that the annual natural expansion of forests and net area of land converted to forest by man are both falling in the EU over the same period, suggesting a change in trend towards future reductions in extent. EU forests have also experienced strong turnovers, reflecting their relation to forest management cycles, felling, regeneration, and natural disturbances due to storms and fires.

The widespread woodland types in Europe with a relatively closed canopy are usually dominated by one or only few tree species, and many European forests habitat types correspond to the potential "natural" vegetation of their distribution range. Still, actual virgin and pristine examples of those potential "natural" forest vegetation only exist in small remnants, and a long history of different use has left its traces on many of these habitats. Old growth forests have also strongly declined over the last centuries, and strictly protecting them will not be enough to meet the 10% strict protection of land area target of the EU Biodiversity Strategy. However, it appears that most of the 261 identified European "primeval forests are already at least partly included within nationally designated protected areas.

National Forest Inventories (NFIs) of European Member-States have different historical origins but they all were established with the primary aim to cover the information needed at country level. But a growing number of target groups require such comparable information from NFIs, as a reliable basis in decision-making processes. In addition, and even if there is no common overall forest policy in the European Union, forest-related objectives are being stepped up by policymakers from different sectors, while the EU Forest Strategies seek to amend the lack of coordination and coherence between the various forest-related policies, within the Union and its Member-States. Moreover, Nature conservation is undertaken by both Birds and Habitats Directives, even if European forests are only covered up to 30% in term of habitat conservation. Finally, the European FISE database now regroups all the available European-wide data and information and integrates the diverse database and information systems within a modular array of models.

Still, the nomenclatures used and the spatial resolution of the different datasets does not always allow straightforward comparisons, whether in terms of distribution estimates or ecological description. In addition, a consequence of forest definitions focusing on forest "land-use" over forest "land-cover" is that large areas of forest clearing done within land that are still classified as forests, and the related huge amount of carbon and biodiversity losses, remain ignored from international statistics. Moreover, new forests resulting of land-use changes, like forests growing on former agricultural land, as well as restored forests and early stages of spontaneous natural regeneration, will go unnoticed for many years until the forest-cover can satisfy the FAO definition. In addition, as most of European forest are semi-natural forests, it is strongly recommended to narrow down this classification as to better integrate the degree of forest "naturalness" in forest management, as a way to better consider and measure the impact of each forestry action in terms of ecological resilience, a key factor to ensure the persistence of European forests within a changing climate.

As for the current protection of forest ecosystems within the EU, it appears that the total cover of the 81 Annex I forest habitat type registered in the Natura 2000 database by the end of 2019 was 14.680.585 ha (146.805 km^2), and 17.693.898 ha (176.939 km^2) if considering the 7 Annex I habitat types newly proposed to be considered as forest habitats. This represents about 30% of the distribution of Annex I habitats in Europe. As for the other nationally designated protected areas, which cover about 852 000 km^2 in Europe, it appears that about 44,5% of their area is forested.

Protected areas with the highest protection status (Ia and Ib) have a strong focus on woody and densely forested areas, together with protected areas meant to conserve ecosystems and habitats together with traditional natural resource management (Category VI), while protected landscapes (category V) include a large spectrum of forest tree cover, in reflexion with the diversity of European landscapes.

Not surprisingly, dominant group of pressures reported for forest habitats are pressures related to “forestry”. The dominant group of pressures in the four main regions of Europe: Boreal region, Mediterranean and sub-Mediterranean region, Macaronesian region and the Temperate zone (all other regions), are also pressures related to “forestry”. They represent from 33% in the Mediterranean region, to 51% in the Temperate zone. Similarly, For both species groups “Species living on dead wood” and “Species living on live, standing trees”, the most important pressures are related to “forestry”.

The Case study in Northern Europe also showed that the many quantitative and qualitative indicators reported by Forest Europe covering specifically forest biodiversity, together with additional data related to national inventories, monitoring programs or red list assessments, and the reporting data on the conservation status of species and habitat types under the EU Habitats Directive, form a well-developed basis for assessing the forest conditions in a more complete manner. However, the general forest indicators only provide information about forest conditions in broad sense but on longer time scales. They are too unspecific and fairly represent general phenomena and characteristics related to the total forest area at national scale. Their information value is therefore quite limited with regard to the status and trends of biodiversity aspects, such as species and forest habitat types with specific ecological requirements and/or restricted biogeographical distribution ranges. The conservation assessments made for Red Lists and the Article-17 reporting are more specific, as they are based on relevant information about the individual biodiversity aspects concerned, and use a common assessment methodology. Thus, when the assessments from several countries are weighed together, they can provide comprehensive and relevant information on important biodiversity aspects and their needs of conservation measures.

Indicators based on national forest inventories allow to show that ecological conditions of forests have been significantly altered over time, compared to reference conditions of natural and unmanaged forests. In contrast, some general indicators reported indicate that the forest condition is somehow improving (overall growing stock, average volume of dead wood, increase of forests dominated by temperate broadleaved tree species, the area of old forest, few symptoms of air pollution and nitrogen deposition, etc.). Red list assessments reported various activities related to forestry, but also the lack of natural disturbances such as forest fire, flooding, etc. and traditional forest grazing are emphasized as the most important reason for the species to become threatened. Likewise, the reporting under EU’s Nature Directives show that forest habitat types, as well as a wide range of forest-dwelling species, are under pressure and have an inadequate or bad conservation status. A general feature is that the proportion of assessments with favourable conservation status for habitat types is lower than for forest-dwelling species. One possible explanation could be that habitat types include specific and natural forest environments whose status is negatively affected by past and current pressures from intensive human land use, while the group of forest-dwelling species includes several species that are adapted and subsist in today's managed landscapes.

Europe figures among the sub-regions where forest cover is expanding, but their condition is considered to be poor, even if certain structural condition indicators have improved. Therefore, improve the condition of the European forest ecosystems will not consist in halting forest loss or re-creating forest habitats, but on ecosystem functional restoration, combining a regain of ecological functionality toward an improved resilience, while ensuring enhanced human well-being and a certain economic value of marketable products and services.

Table of figures